NHTSA/FHWA Pedestrian and Bicycle Strategic Planning Research Workshops

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Draft Final Report

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I. Introduction

On April 13 and 14, 2000, the Federal Highway Administration (FHWA) and the National Highway Traffic Safety Administration (NHTSA) conducted two one-day workshops on the research needed over the next five years to improve pedestrian and bicycle safety. This report presents recommendations from the workshops' participants.

About 40 persons participated in each workshop. About 25 were researchers and practitioners invited to share their expertise and views. The remainder were FHWA and NHTSA staff who contributed factual information as needed. Workshop attendees are listed in Appendix B.

Each one-day workshop followed the same format. Each was divided into three broad areas: data needs, countermeasures, and special issues. Two (in one case, three) invited papers were prepared on each area by eminent researchers. The papers were highly structured: each author was to list his or her top research priorities for the assigned area, with enough background to explain and justify the proposed research. These background papers were circulated to all workshop participants in advance and are reproduced in Appendixes C and D of this report.

Each workshop began with brief presentations by each paper's author followed by general discussion on each of the three areas (see the workshop agendas in Appendix A). This discussion allowed all participants to suggest other research needs that had not been addressed in the background papers.

Following these discussions, each workshop divided into three working groups, one for each area. The working groups considered all research recommendations from the background papers and from the floor and added other recommendations of their own. They reported these research need recommendations to the full workshop. The working group reports are provided in Section II of this report. The workshop as a whole then discussed these recommendations. Points raised in discussion are included in the working group reports.

The working groups and the workshop as a whole did not attempt to prioritize the recommendations. However, individual participants did prioritize these recommendations independently and submitted them for consideration to NHTSA and FHWA. A summary of the participants' individual prioritizations is provided in Section III. In their reports, some working groups noted a few recommendations they believed to be especially important.

Carol Tan Esse, FHWA, and Marvin Levy, NHTSA organized the workshops and commissioned the invited papers. Jim Hedlund, Highway Safety North, served as overall facilitator and drafted the summary report. Carol Tan Esse, Marvin Levy, and Carole Guzzetta and the National Safety Council handled all logistical arrangements. The University of North Carolina Highway Safety Research Center compiled the report and developed it for web access.

II. Summary of Workshop

Pedestrian Data Research Needs

Richard Knoblauch, Facilitator
Joe Cameron and Andy Clarke, Reporters

The Data working group recognized major data needs in four broad categories -- exposure, crash, attitudes, and planning and policy. The group recommends that data systems be established and maintained to collect the necessary information in each area. Rather than suggest specific data elements or procedures, the working group report discussed the types of data needed and key characteristics of good data collection systems. The two background papers, by Preusser and Leaf and by Schwartz, also discuss data needs quite broadly and provide useful information for each of the four data categories. Background paper recommendations especially relevant to a category are noted by the lead author's name and the recommendation number within the author's paper.

D-1 Exposure data. (Preusser #1,2; Schwartz #1,2,3)

There are no ongoing data to describe pedestrian exposure to the risk of a motor vehicle crash. We know the number of pedestrian fatalities annually; we can estimate the number of injuries; but without good exposure data we have no idea of pedestrian risk. As one example, we do not understand whether the recent decrease in child pedestrian casualties is due to improved safety, to children spending more time indoors and in cars rather than as pedestrians, or to more "pedestrian friendly" vehicle bumpers and hoods.

This research first should define appropriate pedestrian exposure measures and then should determine how to collect the necessary data. Appropriate exposure measures should include all people who walk and should account for walking under different situations of risk (pedestrian location relative to the roadway; traffic volume, speed, and roadway type). The data should be straightforward to collect, compatible with crash data, applicable to all pedestrian-roadway situations, and available over time to track trends. The group recognized that major new data collection systems will be expensive and consequently are unlikely to be funded. Consequently, the group suggested that using non-traditional sources (such as information from shoe manufacturers), taking advantage of new technology (such as ITS), and piggybacking on existing surveys be considered. The goal is to track who and how many people are walking, where, why, how far, and under what conditions. To be most useful, the exposure data should be directly compatible with comparable crash data.

D-2 Crash data. (Preusser #3,4)

Police crash reports do not provide an accurate picture of pedestrian traffic crashes. Comparisons with hospital and emergency room data show that many non-fatal pedestrian injuries are not reported to the police. Some are overlooked; some are not eligible since they occur off the roadway or do not directly involve a motor vehicle. Even for those that are reported, the police record lacks vital information, such as pedestrian actions prior to the crash, sight lines for pedestrians and motorists, and special crash characteristics such as pedestrian disabilities. Pedestrian crash types, developed over 30 years ago, have not been widely adopted for use in police reports. Ways to encourage the collection of more potentially useful pedestrian crash report data need to be investigated.

This research should begin by conducting a needs assessment to determine what data, for what crashes, are required both to identify pedestrian crash problems and to develop and evaluate countermeasures. This assessment should include a review and revision of current pedestrian crash types, with a goal of producing types that can be used to define and analyze a community's pedestrian safety problems and assess the effectiveness of their local pedestrian safety programs. The research should develop methods to encourage police to collect the necessary data on pedestrian crashes. As police agencies are moving rapidly to automated crash reporting systems, we have a once-in-a-lifetime opportunity to do this. Good crash reporting software can include a pedestrian crash module that branches to the pedestrian data elements when they are needed and can ask the reporting officer for the necessary information. But unless the data needs are defined quickly, these automated systems probably will treat pedestrian crashes as poorly as do current paper crash reports. Finally, this research should investigate and encourage methods (such as data sharing and data linkage between medical, crash, and infrastructure data systems) to acquire data on crashes not reported to police. In addition to providing a better estimate of the pedestrian injury problem, this will deepen our knowledge by adding information on injury types and on infrastructure involvement to the basic police report data.

D-3 Attitudes. (S-3)

If nobody walked, there would be no pedestrian safety problem. We wish to encourage walking and we wish to make walking safer. Pedestrian activity and pedestrian safety is influenced by what people think as well as what they do. When pedestrians don't feel safe, they may stop walking; if drivers view lower speed limits in pedestrian zones as an obstacle to their driving, then drivers are unlikely to obey the limits.

This research should acquire general information on driver and pedestrian attitudes toward each other. What factors encourage or discourage walking? How does safety enter into the mix? What do drivers and pedestrians think about infrastructure measures to improve pedestrian safety (traffic calming devices, longer signal times, etc.)? What do they understand about right-of-way requirements and practices at marked and unmarked crosswalks or at signalized intersections? This research should seek methods to raise these questions in each location where a pedestrian safety problem is found or where countermeasures are proposed. What do drivers and pedestrians think about a lower speed limit -- will drivers obey the limit? Such information could be obtained through surveys and through followup interviews with crash-involved drivers and pedestrians.

D-4 Planning and policy. (Schwartz #1,2,3; Preusser #5)

Decision-makers require data. Better data will raise the priority of pedestrian issues when cities and subdivisions are planned, when roads are built or modified, and when funds are allocated. Better data can make communities aware of pedestrian issues and can lead to safe and better utilized pedestrian facilities.

This research should begin by evaluating what pedestrian data are now available to planners and policy-makers at both national and local levels. This should include data at all levels, from overall funding levels for pedestrian facilities, to information on successful (and unsuccessful) community pedestrian programs, to an inventory of where pedestrian facilities are present and where they are needed. The research then should consider how to improve the data and make them available to those who need it. How can ITS data be useful (in fact, how can pedestrian issues be incorporated into ITS designs)? How can latent demand for pedestrian facilities be estimated and used to influence planning and policy decisions?

Pedestrian Countermeasure Research Needs

John Fegan, Facilitator
Leverson Boodlal and Linda Cosgrove, Reporters

The Countermeasures working group developed a list of 31 research needs. They are numbered arbitrarily: the numbers do not suggest any group priorities. However, the group wishes to emphasize three in particular: pedestrian facilities at uncontrolled crossings (C-8), traffic signal innovations (C-10), and roadway measures to reduce speeds (C-12). Other important data needs are motivators for communities (C-3), effective information sources (C-4), countermeasure longevity (C-5), trail and path design (C-13), vehicle modifications (C-14), and systematic countermeasure reviews (C-23). Research needs based on or closely related to a background paper recommendation are annotated with the author's name and the recommendation number within the author's paper.

C-1 Information on effective pedestrian safety countermeasures. (Blomberg #1; C-23)

Many pedestrian countermeasures have been developed and implemented. Many have proven effective. Information on the best measures should be collected and packaged so these measures can be implemented more broadly. This research should assess existing pedestrian countermeasures at all levels, from local to national, and of all types, including engineering, education, and enforcement. Information on the most effective and relevant measures should be compiled in a form that's easily accessible and available to communities and states. The information should describe the measure, discuss where it should be considered, describe what's necessary to implement it, and give evidence for its effectiveness. The information could be compiled on a CD or web site that could include pictures or even video clips as appropriate.

C-2 Investigate non-crash events as a tool for evaluating pedestrian safety.

Pedestrian crashes are rare events, so rare that it is difficult for most communities to rely on crashes alone to evaluate their pedestrian safety problems or suggest pedestrian countermeasures. Other measures such as "near misses" may give additional data, in the same way that the air safety community investigates aircraft "near miss" events to improve air safety. This research should investigate and validate whether measures other than crashes can be defined, measured, and used for pedestrian problem identification and countermeasure development. Different intermediate measures may be appropriate for different pedestrian groups and situations (children, rural roads, etc.)

C-3 How can communities be motivated to take pedestrian safety seriously? (Blomberg #2; C-11)

Some communities such as Seattle have strong and effective pedestrian safety programs. Others essentially ignore pedestrians. This research should investigate what motivates community action on an issue and how these "hot buttons" can be used to increase attention to pedestrian issues. The research should seek information and tools that can be applied broadly across the United States and that do not require special situations.

C-4 Determine the effective sources of pedestrian information. (Blomberg #3)

Public information on pedestrian safety comes from many sources and uses many spokes people -- cartoon characters (Willie Whistle), law enforcement, public figures. We don't know which sources are the most effective and most credible for which target groups. This question is part of a broader consideration of pedestrian public information strategy. After deciding **what** information should be conveyed, serious thought (perhaps involving research) is needed to decide **how** the information can be transmitted most effectively: by whom, in what form, through which media. This research should investigate the most effective sources for information on key pedestrian issues for key target groups.

C-5 How long are pedestrian countermeasure effective? (Blomberg #4)

Many pedestrian countermeasures are implemented with substantial publicity, often with outside funding, and may produce immediate changes in driver or pedestrian behavior. Over time, both publicity and funding may disappear. Does the countermeasure effect also decrease or vanish? Or is the new behavior learned over time so that it becomes habitual and the countermeasure effect becomes permanent? We usually do not know and do not even investigate these long-term effects. This research should study the long-term effects of selected countermeasures of different types in different situations, with special attention to potentially slow-acting measures. Long-range cohort studies may be useful.

C-6 Develop better information technology tools for pedestrian data collection and analysis. (D-1, D-2)

The Countermeasure group recognized the data needs discussed by the Data group. The Countermeasures group joined the Data group's recommendation to investigate the use of new information technology techniques to collect and analyze pedestrian crash and exposure data.

C-7 Define countermeasures for non-motorized vehicle crashes. (C-13)

Most pedestrian countermeasures deal with conflicts between pedestrians and motor vehicles on roadways. But bicycles, skateboarders, in-line skaters, and other vehicles also put pedestrians at risk on sidewalks, paths, and parking lots as well as on roads. This research should analyze available data to determine key locations and vehicle types involved in these conflicts and then should proceed to countermeasure development and testing.

C-8 Improve pedestrian safety at uncontrolled crossings. (Zegeer #1)

Many pedestrians cross streets and roads at locations without traffic controls, both midblock and at intersections. Some research has investigated various traffic signs, road markings, and road design measures that attempt to assist pedestrians at these locations, and some communities have implemented them, but results to date are equivocal. This research should identify the specific problems pedestrians face at uncontrolled locations and should develop and test measures to improve their safety. Experience in Europe and elsewhere may be useful.

C-9 How can pedestrians safely cross intersections with roundabouts?

Roundabouts have been introduced in some areas to improve traffic flow through intersections. Traffic entering a roundabout from any direction must slow, but can proceed through the intersection without stopping if no other vehicles are in the intersection. But pedestrians at roundabouts have no stop signs or traffic lights to assist them in crossing. In addition, visually impaired pedestrians (and also bicyclists) have reported problems negotiating roundabouts. This research should investigate the best methods for providing safe pedestrian crossings at roundabouts. Experience in other countries where roundabouts are used extensively should be helpful.

C-10 Traffic signal innovations to improve pedestrian safety. (Zegeer #2)

Traffic lights and pedestrian Walk - Don't Walk signals are not as effective as they could be. Drivers and pedestrians alike may not understand the signals or may ignore them (and pedestrians with poor vision may not even see them). New technology for detecting and sending messages to pedestrians and vehicle drivers may help improve traffic signal performance. This research should summarize problems at signalized intersections, investigate new methods of pedestrian and vehicle detection and control, and conduct field tests of the most promising measures.

C-11 Methods to enhance a pedestrian safety culture. (C-3)

The United States is an automobile, not pedestrian, culture. Driving and parking come first, walking and bicycling are far behind. If the balance can be changed to increase the role of pedestrians, any specific pedestrian safety measure is easier to implement. If it cannot, pedestrian safety measures will continue to be shortchanged. This research should investigate methods to increase the priority of walking and pedestrian safety in the United States. It should investigate connections with health, environmental, and economic issues, organizations, and companies.

C-12 Study roadway features to regulate vehicle speeds. (Zegeer #3; Warren #1,2,4; S-1, S-8, S-9)

We know that engineering changes -- traffic calming devices -- can and will reduce vehicle speeds where speed limit reductions will not. Many such devices have been incorporated into new roads or added to existing roads. Information on these methods should be collected, summarized, and disseminated. This research should analyze and quantify the effects of different traffic calming devices in different roadway environments. In addition to straightforward measures of traffic volume and speed it should consider broader system effects. Does traffic shift to alternate routes? How is pedestrian and bicycle traffic affected? What do drivers, walkers, and residents feel about traffic calming measures?

C-13 Safer design of trails and paths for shared use. (Zegeer #4; C-7)

Trails and paths are used by pedestrians, bicyclists, joggers, in-line skaters, horse riders, and others. This mix may produce crowded conditions, a wide range of speeds, and the potential for crashes and injuries. Road crossings pose special problems, as drivers may not expect non-motorized traffic from the trail while joggers and in-line skaters may not wish to stop to wait for cars to pass. Trail designs often fail to consider these safety issues. This research should analyze use and injury data on selected trails to identify safety problems, investigate and evaluate countermeasures, and develop draft guidance for improving safety on trails while at the same time encouraging trail use. Again, European experience may provide useful information.

C-14 Vehicle modifications to improve pedestrian safety.

It's well-known that some vehicle designs are more forgiving than others in vehicle-pedestrian crashes. Some designs concentrate crash forces on a pedestrian's head or other vulnerable areas; others spread the damage more broadly. It's not clear how the rapid increase in sport-utility vehicles and light trucks in recent years has affected pedestrian injuries in crashes. This research should examine crash data by vehicle type to determine if specific vehicle design features have affected pedestrian injury patterns in crashes.

C-15 Improved lighting for pedestrians. (Zegeer #5; see also Bicycle O-10)

Pedestrians cannot see or be seen as well when lighting is poor. Two obvious remedies are to improve permanent overhead lighting or to improve vehicle headlights. Both are difficult and expensive. This research should summarize existing research on the relation between pedestrian safety and lighting levels and should study situations in which lighting improvements may lead to improved safety. It also should investigate whether vehicle headlight requirements and performance provide reasonable pedestrian safety levels.

C-16 Employ an effective process for countermeasure definition and development.

Pedestrian countermeasures are sometimes developed and implemented without the benefit of good research. This may lead to ineffective measures, poor use of resources, and perhaps even counterproductive results. This recommendation does not require new research. Rather, it reminds everyone that pedestrian safety benefits from following the standard scientific process: define the problems; agree on priorities; develop functional requirements for vehicles and drivers, pedestrians, and the infrastructure; develop and field test countermeasures; evaluate effectiveness; and implement effective measures broadly.

C-17 Wheelchair accessibility at railroad crossings.

Railroad and light rail crossings may contain gaps that are difficult to cross in a wheelchair. This research should study the ease with which wheelchairs of different designs can pass over rail crossings. If appropriate, it should recommend performance standards for rail crossings.

C-18 Pedestrian signing and markings for special populations.

Pedestrian signs and markings are useless if they are not seen and understood. Pedestrians with low or impaired vision may not see the signs or markings; young children and persons unfamiliar with the signs and markings may not understand them. This research should explore whether the MUTCD guidelines on signing and markings (color, contrast, reflectivity, legibility, mounting specifications, viewing distance, and meaning) are effective for persons with visual impairments, children, and others and should suggest any appropriate improvements.

C-19 Determine appropriate curb heights to balance pedestrian, motor vehicle, and environmental concerns.

High curbs (over 6") are difficult for some pedestrians, require long ramps for curb cuts, and may increase vehicle rollovers. Very low curbs do not accommodate street resurfacing unless the old asphalt is removed. Research suggests that the ideal height may be about 4". This research should review existing information on the influence of curb height on pedestrian safety, motor vehicle safety, and road maintenance. It should recommend the appropriate curb height or height range for different roadway situations.

C-20 Develop roadway designs to improve storm water drainage and reduce puddles.

Standing water makes the road surface slippery for pedestrians. Pedestrians walking around standing water may be forced into the roadway. Curb cut ramps often collect standing water unless they are well-designed. Engineering approaches to improve drainage are well-known and have been used for both new construction and retrofitting but have not found their way into standard road design literature. This research should review effective design methods to improve storm water drainage, especially at curb cuts, and should recommend how these design practices can be incorporated as standard practice.

C-21 Investigate other pedestrian research recommendations from the U.S. Access Board

The U.S. Access Board submitted a list of 32 pedestrian research recommendations relevant to persons with some form of physical limitation. Several of these are addressed in detail within these recommendations. The remainder raise issues that should be considered in any complete review of potential pedestrian research needs. The complete list is attached to this working group report as Appendix E.

C-22 Investigate roadway design tradeoffs for vehicles and pedestrians.

Lane widths, curb radii at corners, median widths, and similar roadway design specifications typically have been developed to improve vehicle flow, not pedestrian safety. Some standard practices may not strike the most effective balance. This research should review these design specifications to see whether changes in some situations may improve overall traffic safety.

C-23 Review and synthesize results from pedestrian safety programs. (C-1)

Many pedestrian safety programs have been evaluated, but results are scattered and not well known. This research should conduct a systematic formal review of all pedestrian safety program evaluation results. The review should include education, engineering, enforcement, and combined programs. The results should be summarized and advertised widely.

C-24 Evaluate pedestrian programs that have not yet been evaluated.

Many pedestrian programs have been implemented but not evaluated. This research should evaluate the most promising and the most widely used programs, including education, enforcement, and traffic calming strategies. Candidate programs include "Walk your child to school" and new methods for reducing red light running. Again, the results should be advertised widely.

C-25 Conduct benefit-cost analyses of selected programs.

Effective pedestrian safety programs are not implemented automatically. They cost money to implement, and they must compete with may other issues for limited public funds. Good benefit-cost analyses help convince community leaders and citizens to fund pedestrian safety improvements. This research should conduct benefit cost analyses of pedestrian safety programs whose safety effectiveness already has been demonstrated.

C-26 Determine at what developmental age a child is ready to cross the street alone. (C-28)

Pedestrian education programs teach children to cross the street safely but don't say when this information is appropriate. This research should determine the developmental age at which streets can be crossed safely, should establish how parents and care givers can determine easily when children have reached this developmental age, and should incorporate this information into child pedestrian education programs.

C-27 How do pedestrians and drivers communicate?

Pedestrian safety often is based on common understanding and communication between pedestrian and driver. For example, at a marked crosswalk, can a pedestrian assume that a driver will stop? Can a driver assume that a pedestrian who sees a car approaching will not step into the roadway? This research should investigate effective methods for establishing common expectations for pedestrians and drivers in such situations and explore whether simple hand signals or other communication methods might be useful.

C-28 Determine appropriate supervision standards for children of different developmental ages (C-26).

This research extends the ideas of C-26 to a fuller investigation of how child pedestrian supervision requirements change with developmental age, how to determine when a child is ready for more independent action, and how to communicate this information effectively to parents and care givers.

C-29 Develop and test pedestrian behavior mentoring programs.

Mentors with more experience, knowledge, or ability can be effective educators. This research should investigate whether safe pedestrian practices can be taught in this way. It should investigate using older children to teach younger children, and younger persons to teach senior citizens.

C-30 Investigate the true effectiveness of pedestrian enforcement programs. (C-23,24,25)

It is not clear whether tighter enforcement of laws applying to motorists or pedestrians in fact improves pedestrian safety. Jaywalking law enforcement may not affect pedestrian crashes. Enforcing laws requiring motorists to stop for pedestrians in a crosswalk may cause pedestrians to enter crosswalks without looking for approaching vehicles, so that they are in more danger from vehicles that do not stop. This research should investigate the impact of such law enforcement programs on driver and pedestrian attitudes, behavior, and crashes.

C-31 What can be done to reduce crashes caused by alcohol-impaired pedestrians? (O-1)

Crash data show clearly that many fatally or seriously injured pedestrians are seriously impaired by alcohol. Little is known about what can be done. This research should begin by reviewing the existing literature and then should determine whether any feasible countermeasures can be proposed.

Pedestrian Special Issues Research Needs

Katie Moran, Facilitator
Brian Gilleran and Lori Millen, Reporters

The Special Issues working group developed a list of 22 research needs concentrated in two major areas: special pedestrian groups (SG) and vehicle speed (S). They are numbered arbitrarily: the numbers do not suggest any group priorities. Research needs based on or closely related to a background paper recommendation are annotated with the author's name and the recommendation number within the author's paper.

Special Pedestrian Groups

SG-1 Study pedestrian safety problems of different Native American populations. (Leaf #1)

Native Americans in the Southwest are substantially over represented in fatal pedestrian crashes. We know very little about pedestrian safety issues for other Native Americans. This research should study pedestrian safety problems for Native Americans in different regions of the country, in rural and urban settings, on and off reservations. It should assess the pedestrian safety education provided to Native Americans in these settings and should evaluate its effectiveness. It should develop new pedestrian safety programs for Native Americans as needed.

SG-2 Study the special problems and needs of elderly pedestrians. (Leaf #2)

Older persons present special pedestrian safety challenges. Compared to younger adults, older persons often can't see or hear as well, can't walk as fast, take longer to recognize and react to risky situations, and are more fragile. If the environment isn't safe for elderly pedestrians, some persons may reduce their walking, which in turn may affect their overall health. Also, as noted by Leaf, the distribution of elderly pedestrian fatalities by age varies substantially by ethnicity, for reasons that are not understood. Do ethnic and cultural differences affect the amount and location of walking? Are pedestrian safety countermeasures less effective for elderly persons in different ethnic or cultural groups? Or is ethnicity merely a surrogate for economic status and geographic location, which in turn influence fatality risk? This research should determine whether the observed fatality rate differences for elderly pedestrians are due to ethnicity or to other factors. It should document the safety requirements of elderly pedestrians and should recommend how pedestrian safety can be improved for all elderly persons, including those from different ethnic groups and in different geographic locations.

SG-3 How can inner cities be made safer for pedestrians? (Leaf #3; SG-4)

Inner cities frequently are unsafe for pedestrians due to high vehicle and pedestrian traffic and outdated infrastructure. Some inner city areas are low-income residential neighborhoods; others have a diverse racial or ethnic population. Both factors may make it harder to attract attention and resources for pedestrian issues from the city. This research should study what pedestrian safety measures are most effective in inner city areas and how these measures can best be marketed to residents and community leaders. It should consider both educational measures directed at those who live, work, and drive in these areas and engineering and enforcement measures to calm or divert vehicle traffic as appropriate.

SG-4 Improve pedestrian safety for children in inner city residential neighborhoods (Leaf #4; SG-3)

Children in inner city residential neighborhoods are a critical special case of the previous topic. Their environment frequently does not provide safe places to walk or play outside. Standard pedestrian education programs may not be relevant to their environment or to their culture. This research should investigate engineering, enforcement, and educational methods tailored to the neighborhood's urban environment and its residents' cultural and ethnic values.

SG-5 Improve pedestrian safety for persons with physical limitations.

Many physical limitations increase pedestrian risk substantially. Traffic lights are useless if you cannot see; vehicle horns provide no warning if you cannot hear; curbs and medians can be barriers if you are in a wheelchair; short Walk cycles may be unsafe if you walk slowly. This research should conduct a thorough survey of the problems faced by pedestrians with different physical limitations and the ways in which these problems can be addressed. It should consider the needs of people who limit their walking, to determine what changes would improve their safety and encourage them to walk more. It should include both specific measures to deal with specific problems (how can a blind person best request a Walk signal at a crosswalk and determine that the signal has been activated?) and broad issues of policy (what are likely strategies to encourage appropriate changes to be adopted?).

SG-6 What additional data can be used to address special population pedestrian issues?

We lack good data on pedestrian knowledge, attitudes, and behavior from many cultural, ethnic, geographic, and socioeconomic groups. Are untapped data sources available? Can pedestrian questions be added to ongoing surveys? This research should investigate various ways to improve our understanding. Any data collection or data use must be fully aware that the information may be biased unless it is designed and collected carefully. For example, studies should be designed, questions framed, and interviews conducted by persons who are sensitive to and supported by the community being studied.

SG-7 What are the pedestrian problems of new immigrants?

New immigrants may face special pedestrian problems. They may be unfamiliar with a motor vehicle culture, they may have different expectations of motor vehicle actions, or they may not understand English. This research should examine available data to determine whether new immigrants are in fact at higher risk in certain pedestrian locations or situations. If so, it should recommend appropriate education or other countermeasures.

SG-8 How can pedestrian education and information best be delivered to different populations?

Information for different cultural, ethnic, and socioeconomic groups is most effective if its content, delivery, and medium is tailored to its specific audience. This research should use basic social marketing methods to review how pedestrian education and information is now designed and delivered, see if important groups are not served adequately, compare with the current pedestrian safety problem, and recommend how to fill major gaps. .

SG-9 How will United States pedestrian safety problems change over time?

The United States population will change over the next 20 years as people are born, age, move about the country, immigrate, and emigrate. Cities and suburbs will grow and shrink; roads will be built; public transit will alter; travel patterns will change. All these changes will affect pedestrian safety. This research should consider likely trends, evaluate how pedestrian safety issues will change, and propose measures that can be taken in advance. In particular, the research should consider how birth, death, and immigration patterns will change both national and local ethnic distributions. It should recommend what pedestrian education materials are needed to meet these needs, in what languages, and how they can best be delivered

SG-10 What makes an environment friendly or hostile to pedestrians from different populations?

Pedestrian-friendly environments improve both health and safety. Many pedestrian-friendly features are well-understood. But we don't know how these features might be varied to meet the special needs of persons from different cultural, ethnic, socioeconomic, geographic, or age groups. In fact, there may be conflicts: elderly pedestrians may prefer quite different designs from active teenagers. This research should investigate what pedestrian-friendly features are universal and what features are preferred by pedestrians from different groups. In particular, it should consider the pedestrian needs of those who cannot or choose not to walk under current conditions.

Vehicle Speeds

S-1 How do traffic calming devices affect persons with disabilities and emergency access? (C-12, S-9)

Traffic calming devices (speed humps, narrow streets and other restrictive road designs) are being used more frequently to control vehicle speed. Some devices may pose problems for persons with disabilities: for example, wheelchairs may have difficulty crossing speed humps. Others may hinder emergency vehicle access. This research should examine locations with traffic calming devices to determine if they have affected persons with disabilities or emergency access and, if so, how any problems have been resolved. It should consider guidelines for how traffic calming devices can best accommodate persons with disabilities and emergency access in different environmental conditions.

S-2 Strategies for managing speeds in a community. (Karsch #1,2; S-5)

Speed management in residential or business communities often is contentious. Neighborhood residents want low speeds; commuters want high speeds. Residents and businesses want space for parking; commuters want more traffic lanes. This research should explore how community speed management programs can be planned and implemented so that everyone can participate in the process and so that the decisions reached can best serve the public good. Case studies from successful community speed management programs should be useful.

S-3 Motorist perceptions of pedestrians and other road users. (D-3)

Pedestrian safety depends on appropriate behavior from pedestrians and motorists alike. They share the same road system. Both have their own rights (and right-of-way); both have responsibilities to obey traffic laws. But there's a common belief that many motorists regard pedestrians only as obstacles to their vehicle's progress rather than equal partners in a transportation system. (For an example, consider how many motorists fail to yield to pedestrians at crosswalks or when making a right turn through pedestrians crossing with a Walk signal.) This research should study how motorists perceive pedestrians in different situations and should explore methods to improve cooperative behavior between motorists and pedestrians.

S-4 Pedestrian crash problem identification.

Pedestrian crashes are classified by types based largely on pedestrian actions (such as mid-block dash). Further analysis using roadway and traffic conditions may yield useful information for countermeasure design. This research should analyze pedestrian crash (and, if possible, exposure) data by road type, traffic volume, travel speed, and perhaps even pedestrian trip purpose to better understand why these crashes happened and what can be done to prevent them.

S-5 Public attitudes on speed management. (S-2, S-3)

Successful speed management strategies ultimately depend in a common acceptance by motorists and pedestrians alike that the road and traffic control system should accommodate everyone's needs. This research should take a broad view of the topics addressed for specific communities in S-2 and for specific persons in S-3. It should consider the overall societal issues of how transportation infrastructure systems serve society, how individuals participate in the system every day in different roles, and how they can be encouraged to demand and support systems that provide safe and efficient transportation for everyone.

S-6 What driver and pedestrian behavior changes can best improve pedestrian safety? (Karsch #4)

General admonitions to "watch out for pedestrians" or "cross the street only at crosswalks" may not be effective in improving pedestrian safety. Instead, it may be useful to determine specific driver and pedestrian behaviors that should be targeted with specific education or other countermeasures. Possible examples are excessive speed in elementary school zones when students are arriving or leaving, or pedestrians attempting to cross Interstate highways. This research should seek specific driver and pedestrian actions that produce a high crash risk and are common enough to warrant attention. It then should explore and test methods to change these behaviors.

S-7 What vehicle speeds are reasonable from a pedestrian's perspective? (Warren #3; S-2)

Ideally, speed limits should balance the views of both drivers and pedestrians with overall safety and mobility considerations. Drivers get to vote on speed limits directly: travel speeds are measured, and the 85th percentile speed is the basic factor in setting speed limits on many rural roads. There is no similar method for measuring pedestrian views on appropriate speeds. Most urban streets have speed limits well below the 85th percentile, based in part on pedestrian safety considerations, but the limits typically are set quite arbitrarily. This research should investigate methods for determining pedestrian views on speed limits and should then determine acceptable speed limits for a wide range of conditions (vehicle traffic, pedestrian density, roadway geometry, etc.) If possible, it should develop a rational process for speed zoning that incorporates both driver and pedestrian concerns to balance safety and mobility (see S-2).

S-8 Design guidelines for traffic calming devices. (C-12, S-1, S-9)

At present there is no easy source of information on traffic calming devices. What methods have been used? How effective have they been under various conditions? What caused them to be implemented? How did the community react to them? This research should compile all available information and disseminate it widely.

S-9 What are the system effects of traffic calming devices? (Warren #4, Karsch #2; S-1, C-12)

Several studies of traffic calming devices show that they reduce vehicle speeds. But these studies typically look only at speeds in a small portion of roadway adjacent to the device, over a short period of time after the device has been installed. This research should consider broader system effects. Do traffic calming devices divert traffic onto adjacent roads? Do they affect vehicle speeds beyond the immediate neighborhood of the device? Does their effect persist over time? Do they affect crash rates? Do they affect pedestrian or bicycle travel?

S-10 Effects of community education and enforcement actions to reduce vehicle speeds.

Communities have tried several methods to reduce vehicle speeds on specified streets and neighborhoods, including active speed limit enforcement by officers, automated enforcement with cameras, speed monitoring (signs that display the speed of each passing vehicle), public information campaigns, road signs ("Slow - children"), and the like. Few have been evaluated. This research should assemble and synthesize all available information and make it broadly available.

S-11 Guidelines for automated speed enforcement.

Several communities have used automated speed enforcement for some time. Other communities are implementing this technique. In others it has been considered but rejected. Automated speed enforcement raises difficult issues of community values, priorities, and relationships. How important is traffic safety in general and speed enforcement in particular? Are police using traffic enforcement to improve public safety or to collect fines and harass citizens? Will automated enforcement infringe on privacy rights? This research should study why automated speed enforcement has been implemented in some communities but not in others. It should document the issues involved in adoption and implementation and review the effects on speeds and crashes (not just adjacent to the automated speed monitors but throughout the community).

Other Issues

O-1 Determine effective methods to reduce crashes involving alcohol-impaired pedestrians (see C-31).

Crash data show clearly that many fatally or seriously injured pedestrians are impaired by alcohol, but little is known about what can be done. This research should first determine the nature of the problem more precisely. Who are the drunk pedestrians? Where are they walking when struck? Are there common elements of some crashes that suggest countermeasures? Have any potential countermeasures been implemented? If so, what are the results?

Bicycle Data Research Needs

Lisa Aultman-Hall, Facilitator
Leverson Boodlal and Joe Cameron, Reporters

The Data working group recognized major needs in the two broad areas of crash and exposure data. The group recommends that data systems be established and maintained to collect the necessary information in each area. Rather than suggest specific data elements or procedures, the working group report discusses the types of data needed and key characteristics of good data collection systems. The crash data discussion is organized in three parts, by crash location and data source. The two background papers by Blomberg and by Schwartz also discuss data needs quite broadly, with Blomberg's paper concentrating on crash data and Schwartz's on exposure data.

D-1 Crash data from police reports. (Blomberg Data #1, 2, 3, 4)

Police crash report data provide the most useful information on bicycle crashes involving motor vehicles. They have been used effectively to define bicycle - motor vehicle crash types, monitor trends, and develop countermeasures. What's now needed is to improve these police data to provide more information on what factors may have led to the crash and what measures might have prevented it.

This research should begin by defining crash data needs: what information, for what crashes, is needed to identify bicycle crash problems and to develop and evaluate countermeasures? Next, how can the information be gathered accurately and effectively? The research must take into account the specialized data that may be relevant to bicycle crashes (such as roadway geometry, pavement, and condition; traffic levels; lighting conditions; visual obstructions for bicyclists and motorists; bicycle equipment; bicyclist clothing and helmet use; bicyclist and motor vehicle driver actions and potential distractions), the need to view crash scenes and interview participants quickly to obtain accurate data, and the difficulty of collecting information on rare events. The research should consider various crash investigation techniques, such as a bicycle crash module for automated police crash reporting software, digital cameras for crash scene recording, and links to emergency department or hospital data to acquire injury data. Finally, the research should investigate how to motivate communities and law enforcement departments to collect these data. It should consider how police can use the data to improve testimony in court and how the community can use the data to improve bicyclist safety.

D-2 Crash data from hospitals, emergency rooms, and other medical sources.

Many bicyclist injuries treated in hospitals and emergency rooms come from crashes that did not involve a motor vehicle and were not reported to the police. Data on these crashes are needed both to provide an accurate picture of the overall bicycle crash problem and also to investigate how these crashes were caused and what might prevent them or reduce the resulting injuries.

This research should investigate methods to obtain better information on these crashes. The research must recognize that the hospital or emergency department can provide data on the bicyclist and his or her injuries. Any other data -- regarding the crash location, any other vehicles or drivers, pre-crash actions, etc. -- will require special investigation. The CPSC NEISS system, which obtains product-related injury data from a national sample of hospitals, may be one source. Basic NEISS data could perhaps be supplemented with additional information obtained from very brief and easy to record in-hospital questions or from telephone interviews with injured cyclists. Other data systems using hospital or emergency department data also should be investigated.

D-3 Data on bicycle crashes not reported to police and not requiring hospital or emergency room treatment.

Some bicycle crashes are not recorded in either police or medical data systems. These typically involve minor injuries that do not require hospital or emergency room treatment and do not involve motor vehicles. In particular, many crashes and injuries occurring on bicycle paths and other off-road locations are not reported to police or medical data systems. Information on these non-reported crashes and injuries is needed to round out the overall bicycle safety picture. By analyzing the more frequent minor-injury crashes we may be able to identify and correct bicycle safety problems before they produce major injuries or fatalities. This will help bicyclists feel safe as well as be safe, which in turn should help increase bicycle travel.

This research should investigate methods to obtain information on unreported bicycle crashes. It should consider how the bicycle community might be enlisted, perhaps to survey cyclists on their crash experiences or to investigate potentially dangerous locations in the community's bicycle roadway network. All geographic areas and community types throughout the nation should be represented. The research should consider how to monitor these crashes over time, perhaps with smaller and less intensive data collection.

D-4 Exposure data. (Schwartz #1, 2, 3)

Current data on bicycle travel are limited and sporadic. Most current information comes from surveys, which are expensive to conduct. Better data would help improve both bicycle safety and bicycle facility planning.

This research first should define appropriate bicycle exposure data measures. We'd like to know how many people are bicycling, who and how experienced they are, at what times, for how many miles, on what facilities, under what traffic and weather conditions, for what purpose. How much do we really need to know, how frequently, covering what areas? Next, the research should consider how to collect the data. It should consider surveys (ongoing or periodic), use of new technology (such as ITS and GIS), and cooperative efforts with the bicycle community.

Several potential exposure measures were suggested: bicycle travel distance, travel time, the product of travel distance and motor vehicle traffic volume, the number of intersections crossed, and the number of risky maneuvers attempted. Different exposure measures have strengths and weaknesses and more than one likely will be required. Measuring bicycling exposure by children may require special techniques since children cannot estimate distance and younger children cannot estimate time. Again, all areas of the nation should be represented. The research should coordinate with crash data research of D-1, D-2, and D-3 to assure that the exposure data are compatible with crash data. It should consider if special crash data collection is needed to accompany the exposure data.

Bicycle Countermeasure Research Needs

Andy Clarke, Facilitator
Tamara Broyhill and Marietta Pearson, Reporters

The Countermeasures working group developed a list of 27 research needs. They are grouped below as they were discussed in the workshop, in the three broad categories of engineering, education, and enforcement followed by a few miscellaneous needs. The research needs are numbered arbitrarily, and the numbers do not suggest any group priorities. However, the group wishes to emphasize several in particular: combined education and enforcement campaigns (C-11) and exposure data (C-24) as top priority; complex intersections (C-1), education programs (C-3), signalized intersections (C-4), and law enforcement's role (C-10) as second priority, and traffic calming devices (C-6), lane configurations (C-8), bicycle lanes and paths (C-9), effects of facilities on usage (C-15), developmental age for bicycling (C-17), effects of licensing and registration laws (C-20), and drunk bicycling (C-25) as third priority. Research needs based on or closely related to a background paper recommendation are annotated with the lead author's name and the recommendation number within the author's paper.

Engineering

C-1 Bicycle safety at complex intersections such as freeway ramps and roundabouts (Harkey Countermeasures #5, C-4)

Bicycles have difficulty crossing freeway ramps where vehicles move at relatively high speeds. Other complex unsignalized intersections such as roundabouts also present difficulties to bicyclists. This research should identify the bicycle safety problems at these intersections and should suggest safer designs for new construction. It also should consider how existing intersections can be made safer through engineering modifications, signing, signals (perhaps including bicycle signals), or other means.

C-2 Compare the safety of bicycle lanes and wide curb lanes. (Harkey Facilities #3, O-4)

Two methods used to accommodate bicycle traffic are dedicated bicycle lanes and wide curb lanes shared with motor vehicles. This research should compare the safety of the two designs.
It should develop guidance for lane design: width, storm drain specifications, etc.

C-4 Safe accommodation of cyclists at signalized intersections. (Harkey Facilities #3, C-1)

Signalized intersections present safety problems. Bicyclist left turns across oncoming traffic may be dangerous. Vehicles turning right must cross the path of bicyclists traveling in the curb lane. Innovative methods to improve bicycle safety at intersections include special blue pavement markings, combined bicycle and right turn lanes, and "bike boxes" that permit bicyclists to move to the front of the queue at a traffic light. Initial evaluations in single communities have been positive. This research should identify bicycle safety problems at intersections, document existing countermeasures, and expand the evaluation evidence for the most promising. As appropriate, it should develop and test additional countermeasure strategies for intersection safety problems. It should consider how to accommodate left turns and double right turns. Intersections of bicycle paths with roadways should receive special attention.

C-6 Effects of traffic calming on bicycles. (Harkey Facilities #4, O-1)

Traffic calming devices such as speed humps, curb extensions, mini-roundabouts, and narrowed streets may present safety problems to bicyclists. This research should document the effects of different traffic calming devices on bicycle safety. If problems are found, it should study how bicycle traffic may be accommodated while maintaining traffic calming effects.

C-7 Effects of street conversions on bicyclists. (C-6)

Engineering modifications to streets may affect bicycle safety. In addition to the traffic calming devices discussed in C-6, these include street narrowing or widening, lane changes, median treatments, and intersection redesign. This research should document the bicycle safety consequences of different engineering modifications and should suggest how bicycles may best be accommodated.

C-8 Lane configurations for bicycles and motor vehicles.

Several lane configurations may be used to accommodate shared bicycle and motor vehicle traffic. In addition to the standard single shared lane, these include counter flow bicycle lanes, bicycle lanes that are marked to the left of traffic lanes, shared bus and bicycle lanes, two-way bicycle lanes, and bicycle lanes separated from motor vehicle lanes with a curb or barrier. This research should document these different lane configuration choices: physical requirements, traffic capacity, safety effectiveness, acceptance by bicyclists and motorists, and costs.

C-9 Design and operation of bicycle trails and paths. (Harkey Facilities #5, Pedestrian C-13)

Separate bicycle trails and paths provide bicyclists a roadway free from motor vehicles. But they present other safety issues. They are narrow and may not be designed well for high-speed bicycle travel. They may be heavily used by bicyclists, pedestrians, in-line skaters, and others moving at a wide range of speeds. This research should study the safety problems of bicycle and mixed-use trails and recommend improvements. It should consider trail design and maintenance, lighting, signing, and markings.

C-13 Effects of pavement defects and road surface features on bicycle safety.

Road surface quality affects bicycle performance enormously. Unexpected rough pavement and potholes, debris, sewer caps, and storm drains all can cause a bicyclist to lose control and crash. But bicyclists adapt their riding to the road, riding faster on smooth surfaces than on rough. So, while road surface conditions clearly affect bicyclist travel times and comfort, the effect on safety is not clear. This research should evaluate the safety effects on bicyclists of pavement defects and road surface features.

C-15 Effects of bicycle facilities on usage.

Special bicycle facilities -- paths, separate lanes, parking areas, etc. -- should increase bicycle usage. Good data on these effects could be used to encourage communities to provide additional bicycle facilities. This research should collect and summarize existing information on the usage changes produced by special bicycle facilities. It should encourage usage data collection when additional facilities are being planned and implemented.

C-23 Effects of colored bicycle lanes. (C-4, C-23)

Some communities have marked bicycle lanes by coloring them, so they can be distinguished clearly by motorists and bicyclists. This research should investigate the effects of these special lanes on safety and usage. What colors are most effective? Must the whole lane be colored or only portions -- just the edges, or just at intersections?

C-24 Application of ITS technology. (Harkey #3)

To date, little thought has been given to ways in which ITS technology might improve bicycle safety. This research should investigate potential ITS technology applications to bicycle safety and should test any promising possibilities.

Education

C-3 Quantify the effects of education programs on bicyclists, motorists, and other road users.

Safety education for bicyclists has been conducted for many years but has not been evaluated. We don't know its overall effect, the usefulness of different curriculum components, or the best method of delivery. Some public education and information on bicycle safety issues has been directed at motorists. Again, this has not been evaluated. This research should evaluate the effectiveness of bicycle education and information directed both at bicyclists and at other road users and should suggest any appropriate improvements.

C-11 Quantify the effects of programs combining education, enforcement, and engineering. (O-23)

Combined education and enforcement campaigns have been effective in raising seat belt use and reducing drunk driving. Combined bicycle safety campaigns offer similar possibilities. Education and enforcement can increase the safety benefits of engineering changes. This research should collect any available information on the effects of programs combining at least two of the education, enforcement, and engineering components. If no solid data are found, it should design, implement, and evaluate a combined program.

C-16 Determine effective sources of bicycle safety information. (Blomberg Countermeasures #1; Pedestrian C-4)

Public information and education campaigns have been used extensively to improve bicycle safety. However, little is known about which sources of bicycle safety information are considered most credible by different bicyclists. This research should investigate the most effective sources for information on key bicycle safety issues for major target groups.

C-17 Determine the appropriate developmental age for bicycle riding in different situations. (Pedestrian C-26, C-28)

Bicycling on a driveway or playground, a bicycle path, a quiet neighborhood street, and a busy road presents very different injury and crash risks. Each requires different motor, cognitive, and judgment skills. This research should determine the developmental age at which a child is ready to bicycle in different situations and should develop effective methods for communicating this information to parents and care givers.

C-21 Study the effects of including bicycle safety information in driver education curricula.

Driver education often provides motorists with their first and last formal education in traffic safety issues. This may be an opportunity to educate youth both on driving issues when bicyclists are present and on their actions as bicyclists. This research should evaluate the treatment of bicycle safety in driver education curricula and should consider whether and how the treatment should be expanded.

C-22 Use the commercial media for bicycle safety education.

Television and movies play an important role in forming and validating normal behavior. The bicycle safety implications are clear. For example, if every bicyclist on television wears a helmet, then helmet use appears normal; if no one wears a helmet, then helmet use is perceived as weird. The commercial media have helped safety belt use and designated drivers become socially acceptable and normal practices. This research should develop recommended practices on bicycle safety for news and entertainment media. It should investigate how best to package and distribute this information to the media and how to motivate the media to use it.

C-26 Impact of rider skill level on crashes and injuries.

As bicycle riders become more skilled, they learn many safety skills that a beginning rider lacks. On the other hand, they may ride faster, in more risky situations. The effect on crashes and injuries is unknown. This research should investigate how crash frequency and injury level change as riders become more skilled. As appropriate, it should develop appropriate materials to inform riders of any increased risk and suggest methods to reduce the risks.

<u>Enforcement</u>

C-5 Quantify the effects of red light running.

Both bicyclists and motorists sometimes run red lights. The consequences may be a severe vehicle-bicycle crash. This research study why bicyclists run red lights (lights timed inappropriately for bicyclists, lights not detected by bicyclists, bicyclists don’t want to stop or don’t want to wait for the light to turn green, etc.). It should quantify the bicycle crashes and injuries resulting from red light running. The results may be useful to support red light running prevention campaigns.

C-10 Law enforcement’s role in bicycle safety planning and education.

Law enforcement has a powerful voice in a community’s traffic planning and operations. They can be an important ally for bicycle safety in improving facilities and preventing crashes. This research should study how to increase law enforcement’s knowledge of and support for bicycle safety. As appropriate, it should recommend information and materials for law enforcement use.

C-14 Effects of bicycle patrol officers on bicycle safety.

“Cops on bikes” are used regularly and effectively in many urban areas. These officers are especially knowledgeable and concerned regarding their community’s bicycle facilities and safety. This research should consider the impact of “cops on bikes” programs on bicycle use and bicycle safety. Do they encourage more people to ride bicycles? Do they help improve bicycle facilities? Could they be more effective if they had additional information, materials, or training?

C-18 Longitudinal study of helmet use law effects.

Bicycle helmet use laws in the United States apply only to children and are rarely enforced. But the laws may have important long-term effects. They may start a helmet-use habit that continues after the law no longer applies. This research should conduct a long-term longitudinal study of helmet use patterns in children and their families covered by a helmet use law. It should investigate how helmet use laws affect bicycle use levels.

C-19 Effects of helmet use on injury severity and crash reporting.

The effectiveness of bicycle helmets in reducing head injury has been well documented. But helmet use may have an additional effect. By preventing serious head injuries, helmets may reduce the number of crashes and injuries that are reported to the police or are treated in hospitals or emergency rooms. This research should investigate whether increased helmet use affects reported bicycle crash rates.

C-20 Effects of bicycle licensing and registration laws on bicycling.

Some communities require bicycles to be registered and licensed. This registration often is accompanied by bicycle promotion and bicycle safety education activities. This research should study whether these programs increase or decrease bicycling and bicycle safety.

<u>Miscellaneous</u>

C-12 Methods to increase bicycle conspicuity. (O-10 to O-16)

The Countermeasures working group endorsed the Other Issues group recommendations O-10 through O-16 to study methods to improve bicyclist conspicuity.

C-25 Reduce drunk bicycling. (O-17 to O-20)

The Countermeasures working group endorsed the Other Issues group recommendations O-17 through O-20 to study the issue of alcohol impairment by bicyclists.

C-27 Exposure data. (D-4)

The Countermeasures working group endorsed the need for good exposure data discussed by the Data working group in recommendation D-4.

Bicycle Other Issues Research Needs

Essie Wagner, Facilitator
Linda Cosgrove and John Fegan, Reporters

The Other Issues working group developed a list of 26 research needs, in the four broad areas of facilities, lighting and conspicuity, alcohol, and law enforcement, followed by a few miscellaneous topics. The research needs within each area are numbered arbitrarily, and their ordering does not suggest any group priorities. Research needs based on or closely related to a background paper recommendation are annotated with the lead author's name and the recommendation number within the author's paper.

<u>Facilities</u>

O-1 Effects of traffic calming on bicycles. (Harkey Facilities #4, C-6)

Traffic calming devices such as speed humps, curb extensions, mini-roundabouts, and narrowed streets may present safety problems to bicyclists. This research should document the effects of different traffic calming devices on bicycle safety. If problems are found, it should study how bicycle traffic may be accommodated while maintaining traffic calming effects.

O-2 Compare cost, safety, and mobility tradeoffs produced by facility design and operation decisions.

The roadway system seeks to provide efficient and safe transportation for a wide variety of users at lowest cost. Virtually any facility design or operation decision involves balancing these competing goals. A bicycle path parallel to the roadway may improve safety and encourage bicycle travel, but is expensive to build and maintain. Speed limits on multi-use paths may improve safety but increase bicycle travel times. This research should study the relation between bicycle and motor vehicle traffic volumes and safety on shared-use roadways and paths and should provide general guidance on what facility designs can accommodate a specified traffic volume.

O-3 Guidelines for speed management on shared use paths and trails. (Pedestrian C-7, C-13)

Trails and paths are used by pedestrians, bicyclists, joggers, in-line skaters, horse riders, and others. This mix may produce crowded conditions, a wide range of speeds, and the potential for crashes and injuries. This research should analyze the safety problems raised by the wide speed differentials and should investigate whether speed management would be appropriate, practical, or effective in improving safety. European experience may provide useful information.

O-4 Compare bicycle lanes and wide curb lanes. (Harkey Facilities #3, C-2)

Two methods used to accommodate bicycle traffic are dedicated bicycle lanes and wide curb lanes shared with motor vehicles. This research should compare the two designs for safety, construction and maintenance cost, traffic volume capacity, and preferences by bicyclists and motorists. It should develop guidance for lane design: width, storm drain specifications, etc.

O-5 Roadway features in rural areas.

Rural roads present special bicycle safety issues. Shoulders may be narrow or non-existent. Shoulder rumble strips to waken drowsy motorists may be serious obstacles to bicyclists. This research should study the safety issues presented by such rural road features and should provide guidance on safe and affordable design practices.

O-6 Investigate signal loop detector placement for bicycles.

Loop detectors to request a green light at an intersection typically are placed where vehicles stop for a red light. If no vehicles are present, a bicyclist must slow substantially after crossing the detector before the signal changes to green. In light traffic, bicyclists are tempted to cross against the red light rather than waiting for the green. If a loop detector were placed upstream, in advance of the intersection, the traffic light could be turned to green before the bicyclist approached the intersection. This research should investigate the use of upstream loop detectors for traffic signal control and improved vehicle flow in light traffic.

O-7 Operational requirements for bicyclists. (Harkey Facilities #3)

Most roadway features, traffic control devices, and traffic laws were developed and implemented for motor vehicles, not bicycles. Designs for efficient motor vehicle traffic flow may not be appropriate or safe for bicyclists (see C-1 and C-4). Traffic laws also may be inappropriate or unsafe. Should a bicyclist be required to come to a complete stop (and dismount) at a stop sign, rather than yielding to oncoming traffic and proceeding slowly when it clearly is safe? Should bicyclists or bicycles be licensed (see C-20)? This research should take a broad and fresh view of bicycle operational issues, especially traffic laws and regulations. If it appears that special bicycle laws or regulations are appropriate, it should consider how they should be developed, implemented, and enforced.

O-8 Intersections of bicycle paths and roadways. (C-4, C-9, Pedestrian C-13)

Bicycle paths frequently cross roadways at unsignalized intersections. It may not be clear whether motorists or bicyclists have the right of way. Motor vehicle traffic may not expect crossing bicycles or may not even detect the intersection. On high-speed roadways, motorists may not wish to yield to bicyclists. Bicyclists may wish to continue through the intersection without stopping and may attempt to cross in front of oncoming vehicles. A separate bicycle bridge or tunnel would eliminate these conflicts but is expensive. This research should examine the safety problems posed by these intersections and suggest intersection design and traffic control countermeasures as appropriate.

O-9 Compare the safety of off-road and on-road bicycle facilities. (O-2, O-8; Pedestrian C-13)

Off-road bicycle facilities solve some bicycle safety problems but may create others. They clearly separate bicyclists from motor vehicles, except at intersections. But the intersections may be more dangerous than on-road intersections (see O-8). These facilities frequently are shared with pedestrians, in-line skaters, joggers, and other traffic, which may produce other risky conflicts (see O-3). Off-road surfaces may not be constructed or maintained as well as on-road surfaces. This research should compare the safety of off-road and on-road bicycle facilities for all users -- bicyclists, motorists, pedestrians of all sorts -- under different design conditions.

Lighting and Conspicuity

O-10 Roadway and path lighting guidelines for bicyclist vision and conspicuity. (Freedman #2)

Lighting design standards for roadways where bicyclists are expected appear not to be based on documented research. Research is needed to fill this gap. The research should review the literature on bicycle facility lighting and develop visibility-based guidelines for lighting both on-road and off-road bicyclist facilities.

O-11 Investigate the conspicuity and safety value of active and passive bicycle lighting.

Bicyclists use both active (battery-powered lights on the bicycle or bicyclist) or passive (reflectorized surfaces on the bicycle or bicyclist) systems to improve conspicuity. This research should compare how each affects conspicuity and safety. It should consider issues such as size, color, brightness, and cost (see also O-13).

O-12 Investigate the conspicuity and safety value of LED illumination.

Some bicycle tail lights use LEDs (light-emitting diodes) that flash on and off and are easily visible. In some designs the LEDs flash in unison; in others they flash in a pattern. This research should investigate the overall safety and conspicuity of LED systems. It should consider issues such as size, pattern, color, and recognition of the signal as coming from a bicycle (see O-13).

O-13 What visual cues help motorists detect and recognize bicyclists? (Freedman #1)

Many studies have investigated the relations between lighting and conspicuity features and a motorist's ability to detect an object such as a bicyclist. Other studies show that a motorist recognizes (or identifies) the object as a bicyclist when the whole bicycle and bicyclist profile is visible. Is there a middle ground, "bio motion" cues that enable motorists to recognize a bicyclist before the entire profile is visible? This research should investigate the shape, size, visibility, and motion attributes that can be used to identify a bicyclist from the front, side, and rear. It should develop methods to provide visual cues of these attributes and should test them for recognition by motorists and for acceptability by bicyclists.

O-14 Use and acceptability of conspicuity aids by bicyclists.

Lights, reflectorized clothing, and other conspicuity aids have no effect if they are not used. This research should survey bicyclists on their current and potential use of conspicuity aids. It should include riders of all types, from the bicycle enthusiast, to the bicycle commuter who regularly rides after dark on busy streets, to the occasional weekend rider.

O-15 Conspicuity aids for bicycle enthusiasts.

Bicycle enthusiasts have special conspicuity needs. They ride frequently, often in traffic, often at higher speeds, perhaps at night. They may be willing to purchase and use special clothing, lights, or reflectors, but they may not wish to use anything that hinders their performance. This research should investigate these conspicuity issues and suggest ways to address them. It should begin by analyzing data on crash risk, during daytime and at night, with and without various conspicuity aids. It also should determine what conspicuity aids are and are not acceptable or preferred by enthusiasts.

O-16 Vehicle headlight improvements to improve bicyclist conspicuity.

Low-beam vehicle headlights typically keep their light close to the ground, to reduce glare in the eyes of oncoming motorists. Much of a bicyclist's visible area is more than 3 feet above the road surface and may not be illuminated well by these low-beam headlights. This research should investigate whether other headlight designs can better illuminate bicyclists (and pedestrians) without increasing glare.

Alcohol

O-17 At what alcohol level is bicycling performance impaired? (O-20)

Substantial research documents the relation between a person's alcohol (BAC) level, performance on driving-related tasks, and crash risk. No direct research does the same for bicyclists. This research should investigate the relation between BAC levels and bicyclist-related skills and develop guidance on the risks of bicycling when impaired by alcohol.

O-18 Communication strategies for reducing alcohol-impaired bicycling.

Little is known about strategies for communicating with alcohol-impaired bicyclists. this research first should consider the overall alcohol-impaired bicycling problem (see O-17, 19, and 20) and place it in the context of driving or walking while impaired (see Pedestrian C-31 and O-1). What are appropriate strategies and messages? How can they best be communicated?

O-19 Quantify and describe the alcohol-impaired bicycling problem.

Basic information about alcohol-impaired bicycling is not well-known. This research should study crash and injury data to determine the size of the problem. It should describe the injured alcohol-impaired bicyclists' personal and crash characteristics: age, bicycling experience; crash time, location, trip purpose, license status, alcohol-related infraction record, etc.

O-20 Relative crash risk by bicyclist BAC. (O-17)

Statistical methods used to estimate the relation between motorist BAC level and crash risk may be applicable to bicyclists. This research should examine whether available data permit such estimates; if so, it should conduct the appropriate analyses.

Enforcement

O-21 What traffic laws and rules of the road are appropriate for bicyclists? (O-7)

Bicycles and motor vehicles have very different performance characteristics and safety issues, but both bicycles and motor vehicles are covered by most traffic laws. As discussed in O-7, this research should take a broad and fresh view of traffic laws and regulations as they apply to bicyclists. If it appears that special bicycle laws or regulations are appropriate, it should consider how they should be developed, implemented, and enforced.

O-22 Methods to increase compliance with traffic laws regarding bicycles.

Bicyclists often disobey traffic laws, both those that appear irrelevant to bicyclists and those designed to improve bicyclist safety. Motorists also may disobey laws applying to them, such as requirements to yield to bicyclists in intersections or crosswalks. Police often are reluctant to stop or cite bicyclists for traffic law violations, perhaps because bicyclists do not carry any equivalent to a motor vehicle drivers license with them. This research should examine methods to improve bicycle law compliance and enforcement. It should begin by considering what laws are appropriate (O-21) and whether the behavior required by these laws is broadly accepted by bicyclists and motorists. If it is not, the research should consider whether the laws or the behavior should change, since broad compliance with a law is necessary before enforcement can have any significant effect. If behavior should change, the research should investigate how change can be begun without laws. Finally, the research should investigate how law enforcement can be motivated and assisted to enforce traffic laws affecting bicycle safety.

Miscellaneous

O-23 What education is required to support engineering changes to improve bicycle safety?

Most engineering changes to improve bicycle safety require some public education to be effective. Special pavement markings will be ignored unless bicyclists and motorists understand what the markings mean. Special bicycle facilities won’t be used unless bicyclists know where to find them. This research should investigate how communities have educated the public about engineering changes for bicycle safety and how the amount and quality of education have affected bicycle use and safety. It should provide general guidance on the education needed to implement engineering improvements of different types.

O-24 Review ITS technology relevant to bicycling. (C-24)

The Other Issues working group endorsed the Countermeasure group recommendation C-24 to investigate how ITS technology can improve bicycle safety.

O-25 Effects of education on crash rates. (C-3)

The Other Issues working group endorsed the Countermeasure group recommendation C-3 to evaluate the effects of education programs on bicycle safety.

O-26 Guidance on bicycle safety countermeasures appropriate for specific problems.

Communities continually seek the best up-to-date advice on what countermeasures can be used to address the community’s problems, how they can be implemented, and what they cost. This research should continue to provide current information on these questions, in a form that’s easy to access, understand, and apply.

III. Participant Priorities

This section provides a summary of the participatns' priorities of pedestrian and bicycle safety research. As stated in the Introduction, the workshop participants did not attempt to achieve consensus on the recommendations that were discussed. This was done, in part, to shield individual participants from being influenced by other participants on how they should vote. Instead, near the end of each workshop the participants met in a plenary session and were encouraged to independently prioritize their recommendations among all of the topics identified within each working group. These were then submitted to NHTSA and FHWA for consideration.

A total of 57 pedestrian and 57 bicycle safety research needs were identified during the workshops. Individual participants ranked their top five research priorities for both pedestrian safety research and bicycle safety research. FHWA and NHTSA organized the priorities as High, Medium, and Low based on the average rankings and by the number of votes. There were four High and seven Medium priority pedestrian research needs and four High and 10 Medium prioirty bicycle safety research needs. The High and Medium priorities for both modes are listed below.   Topics that received one or no vote were categorized as Low priority and are not listed. The topics are not ordered by rank within each priority group.

Pedestrian Safety Research Needs

High Priority (4)

- Exposure data (D-1): Currently without good exposure data we cannot estimate risk
- Crash Data (D-2, C-2): Police crash reports do not provide an accurate picture of traffic crashes. Also we need measures other than crashes for pedestrian problem identification and countermeasure development
- Improve pedestrian safety at uncontrolled and controlled intersections (C-8, C-10)
- Study roadway features to regulate vehicle speed and other related traffic calming/speed management activities; (C-12, S-1, S-2,S-8, S-9)

Medium Priority (7)

- Planning and Policy (D-4)
- Guidelines for Automated Speed Enforcement (S-11)
- Identify, synthesize and assess information on pedestrian safety countermeasures (C-1, C-4, C-5, C-23)
- Assess driver and pedestrian attitudes regarding walking, impediments to walking, speed management, laws (D-3, S-5)
- What can be done to reduce crashes caused by alcohol impaired pedestrians (C-31, O-1)
- Safer design of trails and paths for shared use (C-13)
- Vehicle Modifications to Improve Pedestrian Safety (C-14)

Bicycle Safety Research Needs

High Priority (4)

- Crash data from police reports (D-1)
- Exposure data (D-4, C-27)
- Bicycle safety at intersections: complex (such as freeway ramps and roundabouts) and signalized (C-1, C-4)
- Compare the safety of bicycle lanes and wide curb lanes (C-2, O-4)

Medium Priority (10)
- Crash data from hospitals, emergency rooms, and other medical sources (D-2)
- Data on bicycle crashes not reported to police and not requiring hospital or emergency room treatment (D-3)
- Quantify the effects of education programs on bicyclists, motorists, and other road users (C-3)
- Safe accommodation of bicyclists at signalized intersections (C-4)
- Design and operation of bicycle trails and paths (C-9, Pedestrians C-13)
- Quantify the effects of programs combining education, enforcement; engineering and education required to support engineering changes to improve bicycling safety (C-11, O-23)
- Methods to increase bicycle conspicuity (C-12, O-10 thru O-16)
- Effects of helmet use on injury severity and crash reporting (O-19)
- Relative crash risk by bicyclists BAC; at what level BAC is bicyclists performance impaired (O-20, O-17)
- Review of ITS technology relevant to bicycling (O-24, C-24)

IV. Review Comments

In this draft version of the workshop summary, this section is blank. In the final version, this section will contain the technical comments regarding the workshop summary made by the participants and others who have been asked to review the draft document.

Appendix A. Workshop Agendas

The agendas for the pedestrian and bicycle research workshops are shown on the following pages.

Joint NHTSA/FHWA Pedestrian & Bicycle Safety Strategic Planning Research Workshops - April 13th & 14th 2000

Pedestrian Workshop - Thursday, April 13th

8:00 - 8:30 am Nibbles & Talk

8:30 - 8:40 am Workshop Overview - Jim Hedlund

8:40 - 8:50 am Welcome: Mike Trentacoste (FHWA) & Jim Nichols (NHTSA)

8:50 - 9:00 am Workshop Goals and Objectives - Marv Levy & Carol Tan Esse

9:00 - 9:15 am Introduction of Participants

9:15 - 9:45 am Data Needs: Pedestrians, Drivers & Roadways
(Dave Preusser, PRG; Bill Schwartz, Cambridge CSI)

9:45 - 10:15 am Discussion

10:15 - 10:30 am Break

10:30 - 11:00 am Countermeasures: Pedestrians, Drivers & Roadways
(Richard Blomberg, Dunlap; Charlie Zegeer, UNC, HSRC)

11:00 - 11:30 am Discussion

11:30 - 12:00 pm Special Issues: Speed, Diversity
(Bill Leaf, PRG; Davey Warren, FHWA, Dave Preusser,PRG)

12:00 - 12:30 pm Discussion

12:30 - 1:30 pm Working Lunch

1:30pm - 3:00 pm Breakout Sessions:3 (Data Needs, Countermeasures, Special Issues)
Discussion on Research Ideas

3:00pm - 3:15 pm Break

3:15 pm - 4:15 pm Breakout Discussions: Report Out

4:15pm - 5:00 pm Anything Goes: Accommodation, Tech Transfer & Other Issues

5:00pm - 5:15 pm Wrap Up - Jim Hedlund

Joint NHTSA/FHWA Pedestrian & Bicycle Safety Strategic Planning Research Workshops - April 13th & 14th 2000

Bicycle Workshop - Friday, April 14th

8:00 -8:30 am	Nibbles & Talk
8:30 - 8:40 am	Workshop Overview - Jim Hedlund
8:40 - 8:50 am	Welcome: Mike Trentacoste (FHWA) & Jim Nichols (NHTSA)
8:50 - 9:00 am	Workshop Goals and Objectives - Marv Levy & Carol Tan Esse
9:00 - 9:15 am	Introduction of Participants
9:15 - 9:45 am	Data Needs: Bicycles, Drivers & Roadways (Richard Blomberg, Dunlap; Bill Schwartz, Cambridge CSI)
9:45 - 10:15 am	Discussion
10:15 - 10:30 am	Break
10:30 - 11:00 am	Countermeasures: Bicycles, Drivers & Roadways (Richard Blomberg, Dunlap; David Harkey, UNC, HSRC)
11:00 - 11:30 am	Discussion
11:30 - 12:00 pm	Other Issues: Facilities, Conspicuity (David Harkey; Mark Freedman, Westat)
12:00 - 12:30 pm	Discussion
12:30 - 1:30 pm	Working Lunch
1:30pm - 3:00 pm	Breakout Sessions:3 (Data Needs, Countermeasures, Other Issues) Discussion on Research Ideas
3:00pm - 3:15 pm	Break
3:15 pm - 4:15 pm	Breakout Discussions: Report Out
4:15pm - 5:00 pm	Anything Goes: Accommodation, Tech Transfer & Other Issues
5:00pm - 5:15 pm	Wrap Up - Jim Hedlund

Appendix B. Workshop Participants

Included in this appendix will be a list of the individuals who participated in the workshops.

Appendix C. Pedestrian White Papers

In this appendix are six white papers on various aspects of pedestrian research, which were provided to the participants as background material and presented at the workshop by the authors. The six papers include:

& Pedestrian Data Research Needs

& Pedestrian Crash Data

& Pedestrian Countermeasures

& Pedestrian Facilities Research

& Pedestrian Injuries in Relation to Vehicle Speed

& Speed Management and the Non-Motorist

& Race/Ethnicity

Pedestrian Safety Data Needs

William L. Schwartz AICP
Cambridge Systematics, Inc.

Introduction

While walking is the mode that almost every human being experiences from the age of one, in terms of transportation planning data, it is the mode we know the least about. Representing a minor mode for transportation purposes, the resources dedicated to accounting for walking trips are minimal. Even in an environment of increased governmental support for non-motorized modes of travel, walking "facilities" are far different from cycling facilities. While one could imagine a ribbon-cutting ceremony for a new hiking trail, those facilities are quite uncommon. Public officials hardly pay attention to the construction of sidewalks, although it is the lack of sidewalks that presents so many challenges to walking.

Unlike cycling, the data needs for pedestrian safety are more complex. Trips are generally shorter in length than bicycle trips. The overwhelming majority of walk trips are in combination with other modes of travel. Walking to get from one place to another as an exclusive means of travel is a relatively rare compared to motorized modes. This is not a new phenomenon, however. What has changed is the environment for walking, which has deteriorated over time as traffic volumes have increased and cities have expanded into less dense auto-oriented places. At the same time, however, the benefits of walking for physical fitness are being widely promoted by public health officials.

To improve conditions for walking, research, planning, and policy-making efforts are required that rely on good pedestrian data in areas such as walking for recreation and exercise, walking in conjunction with other modes, and walking as a means of transportation. Better data are needed to describe the quality and extent of pedestrian facilities and the risks and effects of crashes involving walkers. Finally, there is a need for the marketplace to have a better understanding of what encourages people to walk and what impediments to walking currently exist.

Current Knowledge

Cambridge Systematics, Inc. recently completed a research project for the Bureau of Transportation Statistics on pedestrian and bicycle data needs. The project included a review of existing data and an identification of data needs and research strategies. Considerable input was obtained from user groups including planners, advocates, and researchers at Federal, State, and local government agencies, universities and nonprofit organizations. Published materials and information from other recent assessments of transportation data needs were also reviewed. Primary data sources were classified by four types: (1) usage, trip, and user characteristics; (2) user preferences; (3) facilities; and (4) crash and safety data. Key types of secondary data (data that are based on analysis of primary data) were also identified, including research-study results and manuals of practice. The following represent some to the sources of data in each classification.

<u>Data Sources on Usage, Trip, and User Characteristics</u>

This broad category of data answers the questions of who is traveling, how, where, when, and why. Sources include:

- Counts of pedestrians (usually at crosswalks);

- The decennial census;
- Metropolitan household travel surveys;
- The Nationwide Personal Travel Survey (NPTS)
- Other surveys conducted sporadically at a national level; and
- Various other local surveys and market studies.

Data on User Preferences

Data on pedestrians' preferences, needs, and attitudes attempt to answer questions such as, how well is the existing transportation system meeting people's need or desire to walk? Which are the most important improvements regarding convenience, safety, and enjoyment of people's travel experience? What improvements would most effectively induce more people to walk, especially for short trips? These data may be collected through attitudinal surveys. Quantitative models of behavior can also be used to develop information on user preferences. These models may be based either on "stated preference" survey data, in which people are asked to make choices among various alternatives, or on "revealed preference" data, i.e., observations of people's actual behavior as based on travel surveys and counts.

Data on Facilities

Data on pedestrian facilities may describe the presence of sidewalks, the extent of clear areas for walking, the physical condition of the sidewalk, topography, crosswalk conditions, signal operations, and other factors. Data on road facilities, such as number of lanes, the presence of buffers between the curb lane and sidewalk, parking characteristics, the number of driveways, adjacent land uses, and distances between activity centers, can also be relevant to analysis of walking. Potential sources of data on pedestrian facilities include:

- Statewide pedestrian plans;
- Local databases and plans; and
- State road databases.

Crash and Safety Data

Data on crashes and falls can include the location of the crash; number and attributes of vehicles and people involved; damage and injuries; characteristics of the crash location; and contributing factors. Also related to safety, data on personal security or crime is often relevant to pedestrians.

Crash and other safety data can be used:

- To identify potentially hazardous locations;
- To identify contributing factors to crashes and severity, including characteristics of the individuals involved, vehicles, and environment;
- To identify potential countermeasures to reduce crashes;
- To evaluate the safety of various facility designs and operational policies;
- To identify crash costs; and
- To prioritize safety improvements.

Secondary Data

Secondary data include research-study results, manuals of practice, summary statistics, and other reports, manuals, or findings that can help practitioners in planning for pedestrian travel. Secondary data are often based on analysis and synthesis of data from the primary sources discussed above. Specific types of secondary data might include: the safety effects of design features; demand impacts of design features, education programs and other policies to promote walking; and recommended design practices.

The BTS study did not include a comprehensive inventory of secondary data sources by type. However, the outreach effort revealed both a strong interest in secondary data sources and significant gaps in what is currently available. The survey revealed a need for better dissemination of existing data and knowledge as well as for additional research in a number of important areas. Two of the most commonly requested secondary sources area research study results and manuals of practice.

Priorities for Data Needs

Priorities for data needs (shown in table 1) were identified based on the following criteria:

- Importance of the data for its intended application(s) and audience(s);
- Quality of *existing* data; and
- Usefulness of the data for a *range* of applications (facility design, trend analysis, etc.), audiences (researchers, planners, policy makers, etc.), and geographic scales (local, state, national).

Table 1 Pedestrian Data Types, Quality, and Recommended Priorities

Type of Data **Description**	**Quality of Existing Data**	**Priority for Better Data**
Number of pedestrians by facility or geographic area	Poor	High
User and trip characteristics by geographic area or facility	Fair	Medium/ High
User Preferences		
Relative preferences for facility design characteristics and other supporting factors	Fair	Medium
Facilities Data		
Characteristics relating to quality for pedestrian travel	Fair	Medium
Crash and Safety Data		
Specific pedestrian-relevant crash variables	Fair	Medium/ High
Non-motor-vehicle crash data	Poor	Medium
Secondary Data		
Safety and demand impacts of *design features*	Fair	High
Safety and demand impacts of *policies, programs*	Fair	Medium

Source: Cambridge Systematics, Inc.

Research Area: Pedestrian Safety Data Needs

Concept Title: How Many People are Walking?

Need

Basic information on how many people walk is generally unavailable. The pedestrian planning community has identified this as a key area of need for the BTS study. Specific needs include:

- Overall indicators of usage as well as trends, such as the number of people who walk, total walk trips, mode shares, and miles of travel by non-motorized modes.

- Counts (trip volumes) on specific facilities, in some cases by characteristics such as time of day, day of week, or type (e.g., work, shopping, recreational).

A related but separate topic is the need to better understand the characteristics of pedestrians, which is described in the next research topic area.

Objectives

More comprehensive and systematic data on usage would assist a wide variety of data users for many purposes, including: determining current travel patterns; prioritizing improvements; and tracking the effectiveness of policies, programs, and facility improvements. Better data would assist in safety analysis and crash prevention by providing researchers and planners with measures of exposure. It would assist efforts to model and forecast demand and to determine preferences for and demand impacts of various improvements. Better data on system usage would assist policy-makers by illustrating overall trends in usage as well.

General Approach

Evaluate new pedestrian-counting technologies (i.e., video imaging, infrared sensors) by synthesizing the results of current pilot-testing efforts, sponsoring additional pilot tests and methodological development. Document the areas where the data would be best applied. Identify walking patterns by trip type, facility type, geographic area type, etc. to develop factors for use in areas with limited resources. Test existing new methods in field tests in a sample of sites. Provide detailed manuals of data collection methods for use by engineers, researchers, and planners.

Outcomes

An ideal system of usage data collection and reporting would permit tracking of usage patterns, would be collected systematically and consistently, could be combined with other data, and could advance the state of the practice .

Research Area: Pedestrian Safety Data Needs

Concept Title: Who is Walking and Why?

Need

Just as we know relatively little about how many people are walking (see separate research topic), we need to know more about who walks and for what purposes. Specifically, we need better data on walking trips by distance, purpose, and time of day and season. We need to understand who walks according to various demographic and socioeconomic characteristics. Finally we need to begin to relate this information to other behavioral research on pedestrians in terms of exposure data, countermeasures, and race/ethnicity data (see separate research data). Currently, the major barrier to gathering better demand/usage data is the *cost and effort* associated with collecting these data. Surveys are extremely labor-intensive and resources are limited. The fundamental component of this research is to explore ways to cost-effectively compile the information needed.

Objectives

With a better understanding of who walks and why, planners, researchers, and engineers, would be able to advance a wide range of practice areas. These include facility design; prioritizing improvements; and tracking the effectiveness of policies, programs, and facility improvements. Better user data would assist in safety analysis and crash prevention by providing researchers and planners with improved demographic characteristics.

General Approach

Develop model surveys and sampling methodologies for collecting pedestrian data. Investigate enhancements to household travel surveys, notably inclusion of purely recreational walk trips, as well as techniques to improve reporting of children's trips, short walk trips, and walk access to other modes of travel. Refine existing techniques to minimize underreporting of walk trips. Evaluate new technologies to collect travel survey data, such as personal monitors to measure physical activity levels. Investigate the potential for pilot survey applications of global positioning system (GPS) units to track and monitor pedestrian travel.

Outcomes

The information obtained in this research effort would address existing needs of researchers and potentially permit considerably more pedestrian travel information to be collected on a cost-effective basis.

Research Area: Pedestrian Safety Data Needs

Concept Title: The Role of Emerging Technologies for Data Collection

Need

PedSmart (www.walkinginfo.org/pedsmart) is the result of an excellent research effort in the use of ITS technologies to improve walking conditions. The orientation of this research was on hardware applications for "in-the-field" applications. As with the data compiled in traffic management centers, there is a simultaneous need to begin to apply some of these devices to the collection of data for planning purposes. Forging links between field devices and desktop computers can make data collection, management, and analysis cheaper and easier. How these technologies can advance pedestrian research and planning needs to be determined

Objectives

To establish a baseline understanding of how available technologies can be applied to pedestrian data collection

General Approach

Evaluate and promote new pedestrian-counting technologies (i.e., video imaging, infrared sensors) by synthesizing the results of current pilot-testing efforts, sponsoring additional pilot tests and methodological development, and conducting outreach efforts to disseminate successful technologies. Investigate new technologies for data collection, such as aerial photography, and disseminate successful applications. Investigate opportunities provided by GIS and GPS for identifying and documenting the precise location of crashes; investigate any potential implications of these technologies for how crash and facilities data should be reported and managed.

Outcomes

Increased availability of pedestrian count data for transportation planning, crash and safety research, and an improved understanding of pedestrian travel patterns.

Pedestrian Crash Data

David F. Preusser and William A. Leaf
Preusser Research Group, Inc.

FARS reported that 5,220 pedestrians were killed in traffic crashes during 1998. GES estimated that 69,000 were injured. While the 1998 figures represent substantial reductions as compared with previous years, pedestrian death and injury remains a substantial proportion of our total highway loss.

Definitions

The National Safety Council (Injury Facts, 1999) defines a pedestrian as ... *any person involved in a motor-vehicle accident who is not in or upon a motor vehicle or non-motor vehicle.* A motor vehicle accident is an ... *unstabilized situation that includes at least one harmful event (injury or property damage) involving a motor vehicle in transport*. A motor vehicle in transport ... *is in motion, in readiness for motion or on a roadway but not parked*. As a general rule, persons "riding" a skateboard, roller blades or child's tricycle, or "walking" a bicycle are considered to be pedestrians. Persons who may have fallen from a bicycle or from a motor vehicle during a crash are considered to be a bicyclist or a vehicle occupant; they are not considered to be pedestrians regardless of where they are when the crash sequence is completed.

Beyond these basic definitions, each data base will have its own inclusion and exclusion rules. One important distinction is whether or not off-road crashes are counted. FARS counts only those crashes that occur on *roadways that are customarily open to the public*. FARS also only counts persons who die within 30 days. Also note that pedestrian falls or other mishaps which do not involve a vehicle in transport would not be tabulated even though the fall may have occurred on a public roadway. That is, pedestrian injury is counted in our primary traffic data bases only as it relates to vehicles and not as it may relate to other roadway hazards or situations without vehicle involvement.

Trends

The number of fatally injured pedestrians has been declining from a high of 15,500 in 1937 to less than 6,000 today (National Safety Council estimates shown in Figure 1).

For the period 1980 through 1998, FARS indicates a 35 percent decline in the number of pedestrian fatalities, from 8,071 to 5,220. This overall 35 percent decline in the number of fatalities has not been uniform across age groups. The number of fatally injured children ages 0-9 declined 62 percent from 1980 to 1998. Much smaller declines were seen for adults ages 18-64, down 26 percent, and for persons ages 65 and older, down 32 percent for the 1980 to 1998 period. The result is that, now, the large majority of pedestrian fatalities involve adults.

Profile (1998)

Males outnumber females among pedestrian fatalities by a factor of 2 to 1, and among non-fatal injuries by a factor of 3 to 2. Older pedestrians (ages 70 and above) account for 18 percent of all pedestrian fatalities and 5 percent of all injuries. These numbers are expected to grow as our population continues to age. Fatalities most often occur between 4 pm and midnight, 4 pm to 4 am on weekends. States with the highest rates of pedestrian fatalities per 100,000 population are Florida, Arizona, and New Mexico.

Alcohol involvement is common. During 1998, 46 percent of all fatal pedestrian crashes were alcohol related. Pedestrians were drinking in 38 percent of the crashes and drivers had been drinking in 18 percent; in 10 percent both had been drinking.

Figure 1. Pedestrian Fatalities 1937-98

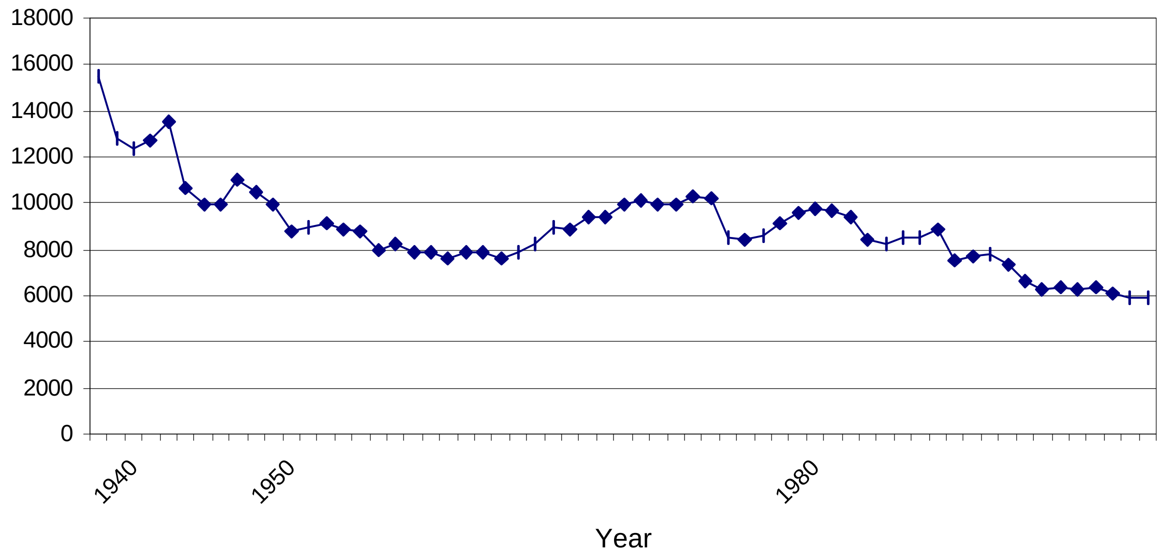
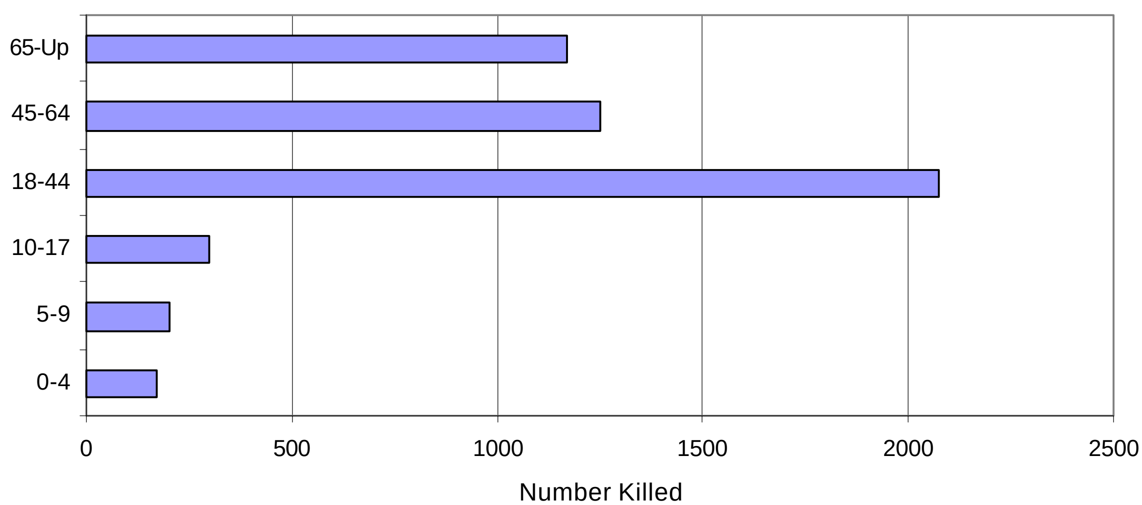


Figure 2. Peds Killed by Ped Age 1998



Research Area: Pedestrian Crash Data

Concept Title: Exposure

Available data indicate how many pedestrians are killed and injured. They do not tell us how many might be expected to be killed or injured based on pedestrian exposure to risk. Specifically, we do not know the amount of walking that various groups of pedestrians are engaged in, or how many street crossings, or how many hours a week they are in close proximity to motor vehicles in transport.

Justification for research or research need

Currently, it is only possible to calculate pedestrian crash rates on a per population basis. However, crash rates per population may not be a sensitive indicator of how many pedestrians are actually at risk. A low crash rate for a given population group could be indicative of safe walking; or a low rate could indicate low levels of exposure to motor vehicles

Objective(s) of research

Develop sensitive measures of pedestrian exposure to risk. Determine how such measures should be collected and applied to develop crash rate estimates. Determine relevant factors, such as pedestrian age, sex, ethnicity; purpose leading to exposure; urban/suburban/rural; type of area, time of day, road type, pedestrian facilities.

General approach including time frame

Meta analysis of published literature to determine those measures that have been used in the past and how each of the selected measures has correlated with actual crashes. Examples include number of street crossings, trips, and on-street observational surveys.

- Collect data for each of the selected measures
- Compare crash rates generated from each of the measures
- Recommend techniques for collecting ongoing estimates of pedestrian risk exposure

Time frame: 2 years

Products and how these link to possible future activities, e.g. future research

The primary product would be an ongoing data system to monitor pedestrian exposure to risk over time. This system would serve the same function as miles driven information collected for drivers or traffic counts collected for various classes of roadway and classes of vehicle.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrian and bicycle problem

Risk of crash involvement is not well understood. Yet, understanding risk is essential for calculating crash rates and developing appropriate countermeasures for identified high risk situations or high risk groups. In addition, identifying risk factors and understanding pedestrian activity choices may help increase pedestrian activity, with resulting benefits to individuals, communities, and the environment.

Research Area: Pedestrian Crash Data

Concept Title: Where are the Children?

Pedestrian crash involvement among children has declined substantially over the last twenty years. Why? What are the underlying factors? What data will be needed to determine these factors?

Justification for research or research need

Child pedestrian fatalities have declined by 62 percent in the last twenty years. The suspicion is that children are spending more time in-doors with computers and television. Is this the full answer? Or, are children now getting more supervision when near traffic? Have they been better educated on how to cross the street safely? Are there some other reasons? How would we get the information to answer these questions?

Objective(s) of research

Develop data sets and measures that will allow for the determination of child crash rates. Should child exposure to risk be measured in the same way as adult exposure? What data do we need to determine why child crash rates have gone down?

General approach including time frame

The first step should be to determine the nature of the crash reduction, as well as possible, from available data sources. Is it rural and urban? Across all ages? Across other crash descriptors?

It is likely that alternate data sources and data collection techniques will be required. Specifically, measures of population distribution and exposure, specific to the types of risk encountered by children, will need to be developed.

Time frame: 2 years

Products and how these link to possible future activities, e.g. future research

Measures of pedestrian crash risk appropriate for children will be useful to urban planners, schools, parents, and others charged with their protection.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrian and bicycle problem

If risk measures can be developed, they may help us to determine why crash rates have gone down. If we know why rates have gone down, then it may be possible to develop long-term programs to keep the rates down and perhaps lower them even further.

Research Area: Pedestrian Crash Data

Concept Title: Crash Reporting

Pedestrian crashes are counted based on their incidence in police crash reports. However, we know that there is a discrepancy between hospital/medical data and police counts with many people receiving treatment for which no report has been filed.

Justification for research or research need

Pedestrian safety countermeasures are developed based on the known incidence of various crashes and crash types. However, not all crashes are reported.

Objective(s) of research

Determine the characteristics of those pedestrian crashes that do and do not lead to a police crash report. Develop techniques to correct for the estimated extent of under-reporting by crash type and crash characteristics.

General approach including time frame

CODES states are developing rich sources of data regarding the correlation between police and medical data systems for injured crash victims. Overall levels of unreported crashes are being estimated. These data sets, perhaps across many CODES states can be used to estimate the extent of under-reporting. Detailed investigation can indicate both the cause and characteristics of the under-reported events.

Time frame: 2 years

Products and how these link to possible future activities, e.g. future research

It is expected that the under-reporting for pedestrian injury crashes in police data sets is substantially greater than for vehicle to vehicle injury crashes. If the extent and cause of under-reporting can be identified, then steps can be taken to correct the situation and develop more precise estimates of the actual number of pedestrian crash injuries.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrian and bicycle problem

Better estimates on the actual number and characteristics of injuries should allow for the better allocation of resources.

Research Area: Pedestrian Crash Data

Concept Title: Pedestrian Crash Typing

Pedestrian crashes have been categorized by a number of schemes since crash typing began in the late 1960s. Although extremely useful to understanding crash causation and developing countermeasures, crash typing has not been widely nor consistently applied.

Justification for research or research need

GES uses a form of NHTSA crash typing which has been available since the 1980s. Recent studies have applied this coding structure to pedestrian crashes in the 1990s. There is an ongoing FHWA project to develop a computer-aided pedestrian/bicycle crash typing approach which introduces another, somewhat incompatible, typing scheme. These typing schemes all have shortcomings which make their results difficult to interpret and apply.

Objective(s) of research

To develop a coding scheme which is as compatible as possible with earlier schemes while addressing their shortcomings; to provide a flexible and powerful coding scheme which is useful for national studies of many thousands of crashes and for local studies of dozens of crashes.

General approach including time frame

A key problem with the current schemes is that they allow only a primary crash type to be assigned. The main effort should be to provide for at least primary and secondary crash types in such a way that data can be reviewed from multiple perspectives yet can be collapsed back onto the previous schemes for comparability. Additionally, crash type definitions should be reviewed, clarified, and tightened, and provisions made for field users of the coding scheme to identify additional characteristics (sub-types) of local interest. Once the scheme is redefined, procedures for manual and computer typing should be developed, tested, and refined. The result should include application procedures and materials for use by experienced researchers as well as lay persons.

Time frame: 2 years

Products and how these link to possible future activities, e.g. future research

As noted, products should include a useful crash typing scheme, well defined and flexible enough to address special concerns while preserving historical and prospective comparability; procedures and support materials for manual and computer-aided typing; approaches for mechanical typing of existing crash databases; and guidelines for the practical use of the procedure. The result will be a tool which can produce consistent and comparable crash typing to be used in problem analysis, countermeasure development, and program evaluation.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrian and bicycle problem

The results of this effort can produce a common vocabulary and structure for understanding pedestrian crash dynamics and causation. It is also a procedure and set of objectives that can benefit bicycle crash studies and countermeasure development.

Research Area: Pedestrian Crash Data

Concept Title: Improved Pedestrian Facilities

Over recent years, pedestrian activity, such as purposeful trips, has decreased significantly in the U.S. One factor behind the decrease can be a lack of appealing pedestrian facilities. Information about current levels of pedestrian activity and attitudes toward improving facilities, plus behavioral and attitude responses to actual improvements in facilities, can be important in designing the most effective projects that increase the healthful practice of walking while also reducing pedestrian crashes.

Justification for research or research need

Through planning oversight, false economy, or gradual encroachment, safe and attractive pedestrian facilities do not exist in many locations where pedestrian travel would be a natural and reasonable way to get from one place to another. Research combining before-and-after surveys on pedestrian knowledge, opinions, and behavior with facilities improvements could produce coordinated strategies that could be successfully implemented by increase the safety for all walkers while encouraging more people to walk rather than use alternative transportation means. Combining existing ways of measuring pedestrian facility quality, trip activity, and knowledge and attitudes with responses to actual facilities improvements can bring together all “system” factors.

Objective(s) of research

The objective of this project will be to show that, in areas where pedestrian traffic is reduced or endangered due to poor provision for pedestrians, improving the facilities will be approved by the public, utilized for more walking trips, and a significant factor in reducing pedestrian-vehicle crashes. In extreme cases where pedestrians now interfere with vehicular traffic, the improvements may also reduce vehicle-only crashes.

General approach including time frame

- Identify urban or suburban areas where there are large numbers of short trips which could be handled on foot but currently are not, and where inadequate pedestrian facilities may be contributing to the problem.

- With focus groups, surveys, public meetings, etc., determine present views on pedestrian travel and likely trips.

- Design and implement facility improvements, with PI&E, supporting the anticipated trips.

- Evaluate before-and-after trip volume, pedestrian safety (crashes, or behavioral indications such as conflicts), and driver, pedestrian, and community opinions.

Time frame: 2 years

Products and how these link to possible future activities, e.g. future research

Before-and-after attitude and behavior measurement can refine our knowledge of how to improve facilities to get the maximum walking increases and safety improvements. The result can be an improved “systems package” that will enable, for example, local jurisdictions to identify problems, tailor the most appropriate corrections, implement them, and confirm their benefits.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrian and bicycle problem

These kinds of "remedial" improvements can be done where it is judged not appropriate to attempt to update whole traffic systems, such as through wide area traffic calming.

Pedestrian Countermeasures

Richard D. Blomberg
Dunlap and Associates, Inc.

Countermeasures to pedestrian crashes with motor vehicles have likely been around since the time the first pedestrian was struck. They probably can even trace their origins to efforts to prevent people walking from being hit by horses and horse-drawn carriages. The true modern era in pedestrian countermeasures, however, was spawned by the publication and widespread acceptance of the definition of pedestrian crash types by Snyder and Knoblauch (1971). The crash types identified in this landmark study together with the associated function/event sequence from which they were derived significantly changed the thinking of researchers about pedestrian crash countermeasures.

Through the use of the Snyder and Knoblauch (1971) crash types and their derivatives, it was possible to target specific factors that had a high likelihood of breaking the causal chain of crashes. This approach, basically the proverbial rifle bullet instead of a shotgun, produced some noteworthy successes. Where relatively simple interventions were available that could produce a profound effect on behavior, large crash reductions resulted. For example, Hale, Blomberg and Preusser (1978) documented a 77% reduction in child pedestrian crashes associated with ice cream trucks in the city of Detroit after passage of the Model Ice Cream Truck Ordinance (MICTO) that had been developed in a previous research effort. In this case, the addition of a stop swing arm to the ice cream trucks effectively slowed motorists so that they could see child pedestrians emerging from the screen of the ice cream truck in sufficient time to avoid striking them.

Not all crash generation situations are amenable to an intervention as simple and powerful as a swing arm on ice cream trucks. For example, the dart-out crash type, which is the most common crash experienced by young children, results from poor search and detection by the child pedestrian and the striking motorist. These failures can be predisposed by factors such as excessive motorist speed, the presence of parked cars as visual screens and running by the pedestrian which produces a short time exposure to the motorist. In this case, however, there is no intermediary agent such as an ice cream truck that can be modified to control behavior. The parties themselves must alter their behaviors if a crash reduction is to be achieved.

The dart-out is therefore an example of a crash type that had to be addressed by attempting to convince the involved parties to alter their behaviors. As a result, initial efforts against the dart-out focused on public information and education (PI&E) and training. Where successful, these efforts produced more modest crash reductions in the 15 to 20% range (cf. Blomberg, et al., 1983). More recently, traffic calming approaches have been added to the fight against dart-outs with apparent success. It may be expected that combining traffic calming with educational approaches will yield better results than either approach alone.

Although pedestrian countermeasures efforts were largely ignored for much of the 1980's, knowledge in this area can be considered relatively mature. There are an abundance of countermeasures in all of the three E's--education, enforcement and engineering--that are based upon sound knowledge of crash causation. In addition to those developed at the federal level, excellent countermeasures have come into use at the state and local levels, many as a result of the "trickle down" of information from federally-sponsored research studies. Unlike the bicycle area, however, these countermeasures have yet to be compiled into a single, authoritative reference source. More detailed data on pedestrian crashes and available countermeasures appears needed to assist the local practitioner in selecting countermeasures for particular locations.

There also is still an abundance of antiquated thinking among local officials when faced with the need to mount pedestrian countermeasures. For example, some jurisdictions continue to focus on the issuance of jaywalking tickets in an attempt stop crashes that are really the result of poor road geometry, excessive vehicle speeds and poorly timed signals. In addition, pedestrian safety has not yet achieved the degree of importance warranted by its position as the second largest killer of people on our highways. Until there is greater understanding of the importance of pedestrian safety among cognizant public officials, countermeasure usage will remain less than desirable. Even when action is taken, however, the selection of the best approaches will not be made routinely unless local practitioners have ready access to the state-of-the-art.

Finally, most countermeasure evaluations to date have focused on the ultimate measure of crash reduction. A few have also examined intermediate measures such as knowledge gain and behavioral change. We know little, however, about the reasons why pedestrian countermeasures succeed or fail. For example, do people misunderstand the advice in PI&E, or do they simply reject it? Can new laws and ordinances result in behavioral change if they are not associated with a relatively massive PI&E campaign? What influences officials to promote pedestrian safety and authorize the mounting of successful countermeasures? Answering questions such as these as part of a coordinated research program is fundamental to improving further our understanding of what makes pedestrian countermeasures successful.

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Research Area: Pedestrian Countermeasures

Concept Title: Pedestrian Countermeasures CD-ROM and web site

Background and Justification

Recent efforts funded by NHTSA and FHWA developed a CD-ROM of bicycle safety countermeasures with a cross referencing to crash problem types and implementers as viewed from the perspective of a local practitioner. This CD-ROM has been well received and widely distributed. No such compendium of pedestrian countermeasures exists.

Given the groundwork laid by the bicycle CD-ROM development, it will be possible to produce a pedestrian safety analog quite efficiently. It also can be implemented from the outset as both a CD-ROM and a web site so that it can be interactive with its users and essentially self-updating.

Objectives

- Adapt the bicycle CD-ROM format for pedestrians
- Collect a cross-section of pedestrian countermeasures developed at the federal, state, local and commercial levels
- Assess the collected countermeasures to ensure that they are consistent with research findings on the causes of pedestrian crashes
- Prepare a CD-ROM and web site to serve as a resource guide for the countermeasures

General Approach

The approach to be followed would be essentially the same as was employed for the development of the bicycle CD-ROM. The initial task of this 12 to 18 month study would be an adaptation of the problem-by-implementor matrix developed for the bicycle safety effort. Then, an extensive search for existing and proposed countermeasures would be undertaken followed by an expert assessment to determine if the collected materials are consistent with prevailing knowledge of the causes of and countermeasures for pedestrian crashes.

The compiled materials would be produced as both a CD-ROM for standalone use and as a web site. In the web site implementation, a feedback component would be included so that the compendium would be dynamic and self-updating.

Products and Linkages

The main products would be the CD-ROM and a web site. While not a specific prerequisite for other pedestrian safety studies, this effort would represent an important step towards improving the understanding of pedestrian safety problems and solutions among those who have local responsibility for the subject.

Possible Impact

Production and distribution of these products has the potential to increase the visibility of pedestrian safety in the minds of local officials. It also should permit local safety practitioners to make more effective selections of countermeasures thereby improving remedial programs and reducing the crash toll.

Research Area: Pedestrian Countermeasures

Concept Title: Factors that motivate the initiation of pedestrian safety countermeasures programs

Background and Justification

A recent effort funded by NHTSA and FHWA examined ways to increase awareness of the importance of pedestrian safety and walking promotion. Materials were developed and distributed to achieve improved awareness, and the Partnership for a Walkable America was founded.

In spite of the efforts of the awareness effort, little is known about what motivates communities of various sizes and demographics to adopt pedestrian safety efforts. This is a vital piece of information because countermeasures developed at the federal level will not flow down effectively if there is significant resistance at the local level. NHTSA and FHWA cannot fund all or even most local programs as the primary implementation motivation. Moreover, programs catalyzed by federal funds tend not to continue after the funding ceases.

The purpose of this research study would be to gain understanding of what it takes to motivate local interest in pedestrian safety efforts that then might become a sustaining part of local safety activities.

Objectives

- Define key variables to discriminate among communities, e.g., size, economics, demographics, on their interest in pedestrian safety efforts

- Collect data from a sample of communities across the defined strata that will indicate what factors can motivate them to adopt and sustain pedestrian safety efforts

- Develop strategies and materials to motivate communities with respect to pedestrian safety

General Approach

This one year study would commence with an analysis to generate a framework of key variables. It would then focus on obtaining inputs from a cross-section of communities to determine what might motivate them to generate and sustain pedestrian safety programs. A sample would be defined that would include similar locales which do and do not support pedestrian safety efforts. The analyses of differences in the resulting dataset by community type would be used to define motivational strategies and materials that are associated with an increased likelihood of mounting pedestrian safety efforts.

The defined materials would be developed and audience tested to determine if they were capable of achieving their objective of motivating pedestrian safety program implementations.

Products and Linkages

The products would include strategies for increasing the motivation of officials to initiate and continue pedestrian safety efforts as a function of community characteristics. Specific materials would also be developed to implement the strategies. These products would then become the initial wave of materials in a widespread effort to increase meaningful pedestrian safety countermeasures efforts nationwide.

Possible Impact

If successful, this effort would ultimately lead to the existence and continuation of an increased number of viable pedestrian crash countermeasures programs. This, in turn, should reduce pedestrian crashes which should further motivate pedestrian safety efforts.

Research Area: Pedestrian Countermeasures

Concept Title: Determining source credibility for pedestrian information

Background and Justification

Public information and education (PI&E) efforts have been a major part of the countermeasure focus for pedestrian crashes. PI&E also has been used in special focused efforts to increase awareness of special groups such as public officials. In spite of the number of these efforts and many documented successes, little is known about which sources of pedestrian safety information are considered most credible by key target groups. Obtaining and applying this information should greatly increase the effectiveness of PI&E efforts.

Objectives

- Enumerate those audience groups for PI&E that are likely to be key targets for future PI&E efforts
- Enumerate potential PI&E topics for forthcoming pedestrian safety efforts
- Develop data collection methods to assess each audience's source credibility level as a function of topic
- Apply the developed methods to collect data
- Analyze the collected data to identify the most credible sources for each audience
- Develop guidelines for the production of future PI&E

General Approach

The approach for this one year effort would involve analyses to enumerate audience groups, potential topics and alternative data collection approaches. Focus groups and surveys are the typical method of conducting source credibility studies, but new approaches such as using the Internet should also be considered. Once the lists are available and a method is chosen, data can be collected and analyzed to determine source credibility as a function of audience.

Products and Linkages

The major product will be a set of guidelines that should help increase the effectiveness of future PI&E efforts. As such, this effort will link with all future PI&E efforts whether directed at the populations at risk or at intermediaries and officials who are critical to mounting successful countermeasures efforts.

Possible Impact

If successful, this effort could significantly increase the effectiveness of future PI&E efforts thereby making them more cost effective.

Research Area: Pedestrian Countermeasures

Concept Title: The persistence of pedestrian countermeasures

Background and Justification

Pedestrian countermeasures have traditionally been deployed in campaigns often funded by sources outside the implementing community such as NHTSA and FHWA. As a result, the program efforts often cease when the external funding runs out. Thus, little is known about the long-term persistence of pedestrian countermeasures. Likewise, there is a paucity of information on the effectiveness of countermeasure approaches that build over time. If these countermeasures do not produce significant crash reductions during the life of any funded evaluation, they are typically declared a "failure," and no further information about them is obtained.

As a result of these limitations, little is known about long-term countermeasure effects or the effectiveness of countermeasures that are slow in developing crash reductions. Further crash reduction potential exists if these approaches are proved effective and brought into more widespread use.

Objectives

- Identify alternative experimental designs to examine countermeasure persistence and long term countermeasure effects

- Select experimental design and candidate projects

- Apply approach to collect data

- Analyze the data to determine how long countermeasures persist and whether the selected countermeasures produced slow-developing effects

General Approach

In order to accomplish this study over a period of approximately 18 months to two years, it will be necessary to identify existing countermeasure efforts that can be used as an experimental basis for the effort. For example, countermeasures that have been in place for a long time could form the basis for two types of evaluations. First, their crash reduction profile can be examined over time to see if it sustains, increases or diminishes. Second, crash rates in selected sites with continuing countermeasure efforts could be compared with rates at sites that have mounted similar countermeasures and then abandoned them.

Selecting the best methodological approach to this effort is challenging but reasonably achievable. Enough pedestrian countermeasures efforts have been mounted nationwide that there should be a sufficient basis for developing and implementing a viable evaluation.

Products and Linkages

The major product would be an evaluation of the benefits of long-term pedestrian safety countermeasure implementation and the effectiveness of selected slower developing countermeasures. These results will greatly increase knowledge of pedestrian countermeasure effectiveness and could lead to new or revised countermeasure deployment strategies that would increase effectiveness.

Possible Impact

The effectiveness of pedestrian countermeasure programs could be significantly increased by the results of this study.

Research Area: Pedestrian Countermeasures

Concept Title: Development of a zoning software module for PBCAT

Background and Justification

In a previous study, the benefits of deploying countermeasures in zones defnied by crash data was demonstrated. For that study, zones were defined both manually and semi-automatically using commercially available mapping software. Both approaches involved considerable effort that likely makes the widespread adoption of the approach unlikely.

The current pedestrian demonstration project in Miami-Dade, Florida is also using the zone approach. For this effort, crashes are being mapped from electronic police crash report data, and zones will be defined interactively with a commercial mapping package. The amount of effort is still extensive.

There would be a great potential for increasing the use of the zoning approach if an automatic zoning option could be added to the existing PBCAT software that collects crash data and determines crash type.

Objectives

Define requirements for a zoning module as part of PBCAT

C Develop program specifications

C Code software

C Verify and validate software

C Beta test software

General Approach

This would be a traditional software development effort preceded by the enumeration of definitions and requirements for defining zones using software. The study would proceed from requirements through program specifications and actual software development and testing. It would take approximately 18 months.

Products and Linkages

The software resulting from this study would link to many future countermeasure efforts and enhance the functionality of PBCAT.

Possible Impact

If zoning is made part of PBCAT and the entire software package is enhanced, it should gain more widespread use. This, in turn, should improve the quantity and quality of countermeasures efforts.

Pedestrian Facilities Research

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Over the past 20 years, much of the safety research involving pedestrians has focused on gaining a better understanding of causes and characteristics of pedestrian crashes. Some of the causal factors involved in pedestrian crashes include dart and dash behaviors by young children, older adults being struck at intersections (e.g., by left turn vehicles), alcohol use by the pedestrian as a factor (particularly among adult males), dark conditions (which greatly increases crash risk to pedestrians), higher crash risk for minorities, and many others. Because of the complex nature of pedestrian crashes, any serious attempt to reduce pedestrian crashes and related injuries on a broad scale requires a comprehensive program of education, engineering, and enforcement. (1)

This 'white paper" focuses on the engineering issues and explores some of the background and needed research in five areas related to pedestrian facilities. While some research has been conducted related to safety effects of various types of pedestrian facilities, there is still much that needs to be learned about the safety effects of roadway and traffic control measures on pedestrian safety under various conditions. Part of the difficulty in quantifying such effects involves the complex nature of pedestrian and motorist behaviors and crashes, which are affected by roadway design features, traffic control devices, and a variety of environmental, driver, and vehicle factors (e.g., weather conditions, alcohol use, vehicle brake failure). In addition, changing traffic and roadway conditions from site to site (and from city to city) can greatly influence the effect that a given facility has on pedestrian safety.

While some of the safety studies on pedestrian facilities have analyzed pedestrian crash data, many of them have had to rely on pedestrian and motorist behavior and conflicts due to the large sample of sites required for adequate crash evaluation purposes. Attempting to adequately address all of the safety research topics on pedestrian facilities is not practical within the limits of this paper. Therefore, the following paragraphs provide a brief summary of research on the five topics of recommended future research.

1. Pedestrian Facilities at Uncontrolled Crossings -- A variety of signs, markings, and other measures have been used to indicate crossing locations for pedestrians at street crossings uncontrolled by a stop sign or traffic signal. Recent research for FHWA (2) has found that having marked crosswalks alone has no safety benefit, compared to having an unmarked crosswalk (and crash risk is actually increased from marked crosswalks on multi-lane roads with ADT's above 10,000). The larger FHWA study also evaluated other pedestrian devices for use at uncontrolled crossings. These included Pedestrian safety cones (i.e., signs placed at the centerline of 2-lane roads with the message "State Law: Stop for Pedestrians on Your Side of Street"), overhead rectangular "Crosswalk" signs (as used in Seattle, WA and Clearwater, FL), flashing crosswalks (lights in the pavement at the crosswalk activated by push button or automated detectors), and 4 x 4 ft illuminated signs "STOP for Pedestrians in Crosswalk" (as tested in Tucson, AZ). While some of these devices showed some positive effects, such as increasing motorist yielding, others showed negative impacts, and none of the devices tested showed substantial improvements in motorist or pedestrian behaviors. (3) Further, some local agencies continue to install various "experimental" devices without formal evaluations of their safety effects. Further study of this problem is greatly needed to allow engineers to better understand which devices are beneficial and which are harmful to pedestrian safety under various site conditions.

2. Traffic Signal Innovations to Enhance Pedestrian Safety – Research for FHWA in the 1980's (4) found that simply having a standard-timed WALK/DON'T WALK signal had no effect on pedestrian crash risk (compared to having a traffic signal alone), although having an "exclusive" phase for pedestrians reduced pedestrian crash risk by half (although this timing scheme results in increased pedestrian and motorist delay and is rarely used in the U.S. anymore). Signal-related devices that were field tested and found to improve pedestrian and/or motorist behavior conflicts included the WALK WITH CARE pedestrian signal message (during the WALK interval) and the DON'T START (to replace the flashing DON'T WALK message). Signs for pedestrians stating "Watch for Turning Vehicles" and motorist signing "Yield to Pedestrians When Turning" (installed on the approaches to intersections) were found to reduce conflicts between pedestrians and turning vehicles.

In the past five years, other pedestrian signal "enhancements" have been tested. For example, automatic (microwave or infrared) pedestrian detectors been used to supplement or replace the pedestrian push-button and have been found to significantly reduce pedestrian signal violations and also to reduce pedestrian/vehicle conflicts. (5) The pedestrian countdown signal (which counts down the number of seconds remaining before the steady DON'T WALK message is displayed) is intended to give useful information to pedestrians to encourage them to not leave too late in the cycle and become trapped after the signal changes to green for motorists. After limited evaluation of that device, there are questions regarding whether the device accomplishes that objective. Devices like the illuminated pedestrian push button are intended to give pedestrians feedback (e.g., like a lighted elevator button), but a recent study did not find any improvement in pedestrian crossing behavior after the lighted button was installed. The "animated eyes" pedestrian signal display has been found by Van Houten (6) to result in increased looking behavior by pedestrians at several test sites. Current technology allows for development of a wider range of messages to address specific pedestrian and motorist problems at signalized intersections.

3. Determining Roadway Features Related to Vehicle Speeds – One of the most severe safety problems for pedestrians involves excessive vehicle speeds on public streets and highways, which puts pedestrians at greater risk of being injured of killed in a collision with a motor vehicle. Simply lowering speed limits typically does not reduce vehicle operating speeds, and police manpower is limited for purposes of speed limit enforcement. The problem comes largely from fact that many streets and roadways are designed and constructed with high design speeds, including long straight sections with wide lanes and shoulders, good separation distances to roadside objects, and in some cases with infrequent driveway openings. Further, some traffic signal systems are timed in a coordinated network which allows for high speeds along a section without interruption by a red light.

While quite controversial in some respects, traffic calming measures, such as speed humps, chicanes, mini-circles, roundabouts, curb extensions, etc. are being used extensively in many cities as a way to slow vehicle speeds and/or to reduce cut-through traffic on neighborhood streets. When not planned properly, however, traffic calming has often shifted a speeding problem from one street to adjacent streets. Further, while such measures can be effective in reducing vehicle speeds on certain low-volume, neighborhood streets, most of them are not considered on arterial and major collector streets, which present some of the greatest problems for pedestrians. (7,8)

4. Safer Design of Trails and Paths for Pedestrians and Bicyclists – An outgrowth of the federal ISTEA legislation in the early 1990's has been a substantial increase in the construction of trails and separated paths for pedestrians and bicyclists. Many of these facilities are being built to accommodate the number and types of trail users expected to be using the facilities over the next 20-or-more years in many cases. Expected trail users include those who walk and bike, as well as those on in-line skates, skateboards, etc. Past experience shows that the population of trail users travel at a wide range of speeds (e.g., up to 25 mph for bicyclists) and demonstrate behaviors that may put them at risk (e.g., using headphones). Some trails in urban areas were built decades ago at the minimum allowed widths, and the volume of users on the trail now exceeds the capacity. This combination often places trail users at risk of serious injury or death from others.

In addition to safety problems on the trail itself, there are considerable risks to trail users at intersections with public streets and highways. Such trail/roadway intersections are often controlled only with a stop sign to the trail users, with minimal, if any, traffic control for motorists. This places some of the trail users (particularly young children and older adults) at high risk of being struck by a motor vehicle. Pein has studied trail intersections in Florida, including behaviors and conflicts of motorists and trail users. (9) A Guide was developed that gives recommendations on traffic control and roadway design alternatives to be used at trail/roadway intersections. (10) However, further research is needed to study various alternatives under a wider variety of trail situations to enhance the safety of trail sections and intersections.

5. Providing Safer Lighting Levels for Pedestrians – Pedestrians are at much greater risk of being struck by a motor vehicle when walking along roads or crossing streets during nighttime conditions, compared to times of daylight. Research by Knoblauch (11) found that 35 to 42 percent of pedestrian crashes occur during dark conditions, even though pedestrian travel is relatively low at night. A study by Blomberg, et al (12) of pedestrian and bicycle conspicuity revealed that a “baseline” pedestrian (i.e., a person wearing blue jeans and a white shirt) can be detected at on 224 feet and recognized at 105 feet by a motorist with low beams illuminated and no overhead lighting. This very much limits the ability of most motorists to adequately see and react to a pedestrian who might be crossing the street or walking along the roadway at night without supplemental overhead lighting. To compound the problem, many pedestrians wear dark clothing and may assume that the driver can see them, just because they can see the oncoming headlights from a substantial distance.

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Research Area: Pedestrian Facilities

Concept Title: Evaluation of Pedestrian Measures at Uncontrolled Crossings

Background and Justification

One of the most serious safety and mobility problems for pedestrians involves the difficulty they have in crossing streets, particularly on multi-lane roads where speeds are high. While installing traffic signals with WALK/DON'T WALK signals is an option at selected crossing locations, it is not practical to install signals at all places where pedestrians try to cross.

Recent research for FHWA has evaluated several types of innovative signs, markings, and flashers that were developed to help pedestrian cross streets. However, the results showed some positive and some negative effects of these devices on pedestrian and motorist behaviors and conflicts. Some local agencies continue to install various "experimental" devices without clear plans for evaluating their effects. Further study of this problem is greatly needed to gain a better understanding of which devices are beneficial and which are harmful to pedestrian safety under various site conditions.

Objectives

- Identify the specific problems associated with pedestrians crossing streets at uncontrolled locations
- Develop innovative concepts and devices for improving safety for pedestrians
- Conduct behavioral evaluations of selected signs, markings (e.g., advance stop lines prior to marked crosswalks), and geometric treatments (e.g., raised medians and refuge islands, curb extensions) at locations in several Cities and recommend promising measures

General Approach

This study will involve conducting field observations of pedestrian and motorist behavior related to pedestrians crossing streets at uncontrolled crossing locations, for various vehicle speeds, roadway width, and other conditions. Based on the observed behaviors and conflicts, potential countermeasures will be identified to improve pedestrian safety for such crossings. Traditional and innovative devices will be identified, and some of the more promising ones will be field tested. Recommendations will be made on what devices may be most appropriate for use under various traffic and geometric conditions.

Products and Linkages

The main product from this research will be a report on the effectiveness of various devices and measures to help accommodated safe street crossings by pedestrians at uncontrolled locations. Such information could also be incorporated into the Pedestrian Facility User Guide: Providing Access and Safety, which will be available soon.

Possible Impact

There are two major types of impact of this study. First, agencies that have done little or nothing to provide safer crossing facilities for pedestrians at uncontrolled locations will have recommendations on promising measures to consider. Agencies that have installed innovative devices, which may be largely untested or even causing negative effects, can use this information to avoid installing devices that may be problematic.

Research Area: Pedestrian Facilities

Concept Title: Traffic Signal Innovations to Enhance Pedestrian Safety

Background and Justification

Research over the past 20 years has identified a variety of problems for pedestrians who cross at signalized intersections. These problems include a lack of understanding of pedestrian signal indications (i.e., particularly the flashing DON'T WALK display), lack of pedestrian compliance to signal messages, failure of motorists to yield to pedestrians when turning on a green light, and problems with motorists running red lights, among others. Research has identified a few promising measures, such as automatic pedestrian detectors to enhance pedestrian safety at signalized intersections. However, many problems still exist at signalized locations that deserve further development and testing. Current technology allows for transmitting much broader types of visual and audible messages to pedestrians and motorists, which needs to be explored in light of pedestrian safety needs.

Objectives

- Summarize the specific safety problems and behaviors associated with pedestrians attempting to cross at signalized locations

- Identify candidate traffic control alternatives which may address these problems

- Determine the effects of selected devices in affecting pedestrian and/or motorist behaviors at signalized crossing locations

- Make recommendations on measures which are expected to improve pedestrian safety under various traffic and roadway conditions

General Approach

This study should first review available literature and conduct focus groups to identify the full range of pedestrian and motorist behaviors that lead to pedestrian crashes at signalized intersections. Potential visual and audible messages and devices will be identified to address specific behaviors that lead to pedestrian crashes. Pedestrian-related signal measures from Europe, Australia, Japan, and other countries will also be studied.

Selected signal messages and devices will be manufactured and field tested at appropriate sites in several U.S. cities. The effects of the device will be documented along with the specific site conditions of the test sites.

Products and Linkages

The results of this study will be a final report and Executive Summary, which will be incorporated into the Pedestrian and Bicycle Information Center (PBIC) web site.

Possible Impact

The results of this study will lead to recommendations to be submitted to the National Committee on Uniform Traffic Control Devices (NCUTCD) for possible inclusion into the MUTCD.

Research Area: Pedestrian Facilities

Concept Title: Determining Roadway Features Related to Vehicle Speeds

Background and Justification

Excessive vehicle speeds on public streets and highways is a major contributing factor to pedestrian crashes and crash severity. Simply reducing speed limits will not effectively reduce vehicle speeds. The problem comes largely from design features of the roadway and roadside which encourage high vehicle speeds. Traffic calming measures have been used on local and residential streets in many cities, but many of these measures are not appropriate on major collector and arterial streets. There is a need for engineers to gain a better understanding of how to design new roads and also retrofit existing roads to reduce vehicle speeds.

Objectives

- Quantify the effects of various geometric and operational features on vehicle speeds
- Analyze speed-related crash risks of various roadway and roadside features
- Recommend treatments that engineers may implement on various roadway types to reduce vehicle speeds and speed-related crash risk to pedestrians

General Approach

This study should identify a sample of street sections in selected cities where vehicle speed data are available. This will involve collecting information on the roadway and roadside features, such as traffic volume, speed limit, number of lanes, lane width, shoulder width, presence of parking, bus lanes and bike lanes, lateral separation to roadside obstacles, roadway alignment, pavement striping pattern, number of intersections and driveways within each section, etc. Information would also be collected on roadways with traffic calming measures. Analyses will be conducted to quantify the effects of various features on vehicle speeds and vehicle crashes. At a sample of the sections, pedestrian exposure data can be collected for use in determining pedestrian crash risk.

Recommendations will be made regarding the factors that are found to influence vehicle speed and crashes. Based on these results, recommendations will be made on how vehicle speeds and crash risk may be reduced on various types of roadways.

Products and Linkages

The output from this study will be a research report and a Guide that recommends measures to reduce vehicle speeds on various types of roadways.

Possible Impact

The study results will be valuable to City engineers and planners in designing new streets and also in retro-fitting existing roadways to achieve reduced vehicle speeds.

Research Area: Pedestrian Facilities

Concept Title: Safer Design of Trails and Paths for Pedestrians and Bicyclists

Background and Justification

Multi-use trails and paths typically handle a variety of trail users, including those on foot or riding a bike, as well as those using in-line skates, skateboards, etc. This mix of trail user types often results in a wide range of speeds and a corresponding risk of serious injury from other trail users, but also from motor vehicles at intersections with public streets and highways. More research is needed to quantify the various traffic control and roadway design alternatives that can be used on trails and at trail/roadway intersections to enhance safety.

Objectives

- Identify sources of injury data on selected trails and analyze the data to quantify injury causes and factors
- Evaluate countermeasures which are implemented on selected trails
- Develop recommendations for improving the safety on trails and at trail/roadway intersections.

General Approach

A review will be conducted of the AASHTO Bicycle Guidelines for trails, as well as other research and information on trail design and traffic control measures. This study should then identify trail systems in several states which have a good reporting system for recording injuries involving trail users. This information should be supplemented by police crash reports involving trail users who are struck by a motor vehicle at trail/roadway intersections. Problem trails and responsible agencies will be identified where a substantial number of injuries have occurred in recent years to trail users. The research team will identify trail sites where countermeasures are being planned to improve safety. A before/after study will be conducted to determine the effects of the treatment(s) on trail user and motorist conflicts and behaviors.

Products and Linkages

The results of the study will be documented in a final report along with recommendations for implementing trail safety improvements.

Possible Impact

The results of this study will lead to additional knowledge concerning methods to improve the safety of users on trails. Responsible agencies can then review their trail system and implement appropriate countermeasures, as needed.

Research Area: Pedestrian Facilities

Concept Title: Providing Safer Lighting Levels for Pedestrians

Background and Justification

Dark conditions presents much greater risks for pedestrians of being struck by a motor vehicle compared to daylight conditions. Adequate overhead lighting is needed along many sections of street and highway to provide a safer walking environment. A study is needed to help engineers to identify such sections where nighttime pedestrian activity and crash risk justify improvements to the overhead lighting. Further, recommendations are needed on the types of lighting sources that are particularly beneficial to pedestrians (i.e., so pedestrians are particularly visible to motorists) under various traffic and roadway conditions.

Objectives

- Summarize available research and knowledge concerning pedestrian safety as a function of nighttime lighting and conspicuity level

- Determine the effects of lighting level and pedestrian nighttime crash experience

- Identify conditions where nighttime lighting should be installed and/or upgraded

General Approach

This study should involve first conducting a thorough review of the literature and research regarding the relationship between lighting levels and pedestrian crash experience. A review of existing lighting guidelines for various state and local agencies should also be conducted. The study should then identify selected sites in several cities with a wide range of lighting levels. Pedestrian and total crash experience can then be quantified in terms of lighting levels, while controlling for traffic volume, vehicle speeds, number of lanes, and other factors. Counts of pedestrian activity (day and night) should also be made to include in the analysis.

Products and Linkages

This study should result in a relationship between lighting and other roadway factors (e.g., vehicle speed, roadway width) and crashes involving nighttime and pedestrian crashes. A final report will be written, and the results of the study will be published in an Executive summary and put on the PBIC web site.

Possible Impact

Local and State DOT engineers will have this information for use in identifying sections which are deficient in lighting and are resulting in a high-incidence in pedestrian and other nighttime crashes. Also, more specific criteria are needed on the types of lighting improvements that are most appropriate under various site conditions.

Pedestrian Injuries in Relation to Vehicle Speed

Heike M. Karsch, William A. Leaf, and David F. Preusser
Preusser Research Group, Inc.

The severity of pedestrian injuries is strongly correlated with the speed of the striking vehicle. Although injuries can range from none to fatal at any speed, an analysis of 23,753 pedestrian crashes that occurred in Florida in 1993-1996 showed that the probability of a crash resulting in an incapacitating injury or fatality is only about 20% at estimated vehicle travel speeds of less than 20 mph and rises to about 70% for speeds above 45 mph. Analysis of pedestrian crashes in the General Estimates System (GES) database from 1994-1996 yielded probabilities of fatalities or incapacitating injuries of about 34% at travel speeds up to 20 mph and about 73% for speeds above 45 mph. Repetition of these analyses for posted speed limits (not necessarily the actual travel speed prior to the crash) yielded slightly lower percentages but the same overall pattern. These findings were confirmed with examination of the Fatality Analysis Reporting System (FARS) database comprising 51,268 pedestrians who were killed between 1989 and 1997.

Injury severity is also dependent on the age of the pedestrian, particularly at high speeds. According to an analysis of the Florida data, 3.1% of pedestrians above 65 years of age die as a result of being hit by a car traveling up to 20 mph; versus less than 1% for all other age groups. At vehicle travel speeds above 45 mph, the relationship between age and fatality rates is more pronounced and ranges from a low of 18% for children under 15 years old to a high of 63% for adults above 65, with incremental increases for the age groups in between.

The results of these analyses suggest that one method of reducing pedestrian morbidity and mortality is reducing speed limits. This was confirmed in France in 1990, where urban speed limits were dropped from 60 km/h (37 mph) to 50 km/h (31 mph), resulting in a 14.5% reduction in urban pedestrian injury crashes, versus a 9.1% reduction in rural areas where speed limits did not change. Graz, Austria, implemented a 30 km/h speed limit, a 20 km/h reduction, on all residential streets in 1992, resulting in a 17% decrease in all pedestrian injuries during the following year. Although in both cases the decrease in actual travel speeds was significantly less than the decrease in speed limits, pedestrian safety was considerably improved.

Unfortunately, a very high percentage of drivers do not comply with posted speed limits, therefore necessitating speed enforcement. It has been shown that enforcement by police is most effective if it is well publicized but its time and place are not predictable. The frequent and random police enforcement necessary to produce consistent compliance with speed limits is very costly, and alternative methods of speed control are desirable. Stationary police cruisers on the side of the road and speed indicators quickly lose their effectiveness once drivers learn that there are no consequences to speeding past them. Photo radar, resulting in mailed citations, has been proven to be quite effective. However, many drivers circumvent speed enforcement rather efficiently with the help of radar detectors, devices that are legal in most states.

An alternative to speed reduction by police efforts or automated speed enforcement (ASE) devices is through traffic engineering approaches. Examples that have been successfully implemented are road humps and speed cushions, horizontal traffic deflections that narrow the roadway (chicanes or bollards), roundabouts, and gateways. Rumble strips effectively attract drivers' attention, but do not lower speeds. Speed control by traffic engineering approaches is also referred to as "traffic calming" and has certain advantages over traditional speed enforcement methods. A big advantage is that, once implemented, speed control through traffic calming is self-sustaining and therefore highly cost-effective for communities. Their success in reducing pedestrian (and motor vehicle) crashes has been well documented. For example, after conversion of 181 intersections in The Netherlands from standard design to roundabouts, fatal crashes at these intersections dropped 76%, fatalities dropped 72%, pedestrian crashes dropped 73%, and pedestrian casualties dropped 89%. Community involvement is crucial for successful implementation of traffic calming approaches, which are typically well received as long as they are part of an integrated area traffic management plan. Moreover, traffic calming encourages alternative modes of transportation, including walking and bicycling, includes beautification of streets, and is generally experienced as improving quality of life.

The U.S. has been relatively conservative about making changes in roadway designs, especially compared to Europe. A handful of American cities such as Portland, Oregon, and Seattle, Washington, have successfully implemented traffic calming strategies, and their positive community response combined with significantly reduced crash rates should serve as a catalyst for implementation of similar traffic engineering changes in other cities nationwide.

Reference

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Research Area: Pedestrian Injuries in Relation to Vehicle Speed

Concept Title: Community Acceptance

What types of limits on motor vehicle access to inner city business districts would be accepted and/or welcomed by area business and residents?

Justification for research or research need

Inner city business districts usually have very high pedestrian and motor vehicle densities, making them particularly dangerous for pedestrians. Some cities have therefore limited vehicle access to parts of their inner city business districts by converting them to, for instance, pedestrian malls. If done properly, pedestrian malls have been well accepted by business and residents and provide a safe place for people to congregate.

Objective(s) of research

Determine the characteristics of those relatively radical traffic calming approaches (e.g., no vehicles allowed in a pedestrian mall) that have been accepted by business and residents. Do these characteristics differ by day of week (e.g., no vehicle traffic on Sunday)? Do they differ by time of day (e.g., no vehicle traffic during midday)? What aspects are less liked, and what accommodations have been made to offset perceived drawbacks?

General approach including time frame

Conduct business and resident surveys.

- Lead focus group discussions with citizens and city government representatives.

- Compare successful strategies from cities that have already implemented these kinds of changes (e.g. Burlington, VT, Ithaca, NY, and Charlottesville, VA).

Time frame: 1 year

Products and how these link to possible future activities, e.g. future research

Guide for cities considering radical approaches on selected streets. This guide would indicate the characteristics of streets and areas most suitable for such treatments and steps needed to implement these "radical" approaches.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrian and bicycle problem

The crash reduction potential for such approaches is obvious. Pedestrian-only streets may also contribute to more livable and safe environments for pedestrians, which may also have advantages for local business.

Research Area: Pedestrian Injuries in Relation to Vehicle Speed

Concept Title: City- or Area-Wide Speed Zones

Demonstrate the crash/injury reduction effects of reduced speed on a city-wide or area-wide basis in the U.S.

Justification for research or research need

There are certain areas where pedestrians are particularly vulnerable to speeding cars, and reducing vehicle speed limits may have a very beneficial effect. Such effects have been demonstrated in Europe. Presumably, even though all vehicles will not conform to the new lower limits, these same approaches might be equally effective in this country.

Objective(s) of research

Implement new, lower, vehicle speed limits across an entire city or within a selected section(s) of a city. Evaluate the effects of the new lower limit.

General approach including time frame

Identify a city interested in reducing its speed limit for the purpose of enhancing pedestrian safety. Implement the speed limit change. Measure vehicle speeds before and after the change. Tabulate the number of vehicle and pedestrian crashes. Assess injury severity in these crashes. Assess community reactions to the new lower limit.

Identify strategies to ensure that the reduced speed limits are effective continuously for the long-term.

Time frame: 3 years

Products and how these link to possible future activities, e.g. future research

A U.S. study of the effects of speed limit changes could be quite useful to urban planners.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrianand bicycle problem

If a U.S. demonstration showed positive effects, it could have an important impact on planning and on long-term crash rates in urban areas.

Research Area: Pedestrian Injuries in Relation to Vehicle Speed

Concept Title: Network Speed Distributions

Fuel crisis-induced speed reductions in the 1970s showed crash reduction effects both on the high speed roads on which the speed limits were reduced and for lower speed roads on which the speed limits were not reduced. It was argued that as drivers adapt to lower speeds on limited access and other high speed roads, they are more likely to travel more slowly on other roads as well. Can traffic calming have the same effect? Namely, will traffic calming in one neighborhood produce lower speeds in adjacent neighborhoods? Or, will drivers increase speed to drive around the calmed areas?

Justification for research or research need

Traffic calming is being implemented in several cities. The benefits of such approaches have been demonstrated for the affected neighborhoods. However, these neighborhoods are necessarily part of a larger traffic network. The effects on the total network would be studied as part of this research project.

Objective(s) of research

Determine the effects of traffic calming treatments on nearby roads and neighborhoods.

General approach including time frame

Select neighborhoods that are about to receive traffic calming engineering treatments. Select adjacent and nearby neighborhoods and roadways as well as comparable but more distant neighborhoods.

For each neighborhood and roadway, measure vehicle speed, traffic volume, and congestion. Measurements should be taken at various times of day and days of the week. Also track pedestrian, bicycle, and overall crash levels.

Repeat measurements after traffic calming treatments have been installed.

Time frame: 2 years

Products and how these link to possible future activities, e.g. future research

The main product of this research would be a technique for estimating the “network” effects for various traffic calming treatments implemented in selected neighborhoods. The (positive) results of this study would provide initial evidence in favor of introducing traffic calming, and the techniques would be useful in gathering specific evidence about specific projects.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrian and bicycle problem

This line of research could lead to guidelines for selecting neighborhoods for traffic calming and then, hopefully, implementing those engineering solutions that are related to positive spillover effects to the traffic network as a whole.

Research Area: Pedestrian Injuries in Relation to Vehicle Speed

Concept Title: Pedestrian Education and Warning

Although it is generally understood that being hit by a high-speed vehicle is harmful to pedestrians, it may be useful to reinforce it through education and to provide warnings in locations where the risk to pedestrians is particularly high.

Justification for research or research need

In spite of general knowledge, pedestrians continue to be struck by fast-moving vehicles, often injured or killed as a result. Some campaigns, e.g., in rural New Mexico, have been undertaken to provide signs that warn both motorists and pedestrians of extreme crash risk. The same kinds of approaches may be generally useful in urban or suburban areas where pedestrian crashes with high-speed vehicles are frequent. The use of general PI&E to increase awareness of the danger and the program is also appropriate.

Objective(s) of research

The objective of the project is to show that identifying and highlighting areas of high risk to pedestrians, supported with PI&E aimed at all the public, can increase awareness and decrease crashes.

General approach including time frame

In one or more urban or urban/suburban areas with a high rate of pedestrian crashes, analyze the crash reports to identify particularly risky locations. Focus on ones with higher vehicle travel speeds and higher injury severities. Divide the sites into test sites, where warnings would be deployed, and comparison sites, where no specific warnings would be posted. Develop warning signs or other devices to alert pedestrians (and drivers) of the very high risk, including possible active devices triggered by the presence of pedestrians or (high-speed) vehicles. Deploy them as part of a general program of PI&E supporting pedestrian safety and the risk of fast-moving vehicles. Evaluate pedestrian and driver awareness of the program in general and knowledge of the specific locations with warning devices. Evaluate the attractiveness and effectiveness of the various warning device designs. Look for reductions in pedestrian crashes overall and at the test and comparison locations.

Time frame: 2 years

Products and how these link to possible future activities, e.g. future research

Design of a general PI&E program and site-specific warning signs or other devices, including possible active devices. Evidence that such a program is effective and therefore worth using in other states and cities.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrian and bicycle problem

The knowledge and devices developed in a project like this can become part of work which combines warnings with engineering alterations, for example channeling pedestrians to crossings designed to respond to pedestrian and vehicle presence.

Research Area: Pedestrian Injuries in Relation to Vehicle Speed

Concept Title: Variable Speed Limits

Speed limits on some roadways can vary as a function of, for instance, time of day, vehicle type, and road conditions. Night limits can be lower than day limits; trucks may have a lower limit than cars; limits can be lowered in construction zones, and variable message signs can indicate a reduced limit during inclement weather. In at least one situation, reduced speed in a school zone on school days, the purpose of the lower limit is to enhance pedestrian safety.

Justification for research or research need

There may be several situations for which a lower speed limit, for example only at certain times of the day or only on certain days of the week, could enhance pedestrian safety.

Objective(s) of research

The primary objective of this research is to identify the range of situations for which lower speed limits, by time of day, day of week, level or type of pedestrian activity, or other factors, may be appropriate. The secondary objective is to suggest ways in which the lower speed limit could be implemented.

General approach including time frame

Evaluate pedestrian crashes by vehicle speed, time of day, day of week, pedestrian activity, road type and other factors to determine situations in which variable limits would be appropriate. Each identified situation would be characterized by: “some of the time” a lower limit would be quite beneficial for pedestrian safety; but the imposition of a lower limit is neither necessary nor desirable “all of the time.”

Review literature concerning the implementation and enforcement of lower variable limits (e.g., school zones, construction zones).

Time frame: 1 year

Products and how these link to possible future activities, e.g. future research

The results of this study could be used to structure a field test of recommended variable limits and how such limits could be implemented.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrian and bicycle problem

Lowered speed limits may not be generally acceptable to motorists. However, if a clear need for the lower limit can be identified and if the lower limit is imposed for only selected time periods, then it may be possible to gain both the expected safety benefit and public acceptance.

Speed Management and the Non-Motorist

Davey Warren, Highway Research Engineer
Federal Highway Administration

Introduction

The legislatures set statutory speed limits that generally apply for various types of roads but recognize no general limit is appropriate for all locations. Accordingly, they give highway agencies speed zoning authority to establish limits above or below the general limit which represent the *maximum reasonable and safe* speed for a particular location. Parker (1985) reports that all states and most local agencies use the 85th percentile speed as the basic factor in setting speed limits. But it is fairly common to reduce the speed limit based on a subjective consideration of other factors. Harkey et al. (1990) found speed limits were posted on average near the 30th percentile speed. Approximately 40 percent of the states and 50 percent of the local agencies consider pedestrian activity. There is a question of whether any adjustment should be made at all, since factors such as roadside development, roadway geometrics, and pedestrian activity are reflected in the drivers' speed choice. Knowles et al. (1997) reported speeds in a school zone were 10 km/h lower when children were present

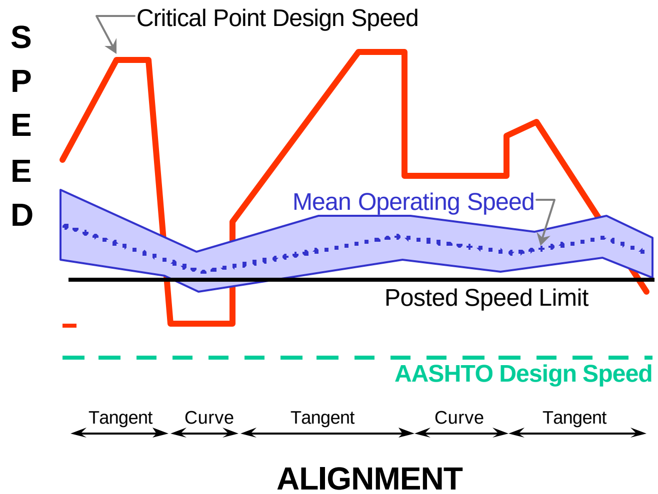
Higher speeds increase pedestrian risk of death. Leaf and Preusser (1999) using Florida data found that fatality risk approximately doubles for each 5 mi/h increase in speed above 20 mi/h. Surprising, the risk is similar to that of drivers for a given change in speed (delta V) but much lower than reported in Europe by Pasanen and Salmivaara (1993). Using crash severity as a criterion for establishing speeds zones, if taken to its logical conclusion, would ultimately lead to a speed limit of zero.

The 85th percentile method largely reflects the collective judgement of motorists and gives low priority to the non-motorist. However little is known about what constitutes a safe speed from the perspective of non-motorists. Smith and Appleyard (1981) in limited tests found that resident opinion as to whether a speed is acceptable or not changes to almost total non-acceptance in the 20-30 mi/h range. However, streets and highways speed limits of 25 and 30 mi/h have the poorest compliance with average speeds more than 6 mi/h over the posted speed and 85th percentile speeds more than 10 mi/h over (Harkey et al, 1990). It is doubtful any speed limit set below the average speed of traffic could meet the legal standard of reasonableness and that speed zoning that meets pedestrian expectation will not be credible to drivers unless physical measures are used to support the lower speed limits.

The public when emotionally aroused often demand and get speed limits lowered in the belief that lower limits will reduce speeds and accidents. This is due in part to the tendency of many associated with rule-making and highway safety to assume that the correct method of dealing with a particular problem is to pass a law making the undesirable behavior illegal and it would cease. The illusionary nature of this concept is perhaps best illustrated in the case of speed limits. Traffic engineering studies over the past 50 years consistently show that raising and lowering speed limits (up to 20 mi/h) in built-up areas has little or no effect on travel speeds (Parker 1997). However, unrealistic speed limits misdirect enforcement resources dealing with reasonable behavior instead of high risk behavior. While it is quite possible to compel compliance with unreasonably low speed limits with overwhelming enforcement, such a level of resources does not exist for traffic law enforcement. Automated enforcement would appear to be a solution but would likely be rejected unless the speed limits are viewed as fair and credible by the motoring public.

The evidence suggests most drivers select travel speeds based on road and traffic conditions and quite independent of illegality. Since the physical design of the road has a major influence on operating speeds, it appears that the best way to ensure that speeds are consistent with the road function is through road design, traffic engineering and other physical measures such as speed humps, mini-circles, roundabouts, curb extensions, center island narrowings and chicanes.

Current practice for highway design stipulates a minimum design speed for coordinating geometric elements. It is a somewhat arbitrary concept and dose not correspond to any clearly defined operating speed or level of safety. The design speed fixes the minimum sharpness of curves and sight distance for stopping. The use of above minimum values is encouraged which, instead of limiting speeds, is conducive to faster operating speeds as shown in the figure (Poe et al, 1996). The fact that the underlying values for a given design speed are based on comfort levels in 1930 vintage cars and near-worst case conditions virtually ensures operating speeds greater than design speeds in low speed environments under normal conditions (Krammes et al. 1996). A more rational approach to control speeds through urban street design would be to establish maximum values or a narrow range of values of curvature, straights, and sight distance for a given desired speed that correspond to actual operating speeds.



Precautions need to be taken to ensure that reduced speeds are not achieved at the expense of increased crash risk. Narrow streets and on-street parking promoted by the new urbanists movement are not very compatible to bicycling and may be unsafe for pedestrians despite slower speeds. The provision of adequate off-street parking, use of curb extensions and flat top humps at crossing points, roundabouts at intersections, and foot paths to connect neighborhood streets would likely create a safer environment more conducive to walking and cycling.

Traffic calming measures can be effective in reducing vehicle speeds especially on low-volume residential streets. Although accident reductions up to 70 percent are reported, it is difficult to draw any definitive conclusions. The before and after studies do not control for time trends, regression to the mean, traffic diversion or other factors that could possibly affect the validity of the results. Most traffic calming measures result in some reduction in traffic. Thus collisions may migrate to other streets as motorists divert to avoid traffic-calmed streets. For a comprehensive view of the safety impact, it is important to examine a wide area, including streets with and without traffic calming. Traffic calming on main roads passing through small towns is in its infancy so even less is known. Unlike urban areas, often there are no good alternative routes for through traffic or local residents and pedestrians.

A credible system of speed management in built-up areas would involve establishing speed zones between the 50 and 85th percentile speed. Where lower speeds are desired to benefit non-motorists, then engineering measures should be implemented first to support the lower speed zone. The traffic calmed area should not be so large as to irritate drivers or unduly impact on emergency response times. The appropriate size of the area is not known at this time although a criterion such as no location should be more than 1 km from a non-traffic street is used in some countries.

Following is an outline of research issues that need to be addressed to improve our knowledge and provide direction for the development and implementation of credible speed management programs that enhance the street environment for non-motorists while at the same time meeting driver expectations.

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Research Area: Speed Management and the Non-Motorist

Concept Title: Effects of Urban Street Design on Speeds

Need

Highway design features, traffic control devices, and the streetscape play a critical role in the behavior of road users and the way in which traffic as a whole operates. However, the relationship between road design, driver behavior, roadside environment, traffic control, operating speed, and safety is poorly understood especially for urban streets. The current design process often results in operating speeds greater than intended or desired. The problem comes in part from the traditional design speed concept of establishing a minimum design speed instead of a maximum speed that would serve to limit speeds. In addition, the current design speed criteria are based on comfort levels in 1940 vintage cars and near worst case drivers and conditions. There is a need reevaluate current design standards for urban streets and better understand how to design new roads to achieve desired speeds.

Objectives

< Quantify the effects of various geometric and operational features on vehicle speeds

< Recommend changes to urban street design

General Approach

Speeds data would be collected on a range of urban streets along with information on the street environment including curvature, grades, cross-section, street length, presence of parking, frequency of driveways and intersections, building offsets, pedestrian and bicycle activity, traffic level and mix (through vs local), etc. Information would also be collected on driver factors (age, trip length, familiarity). Analyzes using mathematical models, neural networks, visual assessment or some combination will be used to quantify the effects of various features on vehicle speeds.
The factors that are found to have the most influence vehicle speed will be identified. Based on these results, recommendations will be made on how the urban street design process and criteria should be changed to limit speeds to desired levels on various types of roadways.

Products and Linkages

The output from this study will be a model for estimating likely operating speeds on new road and modifications to the urban street design standards and procedures.

Possible Impact

The incorporation of operating speed models in the design process will provide planners and engineers with guidance in selecting street designs that result in actual operating speeds more consistent with speeds intended and eliminate the costly retro-fitting of existing roadways to achieve reduced vehicle speeds.

Research Area: Speed Management and the Non-Motorist

Concept Title: Safety Effects of Narrow Streets

Need

As part of a new urbanism and neo-traditional movement, some professionals from planning, engineering, architecture and other disciplines are advocating the use of narrow streets, on-street parking and restrictive geometrics to slow traffic speed and create a more liveable environment. Improved safety is often inferred from slower speeds. While the new standard may reduce speeds, it is not clear that they improve safety for motorists, pedestrians or bicyclists.

There been little or no evaluation of the safety of alternative street designs. Narrow streets and on-street parking promoted by the new urbanists are not very compatible to bicycling and may be unsafe for pedestrians despite slower speeds. The provision of adequate off street parking, use of curb extensions and flat top humps at crossing points, roundabouts at intersections, and foot paths to connect neighborhood streets would likely create a safer environment more conducive to walking and cycling

Objectives

- To determine if narrower streets are safer than wider streets taking parking activity and street function into account

- To determine level of pedestrian and bicycle activity associated with various street design alternative

General Approach

Accident and traffic data will be collected on a large number of urban streets with different widths, parking provisions, volume and type of traffic, pedestrian activity, and land use. Regression models and neural networks will be developed for estimating the safety of alternative designs especially the safety effect of reducing street width and changing parking provisions.

Products and Linkages

The output from this study will be a model for estimating the safety of alternative urban street cross-sections

Possible Impact

Knowledge and understanding of the safety impacts of alternative street designs should help communities avoid dangerous designs and create safe and economical street environments for non-motorists.

Research Area: Speed Management and the Non-Motorist

Concept Title: Acceptable Speed Limits form the Non-Motorists Perspective

Need

Speed limits are intended to reflect the maximum reasonable and safe speed for a given road. The technical literature indicates that the 85th percentile speed of traffic provides the best indicator of a safe speed limit allowing for a small enforcement tolerance. Such a speed reflects the collective judgement of the vast majority of reasonable and safe drivers. The safety needs of pedestrians and bicyclist are given low priority in the process although there are indications that motorists speeds are lower when children and pedestrians are present . Residents often complain about the need to reduce speeds often influenced by a few fast cars. However, the complaints do not provide the engineer with needed information on how fast is too fast. This information is needed in order to determine appropriate speeds levels for traffic calming and to design new roads that are compatible with pedestrians.

Objectives

- To determine acceptable speed levels on various types of streets from the perspective of pedestrians, bicyclists, and residents

- To develop a rational procedure for speed zoning which meets driver and non-motorists expectations while achieving a balance between traffic safety and mobility

General Approach

Data will be collected to determine the speed and volume levels that are considered safe and acceptable from the viewpoint of residents and vulnerable road users such as pedestrians and bicyclists. Vehicles will be driven at various speeds in a random sequence past non-motorists. After each pass, the non-motorists will indicate whether the speed observed is acceptable or not. Similarly, non-motorists in different road environments will be subjected to different traffic flow levels and ask to rate its acceptability. The acceptable speed levels will be compared to the actual speed distribution. The findings will be incorporated into a speed zoning procedure that considers pedestrian activity but still maintains the credibility of posted speeds.

Products and Linkages

A technical brief that delineates target speeds for various street functions to use in new design and traffic calming

Possible Impact

The results will provide objective information on target speeds to use in local street design and result in urban streets more compatible with pedestrian and bicycle activity

Research Area: Speed Management and the Non-Motorist

Concept Title: Traffic Calming Impacts

Need

Traffic calming is the application of traffic engineering measures to reduce traffic speeds and enhance the street environment for non-motorists. A recent review of state of the practice in the US found traffic calming measures such as humps and circles were effective in reducing speed. But because of limitation in how the data were collected only ball park estimates of the impacts could be given. Obviously, where speeds are measured has an effect on the result, as motorists decelerate approaching the slow point and accelerate as they leave. Accidents reduction ranged from 13- 71 percent relation. However, since most traffic calming measures result in some reduction in traffic, it may be that accidents are merely migrating to other streets. Even less is known about secondary impacts.

Objectives

- To quantify the systemwide effects of traffic calming measures on speeds and accidents on various road types

General Approach

Tests will be carried out in cooperation with local agencies to assess the effects of various engineering measures being implemented to control speeds on local and surrounding roads in urban areas and in towns along main roads in rural areas. Issues such as spacing of slow points and traffic diversion will be addressed. Before and after data will be collected to assess the impacts of these measures on speeds, crashes, traffic diversion, mode choice, air quality, noise, vibration and acceptance by non-motorists. Traffic and accident data will be collected on treated and untreated roads across the network to assess local and area wide effects.

Products and Linkages

A report that prescribes the most effective and appropriate measures and combination of measures to achieve desired speeds and tools to estimate accident reduction and other impacts for various street environments.

Possible Impact

The main benefit will be streets and highways with speeds more consistent with the road function and reduction in pedestrian injury risk.

Race/Ethnicity

William A. Leaf, David F. Preusser and Heike M. Karsch
Preusser Research Group, Inc.

Many research projects have been published addressing various aspects of pedestrian morbidity and mortality. Epidemiological studies generally focus on the age and gender of the pedestrians, the time, location and precipitating circumstances of the crash, and/or the type of injuries incurred. Very little information can be found concerning the race/ethnicity of the victims. This is not surprising, since most of these studies are based on police accident reports and databases which often do not include racial information. Although probably intended to prevent discrimination against minority groups, the omission of racial data on police accident reports complicates detection of culturally influenced behaviors that increase or decrease the risk of being involved in a crash.

For the research projects that did include racial/ethnic data, the determination of race/ethnicity of pedestrian and bicycle crash victims was generally accomplished by indirect methods. One such method was to correlate census tracts with the crash location. This technique only suggests the likely race/ethnicity of the victim and assumes that the crash occurred close to the victim's home (Komanoff, 1999). Another method was to collect independent data by providing customized forms to agencies (e.g. emergency room personnel) to complete whenever a crash victim sought help (Stutts, 1997; Stutts and Hunter, 1998). Obviously, this technique can only be used prospectively, making it time consuming and limiting the number of cases that can be analyzed. Moreover, depending on the participating agencies, a selective bias may be introduced into the subject pool by excluding, for example, on-site fatalities who never present themselves to emergency rooms.

Racial/ethnic information is more readily obtainable through official sources when the crash involves fatalities. The Centers for Disease Control's Multiple Cause of Death (MCoD) database includes racial codes and can be cross-linked to NHTSA's Fatality Analysis Reporting System (FARS). State and local sources are another source of race/ethnicity data. Cases obtained from these sources can often be matched with FARS records (Leaf and Preusser, 1997).

One recent study that focused on racial/ethnic characteristics of pedestrian crash victims was published by Leaf and Preusser in 1997. This report investigates the level of alcohol involvement in pedestrian fatalities and correlates these data to race/ethnicity, age, and gender. It was found that some racial/ethnic groups had a significantly higher probability of alcohol intoxication when involved in a fatal crash compared to other racial/ethnic groups or the general population. In particular, black adults over 25 years old, Hispanic males, and Native Americans were significantly over-represented. These findings suggest that culturally influenced behaviors may make these populations more susceptible to being killed by a motor vehicle as pedestrians. Focus group discussions with blacks, Hispanics, and Native Americans helped elucidate these behaviors as well as explore potential countermeasures.

African American pedestrian victims, like white victims, tend to be single males over 25, without a driver's license, poorly educated, unemployed, and who commonly abuse alcohol. There may also be exposure differences between black and white problem drinkers, where blacks spend more time on the street while intoxicated possibly because they are more likely to live in urban environments.

High levels of alcohol consumption among males occurs in Hispanic culture, and being highly intoxicated without showing it is considered a proof of manhood. Hispanics seem to be aware of the dangers (and illegality) of drinking and driving and therefore at least some may choose to walk or ride a bicycle when intoxicated, especially since asking for a ride would undermine their “machismo.”

Problem drinking among Native Americans, both male and female, is well documented. Alcohol is prohibited on many reservations, necessitating traveling to nearby towns for those who wish to consume it. Intoxicated individuals walking home late at night on poorly lit rural roads are at high risk of being hit by a motor vehicle.

There was significant agreement between the three ethnic groups as to which kinds of countermeasures may be effective. Increased education on the dangers of drunk walking was considered useful. All approved of increased police patrolling as long as the officers are racially sensitive and the interventions are benign. “Safe Rides” and “designated walker” programs found general approval. Suggestions for changes in speed limits and traffic signal timing, as well as increased street lighting in areas with many intoxicated pedestrians, were also well received.

Besides alcohol, there are other, as yet unexplored, factors which account for over-representations among crash victims for particular racial/ethnic groups. For example: Why are black children less than 10 years old more likely to be killed by automobiles than white children? Why are Asian males less than 10 years old overrepresented in pedestrian fatality statistics? Why are elderly Asians and elderly whites at increased risk compared to elderly blacks and elderly Native Americans? How do injury rates correlate with fatality rates, and are the same racial biases maintained? Are there differences in injury severity and injury crash characteristics between different ethnic groups?

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Research Area: Race/Ethnicity

Concept Title: Urban/Rural Comparisons among Native Americans

Are Native Americans who live on reservations differently educated about dangers for pedestrians in traffic than Native Americans who live in cities? Is the "traffic IQ" for city dwellers based on experience due to ambient traffic, education, or cultural factors?

Justification for research or research need

Native Americans are significantly overrepresented in fatal pedestrian crashes. Those living on reservations appear to be particularly at risk. There may be differences in the traffic knowledge of Native Americans depending on whether they live and/or spent their childhood on a reservation or in the city.

Objective(s) of research

This project would determine whether Native Americans who live on reservations lack important knowledge about safe pedestrian behaviors. Knowledge of safe walking strategies could reduce the number of pedestrian crashes involving both sober and intoxicated pedestrians.

General approach including time frame

Focus group discussions with Native Americans and non-Native Americans who: have always lived on a rural reservation; lived in both city and reservation environments; always lived in a city. Comparison of traffic education curricula (if any) between schools on reservations and schools in cities.

Survey of traffic specific PI&E campaigns (if any) launched within the last 5 years on reservations and in cities.

Time frame: 1 year

Products and how these link to possible future activities, e.g. future research

The goal of this project would be to help in determining the causes for higher Native American crash rates and suggest possible solutions.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrian and bicycle problem

This special population is sufficiently at risk to warrant in-depth study.

Research Area: Race/Ethnicity

Concept Title: Elderly Pedestrians

Elderly white and Asian pedestrians are at increased risk for crashes compared to elderly blacks, Hispanics, and Native Americans. Is it because of higher exposure? Are there racial/ethnic differences in the willingness to engage in risky behaviors among the elderly?

Justification for research or research need

Thirty-one percent of Asian pedestrians, 25% of white pedestrians, 13% of black pedestrians, and 8% of Native American pedestrians killed by automobiles are over 65 years old. This range is striking and reasons for it are not apparent.

Objective(s) of research

Weight age by crash data as a function of population and population density in urban, suburban and rural environments. Determine the extent of differences in pedestrian mortality between racial groups by age. Determine the characteristics of any differences found.

General approach including time frame

Determination of the locations where elderly pedestrians are most commonly involved in crashes and correlation of crash locations with race/ethnicity of the pedestrians (e.g., crash locations: inner city, suburbia, and rural roads, central business, intersections).

Determination of the crash types that most commonly affect the elderly and correlation of crash types with race/ethnicity of the pedestrians.

Investigation of independence, traffic exposure, and risk-taking behaviors (or traffic conduct) of the elderly and comparison between different racial/ethnic groups.

(a) and (b) could be addressed with the use of police accident reports, databases, and possibly census tracts. (c) could be addressed with focus group discussions with elderly persons of different races/ethnicities, from the country and the city.

Time frame: 2 years

Products and how these link to possible future activities, e.g. future research

Effects seen could be cultural in some way, or they may be a direct result of varying characteristics of exposure. Separation of these factors could suggest culturally sensitive countermeasures for various groups.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrian and bicycle problem

As our society ages, an increasing emphasis will need to be placed on pedestrian crashes involving the elderly. Risk factors, life styles and exposure, etc. will have implications for senior housing, neighborhood design and support services.

Research Area: Race/Ethnicity

Concept Title: Walkable Neighborhoods

How could inner city environments be made more pedestrian friendly? Are there differences in the receptivity to the implementation of various countermeasures by different ethnic/racial groups?

Justification for research or research need

Combinations of high vehicular and pedestrian traffic volumes, especially in areas with outdated infrastructure, increase the risk to pedestrians. The inner city areas that are often the most pedestrian-unfriendly tend to be poor residential neighborhoods, some of which are contain a preponderance of a specific racial/ethnic group.

Objective(s) of research

The objective of this project would be to explore receptivity of various programs to increase pedestrian safety by different racial/ethnic groups. Programs to be explored include special workshops on safe walking, driver awareness education, and traffic engineering approaches, such as traffic calming, the establishment of "play streets," and changes in street lighting, traffic controls and signs.

General approach including time frame

Focus group discussions with inner city residents representing different ethnic/racial groups addressing issues such as:

- General awareness of pedestrian safety concerns,
- Willingness to participate in traffic safety workshops, and
- Receptivity to changes in infrastructure.

Time frame: 1 year

Products and how these link to possible future activities, e.g. future research

The goal would be to provide neighborhoods with culturally sensitive approaches to pedestrian safety that could be implemented at the neighborhood level.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrian and bicycle problem

Many of the countermeasures that we are now examining, such as traffic calming and reduction in vehicle speed limits, can be done on a neighborhood by neighborhood basis.

Research Area: Race/Ethnicity

Concept Title: Children

Countermeasures can be implemented to protect children who grow up in inner city environments. Which countermeasures would most likely be embraced by the children, their families, and other traffic participants? Can strategy development be enhanced with sensitivity to racial, ethnic, and cultural factors?

Justification for research or research need

Due to their immature cognitive abilities, likely lack of traffic skills, and propensity for impulsive actions, children in densely populated areas are at risk for being involved in a crash.

Objective(s) of research

The objective of this project will be to explore community based countermeasures, including possible changes in infrastructure (traffic calming and/or "play streets"), special workshops to educate children and parents about safe walking (e.g. child "pedestrian licensing" programs), and driver education. Each developed countermeasure will be sensitive to cultural factors represented in the community.

General approach including time frame

Conduct focus group discussions with parents designed to explore awareness of their children's vulnerability in traffic, willingness to get involved in safe walking programs with their children, expectation of children's cooperation with such a program, openness towards traffic engineering approaches which may result in inconveniences for drivers.

- Use questionnaires addressing these same issues to get a broader response from communities.
- Design and test a "safe walking" workshop for children and parents.
- Design and implement a driver awareness program in selected communities.

Time frame: 1 year

Products and how these link to possible future activities, e.g. future research

Implementation of "safe walking" workshops and driver awareness programs in many communities and effects on child pedestrian crashes.

Thoughts regarding the impact of the ultimate program or products on the overall pedestrian and bicycle problem

Traffic calming and other potential neighborhood safety countermeasures can be implemented. However, each countermeasure has both costs and benefits. The main goal of this research is to determine how parents of different cultural backgrounds will perceive, or rank order, the costs and benefits of the various approaches.

Appendix D. Bicycle White Papers

In this appendix are six white papers on various aspects of bicycle research, which were provided to the participants as background material and presented at the workshop by the authors. The six papers include:

& Bicycle Data Research Needs

& Bicycle Crash Data Needs

& Bicycle Countermeasures

& Engineering Countermeasures for Bicycling

& Bicycle Facilities Research

& Bicycle Conspicuity Issues and Topics for Future Research

Bicycle Data Research Needs

William L. Schwartz, AICP
Cambridge Systematics, Inc.

Introduction

The role of bicycle travel in providing mobility, reducing congestion, improving environmental quality, and promoting public health has received increasing attention in recent years. To improve conditions for bicycle travel, research, planning, and policy-making efforts are required that rely on data such as travel characteristics, facility characteristics, crashes and safety, and user preferences. Yet these efforts are often hampered by deficiencies and limitations in existing sources of these data related to bicycle travel.

Current Knowledge

Cambridge Systematics, Inc. recently completed a research project for the Bureau of Transportation Statistics on pedestrian and bicycle data needs. The project included a review of existing data and an identification of data needs and research strategies. Considerable input was obtained from user groups including planners, advocates, and researchers at Federal, State, and local government agencies, universities and nonprofit organizations. Published materials and information from other recent assessments of transportation data needs were also reviewed. Primary data sources were classified by four types: (1) usage, trip, and user characteristics; (2) user preferences; (3) facilities; and (4) crash and safety data. Key types of secondary data (data that are based on analysis of primary data) were also identified, including research-study results and manuals of practice. The following represent some to the sources of data in each classification.

Data Sources on Usage, Trip, and User Characteristics

This broad category of data answers the questions of who is traveling, how, where, when, and why. Sources include:

- Counts of bicyclists;
- The decennial census;
- Metropolitan household travel surveys;
- The Nationwide Personal Travel Survey (NPTS);
- Other surveys conducted sporadically at a national level; and
- Various other local surveys and market studies.

Data on User Preferences

Data on bicyclist preferences, needs, and attitudes attempt to answer questions such as, how well is the existing transportation system meeting people's need or desire to bicycle? Which are the most important improvements regarding convenience, safety, and enjoyment of people's travel experience? What improvements would most effectively induce more people to bike? These data may be collected through attitudinal surveys of existing and potential bicyclists. Quantitative models of behavior can also be used to develop information on user preferences. These models may be based either on "stated preference" survey data, in which people are asked to make choices among various alternatives, or on “revealed preference” data, i.e., observations of people’s actual behavior as based on travel surveys and counts.

Data on Facilities

Data on bicycle facilities may describe the type of facility (shared-use path, on-road bike lane, etc.); location; length; width; physical condition; topography; intersection characteristics; and other relevant features. Data on road facilities, such as number of lanes, lane width, pavement quality, and intersection characteristics, can also be relevant to analysis of bicycle travel. Potential sources of data on bicycle facilities include:

- U.S. Bureau of the Census TIGER files;
- The National Transportation Atlas;
- The Rails-to-Trails Conservancy’s recreational trails database;
- State road databases; and
- Local road information.

Crash and Safety Data

Data on crashes and falls can include the location of the crash; number and attributes of vehicles and people involved; damage and injuries; characteristics of the crash location; and contributing factors. Also related to safety, data on personal security or crime is often relevant to bicycle travelers.

Crash and other safety data can be used:

- To identify trends by geographic area, facility type, severity, contributing factors, etc.;
- To identify potential hazardous locations;
- To identify contributing factors to crashes and severity, including characteristics of the individuals involved, vehicles, and environment;
- To identify potential countermeasures to reduce crashes;
- To evaluate the safety of various facility designs and operational policies;
- To identify crash costs; and
- To prioritize safety improvements.

Secondary Data

Secondary data include research-study results, manuals of practice, summary statistics, and other reports, manuals, or findings that can help practitioners in planning for bicycle travel. Secondary data are often based on analysis and synthesis of data from the primary sources discussed above. Specific types of secondary data might include: the safety effects of design features; demand impacts of design features, education programs and other policies to promote bicycling; and recommended design practices.

The BTS Study did not include a comprehensive inventory of secondary data sources by type. However, the outreach effort revealed both a strong interest in secondary data sources and significant gaps in what is currently available. The survey revealed a need for better dissemination of existing data and knowledge as well as for additional research in a number of important areas. Two of the most commonly requested secondary sources area research study results and manuals of practice.

Priorities for Data Needs

Priorities for data needs were identified based on the following criteria:

- Importance of the data for its intended application(s) and audience(s);
- Quality of *existing* data; and
- Usefulness of the data for a *range* of applications (facility design, trend analysis, etc.), audiences (researchers, planners, policy makers, etc.), and geographic scales (local, state, national).

The identified priorities are shown in Table 1.

Table 1. Bicycle Data Types, Quality, and Recommended Priorities

Type of Data Description	Quality of Existing Data	Priority for Better Data
Number of bicyclists by facility or geographic area	Poor	High
User and trip characteristics by geographic area or facility	Fair	Medium / High
User Preferences		
Relative preferences for facility design characteristics and other supporting factors	Fair	Medium
Facilities Data		
Characteristics relating to quality for bicycle travel	Fair	Medium
Crash and Safety Data		
Specific bicycle-relevant crash variables	Fair	Medium / High
Non-motor-vehicle crash data	Poor	Medium
Secondary Data		
Safety and demand impacts of *design features*	Fair	High
Safety and demand impacts of *policies, programs*	Fair	Medium

Source: Cambridge Systematics, Inc.

Research Area: Bicycle Data Needs

Concept Title: How Many People are Bicycling?

Need

Unlike walking, more information on bicycle trips is available. Usage counts are done more frequently on bicycle facilities and better market data exist on bicycle ownership. At the same time, the data that exist are not sufficient to accomplish the planning that is necessary to expand bicycle activities. Specific needs include:

- Overall indicators of usage as well as trends, such as the number of people who bicycle, total bicycle trips, mode shares, and miles of travel by non-motorized modes.

- Counts (trip volumes) on specific facilities, in some cases by characteristics such as time of day, day of week, or type (e.g., work, shopping, recreational).

A related but separate topic is the need to better understand the characteristics of cyclists, which is described in the next research topic area.

Objectives

More comprehensive and systematic data on usage would assist a wide variety of data users for many purposes, including: determining current travel patterns; prioritizing improvements; and tracking the effectiveness of policies, programs, and facility improvements. Better data would assist in safety analysis and crash prevention by providing researchers and planners with measures of exposure. It would assist efforts to model and forecast demand and to determine preferences for and demand impacts of various improvements. Better data on system usage would assist policy-makers by illustrating overall trends in usage as well.

General Approach

Evaluate new bicycle-counting technologies (i.e., video imaging, infrared sensors) by synthesizing the results of current pilot-testing efforts, sponsoring additional pilot tests and methodological development. Document the areas where the data would be best applied. Identify cycling patterns by trip type, facility type, geographic area type, etc. to develop factors for use in areas with limited resources. Test existing new methods in field tests in a sample of sites. Provide detailed manuals of data collection methods for use by engineers, researchers, and planners.

Outcomes

An ideal system of usage data collection and reporting would permit tracking of usage patterns, would be collected systematically and consistently, could be combined with other data, and could advance the state of the practice .

Research Area: Bicycle Data Needs

Concept Title: Who is Cycling and Why?

Need

Just as we know relatively little about how many people are bicycling (see separate research topic), we need to know more about who bicycles and for what purposes. Specifically, we need better data on bicycle trips by distance, purpose, route choices, and time of day and season. We need to understand who bicycles according to various demographic and socioeconomic characteristics. Finally we need to begin to relate this information to other behavioral research on bicyclists in terms of exposure data, countermeasures, and other socioeconomic factors. Currently, the major barrier to gathering better demand/usage data is the *cost and effort* associated with collecting these data. Surveys are extremely labor-intensive and resources are limited. The fundamental component of this research is to explore ways to cost-effectively compile the information needed.

Objectives

With a better understanding of who bicycles and why, planners, researchers, and engineers, would be able to advance a wide range of practice areas. These include facility design; prioritizing improvements; and tracking the effectiveness of policies, programs, and facility improvements. Better user data would assist in safety analysis and crash prevention by providing researchers and planners with improved demographic characteristics.

General Approach

Develop model surveys and sampling methodologies for collecting bicycle data. Investigate enhancements to household travel surveys, notably inclusion of purely recreational bicycle trips, as well as techniques to improve reporting of children's trips, short trips, and bicycle access to other modes of travel. Refine existing techniques to minimize underreporting of bicycle trips. Evaluate new technologies to collect travel survey data, such as personal monitors to measure physical activity levels. Investigate the potential for pilot survey applications of global positioning system (GPS) units to track and monitor pedestrian travel.

Outcomes

The information obtained in this research effort would address existing needs of researchers and potentially permit considerably more bicycle travel information to be collected on a cost-effective basis.

Research Area: Bicycle Data Needs

Concept Title: Strategy for Improving Bicycle Transportation Planning

Need

The question of how many people will actually use new or improved bicycle facilities is gaining interest and importance. Public officials often want to be convinced that the benefits of improvements are worth the costs. Furthermore, agency officials want to know where to spend limited resources to get the most "bang for the buck" as measured by benefits to users.

When considering facility improvements, practitioners often try to determine how many people will use it or choose to travel by bicycle. Regional transportation planners often try to estimate how improvements to non-motorized travel conditions affect mobility, traffic congestion, and air quality.

Objectives

Because practitioners often do not have access to either the data or methodological knowledge to answer these questions with confidence, estimates are left to speculation. The objective of this research would be to develop usable tools that would enable planners and others to quantitatively estimate impacts and benefits. Through the improved availability of reasonable estimates of usage and corresponding benefits, the information available to decision makers will be vastly improved and utilization will increase.

General Approach

In the short term, develop a manual for bicycle sketch-planning featuring simple yet effective tools estimating future demand. Simultaneously, conduct research on factors influencing non-motorized travel behavior. Research should focus not just on identifying specific factors but on how these factors interact and how they can be modeled to assist in forecasting bicycle travel for specific projects. Identify methods/strategies to integrate bicycle considerations into mainstream transportation models and planning. Future improvements to regional travel models hold great promise to improve the quality of non-motorized travel modeling.

Outcomes

Inclusion of bicycle (and pedestrian) modes in regional models and in transportation planning practice will also help place bicycles (and pedestrians) on a "level playing field" with motorized modes of travel in transportation planning. Future estimates of benefits and impacts will be made with more confidence.

Bicycle Crash Data Needs

Richard D. Blomberg
Dunlap and Associates, Inc.

This paper explores possible approaches to obtaining better data on bicycle/motor vehicle crash causation from the normal police crash reporting process.

Background

It is generally accepted that the development of effective crash countermeasures requires insights on crash causation that can only be gleaned from good crash data. The research community has done an excellent job at the macroscopic level in defining bicycle/motor vehicle crash types that are comprehensive, insightful and enduring. The types originally identified by Cross and Fisher (1977) continue to represent the vast majority of bicycle/motor vehicle crashes as shown in a recent study by Hunter et al. (1996). This recent study by Hunter and his colleagues also reaffirmed that a reasonable classification of crash type can be made from the information on a police crash report (PCR). Further, the concept of using crash types as a basis for the development of countermeasure approaches has been proved valid for both pedestrian and bicycle crashes in numerous studies.

Unfortunately, the data-rich environment in which the researcher works to assess crash causation and develop countermeasures has not filtered down completely to the individual practitioner. Instead of the detailed crash information collected by Cross and Fisher (1977), a typical local bicycle safety program coordinator must deal with only the data contained in a PCR unless he or she takes the time to visit crash locations. Moreover, even a visit may not be totally revealing when conducted after the fact since the scene may have changed markedly from the time of the crash.

Anyone who has worked with PCRs, knows that their quality and comprehensiveness varies from extremely sketchy to moderately extensive. They generally focus on describing what happened and determining legal fault rather than assessing the true causal elements of the crash. This is not intended as a criticism of police crash reporting. In an era of reduced budgets and under the pressures of a litigious society, police officers do the best they can. It just is not usually enough to uncover many types of underlying factors that might lead the practitioner using the PCR to the selection or development of the best approach to avoid a recurrence of the unfortunate event. Part of the problem can certainly be traced to the minimal (often non-existent) training police officers receive in bicycle/motor-vehicle crash causation. A better understanding of bicycle/motor vehicle crash types almost surely would result in more insightful narratives and diagrams on the PCR when time pressures permitted the investigating officer to observe and record additional factors.

In order to appreciate where a typical PCR fails to assist the local practitioner, it is important to understand the model of crash causation represented by the *function/event sequence* as proposed by Snyder and Knoblauch (1971) for pedestrian crashes and adapted for bicycle/motor vehicle crashes by Cross and Fisher (1977). In this model, each party must successfully complete a behavioral sequence of *searching* for threats, *detecting* threats, *evaluating* the dangers posed, *deciding* on the appropriate action to avoid a crash, and taking one or more successful *actions* to avoid a crash. Failing to complete one of these functions by the motorist or bicyclist constitutes a *precipitating factor* of a crash. If *both* parties fail to complete the sequence successfully, a crash will result. On the other hand, if *either* the bicyclist or the motorist completes the sequence successfully, a crash will be avoided. The crash types defined by Cross and Fisher (1977) are particular combinations of specific motorist and/or bicyclist precipitating factors
It can be argued that the major area that needs attention to improve the situation for the local practitioner relates to *predisposing factors*. These are conditions in the environment or inherent in one of the parties to the crash that make it more likely that a *precipitating factor* will occur. Predisposing factors, such as

visual screens from shrubbery or parked cars, alcohol use or excessive speed by one of the parties, can often indicate what remedial actions must be taken to avoid a recurrence of the crash. This information is rarely available on a PCR likely because the investigating officer has either not taken the time to examine the scene thoroughly enough or simply is not sufficiently sensitive to the importance of the information. Other types of predisposing factors that can be of particular interest to the local practitioner relate to available *alternatives* that might have avoided the crash or negated the predisposing factor. For example, was there a bicycle path or lane going in the bicyclist's direction that was not used? Was the motorist cutting through a residential neighborhood as a shortcut or to avoid congestion? Answering these types of questions can suggest remedial approaches to apply at the specific location of the crash.

The bottom line is that the person responsible for selecting and applying countermeasures at particular locations generally does not obtain a complete picture of the causal elements of a crash from the PCR. A site visit can fill in many gaps for those features that are a permanent part of the environment. Retrospective visits, however, are often of little benefit in uncovering predisposing factors that are transient in the environment and those related to the participants in the crash. More complete and insightful information is needed from the contemporaneous police investigation itself.. This will require identifying the set of data that is the best compromise between completeness and the additional burden placed on the investigating officers. It will also require the definition and execution of appropriate data collection methods and training to maximize the productivity and minimize the workload of investigating officers.

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Research Area: Bicycle Crash Data

Concept Title: Definition of bicycle/motor vehicle crash data needs

Background and Justification

Before police officers can be expected to improve the detail in their bicycle/motor vehicle crash reports, work has to be undertaken to define what data are needed, how they are to be collected and stored by investigating officers at the scene and what training the officers will need to acquire valid and reliable data. This effort will yield a blueprint for improving the collection of bicycle/motor vehicle crash data so that practitioners, particularly at the local level, have better insight into the causal elements of particular crashes and specific crash locations.

Objectives

- Define data needs and uses for police reporting of bicycle/motor vehicle crashes
- Sort data needs by data origin (e.g., contemporaneous police investigation, follow-up investigation, general database)
- Define burden produced by collection, storage and retrieval of each item of additional data
- Assess additional capacity of police to collect data both manually and using on-site, laptop computer support
- Recommend additional data collection requirements that are the best compromise between information requirements and available capacity
- Develop specific questions/prompts for collection of the defined data on a revised or supplemental PCR
- Assess training needs to achieve police competence in collecting defined additional data

General Approach

This one year to 18 month study would combine expert opinion and analysis with inputs from police officers and bicycle safety practitioners in an iterative fashion. The basic approach would be first to define the questions local practitioners would benefit from having the ability to answer from PCRs if the reports contained adequate data. This would be accomplished through discussions and focus groups with practitioners guided by bicycle safety experts.

The next step would be to define a superset of all useful data using a cross-section of experts. These data would be cross-referenced to the specific questions they could assist in answering. The analytical objective would be to define subsets of information that were necessary and sufficient to answer salient questions. These subsets would then be assessed with police officers and commanders to determine which were acceptable and feasible to include in an on-site, routine bicycle/motor vehicle crash investigation. This would lead to the selection of data packages that were both acceptable and utilitarian.

The final step of the approach would be to determine analytically how the selected data would be captured using paper forms and computer-aided systems.

Products and Linkages

The end product of this study would be the specification of additional data to be collected and the definition of specific prompts/forms/categories to be used in gathering the information. This product will define future bicycle/motor vehicle crash data needs and form the basis for developing promotional materials to motivate police departments to collect the defined data, defining police officer training and producing enhanced data collection software.

Possible Impact

This effort would form the foundation for defining a significantly improved PCR process for bicycle/motor vehicle crashes. It is the precursor of all of the other studies in this topical area. It would also develop and validate a methodological approach that could be applied to pedestrian crashes. Over time as police crash reporting improved, countermeasure identification and application would be facilitated thus reducing crashes.

Research Area: Bicycle Data Needs

Concept Title: Motivating the collection of improved bicycle/motor vehicle crash data

Background and Justification

Police departments have generally reduced their emphasis on traffic data reporting as a result of budget cutbacks and a focus on other police priorities. In order to achieve improved data on bicycle/motor vehicle crashes, police departments will have to increase the priority assigned to investigating and documenting crashes. This, in turn, will lead to greater investments in training and data collection, storage and retrieval. Any increase in priority for investigating and reporting bicycle/motor vehicle crashes will require some "marketing." It is simply not realistic to assume that many police departments will invest greater resources unless they can be convinced of the benefits they will derive from the additional outlays.

Objectives

- Define benefits to a community and a police department from improved investigation and reporting of bicycle/motor vehicle crashes
- Identify ways to motivate police departments concerning these benefits
- Identify media and approaches to present the motivation
- Develop and deliver specific motivational products

General Approach

This study, which can be accomplished in a year or less, will use data collection and expert analyses to generate specific products to market improved bicycle/motor vehicle crash reporting. Focus groups and other discussions with police executives will be used to identify the best marketing points and the preferred motivational approaches. A catalog of existing (e.g., Roadshows, convention booths) and potential (e.g., videos, pamphlets, grants) delivery mechanisms will be prepared and assessed with police experts.
Once the approaches and media have been identified, materials will be drafted and evaluated with target audience members. This will result in developmental iterations that will lead to final products.

Products and Linkages

The final products will be finished motivational materials and delivery mechanisms that have a high potential to promote improved bicycle/motor vehicle crash reporting. The availability and success of these materials and mechanisms is essential to the successful accomplishment of an improvement effort.

Possible Impact

This effort if successful will facilitate the incorporation of the improved reporting scheme developed in a companion study.

Research Area: Bicycle Data Needs

Concept Title: Development of enhanced crash reporting software

Background and Justification

The preparation of police crash reports is increasingly being accomplished through the use of laptop computers. These are employed by police personnel either at the crash site itself or at police stations using notes taken at the scene. Once additional data needs to support improved reporting of bicycle/motor vehicle crashes are identified, there will be a need to develop updated crash reporting software that implements and simplifies the collection of the defined data.

Objectives

- Develop requirements for software that facilitate the collection of the defined bicycle/motor vehicle crash data needs and coordinate with existing, widely-used crash reporting software.
- Prepare software
- User test software
- Prepare software users manuals and training as indicated by the user test

General Approach

This one year study would be a standard software development effort. Requirements would be based on companion studies. Software would be coded and verified and validated. It would then be user tested and updated as necessary. The study would end with the preparation of users manuals and training in appropriate media (self administered and/or classroom) for police users.

Products and Linkages

One product would be a bicycle/motor vehicle crash software module that would complement and coordinate with existing, widely-used crash reporting software. A second product would be a users guide for police officers employing the software. This would be complemented by training materials in media found to be appropriate during the study data collection.

This study links with the development of crash data recording requirements to implement that effort's findings.

Possible Impact

The output of this study when distributed should result in an immediate improvement in the quality of information being collected on bicycle/motor vehicle crashes. As usage increases, the overall quantity of improved crash information will likewise increase. This should, in turn, facilitate the selection and deployment of appropriate countermeasures thereby yielding a crash reduction.

Research Area: Bicycle Data Needs

Concept Title: Development of police training in bicycle/motor vehicle crash investigation

Background and Justification

In the long term, the maximum improvement in police reporting of bicycle/motor vehicle crashes will only be possible if police officers investigating crashes have been trained to have a basic understanding of bicycle/motor vehicle crash causation and the importance of data in the countermeasure identification and application process. Therefore, once the ideal dataset has been identified, training programs must be developed and tested to complete the improvement effort.

Objectives

- Develop specific training objectives based on the data identification study
- Based on the developed objectives, define alternative training approaches
- Assess the viability of the identified training approaches through data collection with police trainers and command structure
- Use the data collection to select one or more types of training to achieve the defined objectives
- Develop the training materials
- Test the training materials with user populations and revise as needed
- Produce finished training materials ready to be distributed

General Approach

Training specialists who are familiar with police crash reporting must translate the data needs and knowledge of existing police training into a set of supplemental training objectives to achieve understanding of bicycle/motor vehicle crash causation and data needs. These objectives will then be discussed with police training specialists, commanders and line officers in focus groups or interviews to determine the best ways to accomplish the training, e.g., roll call, academy.

Once the best training approaches are identified, these will be developed, tested, revised as necessary and finalized into distributable materials.

Products and Linkages

This study culminates the efforts to improve bicycle/motor vehicle crash reporting and builds on the other developmental efforts. It will yield finished training materials as the end products.

Possible Impact

Completion of this study will result in the availability of improved training materials. If the motivational study is successful, these materials should be widely requested and used. This will result in improved data quality with all of its attendant benefits.

Bicycle Countermeasures

Richard D. Blomberg
Dunlap and Assciates, Inc

The situation with respect to the development and application of bicycle countermeasures has both significant similarities with and differences from the pedestrian countermeasures picture. The long-standing existence of bicycle advocates has generated a heritage of private and locally derived countermeasures that are not characteristic of the pedestrian area. Also, budget cutbacks and shifts in safety priorities in the 1980s reduced federal funding for bicycle countermeasures efforts before they could progress to the development level of their pedestrian counterparts. As a result, the plans to follow the definition of bicycle/motor vehicle crash types by Cross and Fisher (1977) with countermeasure development and field testing were truncated before many significant tests were conducted. Therefore, the present situation finds many countermeasures deployed but relatively little large-scale, formal evaluation of their effectiveness.

A recent effort funded by NHTSA and FHWA compiled a large cross section of existing and proposed bicycle/motor vehicle countermeasures and packaged them in an easy to use CD-ROM database. This CD-ROM has been widely distributed, and anecdotal reports are that it has been well received. Little is known, however, about the extent of actual use of the CD-ROM, and there has not ben much feedback from users upon which to base a future update.

Beyond the bicycle/motor vehicle crash problem, there is a paucity of data on the incidence of non-motor vehicle bicycle crashes such as collisions with fixed objects, other bicycles and pedestrians and falls from bicycles. The data that are available suggest that these types of crashes are a significant generator of mortality and morbidity, but little else is known about the types of crashes that occur or the populations at risk for them. Reliable incidence data are not available thereby hampering efforts to convince officials and the public of the need to pursue countermeasures for these crashes.

Bicycle safety also differs from pedestrian safety because bicycles are classified as vehicles by most states and regulated accordingly. In addition, bicycles are considered a consumer product and, therefore, their original equipment, particularly the system of retroreflectors, is regulated by the Consumer Product Safety Commission (CPSC). CPSC has recently conducted some research on the adequacy of the nighttime conspicuity system of retroreflectors currently required. This research has generated significant controversy and, like the NHTSA-sponsored research of Blomberg, Hale and Preusser (1984), did not consider daytime conspicuity-enhancing approaches. A more thorough assessment of conspicuity enhancing approaches may be warranted by the apparently large causal role played by conspicuity in the bicycle/motor vehicle crash generation process.

There is evidence that alcohol plays a major role in bicycle/motor vehicle crashes as it does in pedestrian and vehicle-to-vehicle crashes. However, relatively little is known about the nature of the bicycle alcohol problem. Questions such as whether the drinking bicyclist is often a motor vehicle driver who has been suspended for DWI are largely unanswered.

Overall, then, the situation with bicycle countermeasures is somewhat enigmatic. There is much fervor for mounting bicycle countermeasures of all types because of the positive role of organized bicycle activist groups. There is also significant knowledge about the crash types that involve bicycles and motor vehicles as a result of the Cross and Fisher (1977) study and follow-up efforts. On the other hand, little is known about non-motor vehicle crash types, their incidence or their consequences. Information is also sparse about the details of two of the major crash causal factors--alcohol and conspicuity. A focused research program has a great potential to clarify this enigma and improve the breadth and effectiveness of countermeasures.

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Research Area: Bicycle Countermeasures

Concept Title: Determining source credibility for bicycle safety information

Background and Justification

Public information and education (PI&E) efforts have been a major part of the countermeasure focus for bicycle/motor vehicle crashes. In spite of the number of these efforts and some documented successes, little is known about which sources of bicycle safety information are considered most credible by key target groups. Obtaining and applying this information should greatly increase the effectiveness of PI&E efforts. An analogous effort is proposed for pedestrian safety information. These two efforts employ the same methodology but will be focused on somewhat different audiences. They could be conducted as part of a single, larger effort because of the methodological overlap or pursued separately because of the subject matter differences

Objectives

- Enumerate those audience groups for PI&E that are likely to be key targets for future bicycle/motor vehicle safety PI&E efforts
- Enumerate potential PI&E topics for forthcoming bicycle safety efforts
- Develop data collection methods to assess each audience's source credibility level as a function of topic
- Apply the developed methods to collect data
- Analyze the collected data to identify the most credible sources for each audience
- Develop guidelines for the production of future PI&E

General Approach

The approach for this one year effort (18 months to 2 years if combined with the similar pedestrian safety study) would involve analyses to enumerate audience groups, potential topics and alternative data collection approaches. Focus groups and surveys are the typical method of conducting source credibility studies, but new approaches such as using the Internet should also be considered. Once the lists are available and a method is chosen, data can be collected and analyzed to determine source credibility as a function of audience.

Products and Linkages

The major product will be a set of guidelines that should help increase the effectiveness of future PI&E efforts. As such, this effort will link with all future PI&E efforts whether directed at the populations at risk or at intermediaries and officials who are critical to mounting successful countermeasures efforts.

Possible Impact

If successful, this effort could significantly increase the effectiveness of future PI&E efforts thereby making them more cost effective.

Research Area: Bicycle Countermeasures

Concept Title: Study of bicycle conspicuity needs

Background and Justification

Previous research funded by NHTSA and CPSC has examined systems for the nighttime conspicuity enhancement of bicycles. The NHTSA study concluded that lighting was required to achieve a meaningful and reliable nighttime conspicuity improvement. CPSC, under considerable pressure from bicycle manufacturers and some bicycle advocates, has retained a requirement for only retroreflectors. There is no current recommended U.S. specification for a minimum effective nighttime conspicuity treatment for bicycles and bicyclists. There is also no prevailing U.S. standard or guideline for daytime bicycle/bicyclist conspicuity.

Given the causal role of conspicuity in bicycle/motor vehicle crashes and the efforts that have been undertaken worldwide to define 24 hour conspicuity requirements and guidelines, it would seem time for the U.S. to update its position and offer bicyclists the best possible thinking based on sound research.

Objectives

- Determine the prevailing state-of-the-art of daytime and nighttime bicycle conspicuity including worldwide efforts
- Re-examine existing crash data to assess the role of conspicuity in crashes as a function of ambient lighting and roadway consitions
- Assess the alternate ways in which conspicuity guidelines and standards might be promulgated in the U.S., e.g., voluntary standards, model laws, federal regulations, PI&E
- Define gaps in effectiveness knowledge that can potentially be filled by research
- Develop research approaches and detailed research outlines to fill the gaps
- Establish research priorities and budgets for the proposed research studies

General Approach

This study is an 18 month to two year synthesis of crash data and worldwide efforts in enhancing bicycle/bicyclist conspicuity. Data would be collected from foreign sources and from existing crash data files and analyzed by a team of experts. This team would postulate conspicuity problems and relate them to prevailing countermeasure approaches. Gaps in knowledge would become the basis for defining research studies to provide the missing knowledge.

Products and Linkages

The products of this study would be a synthesis of existing, worldwide conspicuity approaches, an analysis of possible causal roles of conspicuity in bicycle/motor vehicle crashes and a set of proposed research studies with associated approaches and preliminary budgets. The study links to previous conspicuity research, CPSC's regulatory efforts and the standardization activities of organizations such as ASTM.

Possible Impact

This study could begin the process of improving bicycle conspicuity in the U.S. This, in turn, could lead to a major crash reduction as the various defined studies are conducted and their results operationalized.

Research Area: Bicycle Countermeasures

Concept Title: Definition of non-motor vehicle bicycle crash incidence, types and initial countermeasures

Background and Justification

Bicycle/motor-vehicle crashes are only one part of the total bicycle safety problem. Non-motor vehicle crashes such as those with other bicycles, pedestrians or fixed objects as well as falls from bicycles are also likely a major cause of injury and death. The basic approach of defining crash types as the focal point for countermeasure development efforts has worked well for pedestrian and bicycle/motor vehicle crashes. It is therefore reasonable to assume that following a similar approach for non-motor vehicle bicycle crashes will also be successful.

Objectives

- Develop a methodology for collecting a valid sample of non-motor vehicle bicycle crashes
- Define the limitations of the developed sampling methodology so that the coverage of the study data is clearly delineated
- Collect a sample of non-motor vehicle bicycle crash data that can be used to define crash types and estimate their incidence
- Analyze the collected data to define crash types and their incidence
- Use the defined crash types to generate initial countermeasure ideas

General Approach

The approach for this two to three year study would follow the approach pioneered by the efforts of Snyder and Knoblauch (1971) in the pedestrian area and Cross and Fisher (1977) for bicycle/motor vehicle crashes. These efforts defined a model of the crash generation process and then collected in-depth crash data guided by the model. Standard police crash reports were supplemented by follow-up interviews and visits to the crash scenes.

For non-motor vehicle bicycle crashes, one main methodological problem will be to obtain notice of the occurrence of a crash since many, if not most, of these events are not police reported. This study will have to investigate alternative ways to define a sample such as through hospital emergency rooms, bicycle repair shops and survey techniques.

Products and Linkages

The product of this study should be the third landmark crash type definition effort. These crash types would then form a foundation upon which countermeasures could be developed and deployed and their effectiveness tracked over time. As such, this study would link with many future bicycle countermeasure efforts to broaden their effectivity and address more of the entire safety problem.

Possible Impact

This study would begin the efforts of NHTSA and FHWA to address this largely neglected but likely serious component of the total bicycle safety problem.

Research Area: Bicycle Countermeasures

Concept Title: Follow-up on use of the bicycle countermeasures CD-ROM resource guide

Background and Justification

The bicycle countermeasures CD-ROM developed for NHTSA and FHWA has been widely distributed. In many cases, the identity of the person receiving the CD-ROM was gathered as part of the distribution process. This has created a database that could be used to do a follow-up assessment of the use and effectiveness of the CD-ROM. Feedback of this type would be invaluable in improving any next generation products including the proposed pedestrian safety version of the database. In fact, this research idea could be coupled with the development of a pedestrian version of the resource guide so that any ideas for upgrades from this effort could be applied to the initial pedestrian version.

Objectives

- Define evaluation concepts to assess the use, acceptance and utility of the bicycle safety resource guide CD-ROM
- Select a data collection method to elicit information from the individuals known to have received the product
- Execute the selected data collection method
- Analyze the resulting data to provide a profile of reactions to and use of the CD-ROM
- Develop suggestions and guidelines for improving future similar products

General Approach

This 10 month to one year study would follow relatively standard market research type survey or focus group approaches to determine use of and response to the bicycle safety CD-ROM. If this effort is coupled with the development of a pedestrian safety version of the product, it would span two years and delay the availability of a pedestrian resource guide for approximately one year. In return, the pedestrian version would be able to build upon the feedback obtained from users of the bicycle safety product.

Products and Linkages

The product of this study would be an evaluation of the use, acceptance and utility of the bicycle safety resource guide CD-ROM. It would provide insights on ways to improve future products of this type and therefore link to any updates or new guides NHTSA and FHWA may choose to fund.

Possible Impact

This study should provide information to improve future products. If the evaluation shows that the bicycle safety resource guide CD-ROM was well accepted and widely used, it will also provide data to help convince decision-makers to fund the development and maintenance of similar products in the future.

Research Area: Bicycle Countermeasures

Concept Title: The role of alcohol in bicycle crashes

Background and Justification

There are indications that alcohol use on the part of bicyclists is a major causal element in bicycle/motor vehicle crashes. It is reasonable to assume that alcohol use also contributes to non-motor vehicle bicycle crashes because of the impairing ability of this drug. Little focused data collection has been undertaken on the incidence or nature of the role of alcohol in bicycle crashes of all types. Little is also known about the characteristics of the bicyclist who drinks sufficiently to be impaired when riding a bicycle.

Methodologies have been developed for motorists and pedestrians to assess alcohol involvement. These could be adapted to the bicycle area to provide valuable information on this major causal factor in the overall bicycle safety picture. The study could be expanded to encompass an assessment of relative risk due to alcohol if desired. However, this would increase the study cost and duration. Therefore, unless there is a specific need for relative risk data, this focus should be omitted.

Objectives

- Develop methodologies for the collection of a valid sample of bicycle crashes (both with motor vehicle and non-motor vehicles) for which alcohol measurement on the bicyclist can be made and a background interview with the bicyclist can be accomplished
- Apply the methodologies to collect a sufficient set of data to provide an unambiguous picture of the role of alcohol in bicycle crashes
- Analyze the data to highlight the incidence of alcohol in crashes, the characteristics of the alcohol-involved bicyclists and, if desired, the relative risk due to alcohol

General Approach

This two year study (three years if relative risk is included) can be accomplished through a variety of approaches. For example, special teams could go to the scene of bicycle crashes and sample bicyclists using an interview and breath testing techniques. Other studies have shown that cooperation will be good as long as a Certificate of Confidentiality is obtained from the Department of Health and Human Services. While excellent for bicycle/motor vehicle crashes, the potential problem with this approach is the relatively small and possibly biased sample of non-motor vehicle crashes it is likely to produce.

Alternatively, crashes could be sampled at emergency rooms. This could facilitate obtaining non-motor vehicle crashes, but would limit the sample to injuries that required emergency room care.

Still other sampling approaches may be possible including combinations of the various methods. The study must therefore focus its initial effort on screening possible sampling approaches and determining their feasibility. Because of the importance of this step and the need to collect data to assess approaches, this step should be part of the study and not required in the proposal.

Once the sampling method is selected, the major focus will be on the collection of high quality data with as low a refusal rate as possible. If relative risk is to be included, a case control approach will be needed in which control bicyclists are sampled to match the crash victims.

Products and Linkages

The products of this study will be an accurate estimate of the incidence of alcohol in bicycle crashes as a function of crash type and a description of the characteristics (demographics, socioeconomics and behavioral) of the involved bicyclists. If relative risk is included, curves relating the crash risk at elevated BACs relative to a zero BAC will be produced. These relative risk curves should be done separately for bicycle/motor vehicle crashes and non-motor vehicle crashes.

This study links with the development of crash types for non-motor vehicle bicycle crashes and future countermeasures development efforts. If a relationship is found between motorists whose license is suspended and the incidence of bicycling while under the influence of alcohol, this study would also have linkages with future DWI countermeasures efforts and laws relating to driving while intoxicated.

Possible Impact

A better understanding of the role of alcohol in bicycle crashes and the characteristics of the involved bicyclist is fundamental to mounting successful countermeasures. The availability of this information should permit the development of more successful efforts to combat this important causal factor.

Engineering Countermeasures Research for Bicycling

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Background

Improving the operating environment and enhancing safety for bicyclists requires the development, installation, and evaluation of sound engineering countermeasures. In recent years, a limited number of innovative countermeasures have been implemented and evaluated in the U.S. In addition, efforts have been undertaken to explore more fully the details of bicycle crashes with the hope of developing countermeasures targeted at specific types of crashes (e.g., a motorist turning or merging into the path of a bicyclist). Provided below is a brief summary of the work conducted in the past decade in these areas followed by a discussion of new or continued research that is needed. The intent of this paper is not to provide a comprehensive review of all engineering countermeasures-related work conducted to date, but to provide some insights into the type of work that has been performed. Subsequently, the research ideas were developed to prompt one to think about the range of research projects needed in this area to advance the state of safety and operations for bicycle travel in the U.S. For a discussion of needs related to the broader topic of bicycle facilities, refer to the companion paper on *Bicycle Facilities Research*.

Among the countermeasures that have been evaluated are those that are intended to improve conditions for bicyclists approaching and maneuvering through an intersection. One of the treatments was a bike box installed in Eugene, Oregon, which provided a means for bicyclists to move to the front of the queue of motorists at an intersection and have the opportunity to then move through the intersection ahead of motorists.[1] In summary, the treatment worked reasonably well. However, further installations are required under a wide range of operating conditions to determine when and how such treatments can be used effectively and safely. There is also a need for an education campaign for both bicyclists and motorists to fully understand the operation of the facility.

Another treatment evaluated was the use of blue pavement markings in Portland, Oregon to denote where the paths of bicyclists and motorists cross at and on the approaches to a variety of intersection types.[2] This study involved marking the conflict zones (locations where the two modes cross paths) with blue pavement markings. The treatment also made use of supplemental warning signs showing the blue zones and intended maneuvers to increase the awareness of both motorists and bicyclists. Results from the analysis of the 10 sites included in the study showed a significant increase in the number of motorists yielding to cyclists after the markings were in place (72% before vs. 92% after). Considering the bicycle-friendly atmosphere in Portland, more efforts are required in other locations to truly know the effect of such a treatment. The authors also note that the innovative signing used in this effort may, in and of itself, provide an increased level of awareness for both modes. Thus, additional research on the effectiveness of the sign alone may also be justified.

A third countermeasure recently evaluated was the combined bicycle/right-turn lane in which the 5-ft bicycle lane was incorporated into the 12-ft right-turn lane. This particular treatment is being used in Eugene, Oregon and is an example of an innovative approach to accommodate both bicyclists and motorists within the existing right-of-way.[3] Compared to a standard 12-ft right-lane with a bicycle pocket, the shared lane appeared to work just as well with respect to providing space for both modes to co-exist and maneuver through the intersection. As with the countermeasures above, the sample size here was limited. More work is required to evaluate this treatment under different operating conditions in order to be able to provide guidance on when and where to use such a countermeasure.

There are other countermeasures that have installed along roadway segments for which evaluations have been conducted. One of these treatments was the shared-use arrow applied in Gainesville, Florida.[4] The intent of the arrow was to serve as a indication to motorists that bicyclists may be present on the roadway and to provide bicyclists with an indication of where they should ride in the wide lane (based on placement of the stencil). The purpose of the study was to determine if the treatment changed the operating behaviors of motorists and bicyclists. Overall, the results did not show much change in the lateral positioning of motorists or bicyclists. However, the arrow did result in shifting a significant number of bicyclists riding on the sidewalk before the treatment was installed to riding in the street after the installation. Riding in the street is generally considered to be a safer riding environment for adult bicyclists, so this shift was a positive result. Again, this countermeasure and the corresponding results represent a single application. Much more work is needed to determine the true impact of such a treatment on bicycling safety and operations.

There are a multitude of other treatments that have been tried or contemplated, but for which there are no formal evaluations. Some of these treatments are traditional in the sense that they make use of existing technologies and materials, while others are more innovative and take advantage of newer technologies. An example of one of these treatments, which can be classified as falling in between these two extremes, is a warning system outside of Grand Junction, Colorado that is intended to let motorists know that a bicyclist is present on the roadway ahead where there is no paved shoulder. The system provides real-time information to the motorists but still relies upon a bicyclist pushing a button prior to entering this stretch of roadway to activate the system. This is a perfect example of the type of problem that may be addressed through the use of intelligent transportation system (ITS) technology.

Prior to implementing and evaluating countermeasures, it is important to understand the types of bicycle-motor vehicle collisions that may be prevented with a given treatment. Developing this level of understanding requires good crash data from which the pre-crash actions of the parties involved can be extracted and categorized in a meaningful way. Bicycle Crash Typing is a methodological approach to developing these categories of collisions. The original work conducted in the 1970's was applied again in the early 1990's to determine the national picture of bicycle-motor vehicle collisions.[5,6] This information would be useful to practitioners to determine the types of collisions occurring on their streets and to develop appropriate countermeasures. Using the crash typing data base to explore countermeasure options is one of the features within the Pedestrian and Bicycle Crash Analysis Tool (PBCAT).[7] However, a limited amount of effort was available to develop the current list of countermeasures. A much more exhaustive effort is required to truly make this part of the software a valuable resource.

Needed Research

For widespread acceptance of engineering countermeasures related to improving the safety and operations for bicycling, there is a need to more formally and comprehensively evaluate the all treatments. Making this level of commitment to evaluation requires three things:

1) Continued identification and documentation of problems experienced by bicyclists within the roadway that may be addressed through changes in design and operations (either innovative or traditional).

2) Continued installation and evaluation of treatments under the complete and appropriate range of geometric and operating conditions, which in turn, will lead to guidelines on using each countermeasure.

3) Development of a national bicycle crash data base that can be linked to geometric and operational data, which could be used for a variety of analyses (including those identified as needs in the companion paper on *Bicycle Facilities Research*).

Provided on the next few pages are five potential research projects related to engineering countermeasures for bicycling that have the potential to ultimately improve bicycling safety and operations. These projects are intended to serve both short-term needs in terms of evaluating devices and treatments being proposed and implemented today and long-term needs in terms of establishing systems and tools that can be used for making better decisions and more thorough analyses.

Research Area: Engineering Countermeasures for Bicycling

Concept Title: Development and Evaluation of Innovative Treatments

Research Need

As engineers, planners, bicycle coordinators and others continue to install countermeasures that will potentially improve safety and operations for bicycling, there is a need to thoroughly evaluate these treatments. Without solid evaluations on the effect of these countermeasures, two outcomes may result. One, there will be reluctance to install a treatment that truly has the potential of creating a safer operating environment. Or two, a countermeasure may become popular based solely on the concept and be installed widely when, in fact, the treatment actually make conditions worse for bicycling. Sound research is required for any treatment to make sure neither of these inappropriate paths are followed.

Objectives

- Develop a comprehensive list of engineering countermeasures that have the potential for addressing bicycling safety and operations issues.
- Document the use and effectiveness of treatments currently being used in the U.S. and abroad.
- Install and evaluate the most promising treatments (i.e., those with the potential for the largest benefit) under an appropriate range of operating conditions.
- Develop guidelines on when and how to install specific countermeasures.
- Develop educational materials for users and law enforcement regarding the appropriate use and operation of these treatments or facilities.

General Approach

This effort will begin with a review of the treatments currently being used in the U.S. and abroad. It will also make use of the network of national and international bicycle professionals to learn of treatments that may not be documented to date or that are simply concepts at this time. Working with several cities and States, the most promising of these treatments will then be installed and evaluated to determine how these countermeasures change safety and efficiency for bicyclists. These treatments must be installed under the range of conditions where applications are likely in order to be able to provide sound guidelines for use. For example, if a shared right-turn/bicycle lane is a countermeasure that may be appropriate for approach speeds up to 45 mph and traffic volumes up to 40,000 vehicles per day, then the evaluation effort should include an appropriate number of sites with operating characteristics at and below those levels. The evaluation criteria will vary depending on the treatment, but at a minimum should include operational performance and behavioral measures for both bicyclists and motorists, as well as conflicts between the two modes and/or pedestrians if appropriate. Conflicts are likely to have to be used in place of crashes due to the duration of this effort. However, if time permits, and sample sizes are adequate, crash data will also be analyzed.

The documentation of countermeasures and the identification of cities to participate in evaluations will be done within 2 years. The installation and evaluation may require up to 3 additional years, depending on installation schedules.

Products

There will be four products from this effort. The first will be a report (and possibly a web site) in which all treatments currently being used in the U.S. and abroad to improve conditions for bicycling are fully documented. This report will summarize the purpose of the treatment, provide installation specifications, and discuss any formal evaluations that have been conducted in the past. This report may serve as a resource for the selection of further countermeasure evaluation studies, which could not be conducted as part of this study. A second report will include the results of the evaluation studies of the treatments installed as part of this effort. The third document will be the guidelines on when and how to use the treatments that were evaluated, and the fourth will be a set of materials that can be used to educate the public and the law enforcement on how to use the facility containing the treatment.

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Research Area: Engineering Countermeasures for Bicycling

Concept Title: Establishment of a National Bicycle Crash Data Base

Research Need

Almost all of the research projects described in this paper and the companion paper on bicycle facilities would benefit from a national crash data base comprehensive enough to conduct sound safety research. There is currently no data base for bicyclists that allows one to combine crash, roadway inventory, and bicycle operations (i.e., bicycle travel or exposure data) information to perform rate-based studies and other types of evaluations. Creating such a robust data base would allow for the completion of safety and operational studies that can lead to better roadway design, improved traffic control devices, and more sound transportation policies.

Objectives

- Assess the feasibility of creating and maintaining a national bicycle crash data base.
- Establish the criteria to be considered for inclusion in the National data base.
- Create and maintain the system with a limited number of communities.

General Approach

In general, the model for this data base will be very similar to that of the Highway Safety Information System (HSIS). In that system, there is crash, roadway inventory, and traffic operations data from eight States that can be linked via roadway location to conduct comprehensive analyses. The bicycle crash data system will be developed to allow for similar types of analyses, but will focus on at least two different levels of community. The first will be at the local level and will include cities and surrounding suburban areas. These areas represent the locations where most bicycling occurs and will be used to address urban issues. The second will be at the State level and will include one or States. The purpose of the second level of locations is to be able to address the issues associated with bicycling in a rural environment.

The approach to this project will be multi-phased. During phase one, the criteria for selecting communities to participate will be established. These criteria should be based on the needs of the end user, both the researcher and practitioner, and will be developed through expert panel meetings and other forums. One of these criteria will be the availability of bicycle travel (exposure) data or the ability to collect such data. With the criteria established, a pilot community will be selected for inclusion in the system. All data from that community will be obtained and manipulated to allow for analysis. A series of analyses using the data will be conducted to evaluate the system, and a report will be prepared to document the activities of the first phase and the plans for bringing additional communities online. In phase two, up to three additional communities will be selected and included in the data system.

This effort will be a two-phased project conducted over 3 years.

The approach described here also applies to pedestrians. Thus, from an economic feasibility standpoint, one system that encompasses both modes could be established.

Products

The most significant product of this effort would be the data base itself, which would become a living product that would be continuously maintained and updated. As with HSIS, the data would be available to researchers and others for a variety of projects related to bicycling safety and operations.

Research Area: Engineering Countermeasures for Bicycling

Concept Title: Application of ITS Technologies for Bicycling

Research Need

A number of intelligent transportation system (ITS) technologies have been applied to pedestrian access and safety issues as documented on the PedSmart web site.[8] These technologies range from microwave detectors to detect slower pedestrians crossing the street and provide more time to cross to in-pavement lighting systems to provide real-time warning information to motorists that a pedestrian is crossing the roadway. To date however, there have been limited efforts to apply such technology to improve bicycling safety and access or to document those few cases where installations exist.

Objectives

- Develop a knowledge base of applications currently in existence that are considered to be ITS applications.
- Determine the range of technologies that exist and are being used for other modes (e.g., automobiles and pedestrians) that may have application to bicycling.
- Assess which of the safety and access problems for bicyclists may be addressed using ITS technologies.
- Install and evaluate the most promising technologies.

General Approach

This effort will begin with a survey of bicycle professionals both in the US and abroad to learn of ITS applications currently in existence for bicycling. This same network of experts will also be asked to identify problems that could be addressed using ITS technologies. The most promising technologies will then be implemented at a number of locations and evaluated to determine their effectiveness at improving conditions for bicycling. The performance measures will vary depending upon the intent of the technology, but should include interactions between bicyclists and motorists or pedestrians, and behavioral and operational measures for all parties involved.

The duration of this effort will depend upon the number of technologies discovered and evaluated. A preliminary estimate is that the project will require a minimum of 2 years to complete.

Products

The primary product from this effort will be an evaluation report that documents the technologies used, the problems addressed, and the effectiveness with respect to improving bicycle safety and operations. A second product, provided there are enough ITS applications in existence, will be a web site that documents the technologies in use. A third product, and perhaps the most important, will be guidelines on when to use or not use a specific technology. This document should help encourage applications shown to produce benefits to bicyclists and, at the same time, eliminate inappropriate applications. This guidance is currently lacking with respect to ITS pedestrian technologies, and it is likely that the same could occur for ITS bicycling technologies. A fourth product will be educational materials for those devices deemed a success to aid bicyclists and motorists in understanding how they work.

Research Area: Engineering Countermeasures for Bicycling

Concept Title: Development of a Bicycle Countermeasure Selection System

Research Need

Applying countermeasures to specific types of bicycle crashes may be an effective way of improving the chances for success. The Pedestrian and Bicycle Crash Analysis Tool (PBCAT) includes a module that allows users to select countermeasures targeted at specific crash types. However, the countermeasures currently included in the software are not very extensive, and are currently presented in a list without any guidance on the benefits and dis-benefits of each countermeasure, or the appropriateness of the countermeasure under various geometric and operational conditions. For this application to be a useful, an expert system needs to be developed to allow the user to enter both crash and operations data and extract the most appropriate treatment.

Objectives

- Develop a comprehensive list of engineering countermeasures and the problems that may be addressed by each, including the crash types that could be mitigated.

- Design an expert system that would incorporate crash, geometric, and operations data, and use that information to select an appropriate list of countermeasures.

General Approach

This effort will begin with the development of a complete list of engineering countermeasures that may be used to address bicycle crash and accessibility issues. Developing such a list will make use of practitioners in the U.S. and abroad to ensure that the list is comprehensive and covers all aspects of the solution matrix. The benefits and dis-benefits of each countermeasure will be documented along with the specific crash type(s) that each one may address and/or the operational improvement that may result by installing the treatment. The expert system will then be designed to make use of available crash data (including the crash type), operations data, geometric data, and any other relevant information. The system will be designed to use information in the data base and/or lead the user through a series a questions related to the location, and then produce a complete list of countermeasure options with all of the advantages and disadvantages of each. The system will be designed to be user-friendly and will incorporate examples of each of the countermeasures. If feasible, cost information on the installation and maintenance of a specific treatment will also be included. The system will be tested using practitioners and modified to meet their needs.

For this system to be truly effective, it should incorporate not only engineering countermeasures, but enforcement and education countermeasures as well.

This effort will be conducted over 3 years.

Products

The product of this effort will be the bicycle countermeasure selection system, complete with documentation. The system will be developed to be delivered as a CD-ROM product that can be loaded onto a personal computer. The system may also be developed as a web application. The system will be compatible with the PBCAT software to make use of the crash typing data.

Research Area: Engineering Countermeasures for Bicycling

Concept Title: Development and Evaluation of Freeway Ramp Crossings

Research Need

The intersection of freeway ramps and surface streets are often designed to accommodate turning and merging motor vehicles at relatively high speeds. At the same time, many of these locations have auxiliary lanes at the merge points. These free-flow and complex scenarios make it extremely difficult for a bicyclist to safely negotiate these intersections. The need here is to evaluate the variety of bicycle crossing designs currently in place, and if necessary, develop new or modified designs for further evaluation.

Objectives

- Document the types of free-flow on- and off-ramps that result in a high hazard environment for bicyclists.
- Develop alternative designs that will increase safety for bicyclists.
- Evaluate the most promising designs.
- Develop guidance for installing various types of freeway ramp crossings.
- Develop educational materials for using the improved designs.

General Approach

This study will begin with a documentation effort to identify the range of free-flow ramp crossings that exist in this country that would result in problems for bicyclists. Design engineers and bicycle professionals will be relied upon to develop the list of site types. Observational studies will then be conducted at a large sample of these locations to fully understand the problems experienced by bicyclists. Working with an appropriate number of States and cities, alternative designs will be developed for the types of locations that are considered to be problematic. These designs will then be implemented and evaluated to determine if they improve conditions for bicycling. Evaluation criteria will include conflicts with motor vehicles, and a variety of operational and performance measures.

Since this project requires the design and installation of alternative designs, it is anticipated that a minimum of 3 years will be required for this effort.

Products

The products from this effort will include a report documenting the types of free-flow sites that exist in this country and the safety problems those locations pose for bicyclists. The report will also provide alternative designs to accommodate bicyclists, which will be based on the evaluation studies. Educational materials for bicyclists and for law enforcement personnel should also be produced as part of this effort to assist in understanding how the facility is intended to operate.

Bicycle Facilities Research

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Background

During the past 10 years, there have been several studies undertaken to either understand bicycle operations on various types of facilities or to develop quantitative methods to improve safety and operations for bicyclists. These studies can be placed in one of three categories: 1) on-street operational studies, 2) level of service studies, and 3) shared-use facility studies. Provided below is a brief summary of the work conducted over the past decade in each of these areas, followed by a discussion of additional research required to improve conditions for bicycling. The intent of this paper is not to provide a comprehensive review of all bicycle facilities-related work conducted to date, but to provide some insights into the type of work that has been performed. Subsequently, the research ideas were developed to prompt one to think about the range of projects needed to advance the state of safety and operations for bicycle travel in the U.S. For a review and discussion of the specific engineering countermeasures for bicycling, refer to the companion paper on *Engineering Countermeasures Research for Bicycling*.

<u>On-Street Operations</u> - The primary evaluations that have been conducted in this category of studies were related to the type of facility (wide curb lane vs. bicycle lane vs. paved shoulder) and the impact on bicycle and motor vehicle interactions and operations. The issue of which type of facility is best for bicyclists in terms of safety and operations has been debated for years. Two recent studies described below focused on the operational side of the issue.

A 1997 effort that examined operations on roadway segments in between major intersections showed bicycle lanes and paved shoulders to result in almost identical operational characteristics for both modes.[1] The study also concluded that bicycle lanes or paved shoulders offer several advantages over wide curb lanes including:

1. Motorists are less likely to encroach into the adjacent lane to the left when passing a bicyclist when there is a bicycle lane or paved shoulder present.

2. Bicyclists tend to ride further from the edge of the paved surface in a bicycle lane or on a paved shoulder than they do in a wide curb lane, which provides room to the right of the bicyclists to maneuver around debris or objects in the lane, or to move further from traffic if needed. Being further from the roadway edge also improves their sight distance when there are obstructions near the curb, may make them more visible to overtaking motorists, and increases the amount of time to react to motorists pulling into the street from driveways.

3. Motorists have fewer erratic maneuvers and less variation in their lane placement when passing bicyclists in a bicycle lane or on a paved shoulder.

A 1999 study examined bicyclists operating in wide curb lanes and bicycle lanes as they approached major intersections.[2] The results of that effort also showed a significant increase in the number of motor vehicles encroaching into the lane to the left when passing a bicycle in a wide curb lane as opposed to a bicycle lane. The study also showed an increase in the amount of wrong-way riding (in the street and on the sidewalk) at locations with wide curb lanes. Finally, an examination bicycle-motor vehicle conflicts showed no differences between the two facility types.

Even with the operations and behavioral data that tends to indicate slightly better performance with bicycle lanes or paved shoulders, there is still a need for a thorough crash analysis of this issue. Without this missing piece of the puzzle, the debate will continue over which facility type is truly "safest?"

Bicycle Level of Service - For several years now, there have been efforts to develop a methodology that could be used by planners, engineers, bicycle coordinators and others to quantify the suitability of a roadway for bicycling.[3,4,5,6] The shortfall in these efforts is the lack of recognition of the need for the perspective of the bicyclist. In 1997, a study was undertaken to incorporate this perspective by having bicyclists ride on a variety of roadways and providing ratings of their comfort level.[7] The results of this effort provided a model that incorporated variables such as lane width, speed, and volume, which in turn could be used to define the compatibility level for bicycling. The limiting factor in the study was the small number of locations in the study and the inability to have control over some of the variables such as speed and volume when the ratings were being made.

In 1998, a different approach was used to develop a bicycle level of service rating known as the bicycle compatibility index (BCI).[8, 9] The BCI was developed by having bicyclists in different regions of the country watch a videotape and rate how comfortable they would be riding on different roadway segments under a variety of operating and geometric conditions. The approach was validated against field rating results and provided a means of controlling the operational and geometric variables. In the end, the results were used to develop the BCI model and subsequent bicycle level of service criteria. These criteria may be used by practitioners to determine how compatible a roadway is for bicycling or to determine what improvements in the facility would be required to improve the bicycle level of service. Where the model (and any other method) falls short is that the method applies only to roadway segments and not intersections.

Shared-Use Facilities - Studies related to shared used facilities (off-road trails) can be divided into those that have examined the intersection of the trail with roadways and those that have examined the trail itself (similar to the midblock analogy for a roadway). With respect to the former, the primary studies conducted to date have relied on a limited amount of behavioral data at trail/roadway intersections to develop general guidance on the design of these intersections.[10, 11] While the guidance provided is fairly intuitive and was developed based on a limited amount of observational data, there is a need to formally evaluate the suggested designs and to develop additional alternative designs for intersection types outside the scope of that effort.

With respect to the trail itself, a 1998 study examined the operational characteristics of trails in an attempt to develop level of service criteria.[12] The methodology developed was similar to that used in The Netherlands and made use of the frequency of passings and overtakings of other trail users to define the various levels of service. While the methodology accounted for pedestrians that bicyclists were encountering, it did not account for users such as in-line skaters. The methodology was also developed on a very small sample of shared-use facilities. Thus, there is a need for a much more comprehensive study to validate the method.

Needed Research

Some of the immediate needs for bicycle research regarding facilities are related to one or more of the categories previously noted: 1) on-street facilities, 2) level of service tools, and 3) off-street or shared-use facilities. Described on the following pages are five potential research projects related to these three categories. These projects are considered to be essential to a comprehensive bicycle safety research program if major strides are to be made in terms of improving facilities for bicycling. The cumulative results from these five projects would have the effect of significantly changing the way roadways are planned and designed and would dramatically increase bicycling safety and efficiency.

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Research Area: Bicycle Facilities

Concept Title: Bicycle Level of Service Tools

Research Need

To date, the focus of the development of bicycle level of service tools has been on the urban/suburban midblock setting. There has been very little work to develop a methodology that could be applied to other parts of the roadway system, including intersections where the majority of bicycle crashes occur, and rural roadways, which are quite often used for touring and recreational riding. Practitioners need a complete set of level of service tools in order to plan, design, and retrofit facilities and ultimately develop a bicycle route system that is both safe and efficient.

Objectives

- Assess the validity of prior approaches (including the BCI and BLOS methods)[7,8,9] to developing bicycle level of service and devise an approach that is methodologically sound.
- Develop and validate a bicycle level of service methodology for each of three scenarios: 1) urban/suburban intersections, 2) urban/suburban corridors – including intersections, and 3) rural roadways – including segments and intersections.
- Document the procedures developed and work with the Transportation Research Board's Highway Capacity Committee to get the methodology incorporated into the next version of the Highway Capacity Manual (HCM).[15]

General Approach

This project will need to have multiple phases or need to be divided into several projects. The specific phases or projects would be:

1) Development and validation of a methodology for urban and suburban intersections.
2) Development and validation of a methodology for corridors within and urban/suburban areas.
3) Development and validation of a methodology for rural roadways.

For each of these phases, prior methodologies used will be critically reviewed. A methodology for each scenario will be developed that includes the entire range of conditions present on the roadway system. The methodologies will be validated against real-world conditions to ensure that the results accurately reflect the level of compatibility perceived by bicyclists.

This effort will be a 3-phased project conducted over 4 years. *Depending on how this project is proposed and available funding constraints, three separate, but linked, efforts may be more appropriate.*

Products

The end result of this effort will be a bicycle level of service methodology that is complete in the sense that the full spectrum of on-street facilities are covered. The documents will provide practitioners with quantitative methods to plan for, develop, and modify roadways to make them more compatible for bicycling, ultimately improving safety and operations for both bicyclists and motorists.

Research Area: Bicycle Facilities

Concept Title: Crash Analysis of Bicycle Lanes vs. Wide Curb Lanes

Research Need

The issue of bicycle lanes vs. wide curb lanes and which is best for bicyclists continues to be debated. Even though the recent operational and perceptual studies have shown benefits and preferences for bicycle lanes or paved shoulders, there are no safety evaluations to support or contradict these results. A comprehensive safety study of on-street facilities, which incorporates crash and exposure data, is needed to determine the advantages and disadvantages of each type of facility under the array of existing roadway conditions.

Objectives

- Assess the relative safety of the various on-street bicycle facilities (wide curb lanes, bicycle lanes, and paved shoulders) currently used in this country.
- Develop guidelines regarding the appropriateness and implementation of these various types of facilities.

General Approach

To properly conduct this effort, a large number of roadway miles with bicycle lanes, paved shoulders, and wide curb lanes will be required. In addition, both crash data and exposure data will be needed at the sites in order to develop crash rates per bicycle mile traveled. This type of study is an example of the studies that could be accomplished with a complete bicycle crash data base (*see research concept for the Establishment of a National Bicycle Crash Data Base in companion paper on Engineering Countermeasures Research for Bicycling*). In the absence of such a system, sites will need to be selected from a representative number of cities and States throughout the U.S. that have bicycle crash data available. Lane widths and other geometric and operations data will be required for each location. In addition, a methodology for acquiring bicycle exposure data will need to be developed and applied. Once the data are collected, the analysis will be conducted to answer the basic question of which facility type is safest and under what conditions. However, with such a complete data set, there are a number of additional questions related to facility type and crash type that could also be answered and should be pursued under this effort or perhaps through additional follow-on studies.

Acquiring the data for this effort will be the most time-consuming and expensive task. It is estimated the effort will require 4 years to complete. The cost associated with the analysis will be significantly less if a data base with all of the required crash, geometric, and operations data already existed.

Products

The outcome of this project will a report on the safety of on-street bicycle facilities that will answer the question above, but will also provide information on the geometric and operating conditions under which each facility type is preferred. This level of crash analysis has not been achieved before due to the lack of a comprehensive data set; this effort would be a significant step in terms of bicycle safety analysis.

Research Area: Bicycle Facilities

Concept Title: Designing Safer Intersections for Bicycling

Research Need

Traditional intersection design has typically incorporated bicyclists as an afterthought and has assumed that bicyclists should traverse the intersection in one of two ways, either as a motor vehicle would using the travel lanes and traffic signals (if signalized) or as a pedestrian would using the crosswalks and pedestrian signals. While this approach may work in most cases, there is a need to be more innovative in the approach to designing intersections, particularly large complex intersections, such that safety and efficiency for all modes can be maximized. For the bicyclist, this requires designing the intersection from the point of transition out of the midblock area to the intersection approach, then through the intersection itself, and finally transitioning from the intersection departure back to the midblock facility.

Objectives

- Determine the range of intersection configurations typically encountered by bicyclists and select the most promising types for consideration in this effort.
- Document the operational behaviors of bicyclists and motorists and the subsequent safety impacts.
- Develop a series of recommended alternative designs to accommodate bicyclists.
- Conduct real-world evaluations of the most promising designs.
- Develop design guidelines that may be used in developing new intersections or retrofitting existing intersections.

General Approach

The approach to this study will be to develop a matrix of common and complex intersection types and determine through observations, focus groups, and expert panel meetings the difficulties and challenges faced by bicyclists in maneuvering through the various types of locations. All possible maneuvers, including straight-through movements, right turns, and left turns, will be considered. For those location types that pose an increased risk to bicyclists, alternative designs will be developed and presented to bicyclists and others to determine the best designs for further study. Those designs that are most promising will be implemented and evaluated to determine the impact on bicycle behavior and safety.

Since the project requires the implementation and evaluation of alternative treatments, a minimum of 4 years will be required.

Products

One of the products from this effort will include a report that documents the types of intersections typically encountered, the difficulties that may be present for bicyclists, and the subsequent safety impacts. A second report would document the results of the evaluation studies, and a third document would be the intersection design guidelines intended for practitioners to assist them in the design or retrofit of intersections.

Research Area: Bicycle Facilities

Concept Title: Accommodating Bicyclists at Traffic Calming Devices

Research Need

The use of traffic calming devices in the U.S. has become quite popular and the number of treatments is expected to increase significantly in the future. These devices include roundabouts, curb extensions (bulbouts), speed humps, traffic diverters, chicanes, and an array of other treatments. The intent of these devices is to slow motor vehicle traffic, hopefully to a speed that is comparable to the speed of a bicyclist so that the two modes can safely share the same space on the roadway. Experience in other countries, however, has shown that the design of these treatments is not always accommodating to bicyclists.[13] The end result may, for example, create squeeze points where a curb extension is being used, thus increasing risk for the bicyclist. At the same time, there is a lack of guidance on how to appropriately design some features, such as roundabouts, to accommodate bicyclists. The recently published *Roundabout Informational Guide* provides limited guidance on this issue, primarily due to the fact there has been no formal research on this topic.[14]

Objectives

- Determine the types of traffic calming treatments that are being used or will be used in the future in the U.S. and assess the problems that may be associated with these devices from the perspective of the bicyclist.
- Develop and evaluate design alternatives that may mitigate problems for bicyclists.
- Develop guidance on designing and installing the array of traffic calming features to be fully accommodating to bicyclists.

General Approach

This study will begin with a review of the literature, particularly from abroad, to determine the types of traffic calming devices being used and problems associated with the use of such devices and bicycle safety and access. The perspectives of bicyclists that have traveled on roadways with these treatments will also be obtained, along with the expertise of designers, to determine the range of problems that exist and potential solutions that may be implemented and evaluated. Again, designs from abroad will be considered in the development of alternatives. In Australia, for example, some curb extensions are designed with a bicycle lane built into the extension, allowing the bicyclist to avoid the narrow lane (or squeeze point). The most promising alternative designs will be evaluated in the field. The results will be documented and developed into design guidelines for practitioners.

Since this study requires the implementation and evaluation of treatments, a minimum of 4 years should be programmed for this effort.

Products

This study will produce at least two products. The first product will be a report that documents the types of traffic calming devices in use and the problems for bicyclists that are associated with each. The second product will be the results of the evaluation study and will also include design guidelines that will be based on a variety of factors such as number of lanes, traffic volumes, motor vehicle speed, etc.

Research Area: Bicycle Facilities

Concept Title: Safety and Capacity of Shared-Use Facilities

Research Need

There has been limited research conducted on the capacity of shared-use facilities (trails and paths) and the interaction of bicyclists and pedestrians. There is a need to validate that work and expand it to a wider array of facilities and users. For example, there is a continuing concern regarding in-line skaters, the amount of space required for them to operate, and the impact of their presence on other facility users. This research is needed to provide designers with quantitative results that can used to determine appropriate facility widths.

Objectives

- Develop and validate a methodology for determining the capacity of shared-use facilities, which incorporates the full range of widths and the full spectrum of users found in the U.S.
- Develop guidelines for using the methodology.
- Work with the Transportation Research Board's Highway Capacity Committee to get the methodology incorporated into the Highway Capacity Manual (HCM).[15]

General Approach

The development of this methodology will be done based on observations of the interactions of trail users on the complete range of facilities that currently exist in the U.S. The validation of the method will be conducted on a separate set of facilities. Documentation of the methodology will include a discussion of the theory behind the method, detailed procedures, and application examples. Once the documentation is complete, presentations will be made to the Highway Capacity Committee to begin the process necessary to get the methodology incorporated in the HCM.

This effort will be conducted over a 2-year period.

Products

The product of this research will be a procedure for computing the capacity of shared-use facilities (trails). While the methodology will be documented as a stand-alone product, the final goal will be to have the procedure incorporated as part of the HCM. This procedure will provide practitioners with a means of computing existing trail capacities, planning for future trail capacities, and designing new trails to safely and efficiently accommodate all types of users.

Bicyclist Conspicuity Issues and Topics for Future Research

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Westat

Background

This paper briefly summarizes key elements of what is known regarding traffic safety aspects of bicyclist conspicuity and offers several suggestions for research that addresses gaps in the knowledge. The basis for this paper was a literature review on pedestrian and bicyclist conspicuity, conducted in 1999 for the National Highway Traffic Safety Administration, Office of Research and Traffic Records. The broad objectives of the review were to present an updated description of the characteristics of conspicuity-related pedestrian and bicycling traffic safety issues, examine current and potentially new crash countermeasures, and make recommendations for future research regarding pedestrian and bicyclist conspicuity.

Conspicuity is a term used to describe the extent to which an object captures attention. It may be quantified in terms of detection or recognition probability, response time, or response distance from the object. *Attention conspicuity* is the capacity of an object to attract attention of an unalerted observer, while *Search conspicuity* is the property of an object that enables it to be quickly and reliably located by an alerted observer's search (Cole & Hughes, 1984). In many real-world situations, drivers do not expect a pedestrian or bicyclist, in which case a treatment's attention conspicuity is crucial. Overall, conspicuity is associated with the following factors:

- The visibility of the object, determined by its brightness and color contrast with its visual background, its size, observer visual acuity or contrast sensitivity, and glare (Adrian, 1989),
- The magnitude and direction of the illumination directed on the object,
- Other characteristics of the object including its motion against the background and the periodicity of its brightness (e.g., flashing lights or moving retroreflectors),
- Characteristics of the visual background, including how cluttered or busy it is, and the relative importance of other objects to the observer (Gibson and Kelsey, 1998),
- The visual angle from the observer's line of sight to the target (Cole & Hughes, 1984).
- Other observer characteristics, including age, distraction, ability to adapt to changing lighting levels, and attention focus,
- Expectation and motivation of the observer (Cole & Hughes, 1984; Gibson and Kelsey, 1998).

Bicycling represents an important means of transportation for both recreational and business purposes in the U.S. and one that is over-represented in crashes. According to data from the 1995 Nationwide Personal Transportation Survey (NPTS) 9 million bicycle trips are made daily. In 1998, 761 pedalcyclists were killed and 53,000 were injured in traffic crashes. (Traffic Safety Facts 1998, NHTSA).

One of the key factors in many motor vehicle crashes involving bicycles is the relatively low visibility or conspicuity of the bicyclist from the viewpoint of the motor vehicle's driver. The bicyclist presents a much smaller profile than a motor vehicle from the front, rear and side, which makes it relatively difficult for a driver to detect, recognize, and assess its motion during day or night. Compared to a motor vehicle, a bicycle is relatively poorly lighted and poorly reflectorized, making it far more difficult for a motorist to recognize and avoid it at night than a motor vehicle. Adding to the problem is that drivers generally do not expect to encounter pedalcyclists, further reducing their conspicuity.

Crash records provide little information to distinguish conspicuity-related pedalcyclist crashes. Darkness and inclement weather are conditions in which conspicuity is greatly reduced for pedalcyclists. At night, drivers routinely drive faster than the visual range of their headlamps due to "selective degradation," where drivers are unaware of how much their vision is impaired for relatively poorly-lighted or poorly-reflectorized objects, such as bicyclists (Leibowitz, Owens, and Tyrrell, 1998). Twilight and nighttime conditions have a higher crash rate for all rider age groups, compared to daylight. However, lack of conspicuity can be a problem during daytime as well as at night, especially where the background is visually complex and where other objects may obscure the view of the pedalcyclist. While approximately 30 percent of the pedalcyclist traffic deaths in 1998 occurred between 6 p.m. and midnight on weekdays and 53 percent occurred during those hours on weekends, the majority occurred during daylight hours (NHTSA, 2000 rev.). Wessels (1996) found that 82 percent of bicycle-motor vehicle crashes in Washington State occurred during daylight. However, when accounting for exposure, bicyclist crashes are over-represented in low-light conditions and in winter months (Owens and Brooks, 1995). Riding after dark is estimated to present four times the risk of a crash compared to riding during the day (Rogers, 1995).

Certain key crash characteristics that relate to bicyclist conspicuity are known. During non-daylight periods, "crossing path" situations accounted for 53 percent of pedalcycle crashes and "parallel path" accounted for another 40 percent (Hunter et al, 1995). A particular nighttime problem type is when a motorist approaches a bicyclist from the rear, fails to see it, overtakes and crashes into it. In 1975 this crash type represented 63 percent of the non-fatal and 71 percent of the fatal pedalcyclist crashes during darkness (Cross and Fisher, 1977). A factor that may contribute to head on, crossing path and overtaking crashes is that stopped left turning driver's accept gaps for oncoming bicycles that are 60 percent smaller than for cars. When a motorist is closing in on a bicyclist, the gap was almost 40 percent less (2.45 seconds) than the 4.03 seconds a motorist uses when closing in on another motorist. (Taylor and Mahmassani, 1999).

Current Knowledge of Factors Influencing Conspicuity

Bicycle Lighting and Reflectorization

Popular opinion is that the use of retroreflectors and steady or flashing lighting on bicycles and reflectorized clothing by bicyclists should increase conspicuity and reduce crashes. However, research on measures to improve bicyclist conspicuity has not provided definitive answers to what constitutes either sufficient or best methods. Some of the most important findings are:

- Red rear reflectors were visible at up to 60 m in a visually simple background but visibility distance decreased with a visually noisy background, for which a red light was visible at a 20 percent greater distance than the reflectors (Matthews & Boothby, 1980).
- Color, size, frequency of flash, pulse shape and intensity all determine what outcome the flash is to have in different situations. The design of a flashing light should help attract the attention of the motorist without causing confusion or distracting the driver from other safety
- During daytime, riders wearing fluorescent yellow jackets were more conspicuous and resulted in drivers providing wider separation when passing than for riders wearing arm bands and belts, and brightness was a more important factor than color (Watts, 1984a).
- At night, a jacket fitted with retroreflectors designed to present an entrance angle of 10 degrees to the light source resulted in fewer drivers passing at a close distance (less than 0.8 m) than when cyclist wore a jacket with retroreflectors positioned with a 30-degree entrance angle (Watts, 1984a).
- Detection distances are often far greater than recognition distance. For instance, with a rear lamp (11.1 cd) and a small reflector (100 mcd/lx), detection distance was 651 m and recognition distance was 54 m. Even if a driver is able to tell *something* is ahead, he may mistake it for a fixed object, such as a reflective sign, until he is very close to the cyclist Watts (1984b).
- A light mounted on the bicyclist's helmet can help the rider track objects, but may distract motorists when the bicyclist looks at a vehicle in either fog or rain (Langley, 1989).

- Pedal reflectors attract considerable attention because they are in constant movement but are limited to one area of the bicycle. Reflective tape, if placed in strategic places on the bicycle and the bicyclist, are without such limitations. Adding a small, flashing battery light either to the bicycle or the helmet will attract motorist attention faster than a steady beam. The combination of reflective tape, reflectors, small battery lights, and bright clothing are a bicyclist's best defense against motorists (Kukoda 1989).
- In addition to headlights and taillights, flashers and red lights are effective safety features because motorists may associate flashers with danger, and therefore be more aware as they approach the flashing signal on the bicycle (Blumenthal, 1992).
- Helmet lights illuminate the path for riders as well as increase conspicuity (Olsen, 1993).
- Drivers are more likely to recognize moving and flashing rear reflectors or lights than steady or stationary signals because they grab the attention of the motorist. Some tail lights use a number of light-emitting diodes (LEDs) that flash in unison, which provide excellent visibility. However, when LEDs are illuminated in a cyclic manner (i.e., one after the other), the total possible brightness and conspicuity is reduced (Wilhelm and Langley, 1994).
- Using retroreflective markings on limbs to convey the person's shape and motion resulted in significantly earlier recognition of a jogger than when the limbs were not marked or when single point retroreflectors were used. In a busy road environment, the "bio-motion" markings performed better than any of the other markings (Owens, Antonoff, & Francis, 1994, p. 721).
- 80 percent of younger riders feel that the reflectors that come on a bike are sufficient for nighttime riding, when in actuality, they are not, consequently a separate headlight is needed to increase bicyclist conspicuity (Lindstrom, 1994).
- Compared to a variety of bicycle pedal and rear retroreflectors and reflective sheeting treatments, including those meeting current federal regulations, only the addition of a flashing red light significantly improved bicycle rear detection distance but not recognition distance. No self illuminated or reflectorized front, rear or side treatments produced improvements in side detection or recognition distance (CPSC Bicycle Reflector Project Team, undated c. 1999).

Motor Vehicle Headlamps

New headlamp designs have been introduced in production vehicles in recent years, with mixed results.

- Current aerodynamic European style headlight designs sharply cut off the illumination above the horizontal plane of the headlight, reducing the visibility of anything that is more than about 24 inches above the ground. Consequently, front and rear bicycle retroreflectors and reflectorized clothing may not be as conspicuous as with older headlight designs.
- New high intensity Xenon headlamps may provide up to 50 percent more illumination distance with a whiter and broader beam, but have also been associated with complaints of discomfort glare.
- Ultraviolet (UV) headlamps are being tested to evaluate improvements in driver detection of pedestrians and other roadway objects at night. Ultraviolet headlamp technology may increase nighttime detection of pedestrians by over 90 percent of previous detection distance (Turner, Nitzburg, & Knoblauch, 1998).
- An active headlight system that aims a pair of supplemental headlamps provided a 14 percent increase in nighttime pedestrian detection distance (7.5 m) for left curves and a 2 percent increase in detection distance (1 m) for right curves compared to a standard headlight system (Sivak et al, 1994).

Glare

Glare from an oncoming vehicle reduces a driver's ability to detect and respond to a pedestrian or bicyclist on the roadway. The mean detection distance of a pedestrian was 108 m when illuminated by low beams, but reduced to 82 m with low beams plus glare from an oncoming car. Providing the pedestrian with a retroreflective tag resulted in a low beam detection distance of 218 m, and the addition of glare had little effect (Shinar, 1984).

Sensing Technology

Intelligent transportation technology employing video imaging, ultrasonic, infrared, and microwave radar are being developed to help drivers detect and avoid objects in the roadway.

- The Cadillac Night Vision system is an example of a vehicle based system that relies on a night vision camera mounted at the front of the vehicle that projects an image via a head-up display on the windshield (Cadillac, 1999). The effectiveness in increasing detection of pedestrians or bicyclists as well as associated costs in driver distraction that may be associated with use of the head-up display are unknown.

- Signal loop detectors delineated by pavement markings have been used to sense a bicyclist's position and activate the traffic signal so that the bicyclist can cross the intersection safely (Derobertis and St. Jacques, 1995).

Lighting for Roadways, Walkways, and Bikeways

U.S. and international roadway lighting standards provide specifications for area lighting where bicyclists are expected. However, there is no documented research establishing the basis for these recommendations.

- The International Illumination Commission (CIE) provides recommendations that lighting along the approaches to and in areas where conflicts between vehicles and pedestrians or cyclists are likely to occur should be brighter than any of the roads leading into that area. (CIE, 1995).
- The Illuminating Engineering Society of North America (IESNA) does not specify lighting levels for walkways and Class 1 Bikeways, but generally relies on spillover light from the adjacent roadway luminaires. However, such incidental lighting may not produce the proper quality or quantity of light for comfort and safety rians and cyclists (IESNA, 1994).

Traffic Calming Measures

One approach to redesigning the roadway environment involves the installation of "visibility zones." On city streets where midblock crossings by pedestrians are frequent, Schofer et al (1995) suggested removing one or two midblock parking spaces and in the center of that area installing a midblock crosswalk. The removal of the parking spaces would serve to remove barriers to pedestrian visibility, and the placement of the crosswalk at a midblock location would accommodate naturally occurring pedestrian behavior.

Recommendations for Future Research Efforts

Although many concepts, programs and devices that may improve bicyclist conspicuity were identified in the literature review, very few represented significant breakthroughs in new conspicuity enhancing technology or programs. Nonetheless, there are clear gaps in the knowledge that if filled may lead to opportunities to exploit, investigate and evaluate the potentially effective crash countermeasures. The following are recommendations for such future research on ways to improve bicyclist safety through conspicuity enhancement:

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Research Area: Bicycle Conspicuity Issues

Concept Title: Bicycle Lighting and Reflectorization

Research Question

What are the critical details provided by bicycle lighting and reflectorization that enable a driver to recognize a bicycle from the front, rear and side? What are minimum requirements for front, side and rear lighting to improve conspicuity to the extent that drivers will detect and recognize adequately to respond in time (since better reflectors don't seem to improve detection but nothing improved recognition)?

Justification

Numerous studies have examined **detection** distances for front, side and rear views of bicycles and some basic relationships have been established. However, drivers are not likely to respond to the potential conflict with a bicycle until they **recognize** the hazard and decide on an appropriate course of action. Previous research has shown that **recognition** distances are generally short and recognition only occurs when the vehicle illuminates the bicyclist sufficiently illuminated to render the critical details (rider's head, arms, torso, legs, wheels, etc.) visible.

Objectives

Conduct human factors research to determine what visual details provide the "bio motion" cues that promote recognition of bicyclists, and determine promising lighting and/or reflectorization treatments that provide adequate recognition distances.

General Approach

Conduct literature review of shape, size, visibility and motion attributes associated with recognition of a bicyclist from the front, side and rear. Develop a set of conceptual treatments likely to produce adequate recognition distances. Conduct laboratory studies with 20-30 subjects to evaluate the conceptual designs to identify the most promising. Conduct controlled field study to determine real world recognition distances.

Time Frame: 1-2 years.

Products

Empirical relationship between design details and recognition distances. Guidelines for developing conspicuity aids. Application to PI&E material advising bicyclists of effective treatments. Linkage to future field study of device effectiveness.

Impact of products on bicycle safety problem

Potential to reduce crashes, especially rear end overtaking crash types. May stimulate development of new products or revisions in federal regulations for the design and performance of bicycle visibility equipment.

Research Area: Bicycle Conspicuity Issues

Concept Title: Roadway Lighting

Research Question

How should roadway lighting be designed to accommodate bicyclist needs for visibility and conspicuity? What are the roadway lighting design guidelines that are appropriate to satisfy the bicyclist's needs for visibility and the quality of the roadway or bikeway environment?

Justification

Road lighting based and other special lighting approaches - Urban intersections, mid-block crossings and other urban street locations are the most frequent pedestrian and bicyclist locations for crashes with motor vehicles. Some new or improved types of lighting may represent significant infrastructure investments but have not been properly evaluated for effectiveness in reducing crashes.

Objectives

Categorize the types of bicycling facilities that use public roads and separate rights of way. Analyze the most common lighting applications to determine design guidelines. Develop warranting guidelines to help traffic safety program planners and engineers decide on the types lighting needed to facilitate various levels of bicycle facilities and use.

General Approach

Review U.S. and international literature on bicycle facility lighting. Prepare a state of the practice review of devices and lighting equipment suited to bicyclist needs. Develop visibility-based guidelines for illumination and luminance levels for various types of bicycling facilities. Demonstrate use of guidelines in a community and refine recommendations. Prepare a design guidelines document. Consider the following applications:

- Special lighted bikeway and crosswalk delineation using LED strips, such as Lumi-LEDs.
- Urban area lighting upgrade programs that integrate roadway, bikeway and sidewalk lighting to improve area aesthetics and safety.

Time Frame: 2-3 years

Products and Links to Future Activities

Recommended design guidelines. Likely link with IESNA Roadway Lighting Committee to undertake new recommended practice for bike facility lighting. Possible longitudinal study to evaluate safety impacts of improved bike facility lighting.

Impact on program

Likely to promote bicycling and safety, reducing crashes and improving security.

Research Area: Bicycle Conspicuity Issues

Concept Title: Traffic Calming

Research Question

What are the most effective design approaches, benefits and other impacts of traffic calming and other road infrastructure approaches to improve bicycling conspicuity and safety?

Justification

Traffic calming techniques are becoming popular among urban and suburban designers, some of which directly address the conspicuity of bicyclists by placing them on raised crossings or eliminating sight obstructions while also shortening street crossing distances. Other infrastructure features include actuation devices that may heighten the driver's awareness of a pedestrian or bicyclist at a road crossing. However, the impacts of these treatments on bicycle use and safety are unknown.

Objectives

Determine the effectiveness of various infrastructure treatments that are intended to improve bicyclist conspicuity and safety, and produce recommendations for designing and implementing such treatments.

General Approach

Conduct a review to categorize and describe infrastructure treatments used in the U.S. in the past 10 years. Determine the basis for design and the associated costs. Gather data on safety and use impacts. Prepare design and site selection recommendations. Evaluations of the following devices or treatments would be appropriate:

- Intelligent technology actuators for bicyclists that are embedded with special delineation that directs bicyclists to the most appropriate intersection crossing path.
- Raised pedestrian and bicycle crossings
- Clear vision zones (parking removal and sidewalk widening/extension) at intersections and midblock crossings to improve the visibility of pedestrians and bicyclists at crosswalks.

Time Frame: 1-2 years.

Products and Links to Future Activities

Design and site selection guidelines. Could be used as a basis for an area demonstration program that could be followed over time to evaluate safety impacts.

Impacts on Program

Would make useful guidelines available to planners and engineers for the rapidly growing number of areas that are interested in traffic calming and other infrastructure applications to improve pedestrian and bicycling safety and use.

Appendix E. Pedestrian Countermeasure Research Needs from the U.S. Access Board

1. Research on MUTCD pedestrian signage and markings (color, contrast, reflectivity, legibility, mounting specification, viewing distance, meaning) to determine effectiveness for persons with low and impaired vision, older persons, and children.

2. Research on MUTCD pedestrian signal symbols and phasing to determine effectiveness for persons with low and impaired vision, older persons, and children.

3. Research on the development of a technology of cues for blind pedestrians to replace information currently derived from vehicle engine and tire noise and other acoustical input.

4. Data on the involvement of people with vision impairments in pedestrian crashes.

5. Research on engineering solutions to providing access to roundabouts for pedestrians with vision impairments.

6. Engineering R&D to refine truncated dome specification of detectable warnings.

7. Research on the effects of speed bumps on drivers/passengers with disabilities.

8. Technical assistance on designing intersections and other street crossings accessible to pedestrians with vision impairments.

9. Research on pedestrian exposure at one vs two-lane roundabouts.

10. R&D on making light rail and rail crossings accessible to pedestrians who use wheelchairs.

11. Research on curb height function to assess the safety and utility of <6" curbs.

12. New design approaches to street drainage to eliminate ponding at curb ramps.

13. Compare capacity data for 3 vs 4 lane roadways.

14. Assess optimal vehicle speed to maximize roadway capacity.

15. Re-examine concurrent pedestrian/turning vehicle signal phasing vs all red in terms of capacity and delay to vehicles and pedestrians.

16. Assess effects of audible signals on pedestrian crossing times.

17. Assess effect of crossing distance on vehicle capacity/delay.

18. Assess effects of LPI (with accessible pedestrian signals) on establishing right-of-way by pedestrians with vision impairments.

19. Determine ADT and related volume limits for safe gap selection by blind pedestrians using unsignalized roundabouts.

20. Develop treatments for cut-thru medians for pedestrians with vision impairments.

21. Develop treatments for crossings of free-right-turn lanes for pedestrians with vision impairments.

22. Evaluate RTOR with respect to pedestrian safety, including safety and access for pedestrians with disabilities, against objectives of policy.

23. Assess policy issues of pedestrian accessibility vs vehicle safety at intersections.

24. Compare benefits of intersection and midblock crossings for pedestrians relative to safety, delay, and capacity.

25. Quantify usability effects of cross slope, running slope, rate of slope change, and combinations of cross and running slope on pedestrians who use manual wheelchairs and on pedestrians who use walking aids.

26. Assess effects of curb radius on roadway capacity and vehicle delay.

27. Develop treatment of use of pedestrian detection systems by pedestrians with vision impairments and pedestrians who use wheelchairs.

28. Engineering treatments at intersections for establishing crossing direction by pedestrians with vision impairments.

29. ITS applications for independent travel by pedestrians with vision impairments.

30. Assess conflicts between roadway design in hilly terrain and pedestrian accessibility at intersections.

31. Assess usability and effects of grade-breakover angles on driveways for vehicles.

32. Establish criteria for pedestrian lighting that integrates the needs of pedestrians with vision impairments.