International Technology Scanning Program

Infrastructure Countermeasures to Mitigate Motorcyclist Crashes in Europe

AUGUST 2012

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16. Abstract

The number and rate of motorcyclist deaths on U.S. roads are rising dramatically. The Federal Highway Administration, American Association of State Highway and Transportation Officials, and National Cooperative Highway Research Program sponsored a scanning study of five European countries to evaluate infrastructure improvements to aid motorcyclists.

The scan team found that the types of infrastructure safety improvements used in Europe, with the exception of motorcycle-friendly roadside barriers, were those that generally improved safety for all vehicle classes. The biggest differences the team observed were in behavioral safety, helmet laws, training, and licensing. The team also noted great cooperation between road authorities and stakeholder groups representing motorcycle riders.

Team recommendations for U.S. implementation include filling in knowledge gaps to improve motorcycle safety, conducting research on motorcycle infrastructure safety, and updating design guidelines to accommodate motorcyclist safety.

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Sadly, one of our team members, Jeff Kolb, passed away shortly after our scanning study. He was a valuable contributor to the team and a pleasure to have as a traveling companion.

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International Technology Scanning Program

The International Technology Scanning Program, sponsored by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the National Cooperative Highway Research Program (NCHRP), evaluates innovative foreign technologies and practices that could significantly benefit U.S. highway transportation systems. This approach allows for advanced technology to be adapted and put into practice much more efficiently without spending scarce research funds to re-create advances already developed by other countries.

FHWA and AASHTO, with recommendations from NCHRP, jointly determine priority topics for teams of U.S. experts to study. Teams in the specific areas being investigated are formed and sent to countries where significant advances and innovations have been made in technology, management practices, organizational structure, program delivery, and financing. Scan teams usually include representatives from FHWA, State departments of transportation, local governments, transportation trade and research groups, the private sector, and academia.

After a scan is completed, team members evaluate findings and develop comprehensive reports, including recommendations for further research and pilot projects to verify the value of adapting innovations for U.S. use. Scan reports, as well as the results of pilot programs and research, are circulated throughout the country to State and local transportation officials and the private sector. Since 1990, more than 85 international scans have been organized on topics such as pavements, bridge construction and maintenance, contracting, intermodal transport, organizational management, winter road maintenance, safety, intelligent transportation systems, planning, and policy.

The International Technology Scanning Program has resulted in significant improvements and savings in road program technologies and practices throughout the United States. In some cases, scan studies have facilitated joint research and technology-sharing projects with international counterparts, further conserving resources and advancing the state of the art. Scan studies have also exposed transportation professionals to remarkable advancements and inspired implementation of hundreds of innovations. The result: large savings of research dollars and time, as well as significant improvements in the Nation's transportation system.

Scan reports can be obtained through FHWA free of charge by e-mailing international@dot.gov. Scan reports are also available electronically and can be accessed on the FHWA Office of International Programs Web site at www.international.fhwa.dot.gov.

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Executive Summary

In September 2010, a U.S. team of 12 transportation safety and engineering experts and industry representatives visited five European countries to assess and evaluate infrastructure improvements designed to aid motorcyclists. The countries were Belgium, England, France, Germany, and Norway. The scan team met with state and federal government transportation officials, university research center staff, and staff from motorcycle industry and rider associations and other nongovernmental organizations interested in motorcyclist safety. The team selected these countries because of their innovative infrastructure and traffic operations programs aimed at improving motorcyclist safety. The information the team obtained during the scan included several design, maintenance, and operational changes that could be implemented in the United States to improve motorcyclist safety.

Summary of Findings

The focus of this scan was infrastructure improvements, maintenance practices, and traffic operations strategies to enhance motorcyclist safety. Overall, the scan team found great similarities between the United States and the countries visited in these areas. With the exception of motorcycle-friendly roadside barriers, the types of infrastructure safety improvements used were those that improved safety for all vehicle classes, such as roadside clear zones and pavement management. The biggest differences between the United States and the countries visited were in the areas of behavioral safety, helmet laws, training, and licensing. Another difference the team noted was the great cooperation between European road authorities and stakeholder groups representing motorcycle riders.

In Europe, as in the United States, motorcycle ridership is increasing. In the motorcycle industry, the term “powered two-wheeler” (PTW) has evolved to encompass motorcycles, mopeds, scooters, and even newer hybrid machines that may have more than two wheels, such as the Piaggio MP3 and the CanAm Spyder. Motorcycle use can have a beneficial effect on transportation systems by reducing congestion, emissions, and parking space allocation.

On a personal level, motorcycle use can be a less expensive mode of transportation in vehicle purchase price, maintenance and fuel costs, and parking expenses. These countries view motorcycle use as a valid form of transportation that agencies need to accommodate and make as safe as possible. Driver’s license laws in most European countries prohibit those under 18 from driving an automobile, but teens can get a motorcycle license for certain engine sizes. For many people under 18, PTWs are basic transportation.

Both Europe and the United States have seen an increase in leisure riders over age 50. These baby-boomer riders have years of car-driving experience, but their motorcycle riding patterns generally include “Sunday drive” winding rural roads that may pose particular safety problems. The countries in northern Europe the team visited have a similar climate to most of the United States and similar motorcycle riding patterns with heavy rural leisure use and isolated heavy urban use.

The countries visited all had lower traffic fatality rates than the United States, when measured per inhabitant. England, France, and Norway had fatality rates less than half that of the United States. The scan team noted, however, that in each country visited the proportion of fatalities that were motorcyclists was consistently in the 15 to 20 percent range. This proportion of motorcyclists to total fatalities is in line with the United States. Despite a much lower rate of fatal crashes overall in these countries, motorcyclists are still overrepresented in fatalities, much like in the United States.

The team observed the use of roadside and median barriers specially designed for motorcycles in some of the countries visited. The team also noted activities on developing standards for crash testing acceptance of motorcycle barriers. Conclusive data on the effectiveness of these devices and the frequency of motorcycle rider impacts with barriers were unavailable, although a study was underway in France.

The scan team based its inquiries on a list of amplifying questions that focused mainly on infrastructure topics, but also touched on behavioral safety and legal issues. The topic headings in the report reflect these amplifying questions, and a summary of findings for each area is provided. Internet resources and contact information for scan team members and the European officials they met with are in the appendices.

Chapter 1. Background

In September 2010, a U.S. team of 12 transportation safety and engineering experts and industry representatives visited five European countries to assess and evaluate infrastructure improvements designed to aid motorcyclists. The countries were Belgium, France, Germany, Norway, and the United Kingdom. The group met with government transportation officials, university research center staff, and staff from motorcycle industry associations and other nongovernmental organizations interested in motorcyclist safety. The team selected these countries because of their innovative infrastructure and traffic operations programs aimed at improving motorcyclist safety. The information the team obtained during the scan included several design, maintenance, and operational changes that could be implemented in the United States to improve motorcyclist safety.

Motorcycle Crash Trends

In the United States, the number and rate of motorcyclist deaths have increased dramatically. Motorcycle rider fatalities rose 144 percent between 1996 and 2007. During the same time, fatality numbers and rates for passenger car crashes dropped. In 2007, motorcycle crash-related fatalities increased by more than 7 percent (to 5,154), while overall fatalities decreased.

Similar crash patterns exist in the European countries the scan team studied. Overall, the number of roadway fatalities is significantly lower. Despite mandatory helmet laws, higher costs, stricter impaired-driving laws, and more unlimited access roads, however, motorcyclists in these countries represent the same percentage of fatalities compared to drivers of other vehicle types as in the United States.

Several trends have accompanied the rising motorcyclist death toll in the United States. They include a dramatic increase in motorcycle ownership, particularly by riders over 40, and changes in motorcycle size and rider experience. The rate of increase in fatalities has outpaced the rate of increase in motorcycle registrations, and death and injury rates among middle-aged motorcycle riders have increased more rapidly than among other age groups.

Motorcycle riders face more risk of crashing and being injured than passengers in four-wheeled vehicles. Two-wheeled motorcycles are more difficult to operate and more unstable than cars and trucks. Some roadway design and maintenance features add risks. Other vehicle drivers may not expect to see motorcycles on the road, may not watch for them, and may not know how to accommodate them in traffic. When they crash, motorcycles provide minimal protection to their riders.

In 2004, a major motorcycle crash causation study was released in Europe, *MAIDS—Motorcycle Accidents In-Depth Study,*[1] by the Association of European Motorcycle Manufacturers (ACEM) with support from the European Commission. The study indicated that 80 percent of the crashes reviewed involved other vehicles, while 15.5 percent of the crashes involved only powered two-wheelers (PTW). Most multivehicle PTW crashes were caused by human error, 37.1 percent of the time by the driver of the PTW and 50.4 percent by the driver of the other vehicle. Environmental conditions—including weather, roadway design, and traffic control—were the third-largest contributors to crashes. Therefore, vehicle or other failures contributed less than 5 percent to the overall crash mix. The study found that the most frequently struck object was another vehicle and the second most frequently struck object was the roadway itself. It also found that 75 percent of crashes occur in urban areas. In the 921 PTW crashes investigated, only 6 percent (60 crashes) of PTW riders' injuries were caused by roadside barriers. The areas the study sampled may have been biased toward urban areas, and vehicle classification and registration differences exist among countries that make comparisons across crash reports challenging.

While the study cites human error as a major cause of motorcycle crashes, multiple precursors can contribute to these errors. The Haddon Matrix, a brainstorming tool used to plan injury intervention and prevention strategies, is a convenient way to examine the crash event and multiple contributing factors. The matrix shown in table 1 (see next page) illustrates the multicausal nature of crashes (columns) and the timeline of crashes (rows).

Table 1. Haddon Matrix for motorcycle crashes.

	Personal Factors	Agent (Vehicle) Factors	Physical Environmental Factors	Social Environmental Factors
Preevent	Alcohol/drugs Risk tolerance Experience Driver education	Speed Vehicle maintenance Load characteristics	Traffic control devices Lighting Pavement quality Geometric design	Licensing and training Speed limits Public attitudes toward impaired driving
Event	Driving skill	Helmet Protective clothing	Energy-absorbing barriers Clear zones Roadside safety hardware	Traffic enforcement Helmet laws
Postevent	Physical fitness	Gas tank design	First-aid kit Emergency radio	Communication network Transportation network Emergency services

To address motorcycle safety, the U.S. Department of Transportation (DOT) uses a collaborative approach. The National Highway Traffic Safety Administration (NHTSA) focuses on improving the safety of motorcycling through effective training for new riders, strong licensing requirements based on riding skills, and the promotion of helmet use by all motorcyclists. On the highway side, the Federal Highway Administration's (FHWA) system performance goal focuses on providing safe, reliable, effective, and sustainable mobility for all road users, including motorcyclists.

Scan Purpose

Overall, more than 36,000 motorcycle-related deaths have occurred in the United States in the past decade, and because of the large number they have had a significant impact on highway system performance and crash-related congestion. For these reasons, the topic of motorcycle safety improvements was selected for an international scan.

The purpose of the scan was to collect information from abroad with the potential to improve roadway safety for motorcyclists in the United States. Before the scan, a desk scan was conducted of research literature, conference proceedings, and government agency Web sites worldwide for information on motorcycle safety infrastructure improvement programs. The itinerary of countries the scan team visited was selected based on the findings of the desk scan. The countries have lower overall fatality rates than the United States when using population as the denominator.

The main focus of the scan was on infrastructure improvements used in Europe to enhance motorcyclist safety. The scan team also investigated policy options and initiatives on roadside safety devices, traffic operations, work zone practices, and safety data related to motorcyclists. Motorcyclist safety has received increasing attention throughout Europe from government agencies, riders' groups, manufacturers' associations, and university research. These efforts have resulted in standards on roadway design, traffic engineering, and guardrail design.

The team developed amplifying questions to prioritize its goals and shared them with the European officials they met with to aid in agenda planning (see Appendix A). The questions addressed the following issues as they relate to motorcycles:

- Agency policies and standards on motorcyclist safety and design practices
- Work zone activities
- Agency maintenance practices
- Traffic control device design and placement
- Roadway design issues
- Roadside safety design, testing, and implementation
- Pavement design
- Intelligent transportation systems

- Crash patterns and safety data management
- Motorcyclist safety programs (education, research, training, policing, etc.)
- Legal issues related to motorcycle licensing, laws, and enforcement
- Research activities

Report Organization

The scan report is organized by the topic areas addressed in the amplifying questions. Chapter 2 covers infrastructure improvements, Chapter 3 addresses safety data, Chapter 4 discusses behavioral safety and legal issues, and Chapter 5 outlines research activities. The report concludes with recommendations in Chapter 6 for short- and long-term implementation in the United States.

Scan Team Members

The members of the team included transportation agency personnel from four States, university researchers, traffic safety product and motorcyclist association staff, and FHWA staff:

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Figure 1. Scan team members: (front row, left to right) Paul Degges, Carol Tan, Susan Chrysler, James Baron, Keith Cota, Dennis Heuer, (second row) Nicholas Garber, Mark Bloschock, Melinda McGrath, John Almborg, (back row) Ed Moreland, Jeff Kolb, and David Nicol.

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Chapter 2. Infrastructure Improvements

Agency Policies and Standards for Motorcyclist Safety and Design

Norway has published a roadway design guide specific to motorcycles, available in English.[2] This document was motivated by Norway's National Transportation Plan, which has a "Vision Zero" goal of zero fatalities and severe injuries in road traffic. The Norwegian Public Roads Administration acknowledges that motorcycle driving "is a form of activity that entails a high risk of severe injuries" and developed the roadway design and operations guide to mitigate those injuries. The handbook was written for administration staff in the areas of planning, construction, operations, and maintenance. It contains sections on new roads, reconstruction, existing roads, and roadway condition reporting systems. Topics addressed include roadway surface issues such as manhole covers, roadside safety apparatus, lighting, and traffic control devices. The handbook provides useful information about motorcycle physics and vehicle dynamics to help motivate the recommendations.

The scan team found other road design documents and Internet sources produced by stakeholder groups in cooperation with road authorities, most notably the guidelines produced by ACEM.[3]This document has chapters on road design and traffic engineering, road maintenance, traffic management, safety campaigns, and road safety audits. In addition to roadway design standards, a European Commission-sponsored program has gathered best practices for urban motorcyclist safety into an online document called the European Safer Urban Motorcycling (eSUM) project.[4] This Web resource is a collection of best-practice examples from cities throughout Europe and includes evaluation data on several practices.

The Belgian Road Safety Institute produced a document detailing roadway improvements for motorcycles, available in French.[5] The Dutch-speaking area of Belgium, Flanders, also has a motorcycle roadway design book available. This document includes such design standards as pavement friction values for marking material and curve radius specifications for enhanced signing systems that offer the possibility of less injury to motorcyclists.[6]

Several agencies visited had a motorcycle coordinator—Belgium's "Mr. Moto," for example—who served as an internal advocate for motorcyclist safety and priority in planning and operations. This person also was the point of contact between the agency and rider groups. In Belgium, each regional office of the state road authority had a Mr. Moto, who was typically a rider himself (all happened to be male).

The policies and attitudes of the various road authorities toward motorcyclists are in a state of flux. Representatives of several said that in the past motorcycles were viewed like any other vehicle, but recently this has changed, largely because of the increase in motorcycle ridership and the great safety gains realized in passenger and commercial vehicles. Motorcyclists are the last high-fatality group to be addressed in the countries that have adopted Vision Zero safety goals. While many motorcycle riders bristle at the thought of being lumped in with bicyclists and pedestrians in the category of "vulnerable road users," they are much more prone to injury in crashes because of their relative lack of protection. Many of the countries visited have addressed pedestrian and bicycle safety issues by physically separating these users from motor vehicles. This generally is not possible with motorcycles, so agencies are considering other infrastructure and operational changes. The agencies visited are committed to incorporating motorcyclists into design decisions. This is formalized through motorcycle-specific road safety audits at the design phase and motorcycle-specific road assessment programs, such as the European Road Assessment Program (EuroRAP)[7] and the Pilot4Safety Program.[8]

The scan team noted that the agencies it visited were realistic about how motorcycles are actually used. As a result, policies and enforcement of laws on queue-jumping—also called lane-splitting in the United States and filtering in Europe—accommodate the fact that motorcyclists do queue jump and that the practice may have safety and operational benefits (see figure 2 on next page). Likewise, agencies responsible for parking enforcement in urban areas accommodate motorcycles by posting specific parking signs, designating motorcy-

Figure 2. A scooter rider filtering through urban traffic in Brussels.

cle parking areas on surface lots, and allowing multiple PTWs in a single automobile parking space.

Work Zone Activities

In general, the scan team noted that work zone practices are quite different in Europe than in the United States, although the team's exposure was for the most part limited to urban areas. The use of positive separation of active work areas was much less than in the United States, and road authorities reported that they are more likely to close entire lanes or roadways to complete road work than U.S. highway agencies. In general, there was much less signing, barriers, and channelization than in U.S. work areas.

The team observed that some agencies use auxiliary plaques on work zone advance warning signs warning of hazards specifically for motorcyclists. These included warnings of pavement edge differentials in London and grooved pavement (figure 3), loose gravel, and splash and spray warnings in Norway and Belgium (figure 4). The United Kingdom uses a "loose chippings" sign to warn of recent chip-seal activities.

Maintenance Practices

All of the agency maintenance practices discussed were those that benefited all road users, but may provide more benefit to motorcyclists because of their relative vulnerability to injury compared to automobile passengers. For instance, the Norwegian maintenance handbook has sections on clearing roadside obstructions that pose crash hazards and limit sight distance. This practice helps all road users, but can particularly benefit motorcyclists. Two unique maintenance practices organized by stakeholder groups were presented that could be adopted in the United States. One was a "road quality ride" organized by a rider group in Belgium, during which local motorcycle clubs ride together on a specific road to inspect and report on pavement quality and pick up debris and litter on the shoulder. The other was a roadway condition reporting system, either phone- or Web-based, aimed specifically at motorcyclists. Implementation of these systems varied from country to country. In Norway, for example, the Motorcyclists Union maintained a reporting

Figure 3. Work zone caution sign in Belgium with supplemental motorcycle plaque warning of grooved pavement (stries = striations).

IMAGE COURTESY OF BENOIT DUPRIEZ

Web site and a staff member vetted the reports before notifying the appropriate road authorities.

One maintenance practice observed in Norway was to pave the first few feet of gravel roadways and driveways where they intersect with highways and streets. This limited the amount of loose gravel spilling onto the paved roadway surface (see figures 5 and 6).

Traffic Control Device Design and Placement

Several agencies reported that sign post removal, either through consolidation of signs onto one post or relocation behind a barrier, was one strategy to provide a more forgiving roadside for motorcyclists. In several countries, the team observed lighter weight lattice sign posts, which were believed to be less of an injury threat to motorcyclists (see figure 7).

Figure 4. Splash warning sign in a work zone in Belgium.
PHOTO COURTESY OF BENOIT DUPRIEZ

Figure 6. After: 5 meters of driveway paved with asphalt at intersection with paved roadway.
PHOTO COURTESY OF HARALD HERMANSEN

Figure 5. Before: gravel and dirt from side of road washed onto paved roadway.
PHOTO COURTESY OF HARALD HERMANSEN

Figure 7. Lattice sign posts on a suburban arterial in Norway.

In Germany, a road improvement project suggested using flexible bollards or pylons in place of post-mounted delineators or chevron signs in curves (figure 8).

In urban areas, the use of advanced stop lines at signalized intersections (similar to bicycle boxes used in some U.S. cities) was observed (see figure 9). In some areas, queue-jumping lanes were provided to channelize PTWs safely to the front of the queue.

Pavement markings can pose a threat to motorcyclists because of the change in friction at the transition from pavement to marking material. This is particularly true for large pavement marking symbols, such as arrows, text, and crosswalk markings. One practice observed in Belgium and elsewhere was to leave a gap in the marking material so that motorcyclists could thread through the marking without encountering the change in friction (see figure 10).

Pavement marking material choices and application practices are discussed in the Belgian Road Safety Institute document on motorcycle considerations for motorcycles. It recommends textured pavement markings by troweling or using antiskid particles mixed in with retroreflective elements.

Figure 8. German example of curve delineation with flexible post delineators.
PHOTO COURTESY OF ROLF FRIELING, GERMAN BIKER FEDERATION

Figure 10. Gap left in crosswalk marking material for motorcyclist to pass through in Belgium.
PHOTO COURTESY OF BENOIT DUPRIEZ

Figure 9. Advanced stop line with queue-jumping designated lane (dashed line) for bicycles, but often used by powered two-wheelers in Brussels.

Figure 11. Troweled pavement marking binder material to increase texture and friction.
PHOTO COURTESY OF BENOIT DUPRIEZ

The presentations at the German Federal Highway Research Institute (BASt) included a recommendation for a sinusoidal cut design for centerline rumble strips (figure 12). This design reduces sharp pavement edges and height changes, which can pose hazards to motorcyclists.

Roadway Design Issues

The team learned that the agencies it visited use the same roadway design philosophy as the United States, with a desire for design consistency within functional class and harmonization of posted speeds with design characteristics. In Europe, as in the United States, specific vehicle sizes and driver eye heights are assumed for roadway design values. The lack of a design motorcycle and rider was noted in several countries visited. Despite these data gaps, federal transportation agencies, European Union-sponsored coalitions, manufacturers' groups, and research institutes have developed the various roadway design guidelines described in this chapter.

Figure 12. Centerline rumble strips with sinusoidal cut pattern to eliminate sharp edges that pose hazards to motorcyclists.

PHOTO COURTESY OF ANDREAS HEGEWALD, BASt

Roadside Safety Design, Testing, and Implementation

The most significant observation of the scan in the area of roadside safety was the use of motorcycle barriers. Injuries to motorcyclists from the posts of guardrail and cable median barriers have been reported, but the European officials the team met with provided no data on the frequency or rates of motorcyclist-post crashes and injuries or on motorcyclist dismemberment or decapitation because of barriers. The perceived hazard and anecdotal reports of crashes have led some agencies to stop installing cable median barriers, but it should be noted that cable median is used differently in Europe than in the United States. Cable median on European roads is used more frequently in curves and much closer to the roadway than in the United States.

For guardrails, several motorcycle-friendly barrier designs were developed more than 20 years ago to shield a body sliding on the pavement from the posts (see figure 13 on next page for one example). This treatment goes by many names, including the following:

- Slide rail
- Rub rail
- Motorcycle-friendly crash barrier
- Motorcycle-friendly guardrail
- Skirted rail
- Double rail
- Underrun barrier
- BikeGuard™
- Motorbike Protection System
- Motorcycle Protection Device
- Catching Plank
- Security Glide
- Enhanced Guardrail System

The team adopted the generic term "motorcycle barrier" to refer to any addition to a standard barrier specifically

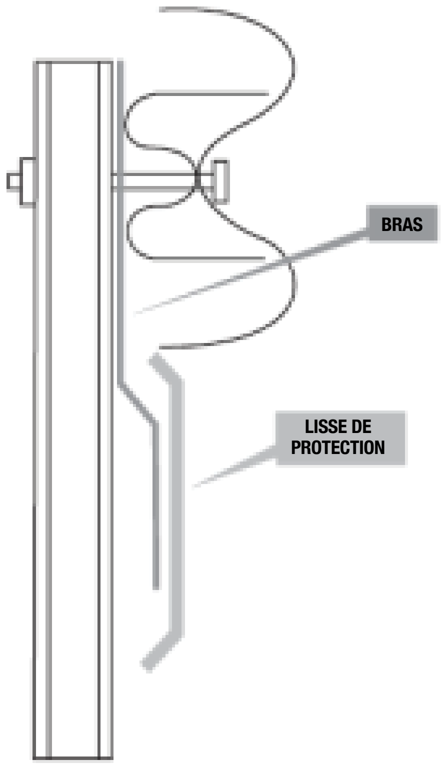

Figure 13. Cross-section drawing of W-beam guardrail equipped with lower motorcycle barrier.
PHOTO COURTESY OF BENOIT DUPRIEZ

Figure 14. Motorcycle barrier and crash test dummy at LIER in Lyon, France.

aimed at minimizing injury to motorcyclists because of unshielded components of the barrier. France, Portugal, Spain, and the United Kingdom have installed many kilometers of motorcycle barriers of various designs.

The Central European Committee for Standardization (CEN) adopted Resolution 319 on June 17, 2008, to improve the standard of safety barriers to take motorcyclists into account and reduce injuries and fatalities. Members of the Technical Committee on Road Equipment (TC226) adopted Resolution 319, registering a new item in their work programmed to "develop a European Standard, which reduces the impact severity of motorcyclist collisions with safety barriers, considering the existing national standards and the possibilities of present-day technologies." In absolute terms, a new part was added to the existing standard for road restraint systems (EN1317) to include "provisions for the evaluation of the performance of safety barriers under impact by a powered two-wheeled vehicle (PTW) rider sliding along the ground." This will take some time to implement.

These motorcycle-friendly barrier designs have been installed widely in some countries and in a limited way in other areas. France was conducting a large before-and-after crash outcome analysis of its installed barriers, which was expected to be completed in 2012. Spain conducted a crash-causation study in 2007 that included some analysis of guardrail crash types.[9] An earlier European Union-sponsored study on advanced protective systems also included some analysis of crash barrier types.[10]

The French government began developing tests and acceptance criteria for motorcycle barriers in 1998. The team witnessed a crash test at the Laboratoire d'essais INRETS Equipements de la Route (LIER) facilities near Lyon, France. In this test, a specially fabricated motorcyclist crash dummy is launched off a sled to slide toward the target guardrail headfirst at two orientations (angle of dummy to barrier). Acceptance criteria are based on forces applied to the head and neck of the dummy (figure 14). Additional standards work is directed at developing a crash dummy with the appropriate articulation and measurement points in the head and neck. The testing procedure proposed and being balloted among European Union members includes testing a motorcycle barrier with a motorcyclist dummy, a passenger vehicle, and a heavy vehicle. The standard was expected to be adopted in 2012. Additional work for a test conducted using an upright dummy on a motorcycle has already begun with an eye toward future revisions of the testing procedure.

German data suggest that in many crashes, motorcyclists impact the guardrail in an upright position and slide along the top of the rail. This crash posture produces an entirely different set of injury types. A barrier was designed that includes a cap along the top to prevent upper-body injuries from sliding along the top of the rail (figure 15).

Testing for this class of crash type and injury profile would require an upright impact. Research in Germany is investigating crash test procedures, including buggies (shown in figure 16 on next page), that deliver an upright motorcycle to the barrier being tested.

Although Spain was not part of the scan, important work in roadside barrier testing is being done there. Following the work done in France, Spain developed a national standard that included the same principle, but further developed the protocol. The main differences between the two are that the French dummy is a modified Hybrid II (with a Hybrid III head and neck), while the Spanish dummy is a modified Hybrid III with a frangible shoulder. Configuration of the second test is different (the Spanish test is headfirst between the posts). The Spanish standard has additional acceptance criteria, an additional speed (70 kilometers per hour), and two severity classes. The definition of the helmet is also different. Much of the standards work in Spain is being conducted at Automotive Transport Energy Research and Development (CIDAUT) in Boecillo.[11]

Spain's research on safety barriers began in 2003 under a mandate to work on a performance-based standard for evaluating safety barriers against full-scale motorcyclist impact. The General Road Directorate of the Spanish Ministry of Fomento and a private company conducted tests to establish the performance-based standard from 2004 to 2005, and in October 2005 Spanish standard UNE 135900-1.-2 was published. The standard defines two types of Motorcyclist Protecting Systems (MPS): punctual systems, or post absorbers, and longitudinal systems, or continuous systems. By 2007, more than 300 kilometers (km) of MPS on guardrails had been installed in Spain. An example of a conforming barrier is shown in figure 17 (see next page).

In 2008, the Norwegian Public Roads Administration rebuilt a 15-km road segment outside Oslo to provide a model of safety improvements for motorcyclists. The Vision Zero Motorcycle Road includes guardrails with motorcycle barriers, redesigned side terrains, consolidated signposts, larger clear zones, and improved sight distance around curves. Most of the improvements were general, low-cost safety improvements that would benefit all road users. The motorcycle barrier (see figures 18 and 19 on next page for before-and-after photos) was the only

Figure 15. Above: System Euskirchen Plus guardrail, which includes a bottom skirting and a cap along the top; right photo shows alternate cap design.

PHOTO COURTESY OF UWE ELLMERS, BASt

change made to specifically benefit motorcyclists. The road is heavily used as a leisure ride by motorcyclists, and this use helped justify the safety improvements.

Pavement Design

The use of high-friction surfaces specifically for motorcycles was not a widespread practice in Europe. Agencies in France reported that if a particular curve is identified as a crash black spot, open-graded asphalt mixes may be laid in that location. In England, high-friction surfaces were used at intersections. Some agencies had specifications limiting both the differential between adjacent pavement types and between the pavement and road markings because that differential causes grip problems for motorcycles.

Figure 16. Upright motorcycle barrier impact test procedure.
PHOTO COURTESY OF UWE ELLMERS, BASt

Figure 18. Norwegian Vision Zero Motorcycle Road before treatment.
PHOTO COURTESY OF PER HARALD HERMANSEN, NPRA

Figure 17. Spanish guardrail that meets motorcycle safety standards.
PHOTO COURTESY OF ALBERTO MANSILLA, CIDAUT

Figure 19. Norwegian Vision Zero Motorcycle Road after brush clearing and installation of motorcycle barrier on outside of curve.
PHOTO COURTESY OF PER HARALD HERMANSEN, NPRA

Intelligent Transportation Systems

As in the United States, Europe had several large intelligent transportation system (ITS) projects in the research and development phase. The one closest to implementation was an automatic emergency notification and localization system linked to a rider's mobile phone named e-Call. The goal is for a trans-European system, but issues remain on dispatch operator training and interagency agreements.

For ITS applications on signals and detection, the agencies visited reported the same problems with motorcycle detection as have been noted in the United States. These detection problems are particularly difficult when motorcyclists ride in platoons or alongside each other. The practice of lane filtering at intersections makes motorcycle lane positioning more variable, which poses additional problems for both video and inductive loop sensor systems.

ITS and vehicle infrastructure integration demonstration projects aimed at improving motorcyclist safety were underway:

- **SAFERIDER**—This multisite, multiyear project was designed to integrate advanced driver assistance systems and in-vehicle information systems into motorcycle design and operation. The project included activities in France, Germany, and Greece focusing on system requirements and human-machine interaction issues.[12] Motorcycle manufacturers were also involved.

- **WATCH-OVER**—This project was designed to provide ITS solutions, similar to vehicle-to-roadside and vehicle-to-vehicle communications, for vulnerable road users such as pedestrians and motorcyclists. This project involved several institutions and was led by Centro Ricerche Fiat near Turin, Italy.

Chapter 3. Safety Data

Both FHWA and AASHTO rely on good crash data and analysis to set safety program priorities. The Strategic Highway Safety Plan described in Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) and implemented by U.S. State DOTs and the AASHTO *Highway Safety Manual* use historical crash data.[13, 14] An FHWA-sponsored project underway in the United States on motorcycle crash causation will supply detailed analysis of a large sample of crashes.[15]

The European agencies the scan team visited had varying levels of detail in their crash report forms for capturing information about the motorcycle itself, the rider's training and protective equipment, roadway conditions, and roadside safety equipment. Each element is needed to conduct a thorough analysis of crash patterns and the efficacy of safety countermeasures aimed at reducing crash frequency and severity.

Crash Patterns

In general, the countries visited had crash patterns similar to those in the United States, with a high rate of single-vehicle roadway-departure crashes in rural areas and crashes involving motorcycles and passenger vehicles in urban areas because of right-of-way violations or visibility. In countries with high urban motorcycle use, crash frequency was higher in urban areas such as London and Paris. Likewise, the demographic pattern of those injured and killed in motorcycle crashes mirrors that of the United States. An increase in older riders on bigger bikes has led to an increase in those casualties. In most of the countries, the minimum age to be licensed for a motorcycle larger than 125 cubic centimeters was 18, so injuries and fatalities among 16- to 18-year-olds were lower than in the United States.

The team noted a great lack of uniformity in the denominator terms for risk exposure across the various agencies and stakeholder groups. Some used inhabitants, others used kilometers traveled by all vehicle types, others had estimates of motorcycle-kilometers traveled, and others used number of registered motorcycles or motorcycle operator licenses. Most agencies admitted that their estimates of motorcycle volume, vehicle counts, and other measures of exposure were not accurate. There was great variation across countries and regions of countries in injury severity scaling and reporting as well, including how many days after a crash to attribute a death. These problems also exist in the United States, and a new National Cooperative Highway Research Program (NCHRP) project will attempt to improve methods of collecting motorcycle volume data.[16]

The effect of seasonality and weather variations on crash patterns was noted in several countries. An unusually warm or rainy spring can cause year-to-year variations in motorcycle crash rates that do not occur in passenger vehicle crash rates. This variation points to the need to consider weather in any analysis of countermeasures and exposure data.

Data Management

Data collection and management practices varied greatly across the countries and even in different agencies of a single country. No agency reported that it had crash data elements specific to motorcycle crashes. There was little use of geocoding or geolocating of crashes at police agencies. Most agencies used traditional locating via mileage and road names, with some mapping through postprocessing.

The Association of European Motorcycle Manufacturers and the European Commission sponsored a large crash causation study (*MAIDS—Motorcycle Accidents In-Depth Study*[1]) with a great emphasis on urban crashes in southern European cities. The data are being used to prioritize safety programs throughout the European Union. The European officials the team met with expressed great interest in seeing the results of the ongoing U.S. crash causation study so that comparisons can be made. They also were interested in adding the U.S. analysis to the European study to increase the overall sample size and further diversify roadway types and traffic conditions.

Chapter 4. Behavioral Safety and Legal Issues

Behavioral Safety Programs

As the report introduction noted, the greatest differences the scan team observed between Europe and the United States were in behavioral safety. All of the countries visited had mandatory motorcycle helmet laws and more extensive initial-licensure training requirements than the United States.

In each of the countries the team visited, cooperation between motorcycle rider groups and government agencies was strong. The Federation of European Motorcyclists' Associations (FEMA) represents 19 countries' rider groups. Its mission is to raise awareness of motorcyclist issues with the European Union and agencies of the United Nations. FEMA has been instrumental in promoting roadside barrier safety testing and regulations as well as roadway design and traffic engineering standards. It also promotes rider safety education programs. Most program materials are published in an English version. Appendix D lists resources to access this material.

In the areas of public information and education, a promotion of respect for motorcyclists as legitimate road users was prevalent. Most agencies had a two-pronged approach to public awareness campaigns, with one effort directed at motorcyclists and the other aimed at making drivers of passenger vehicles more aware of motorcyclists on the road. One example is the THINK! Campaign developed and deployed by the Department for Transport in the United Kingdom.[17] This program uses personality profiles of different types of riders to develop educational campaigns that appeal to their unique set of motivations. Another campaign the scan team observed was aimed at car drivers in Belgium, who were urged to be on the lookout for motorcycles.

Legal Issues

Laws on licensing age, power of motorcycle engine allowed with different license classes, and training requirements varied considerably from country to country. Helmet use is mandatory throughout Europe. As a whole, the laws were more restrictive than those in the United States. The cost of training and licensing is much higher in Europe, as are traffic fines.

The European Union has introduced a new law to standardize European driver's licenses. This law includes provisions for moped permits as well as minimum age requirements based on motorcycle size. The Directive of the European Parliament and of the Council on Road Infrastructure Safety Management (COM(2006) 569 final) includes a general statement about supporting roadway design that includes motorcyclists as design users.

Figure 20. Belgian traffic safety poster: "Do not let yourself be surprised by the bikers. Be doubly careful."

Chapter 5. Research Activities

In the countries the scan team visited, the most significant motorcycle-related research underway is an analysis of the frequency and severity of motorcycle crashes involving guardrails before and after France's 2000 policy change on installing motorcycle barriers. The results of this research will inform further deployment of these barriers in France and U.S. policy on these barriers. A U.S. domestic scan is examining barrier and other infrastructure policy and deployment.

Other research activities of note included development of a motorcycle driving simulator at the National Institute for Transport and Safety Research (INRETS) in France. This simulator will be used to evaluate training and rider interactions with advanced vehicle systems. Research on training curriculum effectiveness and the effect of licensing rule changes, including graduated driver's motorcycle licensing, was also underway in several of the countries visited. A multicountry naturalistic motorcycle driving study sponsored by the European Union was about to start that promises to gather useful information on the types of traffic and roads riders encounter. Naturalistic studies equip vehicles with recording instrumentation and cameras, and research participants drive the vehicles for a long time period. A similar U.S. study, cosponsored by the Motorcycle Safety Foundation and NHTSA, is underway at the Virginia Tech Transportation Institute. A consumer information program for helmet crashworthiness is being developed in the United Kingdom, and test methods are being evaluated at the Transport Research Laboratory there.

The European Union also funds cross-border research and demonstration projects. One project supports the development and testing of the Smart Road Restraint System at the University of Zaragoza in Spain. This ongoing project is developing a smart guardrail that includes sensors to automatically notify emergency responders if it is struck.[18]

Figure 21. Stephane Espie of INRETS demonstrates a motorcycle simulator.

Chapter 6. Major Findings and Implementation Plan

Findings

- Motorcycle crash trends in the European countries visited were similar to those in the United States. Motorcycle use patterns differed from those in the United States, particularly in urban areas where more use of scooters, mopeds, and motorcycles was observed.

- Agencies in Europe work closely with motorcycle rider groups to identify safety problems and promote safety.

- Several European agencies used a motorcycle coordinator to serve as an internal advocate for motorcyclist safety and priority in planning and operations.

- Several European agencies have developed roadway design guidelines and standards that specifically address motorcycle issues.

- Urban areas in the countries visited have recognized an increase in the use of PTWs and have accommodated this mode shift by providing parking, special-use lanes, and reduced road user fees and permitting PTWs in bus and bicycle lanes.

- No single infrastructure change was identified that has been proven to reduce motorcyclist injury frequency or severity.

- Very few pavement surface treatments, such as friction courses, aimed at motorcycle safety were observed. Pavement marking materials that reduce the difference in friction between markings and adjacent pavement were used in some areas. Applications of pavement markings that provide unmarked gaps for motorcycles were observed.

- New guardrail designs intended to reduce injury severity to motorcyclists have been developed in Europe and are being evaluated for safety effectiveness. Crash testing and acceptance criteria for these motorcycle barrier designs are being developed.

- Behavioral safety programs aimed at both motorcyclists and car drivers were the most prevalent safety improvement programs observed.

Recommendations

- Long term (longer than 2 years)
  - ☐ Agencies in the United States should establish goals to reduce motorcycle injuries and fatalities through roadway design, operations, and maintenance practices.
  - ☐ AASHTO should develop PTW design vehicles for use in design guidelines and/or assess current guidelines to determine if design values would change when PTW vehicles are considered.
  - ☐ Metropolitan planning organizations and urban planners should consider motorcycles in decisions on travel demand, land use, and parking as data are available.
  - ☐ Develop curriculum materials for transportation professionals on motorcycle accommodations and considerations in design, maintenance, and operations for both university and continuing education courses.
  - ☐ Promote consideration of motorcycles in connected vehicle programs and other ITS development. Investigate telematics equipment needs specific to motorcycles in terms of size, weight, and exposure to the elements.
  - ☐ Develop a motorcycle research agenda that includes the following activities:

- Document motorcycle crash patterns, types, injury severity and survivability, and causation. These analyses should include consideration of exposure factors, taking into account ridership patterns, traffic volume, roadway type, weather, and other factors unique to motorcycle use. These data will help support subsequent research activities, especially on barrier design. This agenda should include the FHWA crash causation study.

- Evaluate international research findings on safety effectiveness of motorcycle barrier design and installation policies to assess applicability to U.S. roadways and road use patterns.

- Work with motorcycle committees or safety committees at AASHTO or the Transportation Research Board (TRB) to develop research statements that focus on causation and mitigation of injuries in addition to fatalities.

- Evaluate the effect of motorcycle presence in preferential-use lanes on safety, mobility, and air quality.

- Evaluate the need for and develop additional motorcycle-specific warning signs for roadway hazards, geometric design, and work zone conditions. Test effectiveness and comprehension of devices.

- Investigate the benefits of motorcycle-friendly pavement marking materials and application techniques.

- Investigate motorcycle performance characteristics on pavement differentials because of paving operations and other work zone activities.

■ Short term (within 2 years)

☐ Develop a checklist of motorcycle issues in design, maintenance, and operations for use in roadway safety audits in the United States.

☐ Promote the creation of motorcycle safety coordinator positions in State and local agencies.

☐ Foster relationships between DOTs and rider groups, including the creation of advisory groups to DOTs with representatives from the motorcycle community.

☐ Review pavement marking application guidelines to assess whether they can be revised to provide gaps for motorcycles to traverse large pavement marking areas.

☐ Increase use of advance warning traffic control devices for motorcycle hazards (see *Manual on Uniform Traffic Control Devices* Sections 2C.33, 6F.54). This will be achieved by outreach to the appropriate AASHTO committees and communication with State highway agency personnel.

☐ The international motorcycle scan team will coordinate with the domestic motorcycle safety scan team to develop and disseminate research findings, best practices, model policies, and guidance.

☐ Coordinate with domestic scan activity underway through NCHRP.

☐ Encourage motorcyclists to use existing State DOT roadway condition reporting systems by compiling a list of contact information and disseminating it to rider groups.

☐ Write a research statement for an NCHRP synthesis report to review the literature on which maintenance activities provide the best benefit-cost ratio for reducing motorcycle crash numbers and severity. These activities should be prioritized based on those that will prevent crashes (e.g., removing road debris) compared to those that mitigate postcrash injuries (e.g., clear zones).

Implementation

Paul Degges of the Tennessee DOT leads the Scan Implementation Team. Other members are Carol Tan of FHWA, consulting engineer Mark Bloschock, and Nicholas Garber of the University of Virginia. The team is developing a plan that prioritizes the practices observed that can be implemented in the United States and identifies the action steps needed.

The success of this international scan can be measured by the number of ideas brought back to the United States and translated into strategies that will improve roadway infrastructure safety for motorcyclists. The team developed the following strategies from the knowledge it acquired during the scan and believes them to be the most critical for making progress in the United States:

Disseminate Information and Recommendations

The first implementation item the team identified is to disseminate the scan findings. This will be accomplished by presentations at State and national traffic safety conferences, roadway and roadside design conferences, and events attended by operations and maintenance staff. Other venues for dissemination include motorcyclist groups; Web sites maintained by DOTs, safety advocacy groups, and motorcycle manufacturers; and articles in trade journals, professional publications, and newsletters. There is a need to promote motorcycle considerations in guidance documents for planning, design, operations, and maintenance. One way is to promote the idea of a motorcycle coordinator in state DOTs, similar to existing positions for the Bicycle and Pedestrian and Safe Routes to School programs.

Gather Facts and Add Key Details to Motorcycle Safety

The second item the team identified is to fill in gaps in knowledge to develop evidence-based strategies to improve safety for all road users. One example is the need for a standard design motorcycle, similar to design passenger and heavy vehicles used in roadway design manuals. This design motorcycle would include vehicle dynamics parameters, such as braking distance, and physical parameters, such as weight, needed for calculations for design and operations. Another way to gather facts is for DOTs to establish roadway condition reporting systems specifically for motorcyclists. Such a system could identify problem areas such as pavement surface condition, sight distance, traffic signal controller malfunctions, and shoulder condition.

Conduct Research Program for Motorcycle Infrastructure Safety

The third area the team identified is the need to develop a comprehensive research roadmap to evaluate the effectiveness and benefits of various safety strategies. This goal could be accomplished by working with relevant TRB standing technical committees to develop research problem statements for NCHRP consideration. The implementation team developed an initial list of research needs:

- Develop crashworthiness acceptance criteria for roadside safety hardware.
- Evaluate the effect of motorcycle presence in bus lanes on safety, mobility, and air quality.
- Test effectiveness and comprehension of motorcycle-specific warning signs used for pavement surface (e.g., milled pavement, loose gravel).
- Analyze traffic flow in urban and suburban areas to estimate the effect of near-miss events.

Update Design Guidelines to Accommodate Motorcyclist Safely

The final area the implementation team identified is to establish uniform practices across the Nation and improve the overall safety of the highway transportation system through the application of design guidelines. This goal could be accomplished by integrating motorcycle-specific considerations into existing standards and guidelines documents, such as the *Manual on Uniform Traffic Control Devices* (MUTCD), the AASHTO *Policy on Geometric Design of Highways and Streets* (Green Book), and the AASHTO *Roadside Design Guide.* As part of these efforts, criteria for motorcycle-friendly barrier installation must be developed. One way for more motorcycle-specific traffic control devices to be adopted is for a representative from a motorcycle advocacy group, such as the American Motorcycle Association, to apply for membership on the National Committee on Uniform Traffic Control Devices, an independent advisory group to FHWA on MUTCD.

Appendix A. Amplifying Questions

The scan team members developed questions to be answered during the motorcycle safety international scan. The following is a consolidated list of these amplifying questions sorted into topic categories.

1. Infrastructure Improvements
    - 1.1 Standards and Policies
    - 1.2 Work Zone Activities
    - 1.3 Maintenance Activities
    - 1.4 Traffic Control Device Design and Placement
    - 1.5 Roadway Design
    - 1.6 Roadside Safety Design
    - 1.7 Pavement Design
    - 1.8 Intelligent Transportation Systems
2. Safety Data
    - 2.1 Crash Patterns
    - 2.2 Data Management
3. Behavioral Safety and Legal Issues
4. Research Activities

Infrastructure Improvements

1.1 Standards and Policies

1.1.1. How many different agencies address motorcycle safety and how are the overlapping responsibilities addressed?

1.1.2. Is any portion of your safety improvement funding dedicated specifically to issues for motorcycles?

1.1.3. Have you established motorcycle-specific design standards for roads; if yes, what are they?

1.1.4. Have planning, design, and maintenance policies and practices been put in place specifically to address motorcycles? Are these standards and practices national or local?

1.1.5. What engineering techniques have you used that have resulted in significant reductions in the frequency or severity of motorcycle crashes?

1.1.6. Is there a standard time interval for revising infrastructure design and operational standards? Can this be accelerated to accommodate changes intended to aid motorcyclists?

1.1.7. Is motorcycle usage included in travel demand models? How else are motorcycles considered in the planning process?

1.2 Work Zone Activities

1.2.1. What new motorcycle-friendly construction techniques have you employed in the past 10 years, 5 years, 3 years, 1 year?

1.2.2. How do you protect motorcyclists and minimize impact to motorcycles when requiring lane shifts across uneven or irregular pavements, dissimilar pavements, and longitudinal joints?

1.2.3. If using steel plates to cover temporary open work, do you warn motorcyclists? Are steel plates required to be covered with skid-resistant material?

1.2.4. Has your country developed specific guidelines for laying out work zone roadway geometric features to accommodate motorcycle traffic?

1.2.5. For construction projects, do you have any policy or guidance for motorcycle safety on the following:

1.2.5.1. Selection and placement of temporary traffic control devices and barriers

1.2.5.2. Debris removal from travelways and pavement surfaces

1.2.5.3. Pavement surface conditions for temporary traffic shifts

1.2.5.4. Pavement surface conditions for reclaimed pavement

1.2.5.5. Special considerations for pavement reclamation elevation differentials with catch basin, access covers, and utility shutoff valves in suburban and urban systems

1.2.5.6. Control of work zone area loose surfaces, dust control, and application of calcium chloride for dust control (slippery when wet)

1.2.5.7. Use of temporary blackout tape to cover existing roadway markings

1.3 Maintenance Activities

1.3.1. What new motorcycle-friendly maintenance techniques have you employed in the past 10 years, 5 years, 3 years, 1 year?

1.3.2. Do you have policies on maintenance cleanup of sand or salt used for winter applications within the travelway and/or shoulders?

1.3.3. Do you have policies on maintenance cleanup of vehicle fluids on pavement, especially at intersections?

1.3.4. What policies are in place to address repairs to damaged infrastructure following a vehicle crash (any vehicle type)?

1.4 Traffic Control Device Design and Placement

1.4.1. Do you require specific signage on roads and intersections with high motorcycle traffic? How do you make this determination and what do you evaluate or consider?

1.4.2. What type of pavement markings do you use and how have you analyzed their impacts on motorcycle traction (for both longitudinal markings and crosswalks)?

1.4.3. Have motorcyclists raised issues with shoulder or centerline rumble strips? If so, how have these issues been addressed? Do you have specific standards for widths, depths, and/or locations?

1.4.4. How are motorcycles considered in any low-cost safety solutions you use (e.g., signage position, colored pavement in high-crash areas, text or symbols on pavement, sleeping policeman or speed bumps, etc.)?

1.5 Roadway Geometric Design

1.5.1. Do you have specific roadway design practices to accommodate motorcycles? Do any of these conflict with the needs of other road users?

1.5.2. Do you make provisions in intersection design to increase safety for motorcyclists?

1.5.3. Do the design standards consider motorcycle size or assume a standard size?

1.5.4. Are there specific policies for the design of low-volume roads to accommodate motorcycles?

1.5.5. Has your bridge design been changed in any way to accommodate motorcycles (e.g., what is your selection criteria for steel bridge grating and does it consider motorcycle tires in its selection)?

1.5.6. Do you use any special roadway or drainage design in tunnels to accommodate motorcycles?

1.6 Roadside Safety Design

1.6.1. Do you consider motorcycles as you plan the use of roadway barriers and terminal placement on the motorways, rural roadways, and/or urban system?

1.6.2. Have you seen any advancements in guardrail, bridge rail, or median cable barriers to protect motorcyclists (controlled crash) when a crash occurs?

1.6.3. How are appropriate locations identified for implementation on motorcycle-friendly barriers? Is there an incremental cost and how is it evaluated in the selection process?

1.6.4. Has testing of barriers to accommodate motorcycles been performed? Are there any standards governing test procedures and/or acceptance policies?

1.6.5. Are there requirements for clear zones and, if so, have motorcycles been considered in their establishment?

1.6.6. Do you limit the locations for placement of utility access covers and shutoff valves, etc., within travelways?

1.6.7. Do you have any policy or guidance for wildlife animal control along highways to reduce the threat of animal-motorcycle impacts?

1.7 Pavement Design

1.7.1. Do you adjust your pavement treatments to accommodate motorcycles (including things like grooving and use of porous asphalt)?

1.7.2. Have you analyzed the impact of pavement crack sealant on motorcycle traction?

1.7.3. Are pavements monitored for degraded ride surface related to the greater impact on motorcycles?

1.7.4. Do you adjust treatment for pavement delamination (potholing) and wide surface cracks (i.e., wide longitudinal and lateral pavement cracks) to accommodate motorcycles?

1.7.5. Do you consider motorcycles in the maintenance treatment for pavement edge dropoffs along travelways and shoulders (this includes safety edge treatments)?

1.7.6. Do you consider motorcycles in the maintenance of pavement edges at utility access covers, drainage catch basins, and utility shutoff valves located in and next to travelways because of spring freeze-thaw cycles causing different pavement elevation conditions?

1.8 Intelligent Transportation Systems

1.8.1. Is presence detection equipment (e.g., loop detectors) designed to detect motorcycles at signalized intersections? Does this equipment also work for vehicle gap detection at smart intersections?

1.8.2. Do you use any active traffic management techniques to dynamically allow use of motorcycles on shoulders or other flexible operations such as filtering or queue-jumping at intersections?

1.8.3. Are other intelligent vehicle programs aimed at motorcycles?

1.8.4. Is motorcycle license plate (number plate) recognition an issue for automated enforcement or tolling operations?

Safety Data

2.1 Crash Patterns

2.1.1. In your country, what is the trend in motorcycle crashes over the past 10 years? How does this correlate with motorcycle traffic volumes? Are these trends different for different roadway classifications (motorway, rural, urban)?

2.1.2. Do you have a factsheet or summary document on motorcycle crash patterns by roadway class, driver characteristics, time of day, objects struck, etc.?

2.1.3. How often is weather or road conditions a factor in crashes? How does it correlate to the vehicular crashes at the same or adjacent location?

2.1.4. Have you used any of the MAIDS data for crash causation analyses (MAIDS—Motorcycle Accidents In-Depth Study)?

2.1.5. Has vehicle compatibility been addressed in any crash testing standards for other vehicles, that is, when testing car or truck crashworthiness are motorcycles considered either as the struck vehicle or the striking vehicle?

2.1.6. Have you seen an increase in ridership in recent years? If so, what are the contributing factors?

2.2 Data Management

2.2.1. Which agency or agencies are responsible for the collection of data on motorcycle-involved crashes? Is there a centralized database for all motorcycle crashes or is it locally maintained?

2.2.2. Do your crash data include both injury and fatal crashes? Do you use the same crash type and injury severity ratings for motorcycle crashes as passenger vehicles?

2.2.3. Do your crash data include specific motorcycle vehicle configurations, such as sidecars or trailers?

2.2.4. Does your country compute motorcycle-involved fatality rates and/or motorcycle-involved crash rates? If so, what exposure factor is used?

2.2.5. Are your crash data linked to a geographic information system (GIS) or other mapping system?

2.2.6. What roadway design data are recorded in crash reports and investigations?

2.2.7. Do you have vehicle classifications to include motorcycles as part of design traffic counts? If so, do you differentiate several classes of motorcycles based on engine size or other criteria?

2.2.8. How frequently are motorcycle volumes collected? Is this the same for all road classifications, or is this done at different time intervals based on the type of road system?

2.2.9. Are there data you are not collecting that you believe would help you in your safety analyses?

Behavioral Safety and Legal Issues

3.1. Does your motorcycle driver training include specific curriculum on how to avoid roadway hazards such as steel plates, pavement edge dropoffs, etc.?

3.2. Is information on short- and long-term road hazards of particular concern to motorcyclists (construction zones, potholes, metal plates, milled surfaces, etc.) made available electronically?

3.3. How do you receive feedback from motorcycle riders on the conditions of your roadways?

3.4. Do you have any public awareness campaigns aimed at passenger vehicle and commercial vehicle drivers intended to raise awareness of roadway infrastructure hazards to motorcycles? If so, who sponsors these?

3.5. Are motorcycles allowed in high-occupancy vehicle or carpool lanes? Are they buffered? Have studies been done to determine the safety benefit to motorcyclists of buffered carpool lanes?

3.6. Are motorcycles allowed on high-occupancy toll lanes? On shoulder-use lanes used for active traffic management?

3.7. Are motorcyclists allowed to ride between traffic lanes on motorways (freeways)? If so, have the safety impacts been studied? Is this allowed in work zones?

Research Activities

4.1. What research have you conducted or is ongoing on motorcycle safety?

4.2. Has your country conducted an indepth study on the cost of motorcycle injury crashes? If so, are there any specific factors that influence the cost of these crashes? If so, have results been implemented and evaluated?

4.3. What are the key research needs in your view?

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Biographical Sketches

David Nicol (cochair) is the director of the Federal Highway Administration's (FHWA) Office of Safety Design. He leads a staff of safety professionals providing national leadership for the administration of programs and the promotion of practices relating to the development and incorporation of road and roadside features that will improve highway safety performance by reducing the number and severity of highway crashes. His office has expertise in the areas of highway safety infrastructure features, including pavement skid resistance, roadway geometrics and cross-sections, roadside safety features, traffic control devices, and highway-rail grade crossings. Before coming to the Office of Safety in 2008, Nicol served as the division administrator of FHWA's Colorado Division. He previously served in various engineering, planning, and management positions with FHWA in California, Delaware, and Georgia. Nicol has a bachelor's degree in civil engineering from Southeastern Massachusetts University and is a registered professional engineer in Georgia.

Dennis W. Heuer (cochair) is the Hampton Roads District administrator for the Virginia Department of Transportation (VDOT) in Suffolk, VA. He leads 1,000 State employees delivering construction, engineering, maintenance, and operations services over 7,400 lane-miles of highways in southeastern Virginia. He also manages a ferry system, four bridge-tunnels, and a toll bridge with an annual district budget of more than $400 million. Before joining VDOT, he served as a program and project manager for Thompson Engineering in Mobile, AL, after retiring from the U.S. Army as a leader of engineer units. Heuer earned a bachelor's degree in aerospace engineering from the Polytechnic Institute of Brooklyn, NY, and a master's degree in civil engineering from Pennsylvania State University in State College, PA. He is a registered professional engineer in 13 States, including Virginia. Professional memberships include the American Society of Civil Engineers (ASCE), American Society of Highway Engineers, and Harley Owners Group, where he has merged his interest in road and bridges with motorcycle safety.

James Baron is the director of communications and public relations for the American Traffic Safety Services Association (ATSSA), headquartered in Fredericksburg, VA. Worldwide, ATSSA members manufacture and install roadway safety features and devices. Before joining ATSSA in 1999, Baron completed a 23-year career in the military, serving as a print and broadcast journalist and public affairs professional in the U.S. Navy. His many duties, both domestically and abroad, included serving as the primary media spokesman at the world's largest U.S. Navy Base in Norfolk, Va.; a writer, reporter, and director of broadcasting, public relations, and photography; and station manager of a radio and television outlet near Nagasaki, Japan. Baron is a member of the Public Relations Society of America, the American Society of Association Executives and the Fredericksburg (VA) Chamber of Commerce. Baron has a master's degree in education from the University of Phoenix. Since 1983, he has been an avid motorcyclist.

Mark Bloschock is a senior vice president of VRX Engineering in Austin, TX. Bloschock graduated from the University of Houston with a bachelor's degree in civil engineering and worked for the Texas Department of Transportation for almost 26 years. During that time, he was involved with the design and construction of most types of bridges in Texas and with the required full-scale crash testing of safety barriers. He also worked for the FHWA Office of Safety Roadway Departure Team.

Dr. Susan Chrysler (report facilitator) is a senior research scientist in the Center for Transportation Safety and the manager of the Human Factors Program at the Texas Transportation Institute. Her areas of expertise include human factors, driver behavior, older driver issues, visual attention, traffic control devices, and photometry. Since joining TTI in 2001, Chrysler has led projects on sign and pavement marking design, comprehension, and visibility. Before joining TTI, Chrysler was a human factors specialist in the Traffic Control Materials Division Laboratory of the 3M Company. Her work at 3M involved product development, conducting original visibility research, and developing marketing tools. Chrysler received her Ph.D. in experimental psychology, with a minor in cognitive science, from the University of Minnesota in 1993. Her bachelor's degree in psychology is from the University of Minnesota. Chrysler is a member of several Transportation Research Board (TRB) committees and is the past chair of the Surface Transportation Technical Group of the Human Factors and Ergonomics Society. She also chairs Human Factors Resources, a sponsor group for the National Committee on Uniform Traffic Control Devices.

Keith Cota is the chief project manager for the New Hampshire Department of Transportation (NHDOT) and is in charge of the department's project development program. Cota represents NHDOT on the American Association of State Highway and Transportation Officials (AASHTO) Technical Committee for Roadside Safety (TCRS). He has been a TCRS member since 1994 and chairman from 2004 to the present. TCRS is responsible for roadside safety guidance through the updates of two AASHTO documents, *Roadside Design Guide and Manual for Assessing Safety Hardware.* Cota serves on several National Cooperative Highway Research Program (NCHRP) panels on roadside safety. He also represents AASHTO on the Technical Committee for Road Safety for the World Road Association (PIARC). He has a bachelor's degree in civil engineering from Clarkson University and is a registered professional engineer in New Hampshire.

Paul Degges is chief engineer at the Tennessee Department of Transportation (TDOT), where he oversees all engineering projects and divisions as well as the four regions. Degges received a bachelor's degree in civil engineering from Tennessee Technological University and is a licensed engineer. He started his career with TDOT in 1988 working in field construction, roadway design, and information systems and later moved into the Hydraulic Design and Permitting Section of the Structures Division. He joined the Construction Division in 1998 as assistant director managing the departments' Region 4 contracts. Degges served as the director of Region 3 from 2000 until becoming chief engineer in mid-2003.

Dr. Nicholas Garber is the Henry L. Kinnier Professor of Civil and Environmental Engineering at the University of Virginia. He is a past chairman of the department. He is now the director of the Center for Transportation Studies. His research interests are traffic operations and safety. He has served as the principal investigator for many safety-related research projects sponsored by Federal, State, and private agencies. He has authored more than 100 refereed publications and reports, many on causal factors for different types of highway crashes and developing crash estimation models. He has also coauthored two textbooks. Garber is a member of the National Academy of Engineering. He obtained a bachelor's degree from the University of London and master's and Ph.D. degrees from Carnegie Mellon University. He is a member of the National Academy of Engineering and ASCE's Committee on Highway Safety and Traffic Operations. He has also served on several TRB policy studies related to highway safety. He is a fellow of ASCE, the Institution of Transportation Engineers, and the Institute of Civil Engineers of the United Kingdom. He is a registered professional engineer in Virginia and the United Kingdom.

Jeffrey Kolb was the division administrator for the FHWA New York Division in Albany, NY. Kolb administered the $1.6 billion Federal-aid highway program for the State of New York. This included initiating and implementing activities and programs to reduce highway-related fatalities, including the high rate of motorcycle fatalities in New York. Kolb worked for FHWA for more than 25 years with experience in some of the more motorcycle-friendly climates in the country, such as Colorado, Florida, and Southern California, and was a leader in using innovative approaches to address transportation issues. Kolb earned a bachelor's degree in civil engineering from North Carolina State University and a master's degree in civil engineering from Florida State University. He was a licensed professional engineer in Florida. Kolb passed away in October 2010.

Melinda McGrath is chief engineer and deputy executive director of the Mississippi Department of Transportation (MDOT) She earned a bachelor's degree in civil engineering from Mississippi State University in 1985 and began her engineering career in MDOT's Bridge Division. After serving as project engineer in both the Northern and Southern Districts and district area engineer over six coastal counties, she was named assistant chief engineer in 2003. In August 2008, she was promoted to chief engineer.

Edward Moreland is senior vice president for government relations of the American Motorcyclist Association (AMA). AMA, formed in 1924, aims to promote the motorcycle lifestyle and protect the future of motorcycling. It is the world's largest individual motorcyclist membership advocacy organization, representing more than 280,000 U.S. riders before lawmaking bodies at the local, State, national, and international levels. Moreland represents AMA on several international committees, including the Commission on Public Affairs of the Fédération Internationale de Motocyclisme (FEMA). Before joining AMA in 1998, Moreland served on the staffs of legislators from his native Minnesota. Moreland earned a bachelor's degree in political science from the University of Minnesota.

Dr. Carol H. Tan is the team leader for safety management in FHWA's Office of Safety Research and Development at Turner-Fairbank Highway Research Center in McLean, VA. Her team focuses on identifying safety problems, developing analysis tools, and evaluating the effectiveness of potential solutions to ensure that highway safety resources are appropriately allocated to maximize the reduction of the frequency and severity of all highway crashes. She is the coteam leader of FHWA's Motorcycle Safety Program and the project manager for a congressionally mandated Motorcycle Crash Causation study. Tan has a master's degree in civil engineering from Texas A&M University and a doctorate degree in civil engineering from Pennsylvania State University. She has served on NCHRP panels and is a member of TRB's Safety Data, Research, and Analysis Committee.

Appendix D. References and Additional Internet Resources

International Technology Exchange Program. Federal Highway Administration Web site, Federal Highway Administration, U.S. Department of Transportation. http://international.fhwa.dot.gov/tmpl.cfm?title=scanning.

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Norwegian Public Roads Administration Handbook 245e: *Motorcycle Safety Design and Operation of Roads and Traffic Systems.* http://arkiv.nmcu.org/publ/vegdir_handbok245/handbook245e.pdf.

Association of European Motorcycle Manufacturers, *Guidelines for PTW-Safer Road Design in Europe.* www.acem.eu/media/d_ACEMinfrastructurehandbookv2_74670.pdf.

European Union, *European Safer Urban Motorcycling, eSUM, Good Practice Guide.* www.esum.eu/gpg.html.

European Road Assessment Program. www.eurorap.org/.

Barriers to change: designing safe roads for motorcyclists. www.eurorap.org/library/pdfs/20081202_Bikers.pdf

Lattix Lightweight Sign Post System. www.lattix.net/.

National Cooperative Highway Research Program Project 08-81: Improving the Quality of Motorcycle Travel Data Collection. http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2956.

U.S. Department of Transportation, Federal Highway Administration, Motorcycle Crash Causation Study. http://safety.fhwa.dot.gov/safetealu/fact_sheets/ftsht5511.cfm.

THINK! Road Safety. Department for Transport, United Kingdom. www.dft.gov.uk/think/focusareas/motorcycling?whoareyou_id=&page=Overview.

U.K. Motorcycling Web Sites

www.shinysideup.co.uk/

Bare Bones Project: For riders of Twist ‘n’ Go’s and bikes under 125 cc
www.bare-bones.org/

U.K. Police Bikesafe
www.bikesafe.co.uk/

Bedfordshire Police Ridesafe
www.motorcyclingmatters.org/ridesafe/

Hampshire Police Edge44
www.hampshire.police.uk/Internet/Specialist+Units/operations/rpu/bikesafe.htm

Avon and Somerset Police Ride to Arrive
www.ridetoarrive.org/main_page.asp

Buckinghamshire Better Biker
www.buckscc.gov.uk/bcc/transport/motorbikes.page

Devon County Council
www.devon.gov.uk/bikers

Devon County Council
www.maxrider.co.uk/

Lancashire County Council
www.ridesafebacksafe.co.uk/

South Gloucestershire Council
www.smidsy.co.uk/

Somerset and Gloucester Councils
www.castlecombecircuit.co.uk/trackdays/events/motorcyclesafety.asp

Lincolnshire County Council Performance Plus
http://microsites.lincolnshire.gov.uk/LRSP/section.asp?docId=63394

Driving Standards Agency Enhanced Rider Scheme
www.direct.gov.uk/prod_consum_dg/groups/dg_digitalassets/@dg/@en/@motor/documents/digitalasset/dg_171825.pdf

Department for Transport Think!
www.dft.gov.uk/think/focusareas/motorcycling?whoareyou_id=&page=Overview

Detail of training and testing regime
www.dft.gov.uk/think_media/241027/241127/2010mc-routestomotorcycling.pdf

Get On campaign
http://www.geton.co.uk/

Report road defects
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