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16. Abstract

The objective of this research project was to develop a statewide plan to reduce motorcycle crashes and injuries in the state of Texas. The project included a review of published literature on current and proposed countermeasures for reducing the incidence and/or severity of motorcycle-involved crashes and related injuries, a review of existing and emerging Intelligent Transportation System (ITS) and other advanced technologies for motorcycles and other vehicles, an analysis of Texas motorcycle crash and injury data, and a statewide survey of Texas motorcycle riders that explored the demographics, riding histories, training and licensing status, use of protective gear, crash involvement, and attitudes toward various motorcycle safety countermeasures. These data collection activities culminated in a list of potential motorcycle crash and injury countermeasures; these countermeasures were then evaluated and prioritized in a workshop attended by motorcycle safety experts and advocates.

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DEVELOPMENT OF A STATEWIDE MOTORCYCLE SAFETY PLAN FOR TEXAS: TECHNICAL REPORT

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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

This report is not intended for construction, bidding, or permit purposes. The researcher in charge of the project was Patricia Turner.

The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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CHAPTER 1. INTRODUCTION

Nearly one in seven people killed on Texas roadways each year is a motorcycle rider. While motorcycle crashes, injuries, and fatalities declined 19 percent from 2008 to 2010, these trends are already showing a reverse. Early 2012 data from the TxDOT Crash Records Information System (CRIS) show motorcycle deaths rising by 10 percent from 422 to 462 in 2011.

This report documents the research conducted in TxDOT Project 0-6712, "Evaluation of the Measures and the Development of a Plan to Reduce the Number and Mitigate the Severity of Crashes Involving Motorcyclists on Texas Highways." The product of this research effort is a statewide motorcycle safety plan, which includes countermeasures and outreach activities to prevent and/or mitigate motorcycle crashes and associated injuries and fatalities in Texas. The plan is intended to provide a baseline from which TxDOT's districts and Traffic Operations Division can effectively measure and track implemented countermeasures and programs, and, if necessary, make changes to motorcycle safety efforts.

Project 0-6712 included six tasks:

- A review of published literature from the United States and abroad on current and proposed countermeasures for reducing the incidence and/or severity of motorcycle-involved crashes and related injuries.
- A review of existing and emerging Intelligent Transportation System (ITS) and other advanced technologies for motorcycles and other vehicles that help to address key safety issues.
- An analysis and synthesis of Texas motorcycle crash and injury data.
- A statewide survey of Texas motorcycle riders that explored the demographics, riding histories, training and licensing status, use of protective gear, crash involvement, and attitudes toward various motorcycle safety countermeasures.
- Identification of countermeasures to reduce the risk of a crash from occurring and to reduce the severity of injury in the event of a crash.
- A workshop in which motorcycle safety experts and advocates evaluated and prioritized potential crash countermeasures for implementation in Texas.
- The development of a broad-based plan for improving motorcyclist safety.

The remainder of this report is divided into five chapters. Chapter 2 is the literature review describing proposed motorcycle crash and injury countermeasures. Chapter 3 describes ITS and advanced technologies for motorcycle and motor vehicles that have potential to increase motorcyclist safety. Chapter 4 is an analysis of motorcycle crash and injury data in Texas covering the years 2006 to 2010. Chapter 5 describes the statewide survey of motorcyclists and its results. Chapter 6 presents the list of potential crash and injury countermeasures that was assembled by the research team as well as the revised list that resulted from the countermeasures workshop discussions held at TTI on January 24, 2013.

CHAPTER 2. LITERATURE REVIEW

Researchers completed a review of the literature on studies identifying approaches to reduce motorcycle crashes and mitigate injuries after a crash has occurred. Transportation Research Information Service (TRIS) and Transport database searches yielded over 100 journal articles, government reports, comprehensive studies, broad-based syntheses, technical references, and meta-analyses of the motorcycle safety research between the years 2000–2010. After initial review, researchers identified 32 references that were most relevant to the completion of this task.

CRASH CAUSATION

The last in-depth research into motorcycle crash causation in the United States occurred during the late 1970s. Commonly referred to as the Hurt study, the report entitled, *Motorcycle Accident Cause Factors and Identification of Countermeasures* was published in 1981 (*1*). Among the study's findings:

- Approximately three-fourths (75 percent) of the motorcycle crashes involved a collision with another vehicle, which was most often a passenger vehicle.
- Approximately one-fourth (25 percent) of the motorcycle crashes were single vehicle crashes involving the motorcycle colliding with the roadway or some fixed object in the environment.
- Almost half of the fatal crashes showed alcohol involvement.
- Motorcycle riders in crashes showed significant collision avoidance problems. Most riders would over-brake and skid the rear wheel, and under-brake the front wheel, with the typical error being a slide-out and fall due to over-braking or running wide on a curve due to excess speed or under-cornering.
- Roadway defects (pavement ridges, potholes, etc.) were the crash cause in 2 percent of the cases; animal involvement was 1 percent of the accidents.
- In two-thirds of multiple vehicle crashes, the driver of the other vehicle violated the motorcycle's right-of-way.
- The failure of motorists to detect and recognize motorcycles in traffic was the predominating cause of motorcycle crashes. The driver of the other vehicle involved in the collision with the motorcycle either did not see the motorcycle before the collision or did not see the motorcycle until too late to avoid the collision.
- Intersections are the most likely place for a motorcycle crash to occur, with the other vehicle violating the motorcycle right-of-way, and often violating traffic controls.

- The view of the motorcycle or the other vehicle involved in the crash is limited by glare or obstructed by other vehicles in almost half of multiple vehicle crashes.
- Conspicuity of the motorcycle is a critical factor in the multiple vehicle crashes, and crash involvement is significantly reduced by the use of motorcycle headlamps (on in daylight) and the wearing of high visibility yellow, orange, or bright red jackets.

For the past 35 years, the Hurt study has provided the foundation for the development of many State motorcycle safety programs. But after over three decades, the study findings no longer reflect present day motorcycling. Numerous advancements, including improved motorcycle and helmet designs, intelligent transportation systems, increased licensing and training, and changes to the roadway and traffic environment, have enhanced safety, and some, such as increased traffic volumes and speeds, have not.

In the late 1990s, the Association of European Motorcycle Manufacturers (ACEM) with support from the European Commission conducted a comprehensive in-depth crash study, the Motorcycle Crash In-Depth Study (MAIDS) (*2*). MAIDS is currently the most available crash causation study of motorcycle (referred to as Powered Two-Wheelers [PTWs]) crashes in Europe. The investigation was conducted over 3 years and included 921 crashes from 5 countries using the Organization for Economic Co-operation and Development (OECD); a common research methodology for on-scene, in-depth motorcycle crash investigations. Among the study findings (*3*):

- In 37 percent of cases, the primary crash contributing factor was a human error on the part of the PTW rider. In some situations, the human errors that occurred involved skills that were beyond those that typical drivers or operators might currently possess. This is often due to the extreme circumstances of some of the crash cases, including an insufficient amount of time available to complete collision avoidance.
- Among the secondary contributing factors, PTW riders failed to see the other vehicle (OV) and made a large number of faulty decisions, i.e., they chose a poor or incorrect collision avoidance strategy. In 13 percent of all cases, there was a decision failure on the part of the PTW rider.
- The number of cases involving alcohol use among the PTW riders was less than 5 percent, which is low in comparison to other studies. However, such riders are more likely to be involved in a crash.
- In 50 percent of cases, the primary crash contributing factor was a human error on the part of the OV driver.
- Among the primary contributing factors, over 70 percent of the OV driver errors were due to failure of perceiving the PTW.
- Ninety percent of all risks to the PTW rider, both vehicular and environmental, were in front of the PTW rider prior to the crash.
- The roadway and OVs were the most frequently reported collision partner.

- In 60 percent of crashes, the collision partner was a passenger car.
- Of all PTW riders, 73.1 percent attempted some form of collision avoidance immediately prior to impact. Of these, 32 percent experienced some type of control loss during the maneuver.
- Of the PTW riders, 90.4 percent wore helmets. However, 9.1 percent of these helmets came off the wearer's head at some time during the crash, due to improper fastening or helmet damage during the crash.

Currently in the US, the Federal Highway Administration (FHWA) is leading a national effort to update the Hurt Study. The Motorcycle Crash Causation Study (MCC), headed by Dr. Samir Ahmed at Oklahoma State University, is a $2.4 million study with the purpose of investigating the causes of over 900 motorcycle crashes, and provides information for the development of countermeasures that can be effective in reducing these crashes. The FHWA is seeking states to participate in a pooled-fund study in an effort to provide additional funding to increase the number of crash investigations that will be used to expand the database (Texas contributed). Using the field tested methodology developed by the OECD, the study will focus on all relevant aspects of motorcycle crashes so countermeasures that prevent motorcycle crashes from occurring or lessen the harm resulting from them can be identified (*4*).

NHTSA recently completed a pilot study to test the methodology and evaluate the data collection forms for conducting the full scale MCC study (*5*). The study included 23 cases (out of the 53 initial cases) and found that the average number of hours to complete a crash investigation is about 60 hours with a cost per completed case of about $7,500, minus materials and training for investigators (*5*). Study results are expected to help reformulate countermeasures and redevelop training and strategies for crash prevention.

INCREASING EXPOSURE TO CRASH AND INJURY RISK

Motorcycles are becoming more and more prevalent in the vehicle fleet mix. The popularity of this mode of transportation is attributed to the low initial cost of a motorcycle, its use as a recreational vehicle, and, for some models, the good fuel efficiency. Recently released industry numbers show that motorcycle crash exposure risk, measured by miles of travel per vehicle classification (VMT), is increasing (*6*). Per vehicle mile traveled, motorcyclists were 39 times more likely than passenger vehicle occupants to die in a motor vehicle traffic crash and 9 times more likely to be injured (*7*).

There has been widespread acknowledgement about the need for more accurate and reliable data on VMT, as these data are used to calculate crash, fatality, and injury rates per mile traveled. Additionally, these rates are used to evaluate federal, state, and local funding levels, effectively assess safety countermeasures, and address the growing safety issues related to motorcyclists. TTI researchers will analyze methodologies that may potentially be used to obtain accurate motorcycle volume and VMT-related data as part of the NCHRP *80-81: Improving the Quality of Motorcycle Travel Data Collection Research* project.

CRASH FACTORS

Two major factors contribute to the higher crash and injury rates: motorists' detection of a motorcycle and higher levels of risk taking behavior (including riding while impaired, lack of helmet use, and speeding) engaged in by motorcyclists.

With the proliferation of cell phone use and texting while driving, drivers need continuous encouragement to share the road safely with motorcyclists, give riders plenty of space, and be courteous and respectful. At the same time, riders need to take extra precautions, such as making themselves more visible (increase conspicuity), using signals, and allowing more space and time for responding. Drivers, on the other hand, need to increase their awareness of the existence of motorcyclists on the road.

When compared to national averages, Texas riders have higher rates of improper licensure, non-helmet use, and alcohol consumption. According to NHTSA's Fatality Analysis Reporting System (FARS) data (*8*):

- Thirty-one percent of the fatality-injured motorcycle riders in Texas were not properly licensed, compared to 26 percent in the United States.
- Thirty-nine percent of the fatally-injured motorcycle riders in Texas were impaired (with a blood alcohol concentration (BAC) greater than or equal to 0.08 g/dL), compared to 28 percent in the United States.
- Fifty-seven percent of the fatally-injured motorcycle riders in Texas were not wearing a helmet, compared to 41 percent in the United States.

TRAINING/LICENSING

Before riding on public highways, all 50 states and the District of Columbia require motorcycle riders to obtain a motorcycle operator license or endorsement; however, many motorcyclists are not properly licensed (*7*). In 2009, 22 percent of motorcyclists involved in fatal crashes did not have a valid motorcycle license, compared to 13 percent of drivers of passenger vehicles who were not properly licensed (*7*). Lack of motorcycle training programs and experience has also been recognized as a potential cause of crashes. However, that debate is still ongoing and further research would clarify that postulation.

Crash Causation

MAIDS

MAIDS determined younger individuals are more likely to get in a crash; indicating that training and experience are greatly linked to crash causation. It is also implied that those with less than 6 months of riding experience are more likely to be involved in a crash. Not having a license can be linked to crash causation, but may not be a definitive factor in total crash causation (*2*).

Thailand's Motorcycle Accident Causation Study

As many motorcycle riders are self-taught, the lack of training brings about insufficient riding strategies and skills that could be used to avoid crashes. Those not going through formal licensing programs increase their risk of crashes due to lack of motorcycle safety and riding knowledge (*9*).

NHTSA Pilot Study

The NHTSA Pilot Study recognized motorcycle licensing and training as having an impact on the causation of crashes. The more riders who get formal training and transition from permit to a license, the lower the risk of crashes. Determining the impacts training and licensing have on crash causation were tested in this pilot study (*5*).

NHTSA Traffic Safety Facts 2009

The NHTSA Traffic Safety Facts of 2009 found that 22 percent of riders involved in fatal crashes did not have a valid license (*7*).

European Agenda for Motorcycle Safety FEMA

FEMA, or the Federation of European Motorcyclists' Associations, is the federation for motorcycle users across Europe. Although FEMA recognizes advanced training does not necessarily make a rider the safest rider on the road, they see training as a vital component of safety. Basic rider training and applied practice through the licensing test will give riders tips they may not learn until it is too late. FEMA agrees that riders need the skills to maneuver the roads and avoid crashes; not just the skills to pass the test (*10*).

Literature Review on Motorcycle Collisions – University of Oxford

The Transport Studies Unit at the University of Oxford compiled data on crashes to analyze various motorcycle riding components, but specifically used the data to determine crash causation. They found not having rules and regulations on licensing and training requirements increases the risk of crash. Riders may miss out on techniques that could later save their lives by taking training courses and going through the restricted licensing system (*11*).

Increasing Age and Experience: Are Both Protective against Motorcycle Injury?

Auckland, New Zealand examined whether or not there is an association between age, experience, and motorcycle injury. Discovered was that the older the rider, the less risk of injury present. While controlling for age, the results indicated those with less than two years of experience had two to four times as many crashes resulting in injury, than the more experienced rider (*12*).

Effectiveness of Motorcycle Training and Licensing

This study was conducted to determine if prior research on motorcycle licensing procedures and education courses were effective. Lower crash rates have been found in areas where there are stricter licensing regulations. Training programs have also increased the use of personal protective equipment, which decreased the severity of injury in some crashes. For example, the California Motorcyclists Safety Program is required for all riders under the age of 21 wanting a motorcycle license. Nine years after the program was initiated, fatal crashes dropped 60 percent. There were other factors involved in this decrease, but the CMSP contributed greatly. States with longer permit holding periods also had less fatal crashes, as they had more time to practice under restrictions (*13*).

Countermeasures to Reduce/Prevent Crashes

NAMS Implementation Guide

Motorcycle training and education according to NAMS is “the centerpiece of a comprehensive motorcycle safety program.” If the availability of training is scarce, adjusting or increasing access to trainings is the first step in improving the knowledge and skill of motorcycle riders. Making sure the curriculum meets safety guidelines, adequate protective gear is promoted, and incentives for getting a license are given, then the risk of crashing is reduced. However, in order to participate in trainings, riders need to know what is available. Having dealers, rider groups and the media promote the trainings would decrease the excuse of not knowing where to go (*14*).

AASHTO Plan/NCHRP Report 500

One strategy to increase licensing and training is to make the statistics available to the public about how many crash, and their severity, occur due to lack of training and licensing; this will increase the motivation of some to pursue further education or sustain a license. Another

AASHTO strategy is to provide adequate licensing and training programs that teach skills specifically to crash avoidance (*14*).

Monash Motorcycle Crash Countermeasures

Simulator-based programs to train riders on real-life situations are currently being developed to mitigate crash involvement and give riders on-hands training. Training programs need to be developed for all levels as all riders can improve their skills throughout their lifetime. South Australia introduced the Ridersafe program, which is a two-level pre-licensing training. Riders have to attend two four-hour training sessions before gaining their learners permit, and a four-hour training session to gain a probationary license. The sessions both include lectures, videos, and hands on training. However, no evaluation has been done to prove success (*15*).

Literature Review on Motorcycle Collisions-University of Oxford

The UK motorcycle registration process requires beginner riders to take a Compulsory Basic Training (CBT) before permission is given to ride on the road. No specific evaluation of CBT directly decreasing motorcycle crashes has been done, but there has been an overall decrease and it can only be assumed that CBT is helping. In regards to licensing, the UK requires a Hazard Perception Test (HPT) to be taken as a component of the licensing theory test. This test uses video footage of real-life situations and allows individuals to touch a screen to increase speed, maneuver, or stop to avoid the hazard. Studies have shown a correlation with low scores on the test and riders being involved in crashes 18 months following their crash. Scotland created a Police Assessed Ride Program that allows riders to be trained and assessed for free by police motorcyclists. Individuals who participated in this program reported it as being 'very' or 'fairly useful' and encouraged other riders to participate (*11*).

European Agenda for Motorcycle Safety FEMA

Training and licensing need to increase, or improve, in order for the cessation of crashes to occur. FEMA recommends increasing the availability of training sites as well as improving the curriculum taught in the program. Crash avoidance skills need to be emphasized along with the basic motorcycle skills. The training programs then need to promote obtaining a license and stress the importance of post-license training programs throughout their motorcycle career. FEMA has tried to coordinate with insurance companies by rewarding a discounted insurance premium to those who obtain their license or routinely participate in post-license training programs (*10*).

FEMA Motorcyclists Point of View Report

Within training programs, making sure riders understand the laws and regulations of traffic safety is ideal in preventing crashes. It is believed that "rider attitude and behavior, interactions with other road users, speed choice, lane positioning, visual direction control, active hazard search, perception and anticipation" are missing from most countries' training programs and those areas need to be improved. Those who commit safety offenses should be required to take remedial training to improve their perception of safety and skills. Licensing was also mentioned to be glazed over by many programs and needs to be emphasized as an important factor in mitigating crashes. Many licensing tests look at the basic motorcycle skills that are typically not relevant to real world situations. Creating licensing tests that truly test the rider's motorcycle skills and safety awareness would be a beneficial countermeasure (*16*).

Increasing Age and Experience: Are Both Protective against Motorcycle Injury?

Conclusions from this study provided recommendations that licensing regulations need to emphasize the importance of age and experience. Training needs to be promoted to those who are novice riders and that certain motorcycles may be more suitable for those with more experience (*12*).

Asia-Pacific Economic Cooperation – A Review of Potential Countermeasures

The Asia Pacific Economic Cooperation (APEC) addressed needed changes to rider training, licensing, and testing in order to prevent and mitigate crashes. APEC recommends the implementation of a Graduated Licensing System (GLS), which puts restrictions on the less experienced. Restrictions are lifted as experience increases and required tests are passed. New Zealand is one of few who implemented the GLS and has shown a decrease in hospitalizations of 15–19 year olds. Restricting passengers for those with novice riding skill will reduce crashes and severity. In regards to training, improving the curriculum in the training is a must. The training should be done at the novice level including on-road skill training, hazard perception training, and passenger carrying training, then completing the courses with tests. Those tests will allow individuals to climb the GLS (*17*).

LACK OF ATTENTION AND AWARENESS

Many crashes occur due to other drivers on the road not paying attention to the idea of motorcycles being on the road. Those who are familiar with motorcycles tend to be more aware of their existence, but that is a small percentage of the driving population. Research has shown that increasing the awareness about motorcycles to the general public would reduce crashes (*17*).

Crash Causation

MAIDS

MAIDS determined that failure to pay attention while riding contributed to 10 percent of motorcycle crashes. Causes ranged from being distracted by something off the side of the road and not paying attention to what is in front or behind them at all times. This ultimately reduces the reaction time of the rider, increasing the risk of crash. Also, drivers of other vehicles tend to not pay attention or look out for motorcycles. They do not anticipate that there will be a large volume of motorcycles on the road and thus only scan the road for vehicles, trucks, and any obstacles in their path. Blind spots also cause problems and as motorcycles are not large, they can get trapped in those blind spots easily (*2*).

Monash Motorcycle Crash Countermeasures

Monash University concluded that "car drivers who have motorcycle experience have a lower chance of being involved in a crash with a motorcyclist than drivers without such experience." Drivers who are familiar with motorcycles, either through personal experience or someone close to them rides, typically anticipate motorcycles being on the road and are more aware. This means that those with no relation to motorcycles are going to lack the awareness of motorcycle existence; driver awareness is therefore a key causation in motorcycle injuries and fatalities (*15*).

Countermeasures to Reduce/Prevent Crashes

AASHTO Plan/NCHRP Report 500

AASHTO supports education on the consequences related to reckless driving, impairment, fatigue, and all other unsafe riding strategies that deter riders from pushing the limits. Not only do riders need the awareness, but drivers need to be educated that there is an increase of riders on the road and thus, they need to be more conscientious about their surroundings (*14*).

Monash Motorcycle Crash Countermeasures

Public campaigns to increase awareness while riding have been attempted as an educational tactic. Studies have shown drivers who have motorcycle training or education are more aware of riders on the roads; training and educating drivers during driving training courses on motorcycles would benefit their 'surrounding awareness' on the road (*15*).

FEMA Motorcyclists Point of View Report

Research has shown individuals with duel licenses, or have family members who ride motorcycles, are more likely look out for motorcycles. To reduce crashes, the mindset of drivers realizing there are motorcycles on the road needs to change. This can be done through campaigns, billboards, and changing the curriculum in drivers education classes. If awareness increases, then motorcycles will be detected, and the risk of crashing decreases. Ultimately, riders and drivers need to be aware to reduce crashes (*16*).

Asia-Pacific Economic Cooperation – A Review of Potential Countermeasures

APEC has presented a different approach in presenting mitigation and reduction of crashes by putting some focus on other road users not paying attention or looking out for motorcycles. Awareness and education campaigns should focus on teaching other road users about the existence of motorcycles on the road. California created billboard and bumper stickers stating "My brother (sister, father, etc.) rides, please drive carefully," in hopes of increasing awareness and attach a personal connotation to the message (*17*).

ALCOHOL AND OTHER IMPAIRMENTS

Motorcyclists have the highest intoxication rates of all road users involved in fatal crashes. In 2008, 29 percent of all fatally-injured motorcycle operators had blood alcohol concentration (BAC) levels greater than or equal to 0.08 g/dl, compared to 23 percent for drivers of passenger cars, 23 percent for light trucks, and 2 percent for large trucks. An additional 8 percent had lower alcohol levels (BAC 0.01 to 0.07 g/dL) (*18*). Texas consistently ranks above the national average in the percentage of motorcycle operator fatalities with known BAC ≥0.08 g/dL. In 2008, 46 percent of all Texas motorcycle operators killed were impaired by alcohol (BAC ≥0.01 g/dL), compared to 37 percent nationally (*18*). The age groups of 40 to 44 and 45 to 49 had the highest percentage of BACs over 0.08 with 41 percent among all fatally injured motorcycle riders, compared with 36 percent for age groups 35 to 39 (*11*). The BAC proportion was higher on weekend nights compared to weekend day times: 65 percent of motorcycle riders had BACs of 0.08 or higher for operators who died in single-vehicle crashes (*7*).

To address the impaired-riding problem in Texas, TTI researchers developed an impaired rider campaign under a TxDOT 402 highway safety grant. *Drink. Ride. Lose.* addresses the need for educating riders about the importance of not operating a motorcycle under the influence of alcohol and other impairments by raising awareness that impaired riding could result in serious harm or death. Information about the campaign is on the LookLearnLive.org website.

Crash Causation

Thailand's Motorcycle Accident Causation Study

Study results showed 40 percent of individuals (289 out of 723) involved in crashes had consumed alcohol prior to the crash. Out of those who consumed alcohol, 86 percent had considerably high impairments. Amongst the riders analyzed, 50 had fatal outcomes; 37 had been impaired by alcohol; showing the risk of death increased when alcohol had been consumed (*9*).

MAIDS

A total of 4.6 percent of riders in this study were impaired, adding to crash causation in motorcycles. It was determined riders who are impaired are 2.7 times more likely to be in a crash than those not impaired (*2*).

NHTSA Traffic Safety Facts 2009

In 2009, motorcycle riders had the highest number (29 percent) of fatal crashes involving high BAC levels than any other motor vehicle drivers. Higher percentages of crashes occurring at night had riders with high BAC, adding to the support of alcohol consumption having a place in crash causation (*7*).

Literature Review on Motorcycle Collisions – University of Oxford

University of Oxford stated alcohol and other impairments as being major factors in motorcycle crashes and more than half of fatal motorcycle crashes involve alcohol. Alcohol and other impairments affect the judgment and skill of a rider, increasing their risk of crashing (*11*).

Monash Motorcycle Crash Countermeasures

A number of studies across that globe have found alcohol involvement to be greater in motorcycle crashes than other vehicle crashes. The more severe a crash is, the more likely alcohol was involved and increased alcohol creates a decreased likelihood of a helmet being worn. The risk of crash increases as well as the severity of injuries (*15*).

Effects of Alcohol on Motorcycle Riding Skills US Dot/NHTSA

This study by NHTSA proved that alcohol consumption does create change in riding behavior and becomes a factor in crash causation. Effects of alcohol were shown with individuals at BAC of 0.08 and some even at BAC of 0.05. Alcohol impairment causes weaving, inability to avoid hazards, and overall decreased perception of the road (*19*).

Countermeasures to Reduce/Prevent Crashes

NAMS Implementation Guide

Communication has been identified as a strategy to decrease impaired riding. State safety offices, insurance companies, motorcycle rider groups, law enforcement, dealers, and the media should distribute materials and conduct campaigns advocating how alcohol and drugs affect motorcycle riding. Educating law enforcement on detecting impaired driving and increasing DUI checkpoints are also recommendations from NAMS to stop impaired riding (*20*).

AASHTO Plan/NCHRP Report 500

It has been recommended that further studies be done to determine how, and at what extent, alcohol and drugs affect the operating skills of a motorist. Those results will be presented to law enforcement, rider groups, and the community so accurate information is being passed along and people can spread the word about the risks. The best way to reduce the risk of impairments is through education, awareness, and detection. Law enforcement needs to be taught how to detect impaired driving and reprimand those who they catch in the act. Being consistent with detection and laws against impaired driving will hold a standard and make those who push the limits more attentive (*14*).

Monash Motorcycle Crash Countermeasures

As alcohol is a major contributor to many crashes, many Australian states have a zero BAC for novice riders. Novice riders are still mastering the basic motorcycle skills and do not need the additional impairment putting them at greater risk. Some US states are trying to enact a zero BAC for all motorcyclists as riding a motorcycle takes great skill. Random Breath Testing (RBT) is said to be more sophisticated than many US sobriety examinations and needs to be researched further (*15*).

Green Yellow Red NHTSA

Project Green-Yellow-Red was created by NHTSA to be used as a social marketing initiative to reduce impaired motorcycle operation and was executed in Wisconsin in 2006–2007. According to NHTSA's Fatality Analysis Reporting System, 28 percent of all fatal motorcycle riders had a BAC of 0.08 g/dL or greater and 8 percent had BAC of 0.01–0.07 g/dL. The program focused on those who believe it is okay to drink and ride. Three decisions points of drinking and riding were based on the colors green, yellow, and red. Green represented riders who chose to ride alcohol free, yellow represented riders who chose to drink alcohol and ride after consuming at least one drink, and red represents riders that are severely impaired by alcohol and should not ride. The green campaign encouraged and supported riders that chose to ride alcohol free. The yellow campaign encouraged less alcohol consumption and to wait to ride after drinking. The red campaign focused on leaving motorcycles behind and taking alternative transportation home after consuming large amounts of alcohol. The GYR program targeted support from fellow riders, bars, law enforcement, and motorcycle dealers to participate in events and training programs. Some of the successes of the GYR program included marketing materials/events promoting GYR and safe riding, bars providing and promoting different drink or ride options, acceptance from the motorcycle community, and law enforcement getting involved in detection and promotion of GYR. The biggest success was the strong brand name recognition of GYR, as many riders became familiar with it and took time to see what it was all about (*21*).

FEMA Motorcyclists Point of View Report

Motorcycle events are often associated with alcohol consumption and most likely always will. In order to prevent crashes due to impairments, safe drinking and riding needs to be promoted at these events. Motorcycle groups need to self-monitor their own, and report or stop those who are impaired. Drink-drive campaigns need to address these concerns and educate the public during these events. Getting one individual to put down their drink is one less life that will be lost on the road (*16*).

Asia-Pacific Economic Cooperation – A Review of Potential Countermeasures

According to APEC, random blood testing (RBT) has been found to be the most successful countermeasure in reducing alcohol related crashes. Australia has promoted safe riding through campaigns and events, but found the RBT to be most effective; there was an 18 percent reduction in alcohol related crashes and fatalities. Due to this, riders are on alert as they know an RBT could take place at any time and choose to stay away from riding impaired (*17*).

Literature Review on Motorcycle Collisions – University of Oxford

It has been stressed that interventions to reduce impairment for drivers does not apply directly for motorcyclists. Interventions known to work for motorcyclists are including a MRC/RSS (Motorcycle Rider Course/Riding and Street Skills) module in training courses and handbooks. Also, having motorcycle groups self-police and promote safe riding amongst their peers as well as promotion during events has shown to have success. Making "dial-a-ride" programs known amongst riding groups is beneficial because if riders do not have numbers available, they are less likely to call for a ride. Most importantly, law enforcement needs to increase their impairment detection training specifically for motorcycles. An example of law enforcement training that has been implemented in many countries and throughout the United States is the Standard Field Sobriety Testing Curriculum (*11*).

Riders Helping Riders

Riders Helping Riders (RHR) is a program developed by the South Carolina Rider Education Program, and was designed to encourage motorcyclists to prevent impaired riding amongst other motorcyclists. RHR wants to bring awareness of the problem to motorcyclists and explain how they are the ones who can prevent others from riding impaired. Studies have shown people will listen to others with commonalities. The program produced a toolkit with techniques on how to discourage others from drinking, how to recognize impairment, and how to discourage individuals who are impaired not to ride. RHR was presented to motorcyclists during training programs, community forums, and events, and were voluntarily asked to sign a pledge to join RHR. The program was pilot tested by instructors of the Georgia's Department of Driver

Services, Motorcycle Safety Program. The pilot study showed many participants signed the pledge and had eagerness to join the force in intervening with drinking and riding. Crash data did not show any support in this program being successful, but researchers believe more time will tell (*22*).

Drink.Ride.Lose

The Texas Department of Transportation's (TxDOT) Traffic Safety Section, launched a campaign called *Drink.Ride.Lose.*, which focuses on rider impairment on the LookLearnLive.org website. The purpose of this campaign is to bring awareness of impaired riding to the motorcycle community in Texas and encourage riders to practice safe riding (*23*).

SPEED

In 2009, 35 percent of all motorcycle riders involved in fatal crashes were speeding, as compared to 23 percent for passenger car drivers, 19 percent for light-truck drivers, and 7 percent for large-truck drivers (*7*). In Texas, speeding was cited as a contributing factor in 37 percent of all fatal motorcycle crashes in 2009 (*24*).

Crash Causation

NHTSA Pilot Study

This study analyzed the speeds of riders at impact and found speed ranges vary. Four out of the 23 riders in the study were going at speeds great than 60 mph making speed one of the major causations in their crashes. The study did not show speed to be the number one cause, but is a contributing factor in some crashes (*5*).

MAIDS

MAIDS found speed can be a contributing factor to motorcycle crashes, but did not have as high of numbers as one would expect; only 18 percent of their crash studies were traveling above or below the flow of traffic, but is still considered an aspect in crash causation (*2*).

Asia-Pacific Economic Cooperation – A Review of Potential Countermeasures

Not only does the speed of motorcyclists cause crashes, but the speed of other drivers increases the motorcycle crash rate as well. In Australia, 37 percent of fatal motorcycle crashes had speed as the contributing factor, whether the driver or rider was the perpetrator of speeding. Speed is not well monitored by law on motorcycles as front license plates are not always required and some riders do not make the back plates visible, causing problems for speed cameras. Some motorcyclists view metal front plates as being potentially harmful to themselves and others (*17*).

Countermeasures to Reduce/Prevent Crashes

AASHTO Plan/NCHRP Report 500

Speeding has been noticed amongst novice riders and it has been suggested to limit the speed for beginning riders. Only allowing certain motorcycles to be purchased that have speed limits for beginning riders would prevent against excessive speeds. Riders make the claim how that is not cost effective as they would have to purchase a new bike very soon after their beginner bike. Others argue that it is not the speed that is the problem, but the judgment and behavior of the rider. Increasing education at training programs about the risks of excessive speed would help target part of the problem. Also, holding law enforcement accountable to enforcing speed laws would be ideal (*14*).

Asia-Pacific Economic Cooperation – A Review of Potential Countermeasures

In order to monitor speed and reprimand those who cause infractions, speed detection need to improve. As motorcycle cameras do not always have front plates, a duel-lens camera needs to be investigated further. If a motorcyclist is caught speeding, the lens will be activated to capture an image of the front and rear of the motorcycle. If riders are not being held responsible to their mistakes, then the bad behavior will continue and risk of crashing will not decrease (*17*).

CONSPICUITY

Driver inattention is a significant factor in all motorcycle crashes. Half (50 percent) of car-motorcycle crashes in Texas are the fault of drivers because they generally do not see the motorcyclist in time or they misjudged the bike's approaching speed (*24*). The ability of other road users to see and notice the motorcycle is termed, conspicuity, and crashes usually occur because motorcycles are less conspicuous than passenger cars or trucks; thus, are more difficult to detect.

Crash Causation

MAIDS

When motorcyclists are not visible to the world around them, this can be considered a contributing factor to motorcycle crashes. MAIDS found those who wear dark clothes are less visible to other traffic and put themselves at greater risk of being hit. Not using headlights and making themselves visible to those around them can increase the risk of crash (*2*).

Thailand's Motorcycle Accident Causation Study

Not only did this study find that when motorcyclists wear dark clothing or do not use their headlights conspicuity decreases, but having the surroundings visible to motorcycle riders is imperative. Headlights on motorcycles may not be as reflective against signs or traffic around them and crashes occur because the conspicuity of motorcyclist's surroundings decreases (*9*).

NHTSA Pilot Study

Analysis on conspicuity was done in regards to clothing the motorcyclist wore, if a reflective helmet was used, or if headlights were on during time of crash. NHTSA recognized that conspicuity can play a role in crash causation and included it in their study for further analysis (*5*).

European Agenda for Motorcycle Safety FEMA (PC)

FEMA agrees that the use of headlamps and wearing brightly colored clothing increases conspicuity. However, they also argue focusing on conspicuity may take away from the real problem in being the actual skills and awareness of the riders and other drivers. They also see that in cities where there are a lot of sunshine and bright buildings, wearing brightly colored clothing and using headlamps could create a camouflage effect. All in all, conspicuity is a factor in crash causation, but actual cause is debatable (*10*).

Literature Review on Motorcycle Collisions-University of Oxford

Motorcycle detection is a problem on the roadway and the University of Oxford separated the conspicuity into two categories. First they determined the size of motorcycles can cause crashes as they are not as visible; but that cannot be changed. Secondly, motorcyclists' not wearing brightly colored clothing or using their headlamps to help with visibility is a causation factor that can be changed. Ultimately, motorcycles are small and tend to go at greater speeds, so their conspicuity decreases, increasing their risk of crashing even more, as they may not be seen until it is too late (*11*).

Countermeasures to Reduce/Prevent Crashes

AASHTO Plan/NCHRP Report 500

To increase conspicuity, recommending riders to wear bright colored clothing is greatly promoted. Researching technologies that could increase conspicuity are also being encouraged (*2*).

Monash Motorcycle Crash Countermeasures

Monash University studies found wearing solid, bright colored clothing, having motorcycles of bright colors, and using headlights reduces the chance of collision during the daytime. At night, having retro reflective garments for oncoming traffic reflection plus headlamps increases conspicuity. Monash University suggested that having demonstrations on headlights and bright colored clothing increases conspicuity, because when people see firsthand evidence, they are more likely to change their own behaviors (*14*).

Enhancing Motorcycle Conspicuity Awareness in Iowa

Iowa Department of Transportation and Iowa State University researched the problems with motorcycle conspicuity through the analysis of helmet use and crash data. Through the analysis, Iowa DOT developed eight countermeasures in their motorcycle manual to combat conspicuity. Iowa DOT has the following variables listed to increase conspicuity: "clothing, headlight, signals, brake lights, mirrors, head checks, horns, and riding at night." Adding reflective materials on clothing, motorcycles, and helmets have been shown to be more successful in increasing conspicuity than only focusing on bright colored clothing and using headlamps. Iowa DOT also realizes improvements in the way motorcycle training and education is provided, in means of rider skills, can increase as well as safety campaigns (*25*).

European Agenda for Motorcycle Safety FEMA

FEMA agrees motorcycle riders need to wear bright colored clothing or use their headlamps to increase conspicuity, but other motorists need to be on the lookout as well. Motorcycles are not impossible to see and during regular driver training courses, motorcycle awareness needs to be stressed. A motorcycle being on the road does not even cross the mind of many drivers. Having campaigns stressing this issue by advertising on the TV and/or through billboards would increase driver awareness of motorcycles being on the road (*10*).

FEMA Motorcyclists Point of View Report

Motorcyclists have lobbied that requiring headlights during the day could cause more harm than good. Glare, distorted perception, and distractions are all argued to be problems with using headlights during the day. They believe that increasing awareness, better training programs, and wearing bright colored clothing are the best countermeasures in decreasing crashes and increasing conspicuity (*16*).

Literature Review on Motorcycle Collisions-University of Oxford

The University of Oxford supports the theory of daytime running lights, as the lights spark drivers' attention that a motorcycle is in the vicinity. Studies have shown the use of daytime headlights decreased many daytime crashes. It has been recommended that lights have a minimum intensity of 1,600 cd for two lamps at 180 mm diameter or more. Also, having fluorescent yellow-orange, yellow, white, or red-yellow motorcycles or materials on the motorcycles are detected quicker than other designs. The same goes for clothing as riders are encouraged to wear red, yellow, or white clothing, which all increase conspicuity. Wearing black or riding black motorcycles decreases conspicuity and increases the risk of being involved in a crash. As most of these countermeasures are voluntary, laws and regulations could be proposed requiring daylight running headlights and reflective measures on motorcycles (*11*).

Asia-Pacific Economic Cooperation – A Review of Potential Countermeasures

APEC has seen instances where larger trucks, vehicles, and road obstructions have blocked the existence of motorcycles on the roadways. If motorcyclists wore bright colored clothing or had light colored motorcycles, they would have been more visible to their surroundings. Riders are dissuaded from wearing patchwork patterned clothing as that causes a camouflage effect (*17*).

ROADWAY FACTORS/DEFECTS

Being two wheelers, motorcyclists are more susceptible to difficulties and hazards created by the design, construction, maintenance, and surface condition of roads. Common surface irregularities are problematic for motorcycle users such as potholes, tire rutting, surface drop-offs or rises, and deteriorating pavement and railroad grade crossings. Pavement drop-offs, gravel, temporary steel plates, large grooves, etc., are also prevalent in work zones and pose many hazards for motorcyclists. Roadside barriers and sign supports can also be dangerous when struck by motorcyclists.

Crash Causation

MAIDS

Roadway defects have been known to be factors of motorcycle crashes. Defects can range from inadequate signage, visibility barriers, roadway reflectors, angles of curves, and even the distance given for passing or merging lanes. Roadway defects have been identified by the MAIDS study to potentially cause motorcycle crashes, but most of the time cannot be contributed as being the only cause (*2*).

Thailand's Motorcycle Accident Causation Study

Roadway design defects contributed to 13 percent of the 723 crashes in the Thailand study. Poorly marked construction zones were recorded as a cause to some crashes. Riders were unable to see the warning signs adequately or react quickly enough to construction vehicles not properly stowed away. However, roadways in Thailand and the United States are not identical, but can be used to show how roadways are causation in some crashes (*9*).

Literature Review on Motorcycle Collisions – University of Oxford

One-quarter of crashes were recorded as having a roadway component or object in the environment contributing to the crash. Other factors such as rider awareness and impairments were looked into as well to see if various roadway defects could have been avoided (*11*).

Monash Motorcycle Crash Countermeasures

Engineering on the road and road maintenance have all been targeted as potential causations or contributors to crashes. Road markings, such as paint and thermoplastic material, can become slippery when wet and cause motorcycles to lose traction. Raised pavement markers, man-hole covers, and roads made of brick have been known to throw motorcycles off balance during maneuvers, particularly in intersections (*15*).

Asia-Pacific Economic Cooperation – A Review of Potential Countermeasures

Hazards on the roadway may be drivable for cars and trucks, but motorcycles are more susceptible to crashing when hazards are present. Some road conditions that can cause crashes are unsealed or gravel roads, tramlines, railway lines, painted lines on the road, potholes, oil or gravel, melted tar, stationary vehicles, no-signal intersections, vegetation, and horizontal and vertical curves. Many of these conditions could cause problems when a rider is doing normal turns and braking, but also when quick maneuvers are needed (*17*).

Countermeasures to Reduce/Prevent Crashes

NAMS Implementation Guide

Many crashes are caused by inadequate warning of upcoming hazards in the roadway. Ensuring appropriate signage is in place to warn oncoming motorists of those hazards will mitigate the risk of a crash. Road conditions need to be monitored and maintained so there are no debris, slippery surfaces, or repairs that need to be done. Law enforcement, construction companies, and state departments will all have to monitor whether or not warning signs are being used appropriately and road conditions are satisfactory. NAMS recognizes educating the community, law enforcement, and motorcycle groups to look out for any roadway obstacles that could cause crashes and report any findings, will alleviate causation factors (*20*).

AASHTO Plan/NCHRP Report 500

When motorcyclists pull over on the side of the road, they are not sufficiently visible to oncoming traffic. A component of the AASHTO strategic plan is to design and fix roadways to have adequate shoulders for motorcyclists to stop without being in a hazardous situation. This would allow a safety net for areas where roadway visibility may lack and reduce crashes. Motorcycles also run into problems due to roadways not being adequately maintained. Potholes, tire ruts, surface drop-offs, deteriorating pavement, and railroad grade crossings all pose threats to motorists. AASHTO believes maintaining these surfaces through regular inspections and repairs would be a strategy to mitigate crashes. Having a hotline number or online database for individuals to report needed roadway repairs would be another strategy (*14*).

FEMA Motorcyclists Point of View Report

Motorcyclists need to be kept in mind when designing and constructing roadways. A committee designated for motorcycle roadway design should be made that way engineers and construction workers have more information to make the roadways motorcycle friendly. Signs need to be made visible to everyone and the surfaces of the road need to be smooth and free of pot holes. There should be a forum, hotline, or online database that motorcyclists can report roadway malfunctions and emphasize improvements that need to be made in these areas (*16*).

Asia-Pacific Economic Cooperation – A Review of Potential Countermeasures

As road conditions can potentially contribute to or cause crashes, APEC proposed various countermeasures: having intersections with signals, and fully-controlled turn signals, have shown to reduce crashes; making sure vegetation, billboards, and parking around intersections is minimal, as that will give everyone a full view reducing the risk of collision; roadway design could improve by creating a separate motorcycle lane (this would prevent any crashes caused by merging where the motorcycle was not seen or risky maneuvers made by motorcyclists); and having regular road maintenance inspections done would insure fixable defects on the roadway, as to not cause crashes (*17*).

Successful Infrastructure Countermeasures to Mitigate Motorcyclist Fatalities

Transportation safety and engineering professionals visited five European counties to gain insight on their infrastructure and safety measures to provide safe riding for motorcyclists. Collecting this information gave the team potential countermeasures to improve the roads for motorcyclists in the United States. The team found it valuable for the United States to integrate roadway design standards pertaining to motorcycles into current documents. An example was given to add the standards to the AASHTO Green book, which recommends safe roadway and traffic guidelines. Other countries had less visual barriers such as signs and construction equipment, and gave advance warning of any obstacles in the vicinity. Another valuable organization that was developed in Belgium was the "road quality ride," which allowed individuals to ride the roads of Belgium inspecting and reporting any problems. A phone system and website was created for motorcyclists to report any problems as well. The markings on the road sometimes cause motorcycles to lose traction, so in Belgium; a gap is left unmarked on some road markings for motorcyclists to pass through without risking the loss of traction (*26*).

Countermeasures to Reduce Injury

Helmets and Riding Gear

Helmets are estimated to be 37 percent effective in preventing fatal injuries to motorcycle riders and 41 percent for motorcycle passengers (*27*). Unfortunately, the proportion of riders who use helmets declined sharply to 54 percent in 2010 from 67 percent in 2009 (*27*). NHTSA estimates that helmets saved the lives of 1,483 motorcyclists in 2009 (*7*). An additional 732 lives could have been saved if all fatally-injured motorcyclists had worn helmets (*7*). In Texas, only 36 percent of the 432 riders killed in crashes were helmeted in 2009 (*24*). CTS researchers estimated that helmets could have saved 190 additional lives. The National Transportation Safety Board (NTSB) recently added motorcycle safety to their Top 10 Most Wanted List of Transportation Safety Improvements, encouraging states to require all riders and passengers aboard a motorcycle to wear a helmet that complies with DOT's Federal Motor Vehicle Safety Standard 218 (*28*). Protective clothing decreases the severity of injury during an accident. Conclusions of many studies have resulted in recommendations of wearing protective clothing to include helmets, jackets, gloves, long pants, and boots.

Monash Motorcycle Crash Countermeasures

The use of helmets is believed to be the best countermeasure against injury during a crash. To decrease injury during a crash, researching improvements to crash performance and restraint systems for the helmets would be beneficial. Also, developing helmets that improve rider vision to increase the superior and peripheral vision will decrease crash rates, but also may be more appealing to riders to wear. Protective clothing such as snug, leather clothing, is recommended versus wide-flared pants and flowing scarves in decreasing injury severity (*15*).

NAMS Implementation Guide

NAMS recognizes that even the most cautious, best trained riders can be involved in a motorcycle crash. That is why wearing appropriate personal protective equipment such as, helmets, pants, boots, jackets and gloves, are highly recommended in reducing crash injury. Information should be distributed to motorcyclists to educate them on how FMVSS 218 helmets are the standard helmet to wear to reduce head and brain injuries. Motorcycle groups and organizations, dealers, and law enforcement should all be promoting the effectiveness of personal protective equipment (*20*).

AASHTO Plan/NCHRP Report 500

To decrease severity of the crash, AASHTO promotes the use of FMVSS 218 compliant helmets, a proven countermeasure, and using protective clothing (*14*).

European Agenda for Motorcycle Safety FEMA

Increasing the research put into helmet design to make them more comfortable to wear, especially in warm climates such as Texas, is what FEMA recommends to increase their usage. FEMA also believes individuals need to replace old and worn helmets as they may be causing discomfort or do not provide the same protection as a helmet in good condition (*10*).

FEMA Motorcyclists Point of View Report

Protective equipment needs to be replaced or upgraded often and the cost is sometimes too much for individuals. Reducing the cost of personal protective equipment would make it more affordable and appealing to wear. Having governmental or sponsored incentives for use of equipment would put using it in a more positive light (*16*).

Asia-Pacific Economic Cooperation – A Review of Potential Countermeasures

Helmets are the most effective piece of equipment to mitigate injury and reduce fatality in crashes. APEC believes the best way to increase wearing rates of helmets is to mandate their use. Community programs and campaigns to encourage helmet use are other countermeasures to employ. Thailand created the Community Youth Helmet Use Project to encourage young riders to wear helmets. APEC also encourages further research to improve crash performance of helmets to mitigate severity of injury. In regards to clothing, wearing leather gloves, jackets, and pants can mitigate injury and should be promoted by the motorcycle community (*17*).

Airbags

The purpose of airbags and other restraints are to decrease the severity of injury to the head and chest after the motorcycle gets hit. The airbags and restraints would decrease the initial velocity after the accident and soften the impact (*17*).

Monash Motorcycle Crash Countermeasures

Airbags attached to petrol tanks have been found to be an effective countermeasure during 90 degree collisions with other vehicles. Many safety precautions are not found appealing due to their obstruction or discomfort during normal riding; however, airbags are the one safety component that does not get in the way. The cost of installing airbags or purchasing motorcycles with airbags deters riders away and thus, researchers are looking for a more cost effective airbag that would increase rider interest (*15*).

Asia-Pacific Economic Cooperation – A Review of Potential Countermeasures

Restraint systems such as belts, saddle restraints, chest pads, and air bags on the motorcycle or clothing of the rider, are all proposed to reduce injury during a crash. These restraints would decrease the initial velocity of crash impact. More research needs to done in order for many of these restraints to become used by motorcyclists (*17*).

RESEARCH IN PROGRESS TO IMPROVE MOTORCYCLE SAFETY

The research team is aware of several additional research efforts underway which will likely yield important results for this project, including potential roadway design criteria and guidelines to mitigate motorcycle crashes. These projects currently underway include:

- Update of NAMS Implementation Guide – this guide will include new or innovative strategies and safety countermeasures for states and communities to use to improve motorcycle safety.
- 'Naturalistic' Motorcycle Safety Study –this study collects continuous data with instruments mounted on bikes to enhance understanding of interactions among rider, motorcycle, roadway, other roadway, and the environment.
- Motorcycle Crash Causation Study – the purpose of the study is to determine the underlying causes of motorcycle crashes.
- The Motorcycle Safety International Scan Tour – the plan prioritizes practices observed that may be implemented in the United States and identifies the action steps needed to complete the implementation.
- US Domestic Motorcycle Scan – this study examines infrastructure and behavior-related countermeasures being implemented in the United States.
- Evaluation Design for Motorcycle Countermeasures – this research will identify two to three promising infrastructure countermeasures outlined in *NCHRP Report 500 Volume 22: A Guide for Addressing Collisions Involving Motorcycles* and other key resources for evaluation.

CHAPTER 3. SYNTHESIS OF ITS TECHNOLOGIES

The objective of Task 2 was to identify existing and emerging Intelligent Transportation Systems (ITS) and other advanced vehicle technologies for all vehicle types, including motorcycles, and to evaluate their potential as applications to improve motorcycle safety. Researchers reviewed existing literature, including published studies and industry-produced reports, for descriptions of technologies for motorcycles or passenger vehicles that appear to hold promise for reducing multi-vehicle or single-vehicle crashes involving motorcycles, or for reducing the severity and resulting injuries from a crash.

A discussion of these technologies was included as part of the Crash Countermeasures Workshop, described in Chapter 5 of this report.

TECHNOLOGIES TO PREVENT RUN OFF ROAD CRASHES

The following are technologies intended to prevent run-off-road crashes, in which a rider inadvertently departs a lane or a roadway or overturns his or her motorcycle, without colliding with an object or another vehicle.

Electronic Stability Program

This program, currently existing in passenger vehicles, is "an on-board car safety system that enables the stability of the car to be maintained during critical maneuvering and to correct potential under-steering or over-steering" (*29*).

Curve Speed Warnings

Curve Speed Warnings are an emerging technology, currently used Yamaha ASV-2s, which allows for assessment of hazard levels when the driver is quickly approaching a curve in the road by using GPS and digital maps (*30*).

Lane Keeping and Departure Programs

These programs use forward facing cameras to scan the roadway and determine if the vehicle is migrating toward the lane markings. All systems will vibrate the wheel to ensure the driver is awake, while some will also lightly apply the brakes to keep the vehicle in line. These programs are currently active in passenger vehicles and are used in many car companies such as Volvo, Audi, and BMW (*31*).

Roll Stability

Roll stability systems monitor the motorcycle's speed and yaw rate (i.e., the rate at which the motorcycle is tilting away from vertical), and warn the rider if the motorcycle is in danger of tipping over (*32*).

Adaptive Front Lighting

Adaptive Front Lighting is an emerging technology, currently used in Yamaha ASV-2s, which uses the angle of the steering wheel and the speed of the vehicle to ensure that the headlight is illuminating the roadway in front of the driver (*33*).

Road Surface Condition Monitoring

This emerging technology uses laser scanning linked to the ABS or speed limiting systems, which scans the road and alerts the driver of any potential hazard on the road's surface. This system can be combined with information from roadside beacons or other sources of data (*32*).

BRAKING SYSTEMS

Advanced braking systems increase a driver or rider's ability to stop quickly and safely without losing control of the vehicle or motorcycle.

Anti-Lock Braking System

Anti-lock braking system is an existing technology that monitors wheel speed and adjusts braking pressure evenly among wheels to ensure that the brakes do not lock when applied in an emergency situation (*34*).

Brake Assist

This existing technology in passenger vehicles was developed to help prevent a collision, under sudden braking, by applying maximum pressure to the brakes (*35*).

Linked Braking Systems

Linked Braking Systems is an existing motorcycle technology that applies pressure to both brakes simultaneously to ensure balance (*32*).

COLLISION WARNING AND AVOIDANCE SYSTEMS

Using radar, Collision Warning Systems monitor the forward roadway and warn the driver both audibly and visibly that they are nearing an object or vehicle in their lane. As the object gets closer, the warning becomes more intense (*36*).

Pedestrian Detection System

This emerging technology, currently used in Volvo, uses radar sensors and data from an on-board camera, which allows the vehicle to automatically apply the brakes in order to reduce or mitigate the risk of hitting a pedestrian (*37*).

Animal Detection

Animal Detection, currently used in Volvo, uses the same radar and camera technology combination as the pedestrian detection system to determine if the vehicle is in line to strike an object. An audible warning will be displayed, and then the brakes will automatically be applied (*38*).

DRIVER ASSISTANCE AND MONITORING

These technologies include advanced displays, speed warnings, and limiters, driver/rider monitoring to prevent crashes caused by alcohol impairment or drowsiness, and systems to prevent riding by unlicensed riders.

Advanced Driver Assist

This emerging technology, currently used in Yamaha ASV-2s, will "employ a range of telematics and vehicle control systems to reduce driver workload and error" (*32*).

Alcohol Detection/Interlock

Alcohol Detection, also known as Interlock, is an active technology currently used in passenger vehicles that requires drivers to blow into a device in order to start their vehicle. If no alcohol is detected on their breath, then the vehicle will start, but drivers will be required to blow into the device periodically on their trip (*39*).

Driver Status Monitoring

This emerging technology uses facial detection software, which monitors and analyzes facial features of the driver to ensure driver alertness (*40*).

Electronic Licenses or Smart Cards

Electronic Licenses are an emerging technology currently used in Honda products that prevents unlicensed riding and ensures all operators have the proper safety training. Electronic licenses would require 'smart cards' to be placed into the ignition to operate the motorcycle. This would also allow the ability to monitor drivers who are inexperienced or deemed "at-risk" (*32*).

Helmet Mounted Displays

Helmet Mounted Displays is an emerging technology that projects information from the instruments to a display inside the operator's helmet, reducing the need to fully take their eyes off the road and look at their panel (*41*).

Rearview Displays

Rearview displays are an emerging technology, currently present in Honda ASV-3s and Yamaha ASV-2s, which uses backward facing cameras (mounted on the helmet or vehicle) to project real time images of the road environment behind the motorcycle to increase visibility over traditional rear-view mirrors (*32*).

Speed Alert/Limiting Systems

Speed Alert Systems is an existing technology that warns drivers when they have exceeded the posted speed limit, or exceed the maximum limit set by the motorcycle operator, in order to minimize the role that excessive speed plays in motorcycle crashes (*42*).

CRASH INJURY MITIGATION

These technologies are intended to reduce injuries when a crash occurs, and/or to bring emergency responders to the site of a crash more quickly.

Airbag System

The Airbag System is an existing technology such as those used in Yamaha ASV-2s and the Honda motorcycle airbag introduced on the 2006 Gold Wing that will deploy an airbag in the case of impact at a certain intensity level and can assist in keeping the rider from being thrown (*32*).

Airbag Vest

An Airbag Vest is an existing technology that is worn by the rider to protect the front and back of the body if thrown off the motorcycle (*43*).

Automated Crash Notification System

This system is an emerging technology actively being utilized in many car companies, such as Lexus and Toyota, that uses sensors, airbag deployment, and other cues to automatically notify emergency personnel of a crash; ensuring help can arrive more quickly while simultaneously collecting crash severity data (*44*).

Crash Data Recorder

Currently used in car companies such as Ford, Fiat, and Chrysler, this system is located in the airbag control, or power-train control on automobiles, and can record information such as driver's pre-impact speeds, whether the seatbelt was on or off, the driver's brake or throttle position pre-crash, and crash severity (*45*).

Table 1. ITS Matrix.

Crash Type	Technology to Address	Definition	Status	Active/ Passive	Companies Using	Ref.
Technologies to Prevent Run Off Road Crashes	Electronic Stability Program	"An on-boardcar safety system that enables the stability of the car to be maintained during critical maneuvering and to correct potential understeering or oversteering."	Existing in passenger vehicles	Active		(*29*)
	Curve Speed Warnings	Technology allows for assessment of hazard levels when driving is quickly approaching a curve in the road by using GPS and digital maps.	Emerging	Active	Yamaha AVS-2	(*30*)
	Lane Keeping and Departure Warnings	Uses forward facing cameras to scan to roadway and determine if the vehicle is migrating toward to the lane markings. All systems will vibrate the wheel to ensure the driver is awake, while others will also lightly apply the brakes to keep the vehicle in line.	Existing in passenger vehicles	Active	passenger: Volvo, Audi, BMW, Mercedes-Benz, Infiniti, Lexus, Cadillac, Ford in 2012	(*31*)
	Roll Stability	Roll stability systems monitor the motorcycle's speed and yaw rate (i.e., the rate at which the motorcycle is tilting away from vertical), and warn the rider if the motorcycle is in danger of tipping over.		Active		(*32*)
	Adaptive Front Lighting	Uses the angle of the steering wheel and the speed of the vehicle to ensure that the headlight is illuminating the roadway in front of the vehicle operator.	Emerging (for moto)	Active	Yamaha ASV-2 Model 1	(*33*)
	Road Surface Condition Monitoring	Using laser scanning technology linked to the ABS or speed limiting systems, technology scans the road and alert the driver to any potential hazard in the road surface. Can be combined with information from roadside beacons or other sources of data.	Emerging			(*32*)
Braking Systems	Anti-lock Braking Systems	Monitor wheel speed and adjust braking pressure evenly among wheels to ensure that brakes do not lock when applied in an emergency situation.	Existing	Active		(*34*)
	Brake Assist	To help prevent a collision, under sudden braking, brake assist systems will apply maximum pressure.	Existing on passenger	Active	Yamaha ASV-2 Model 1	(*35*)
	Linked Braking Systems	Applies pressure to both brakes simultaneously to ensure improved braking performance.	Existing on moto	Active		(*32*)

Crash Type	Technology to Address	Definition	Status	Active/ Passive	Companies Using	Ref.
Collision Warning and Avoidance Systems		Using radar, collision warning systems monitor the forward roadway and warn the driver audibly and visibly that they are nearing an object or vehicle in their lane. As the object gets closer, the warning becomes more intense.	Emerging	Active		(*36*)
	Pedestrian Detection System	Using radar sensors and data from a n on-board camera, the vehicle will automatically brake to reduce or mitigate the risk of hitting a pedestrian.	Emerging	Active	Volvo	(*37*)
	Animal Detection	Uses same radar and camera technology combination as pedestrian detection system to determine if the vehicle is in line to strike an object. An audible warning will be displayed and then brakes will automatically be applied.	Emerging	Active	Volvo	(*38*)
Driver Assistance and Monitoring	Advanced Driver Assist	"Employ a range of telematics and vehicle control systems to reduce driver workload and error."	Emerging	Active	Yamaha ASV-2 Model 1, BMW	(*32*)
	Alcohol Detection/ Interlock	Drivers blow into device in order to start the vehicle. If no alcohol is detected on their breath, then the vehicle will start but drivers will be required to blow into the device periodically on their trip.	Existing on passenger	Active		(*39*)
	Driver Status Monitoring	Using facial detection technology, facial features of the driver are analyzed to ensure driver alertness.	Emerging	Active		(*40*)
	Electronic Licenses or Smart Cards	In order to prevent unlicensed riding and ensure all operators have the proper safety training, electronic licenses would require smart cards to be placed into the ignition to operate the motorcycle. This would also allow the ability to monitor drivers who are inexperienced or deemed at-risk.	Emerging	Active	Honda	(*32*)
	Helmet Mounted Displays	Projects information from the instruments to a display inside the operator's helmet, reducing the need to fully take their eyes off the road and look at the panel.	Emerging	Active		(*41*)
	Rearview Displays	Helmet or vehicle based, rearview displays use backward facing cameras to project real time images of the road environment behind the motorcycle to increase visibility over traditional rear-view mirrors.	Emerging	Active	Reevu, Honda ASV-3, Yamaha ASV-2	(*32*)

Crash Type	Technology to Address	Definition	Status	Active/ Passive	Companies Using	Ref.
	Speed Alert/ Limiting Systems	System warns drivers when they have exceeded the posted speed limit or exceed the maximum limit set by the motorcycle operator in order to minimize the role that excessive speed plays in motorcycle crashes.	Existing	Active		(*42*)
Mitigation	Airbag System	Airbag systems will deploy in the case of impact at a certain intensity level and can assist in keeping the rider from being thrown.	Existing	Passive	Yamaha ASV-2 Model 1, and Honda motorcycle airbag system	(*32*)
	Airbag Vest	Worn by the rider to protect front and back of the body if thrown off the motorcycle.	Existing	Passive		(*43*)
	Automated Crash Notification System	Using sensors, airbag deployment and other cues, this system will automatically notify emergency personnel of a crash so that help can arrive more quickly; advanced systems also collect crash severity data from sensors on the vehicle.	Emerging		eCall (Europe), onStar, Ford Sync 911 Assist, Lexus Link, Toyota Safety Connect, BMW Assist, next generation 9-1-1	(*44*)
	Crash Data Recorder	Located in the airbag control or powertrain control on automobiles, the crash data recorder can record information such as driver's pre-impact speeds, whether the seatbelt was on or off, the driver's brake or throttle position pre-crash and crash severity.	Existing in some passenger vehicles	Passive	Bosch CDR system in select GM, Ford, Chrysler, Fiat, Toyota	(*45*)

CHAPTER 4. MOTORCYCLE CRASH DATA ANALYSIS

This chapter presents the results of the analyses carried out as part of Task 3. Task 3 was divided into two sub-tasks: Subtask 3.1 consisted of conducting an exploratory analysis of motorcycle crash data to provide key characteristics, patterns, and trends associated with motorcycle crashes. In Subtask 3.2, researchers performed a regression analysis of the data and developed regression-based models of crash severity.

DATA DESCRIPTION

The researchers obtained data on crashes involving motorcycles that occurred from 2006–2010 on the Texas state highway system from the TxDOT CRIS. The dataset contained information on crash severity, crash type, roadway information, environmental condition, rider gender and age, vehicle age, and driving under alcohol influence. In total, there were 44,928 motorcycle crashes in the 5-year period.

EXPLORATORY ANALYSIS

This section consists of conducting an exploratory analysis of the crash data to determine risk factors. Understanding how the risk factors are related to the occurrence of a crash is useful because risk factors potentially play a vital role in road safety and will help in identifying appropriate countermeasures for reducing motorcycle fatalities and injuries. Descriptive statistics were used to examine motorcyclists as well as the environmental and roadway characteristics associated with motorcycle crashes. The purpose of the descriptive analysis is to understand the characteristics of motorcycle crashes with the intention of examining the probability of a motorcyclist being fatally or seriously injured. Detailed analyses were conducted to identify driver, vehicle, and environmental characteristics that are prevalent in motorcycle-related crashes. Age, gender, license status, and alcohol intake of the motorcyclists, roadway surface condition and geometry, as well as roadway functional class are some of the factors that the researchers analyzed.

Table 2 displays the motorcycle crash frequency by severity. This table shows that a majority of the motorcycle crashes are either fatal or caused serious injuries. Although the total crash frequency in 2010 decreased when compared to 2006, there was an increase in the fatal crashes when the same years were compared.

Table 2. Motorcycle Crash Frequency by Severity.

Year	Crash Frequency					
	Incapacitating (A)	Non-Incapacitating (B)	Minor Injury (C)	Fatal (K)	PDO (O)	Total
2006	1,955	3,418	1,805	356	834	8,368
2007	1,873	3,507	2,026	424	904	8,734
2008	2,415	4,325	2,431	559	1,143	10,873
2009	1,877	3,724	2,124	482	990	9,197
2010	1,739	3,189	1,498	426	849	7,701
Total	9,859	18,163	9,884	2,247	4,720	44,873

Table 3 summarizes the characteristics of the motorcycle crashes. Since it is widely-recognized that property damage only (PDO) crash counts vary widely on a regional basis due to significant variation in reporting threshold, only those crashes that are associated with injury or fatality (KABC) were used in the analysis.

About two-thirds (60 percent) of all motorcycle crashes occurred between noon and 8:59 p.m. and the highest percentage recorded from 3 p.m. to 5:59 p.m. irrespective of the day of the week. Weekdays experienced a higher number of crashes during the period between 6 a.m. to 8:59 a.m., but weekends experienced this increase from 9 a.m. to 11:59 a.m. When the day of the week is considered, weekends (Saturday and Sunday) experienced more crashes followed by Friday and least on Monday. In Texas, motorcycle crashes were more likely to occur from March to October and less likely during winter months (November to February). An important thing to note is that the month of May experienced more crashes but the April month had more fatal crashes. Almost half of the crashes involved multiple vehicles and other half were just the motorcycle (i.e., single vehicle).

Table 3. Motorcycle Crash Characteristics.

Variable	Level	All (KABC) Crashes		Fatal (K) Crashes	
		Count	Percent	Count	Percent
Weekday Crash time	0–3	1,358	5.6	167	13.1
	3–6	620	2.5	51	4.0
	6–9	2,530	10.4	92	7.2
	9–12	2,301	9.4	102	8.0
	12–15	3,899	16.0	153	12.0
	15–18	6,059	24.8	200	15.7
	18–21	4,724	19.4	248	19.5
	21–24	2,913	11.9	257	20.2
Weekend Crash time	0–3	1,460	9.9	161	16.5
	3–6	358	2.4	48	4.9
	6–9	481	3.3	34	3.5
	9–12	1,741	11.8	85	8.7
	12–15	3,113	21.1	156	16.0
	15–18	3,394	23.0	210	21.5
	18-21	2,718	18.4	164	16.8
	21–24	1,505	10.2	119	12.2
Day of the week	Sunday	7,121	17.7	488	21.7
	Monday	4,246	10.6	199	8.9
	Tuesday	4,402	11.0	184	8.2
	Wednesday	4,660	11.6	227	10.1
	Thursday	5,124	12.8	282	12.6
	Friday	6,371	15.9	378	16.8
	Saturday	8,229	20.5	489	21.8
Month	January	1,921	4.8	84	3.7
	February	2,355	5.9	140	6.2
	March	3,349	8.3	148	6.6
	April	3,927	9.8	255	11.3
	May	4,156	10.4	229	10.2
	June	3,968	9.9	230	10.2
	July	3,674	9.2	244	10.9
	August	3,858	9.6	213	9.5
	September	3,970	9.9	234	10.4
	October	3,919	9.8	206	9.2
	November	2,990	7.4	154	6.9
	December	2,066	5.1	110	4.9
Crash type	Single vehicle	20,642	51.5	1,091	48.2
	Multi-vehicle	19,458	48.5	1,172	51.8

Table 4 shows the effect of roadway and area type on motorcycle crashes. More than one-third (37 percent) crashes occur on city streets. This could be attributed to the greater number of motorcycles that travel on city streets. When the percentages in all crashes and fatal crashes are compared, the farm-to-market roads are over-represented and city streets are under-represented in fatal crashes. Most of the motorcycle crashes occur on level roads, of which a large portion is in cities. However, the increased percentage of fatal crashes on horizontal curves shows that the chance of fatality increases when the motorcyclist is involved in a crash on horizontal curve. About one-third of the crashes are non-intersection related and are mostly multi-vehicle crashes. A little less than one-third of the total crashes occur in rural areas. The difference in percentages between all crashes and fatal crashes in rural areas suggest that the probability of a fatality increases when the crash occurs in a rural area.

Table 4. Roadway and Area Type.

Variable	Level	All (KABC) Crashes		Fatal (K) Crashes	
		Count	Percent	Count	Percent
Road class	Interstate	4,495	11.2	260	11.6
	US & State highways	10,691	26.6	693	30.8
	Farm-to-market	7,073	17.6	552	24.6
	County road	2,881	7.2	168	7.5
	City street	14,850	37.0	563	25.1
	Tollway	140	0.3	10	0.4
	Other roads	23	0.1	1	0.0
Road alignment	Straight, level	27,435	68.8	1,222	54.4
	Straight, grade	3,030	7.6	194	8.6
	Straight, hillcrest	816	2.0	68	3.0
	Curve, level	5,046	12.7	428	19.1
	Curve, grade	2,920	7.3	288	12.8
	Curve, hillcrest	448	1.1	39	1.7
	Other	163	0.4	6	0.3
Intersection related	No	29,359	73.1	1,673	74.5
	Yes	10,794	26.9	574	25.5
Population group	Rural & Town under 2,499	12,319	30.7	991	44.1
	2,500–99,999	9,469	23.6	410	18.2
	100,000 and over	18,364	45.7	846	37.7

Table 5 summarizes the helmet usage by motorcyclist age, ethnicity, and gender. There is no significant difference in the helmet usage according to motorcyclist age, ethnicity, or gender. However, the helmet usage is under-represented in the fatal crashes when compared to all crashes. This table shows that when the motorcyclist is without a helmet, then the chance of fatality goes up when he is involved in a crash.

Table 5. Helmet Usage.

Helmet Use by	Level	All (KABC) Crashes		Fatal (K) Crashes	
		Count	Percent	Count	Percent
Motorcyclist age	≤20	3,279	95.4	115	93.5
	21–30	9,589	94.2	509	91.2
	31–40	7,004	92.4	389	87.8
	41–50	7,432	90.9	458	87.2
	51–60	5,384	91.6	327	88.4
	>60	1,855	92.3	139	90.3
	Total	34,943	92.7	1,939	89.1
Motorcyclist ethnicity	White	25,047	92.7	1,422	88.7
	Hispanic	6,226	91.6	310	88.8
	Black	2,989	95.2	176	92.1
	Asian	355	97.0	12	100.0
	Other	147	95.9	15	100.0
Motorcyclist gender	Male	32,704	92.6	1,874	89.1
	Female	2,179	94.5	63	90.0

Table 6 displays the motorcycle crash contributing factors. Only those crashes whose contributing factor is known were considered. Of all known factors, speed is the primary contributing factor in motorcycle crashes. Kim stated that speeding is one of the factors that increase the odds of a motorcyclist being at fault in a collision (*46*). In Texas, speed is the major factor in about one-half (49 percent) of all crashes whose contributing factor is known. Potts et al. documented that about 37 percent of crashes have speeding as the primary contributing factor nationally (*47*). Other major factors that contribute to motorcycle crashes are inattention and faulty evasive action. When only fatal crashes were considered, speeding, lane indiscipline, and alcohol influence are over-represented. This basically means that when these factors are contributing to a crash then the chance of motorcyclist fatality increases.

Table 6. Contributing Factors.

Factor	All (KABC) Crashes		Fatal (K) Crashes	
	Count	Percent	Count	Percent
Animal on road	1299	5.8	37	2.5
Unsafe lane changing	420	1.9	21	1.4
Defective parts	196	0.9	6	0.4
Disregard signs	438	1.9	37	2.5
Inattention	2645	11.7	97	6.6
Speed related	11011	48.9	860	58.8
Lane indiscipline	1369	6.1	155	10.6
Failed to pass	297	1.3	11	0.8
Failed to yield	708	3.1	26	1.8
Faulty evasive action	2213	9.8	50	3.4
Fleeing or evading police	199	0.9	18	1.2
Followed too closely	763	3.4	13	0.9
Had been drinking	283	1.3	21	1.4
Under influence–alcohol	686	3.0	110	7.5

REGRESSION ANALYSIS

This section gives a brief background on the crash severity models, methodology, and modeling results.

BACKGROUND

Several statistical models are available to develop crash severity models. The most common ones that transportation safety analysts have used include the ordered logit or probit, partially-ordered logit, ordered mixed logit, multinomial logit, nested logit, and random parameters (mixed) logit. Each of these statistical models is briefly described in the following paragraphs, Savolainen et al provides a thorough review of data and modeling issues as well as the availability of several methods (*48*).

Due to the ordinal nature of crash severities, an ordered logit or probit model is the logical choice for the model development. This kind of models recognizes the natural order of increasing severity among the response alternatives (C, B, A, K) by fitting one function for all severity categories (with a unique cutoff value for each severity level). In this manner, the ordinal structure is well-suited to modeling factors that have the same effect across all severity levels (e.g., speed). Many traffic safety analysts have used the ordered logit and ordered probit models extensively for injury severity analysis (*49, 40, 51*).

Savolainen and Mannering documented the two important limitations when the ordinal model is used (*52*). The first limitation relates to under-reporting issues associated with low-severity injury crashes. When underreporting occurs, the ordered probability model yields biased and inconsistent coefficient estimates (*53*). The second limitation corresponds to the restriction that these models placed on a variable's influence. The ordered models constrain the effects, so a variable that increases the probability of the most (least) severe outcome would also decrease the corresponding probability of the least (most) severe outcomes. However, this is not the case with some of the more important variables that may influence crash-injury severity outcome. For example, an increase in barrier offset is not likely to have the same effect on fatal crash frequency as on property-damage-only crash frequency.

The partially ordered logit model can be used to overcome the aforementioned disadvantage of the ordered logit model. This model allows the coefficient of some variables to vary across severity categories, while the effect of other variables will be fixed across severity levels. Wang and Abdel-Aty (*51*) used this model to examine the injury severity of the total and specific left-turn crashes and found that partial proportional odds models consistently perform better than ordered probability models. Wang et al. (*54*) used this model to evaluate the effect of geometric and environmental conditions on crash severity in freeway diverge areas.

An ordered mixed (i.e., random effects) logit model represents an extension of the ordered logit. It quantifies that portion of the response variability that represents unobserved heterogeneity among sites (i.e., variation among sites that is likely explainable by missing variables). This technique reduced the response variability, with the result being more efficient regression coefficient estimates. Srinivasan (*55*) used this model structure to evaluate the driver and vehicle factors that influence crash severity on highways.

The multinomial logit model (MNL) is another type of discrete model that has been widely used to analyze crash severities (*56, 57, 58*). It offers a flexibility of constraining some variables to have the same effect, while allowing the other variables to vary among all severity levels. A multinomial logit model also offers advantages of estimating more flexible variable influences on estimation of probabilities of ordered or unordered outcomes. The MNL model was derived assuming that the error components are extreme value (or Gumbel) distributed. Though this assumption simplifies the probability equation, it also adds the Independence from Irrelevant Alternatives (IIA) property in the MNL model. The IIA property of the MNL restricts the ratio of probabilities for any pair of crash severities to be independent of the existence and characteristics of other crash severities in the set of severities considered in the model. This restriction implies that the introduction of a new crash severity type in the set will affect all other severities proportionately (*59*).

The nested logit overcomes the limitation of multinomial logit model by accounting for IIA assumption. Nested logit model groups crash severities that share unobserved attributes at different levels of a nest, which allows error terms within a nest to be correlated. Previous studies have also used nested logit model for crash severity analysis (*52, 56, 60*).

The (multinomial) random parameters logit model (or simply mixed logit model) represents a more generalized version of the ordered mixed logit model. Many studies have more recently used this type of model to examine the crash injury severity (*61, 62, 63*). This model overcomes the aforementioned disadvantage of the ordered logit structure by allowing a more flexible formulation that calibrates separate functions to each severity category. The "random parameters" element of this model quantifies the portion of the response variability that is due to site-to-site variation in the influence of individual model variables. One disadvantage of this model structure is that it requires simulation-based methods to estimate the model regression coefficients, which leads to an increase in model development time. Another disadvantage is that it does not consider the hierarchy of the severity categories.

In this research, the MNL model was used to predict the probability of crash severities. Recognizing the limitation of the MNL model, nested logit (NL) models were also developed to evaluate the IIA property. The test showed that the nesting parameters/inclusive value parameters for these models were not significantly different from one. For an acceptable nesting structure, the inclusive values need to be between 0 and 1. An inclusive value parameter equal to 1 indicates that there is no correlation in the unobserved factors within the nest; hence, the model is not different than the standard MNL model. A linear function is used to relate the crash severity with the geometric and traffic variables.

METHODOLOGY

As discussed above, the MNL model was used to predict the probability of crash severities. An individual crash severity among the given severities was considered to be predicted if the crash severity likelihood function was maximum for that particular severity. Each crash severity likelihood function, which is a dimensionless measure of the crash likelihood, was considered to have a deterministic component and an error/random component. While the deterministic part is assumed to contain variables that can be measured; the random part corresponds to the unaccounted factors that impact injury severity. The deterministic part of the crash severity likelihood was designated as a linear function of the driver, roadway, vehicle, and weather characteristics as shown in the following equation:

$$V_j = ASC_j + \sum_{k=1}^{K} b_{k,j} X_k \qquad \textbf{(1)}$$

where

V_j = systematic component of crash severity likelihood for severity *j*;

ASC_j = alternative specific constant for crash severity *j*;

$b_{k,j}$ = regression coefficient for crash severity *j* and variable *k*, *k* =1, ...,K;

X_{ki} = independent variable *k*; and

K = total number of independent variables included in the model.

The logit model was derived assuming that the error components are extreme value (or Gumbel) distributed and the probability for each crash severity is given by the following equation:

$$P_j = \frac{e^{V_j}}{\sum_{j=1}^{J} e^{V_j}} \quad \textbf{(2)}$$

where

P_j = probability of the occurrence of crash severity *j*; and

J = total number of crash severities to be modeled;

Thus, the final form for calculating the probability for each severity category is given as:

$$P_A = \frac{e^{V_A}}{1 + e^{V_K} + e^{V_A} + e^{V_B}} \quad \textbf{(3)}$$

$$P_B = \frac{e^{V_B}}{1 + e^{V_K} + e^{V_A} + e^{V_B}} \quad \textbf{(4)}$$

$$P_C = \frac{e^{V_C}}{1 + e^{V_K} + e^{V_A} + e^{V_B}} \quad \textbf{(5)}$$

$$P_K = 1 - (P_A + P_B + P_C) \quad \textbf{(6)}$$

where

P_A = probability of severity level A (incapacitating injury).

P_B = probability of severity level B (non-incapacitating injury).

P_C = probability of severity level C (possible injury).

P_K = probability of severity level K (fatal);

The SAS (*64*) non-linear mixed modeling procedure (NLMIXED) was used for model calibration.

DATA SUMMARY

The dataset contained information on crash severity, crash type, roadway information, environmental condition, rider gender and age, vehicle age, and crash contributing factors. Table 7 summarizes the data used in the analysis and is useful in identifying variables that may significantly affect motorcyclists' crash-injury outcomes. Further, the summary highlights variables for use in developing probabilistic models to identifying factors that significantly influence injury severities in urban and rural motorcycle crashes. The urban/rural split was intended to capture differences in factors influencing crash severities such as rider behavior and characteristics of rider populations. Accordingly, crash data were divided into two datasets: rural and urban, depending on the location of crash occurrence.

Table 7. Summary of Motorcycle Fatal and Injury Crash Data in Texas.

Variable	Value	Urban			Rural		
		Mean (std. dev)	Crash Freq.	Percent	Mean (std. dev)	Crash Freq.	Percent
Helmet Use	Yes (1)	--	22,058	88.20	--	11,013	90.60
	No (0)	--	2,951	11.80	--	1,142	9.40
Crash Type	SV	--	11,179	44.70	--	8,307	68.34
	MV	--	13,830	55.30	--	3,848	31.66
Time of the Crash	6.00–22.00	--	20,575	82.27		10,503	86.41
	22.00–6.00	--	4,434	17.73		1,652	13.59
Presence of Vertical Curve	Yes (1)	--	3,482	13.92	--	3,233	26.60
	No (0)	--	21,527	86.08	--	8,922	73.40
Presence of Horizontal Curve	Yes (1)	--	3,461	13.84	--	4,524	37.22
	No (0)	--	21,548	86.16	--	7,631	62.78
Speed Related	Yes (1)		6,268	25.06		4,219	34.71
	No (0)		18,741	74.94		7,936	65.29
DUI - Drug or Alcohol	Yes (1)	--	241	0.96	--	458	3.77
	No (0)	--	24,768	99.0	--	11,697	96.23
Lane Indiscipline	Yes (1)	--	1,794	7.17	--	565	4.65
	No (0)	--	23,215	92.83	--	11,590	95.35
IH, US or SH	Yes (1)	--	1,794	7.17	--	3,825	31.47
	No (0)	--	23,215	92.83	--	8,330	68.53
FM	Yes (1)	--	--	--	--	4,473	36.80
	No (0)	--	--	--	--	7,682	63.20
Motorcycle Rider Age	--	36.70 (13.44)	--	--	40.33 (14.16)	--	--

Note: Only the variables that are significant in influencing the severity are reported here.

MODELING RESULTS

The estimation results of motorcycle crashes in urban and rural areas are presented in Table 8 and Table 9, respectively. The t-statistics indicate a test of the hypothesis that the coefficient value is equal to 0.0. Those t-statistics with an absolute value that is larger than 2.0 indicate that the hypothesis can be rejected with the probability of error in this conclusion being less than 0.05. For those few variables where the absolute value of the t-statistic is smaller than 2.0, it was decided that the variable was important to the model. Trends for these variables were found to be consistent with previous research findings (even if the specific value was not known with a great deal of certainty as applied to this database).

Many variables were found to significantly influence motorcycle crash-injury severities in both urban and rural areas. Driving under the influence, rider age, the presence of horizontal and vertical curvature, crash type, crash time, speed, lane indiscipline, and highway type were significant in influencing crash severities. In rural areas, the farm-to-market (FM) roads variable was also found to influence the motorcycle crash severity (see Table 9).

Table 8. Parameter Estimation for Multinomial Logit Model–Urban Area.

Variable	Incapacitating Injury (A)		Non-Incapacitating Injury (B)		Minor Injury (C)	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Alternative-Specific Constant	2.2568	15.39	3.3599	23.78	3.1229	21.47
Helmet Use	--	--	0.2318	2.5	0.1909	1.98
Single Vehicle	0.3928	5.26	0.6629	9.23	0.3065	4.14
Motorcycle Rider Age	−0.0061	−2.43	−0.0157	−6.47	−0.0156	−6.26
Time (22.00–6.00)	−0.6157	−8.35	−1.0052	−14.2	−1.0855	−14.44
Presence of Vertical Curve	−0.1604	−1.86	−0.2581	−3.12	−0.3968	−4.52
Presence of Horizontal Curve	−0.4427	−5.15	−0.7404	−8.97	−0.8367	−9.45
Speed Related	−0.691	−9.04	−0.9963	−13.59	−1.2327	−16.05
DUI–Drug or Alcohol	−1.193	−5.95	−1.6693	−8.59	−2.2875	−9.09
Lane Indiscipline	−0.6674	−5.84	−0.8174	−7.52	−0.9507	−8.33
IH, US, or SH	−0.1335	−1.98	−0.1955	−3.02	−0.2035	−3.04

Note: Fatal crash is the base scenario with coefficients restricted at zero.

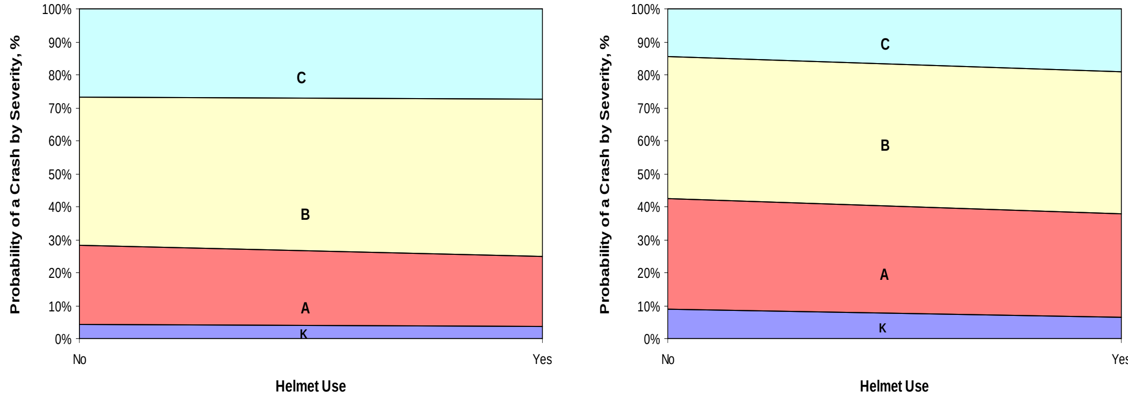
Table 9. Parameter Estimation for Multinomial Logit Model–Rural Area.

Variable	Incapacitating Injury (A)		Non-Incapacitating Injury (B)		Minor Injury (C)	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Alternative-Specific Constant	1.6087	9.15	2.2059	12.82	1.5746	8.3
Helmet Use	0.2752	2.42	0.3565	3.19	0.6051	4.7
Single Vehicle	0.8693	9.98	1.1748	13.73	0.8456	9.2
Motorcycle Rider Age	−0.00747	−2.74	−0.01549	−5.81	−0.01384	−4.78
Time (22.00–6.00)	−0.5493	−5.63	−0.7545	−7.84	−0.8118	−7.44
Presence of Vertical Curve	−0.1697	−1.99	−0.1803	−2.16	−0.3959	−4.22
Presence of Horizontal Curve	−0.1978	−2.15	−0.3678	−4.08	−0.5029	−5.06
Speed Related	−0.378	−4.37	−0.4501	−5.32	−0.6175	−6.64
DUI–Drug or Alcohol	−0.7804	−5.02	−1.2158	−7.73	−1.6705	−8.14
Lane Indiscipline	−0.3772	−2.25	−0.6595	−3.96	−0.6183	−3.38
IH, US, or SH	−0.3798	−3.8	−0.5186	−5.3	−0.6021	−5.74
FM	−0.2813	−2.89	−0.4054	−4.26	−0.5982	−5.8

PREDICTED PROBABILITIES

Helmet Usage

Figure 1 shows the relationship between the helmet usage variable and severity level. The positive value of the associated coefficient (in Table 8 and Table 9) indicates that, with the use of helmet, the likelihood of severity levels K and A decreases. The trends in Figure 1 indicate that the fatal crash percentage changes from 4.2 percent without a helmet to 3.6 percent with a helmet in urban areas, and from 9.1 percent without a helmet to 6.4 percent with a helmet in rural areas. It is rationalized that the higher percentages in rural areas than urban areas are due to the higher running speeds. A similar trend is shown for severity level A. The trends shown in Figure 1 are consistent with the findings of other studies (*65, 66, 67*).

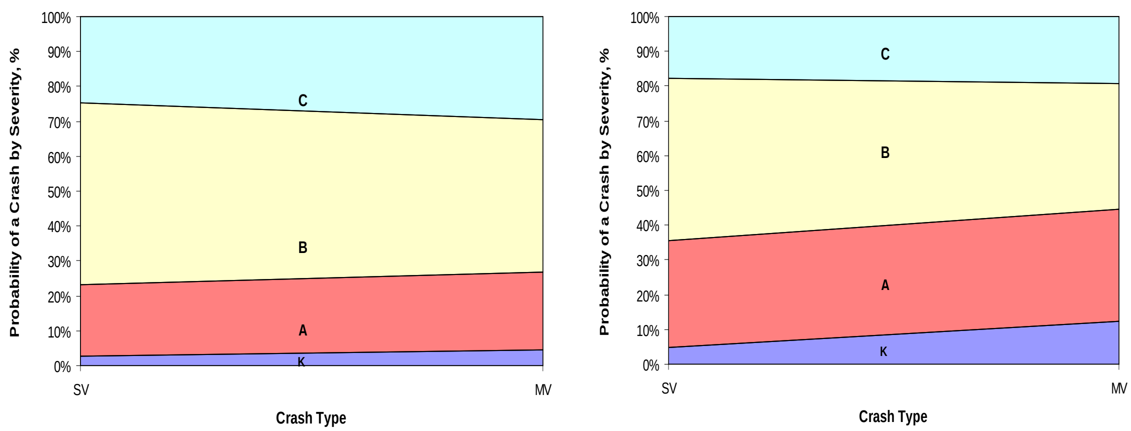


a) Urban Area b) Rural Area

Figure 1. Severity Distribution Based on the Helmet Usage.

Crash Type

Figure 2 shows the relationship between the crash type variable and severity level. The positive value of the associated coefficient (in Table 8 and Table 9) indicates that single-vehicle crashes are less likely to result into serious injuries when compared to multi-vehicle crashes. This is expected because MV crashes on average have a greater transfer of energy than do SV crashes. The trends in Figure 2 indicate that the likelihood of fatality changes from 2.8 percent in a single vehicle crash to 4.5 percent in a multi-vehicle crash in urban areas, and from 4.9 percent to 12.3 percent in rural areas. A similar trend is shown for severity level A.

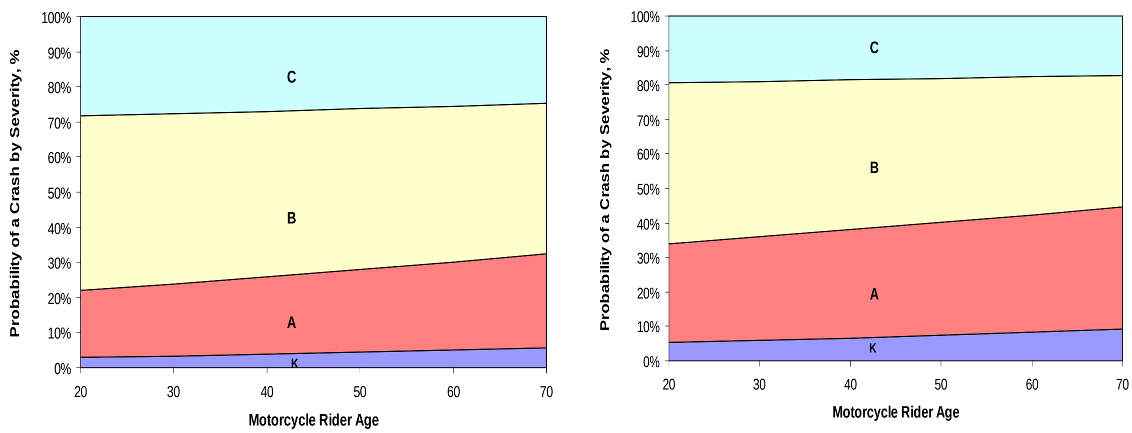


a) Urban Area b) Rural Area

Figure 2. Severity Distribution Based on the Crash Type.

Rider Age

Figure 3 shows the relationship between the motorcycle rider age and severity level. The negative value of the associated coefficient (in Table 8 and Table 9) indicates that a crash with an older rider will more likely result into serious injuries when compared to a crash with a young rider. The trends in Figure 3 indicate that the likelihood of fatality changes from 2.9 percent for a crash with rider age of 20 to 5.6 percent for a crash with rider age of 70 in urban areas, and from 5.2 percent to 9.3 percent in rural areas. A similar trend is shown for severity level A. The main reason could be due to the fact that the elder riders are more susceptible to injury. Previous studies have also found that increasing age is more likely correlated with fatal and serious injury crashes (*65, 68*).



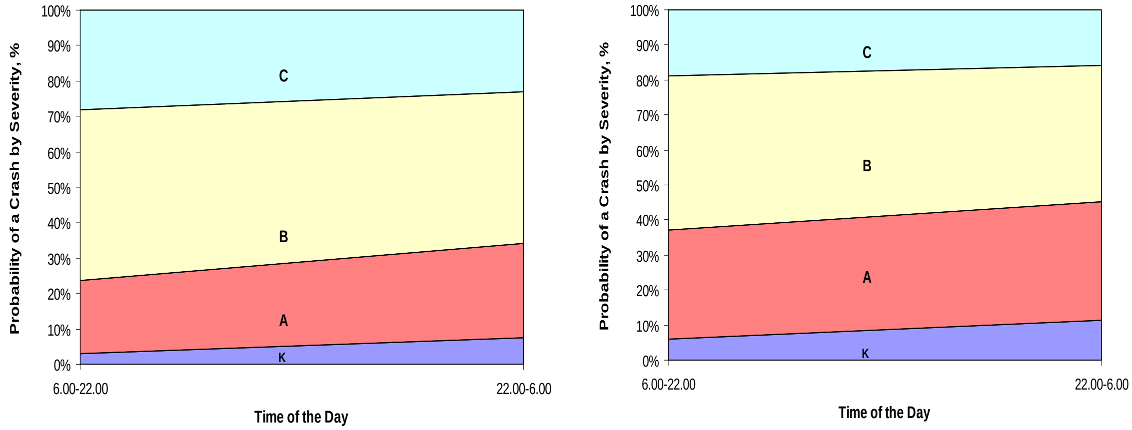
a) Urban Area

b) Rural Area

Figure 3. Severity Distribution Based on the Motorcycle Rider Age.

Time of the Day

Figure 4 shows the relationship between time of the day and severity level. The negative value of the associated coefficient (in Table 8 and Table 9) indicates that a crash occurring between 6am and 8pm will be less severe than the crash occurring between 8 p.m. and 6 a.m. The trends in Figure 4 indicate that the likelihood of fatality changes from 3.1 percent for a daytime crash to 7.5 percent for a nighttime crash in urban areas, and from 6.1 percent to 11.5 percent in rural areas. A similar trend is shown for severity level A. The main reason could be attributed to the visibility of motorcycles. When the visibility is limited, the crash occurs at a higher speed, resulting in a high severity. Quddus et al. also found a similar trend with respect to the time of the crash (*68*). They stated it is likely that speeds and alcohol use are greater during midnight to the early morning hours, and could lead to more severe injuries and damage.

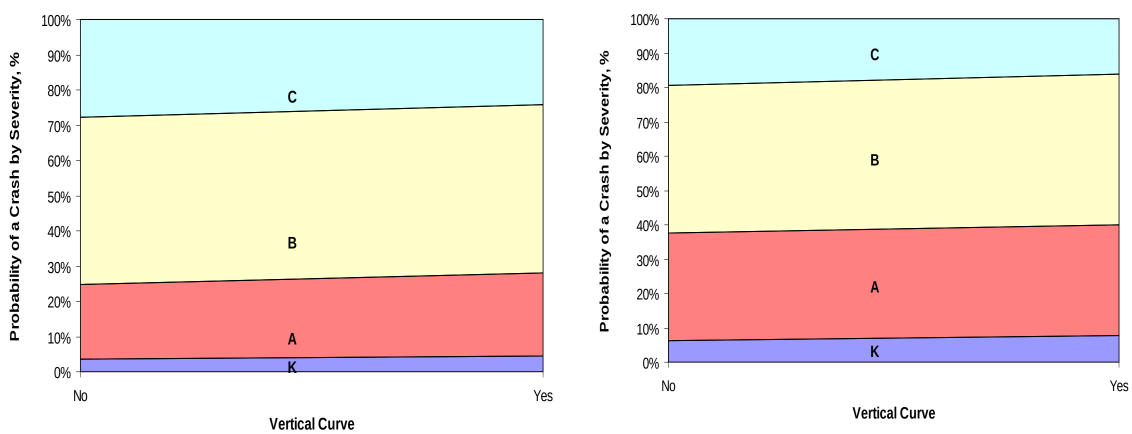


a) Urban Area b) Rural Area

Figure 4. Severity Distribution Based on Time of the Day.

Vertical Curvature

Figure 5 shows the relationship between the vertical curvature and severity level. The negative value of the associated coefficient (in Table 8 and Table 9) indicates that a crash occurring on a road with vertical grade will be more severe than the crash occurring on a flat road, although the difference is minor. The trends in Figure 5 indicate that the likelihood of fatality changes from 3.5 percent for a crash on a flat road to 4.6 percent for a crash on a road with grade in urban areas, and from 6.3 percent to 7.7 percent in rural areas. A similar trend is shown for severity level A. The main reason could be attributed to the visibility of motorcycles on roads with a vertical curve. When the visibility is limited, the crash occurs at a higher speed, resulting in a high severity.

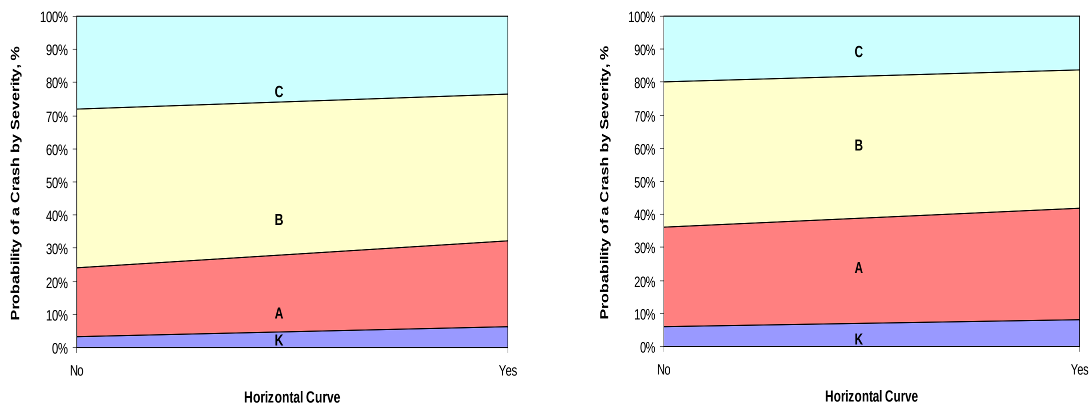


a) Urban Area b) Rural Area

Figure 5. Severity Distribution Based on the Vertical Curvature.

Horizontal Curvature

Figure 6 shows the relationship between the horizontal curvature and severity level. The negative value of the associated coefficient (see Table 8 and Table 9) indicates that a crash occurring on a horizontal curve will be more severe than the crash occurring on a straight road. The trends in Figure 6 indicate that the likelihood of fatality changes from 3.3 percent for a straight road to 6.4 percent for a horizontal curve in urban areas, and from 5.9 percent to 8.1 percent in rural areas. A similar trend is shown for severity level A. Most of the curve-related fatal crashes involve motorcycles leaving the roadway and striking trees, utility poles, rocks, or other fixed objects; or overturning; or head-on collision with vehicles traveling in the opposite direction.

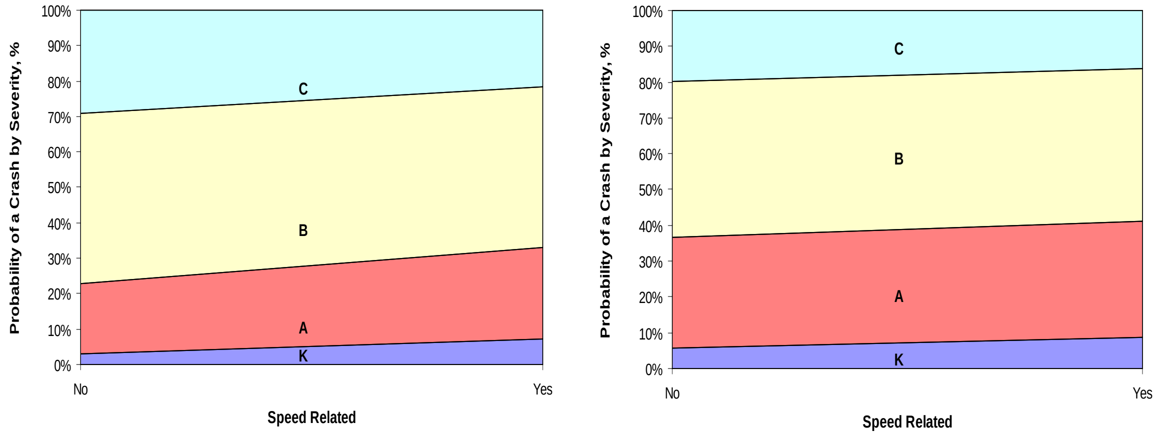


a) Urban Area b) Rural Area

Figure 6. Severity Distribution Based on the Horizontal Curvature.

Speeding

Figure 7 shows the relationship between speeding and the severity level. The negative value of the associated coefficient (see Table 8 and Table 9) indicates that a crash occurring while overspeeding will be more severe than the crash without speed as a primary contributing factor. The trends in Figure 7 indicate that the likelihood of fatality changes from 2.9 percent for a non-speed-related crash to 7.3 percent for a speed-related crash in urban areas, and from 5.7 percent to 8.8 percent in rural areas. A similar trend is shown for severity level A. According to FARS (*69*), speed is a contributing factor in fatal motorcycle crashes 36 percent of the time, about twice the rate for drivers of passenger cars or light trucks. Potts et al. stated that, for motorcycles, it is common to witness speeds double, and sometimes triple, that of posted limits (*47*).

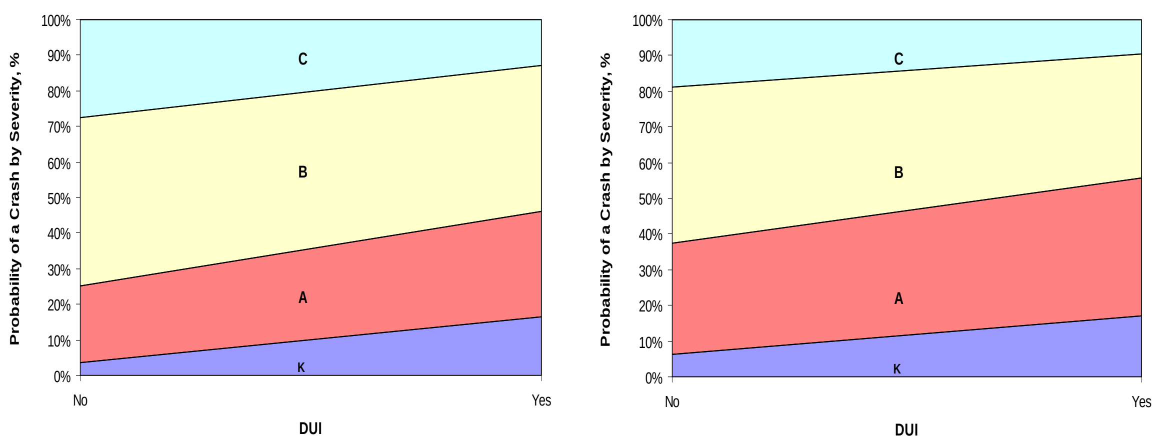


a) Urban Area b) Rural Area

Figure 7. Severity Distribution Based on Speeding.

Driving Under Influence (DUI)

Figure 8 shows the relationship between DUI and the severity level. The negative value of the associated coefficient (in Table 8 and Table 9) indicates that a crash with a rider under influence tend to be more severe than the crash without a rider under influence. The influence here refers to either alcohol or drugs. The trends in Figure 8 indicate that the likelihood of fatality changes from 3.6 percent for a crash without DUI to 16.5 percent for a crash with DUI in urban areas, and from 6.4 percent to 17.2 percent in rural areas. A similar trend is shown for severity level A. DUI has a slightly more pronounced impact on the likelihood of fatal injuries in urban areas when compared to rural areas (see Figure 8). This result is consistent with the findings of other studies (*67*).

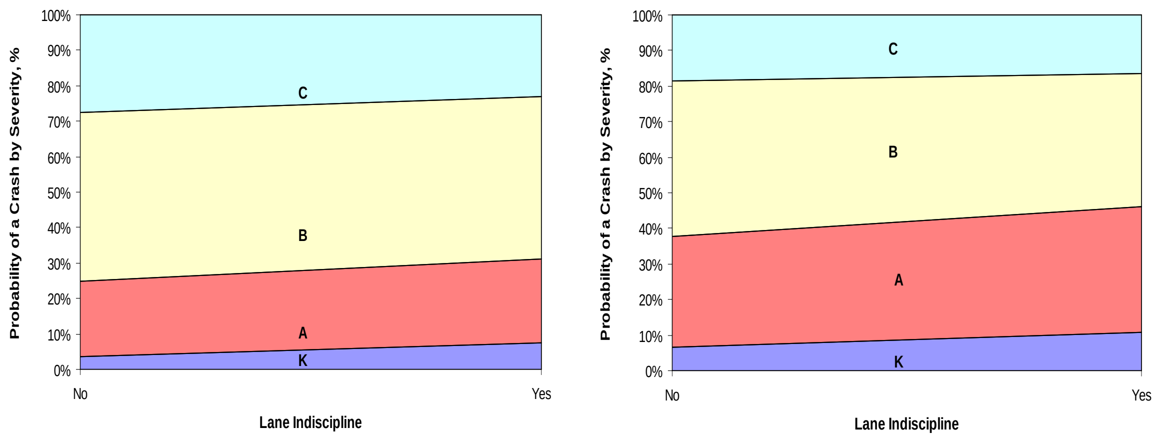


a) Urban Area b) Rural Area

Figure 8. Severity Distribution Based on DUI.

Lane Indiscipline

Figure 9 shows the relationship between lane indiscipline and the severity level. The negative value of the associated coefficient (in Table 8 and Table 9) indicates that a crash with lane indiscipline as a contributing factor tends to be more severe than a crash without lane indiscipline. The trends in Figure 9 indicate that the likelihood of fatality changes from 3.5 percent for a crash without lane indiscipline as a contributing factor to 7.5 percent for a crash with lane indiscipline in urban areas, and from 6.5 percent to 10.7 percent in rural areas. A similar trend is shown for severity level A.

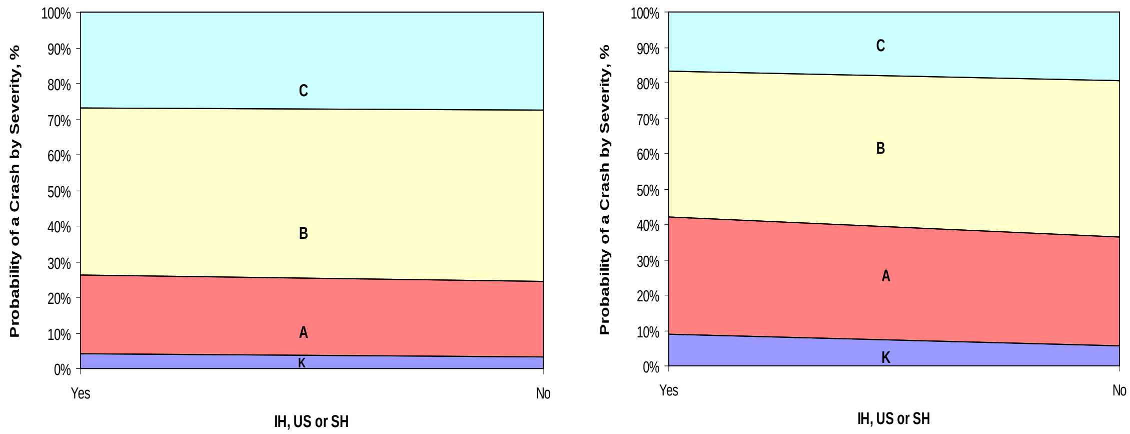


a) Urban Area b) Rural Area

Figure 9. Severity Distribution Based on Lane Indiscipline.

Highway Type

Figure 10 shows the relationship between highway type and the severity level. The negative value of the associated coefficient (see Table 8 and Table 9) indicates that a crash occurring on high standard roads (such as interstate, US, and state highways) tends to be more severe than the crash on other roads (such as city streets and county roads). The trends in Figure 10 indicate that the likelihood of fatality changes from 4.1 percent for a crash on high standard roads to 4.1 percent for a crash on other roads in both urban and rural areas. A similar trend is shown for severity level A. The main reason for this trend could be attributed to the higher speed limits.



a) Urban Area b) Rural Area

Figure 10. Severity Distribution Based on Highway Type.

Farm-to-Market (FM) Roads

Figure 11 shows the relationship between FM road type and the severity level. The negative value of the associated coefficient (see Table 8 and Table 9) indicates that a crash occurring on FM roads tends to be more severe than the crash on other roads. This variable is only significant in motorcycle crashes occurring in rural areas. The trends in Figure 11 indicate that the likelihood of fatality changes from 5.8 percent for a crash on FM roads to 8.4 percent for a crash on other roads in rural areas. The main reason for this trend could be attributed to the higher speed limits and roadway design.

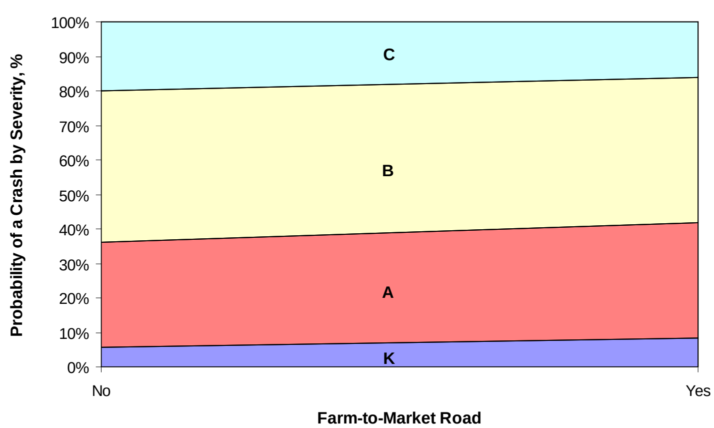


Figure 11. Severity Distribution with Respect to FM Roads in Rural Area.

CHAPTER 5. STATEWIDE RIDER SURVEY

The objective of Task 4 was to develop a database of Texas motorcycle riders that captures demographic characteristics, riding history and training, protective gear use, crash experiences, and attitudes about safety practices and countermeasures. To accomplish the objective, the research team conducted a web-based survey of Texas motorcyclists.

SURVEY DEVELOPMENT

The research team reviewed previous behavioral studies involving motorcyclists in the United States and other countries. These studies, many of which involved surveys, individual interviews, or focus group discussions with motorcycle riders, provided examples of question topics and survey structure which were used in developing a draft survey. Early results from Task 2 (ITS technology review) and Task 3 (crash analysis) helped to develop questions specific to technology-based countermeasures and crash experiences.

The draft survey was pre-tested in a paper format at the Motorcycle Safety Forum held at TTI Headquarters in February 2012. Based on pre-test results and reviews from pre-test participants, the draft survey was revised and an online version was developed and posted on the Survey Monkey website.

Additional revisions to the online survey were made following a second review by the project management committee, members of the Texas Motorcycle Safety Coalition Executive Board, and selected TTI staff members. The completed survey, as it appeared online, is included as an appendix to this report.

SURVEY CIRCULATION AND RECRUITMENT

The research team pursued multiple channels to circulate the online survey link to Texas motorcycle riders. E-mails explaining the purpose of the survey and inviting participation of Texas riders were sent to TTI's extensive contact list of motorcycle riders, safety instructors, and dealers, which has been built over several years through the TMSC, the outreach website Look-Learn-Live, and contacts made at motorcycle rider events. The team also enlisted the help of motorcyclist groups including TMRA and COC&I. Other outreach methods included social media (including postings about the survey on TTI's Facebook page) and press releases.

RESULTS

Between July 4 and August 31, 1,386 responses were received. The number of responses to each survey question varied, since some respondents chose not to answer every question. Therefore, the results for each question will include the number of responses received, with response percentages based on that total number.

Demographics

Demographic questions included year of birth, sex, current job field, annual income, and race.

Age and Sex

To calculate respondent ages, respondents were asked for the year in which they were born, and that year was subtracted from 2012 (the year of this survey). Eighty-five percent of respondents were male and 15 percent were female. Ages ranged from 21 to 81 years, with an average age of 52.5. Figure 12 shows the distribution of ages for men and women.

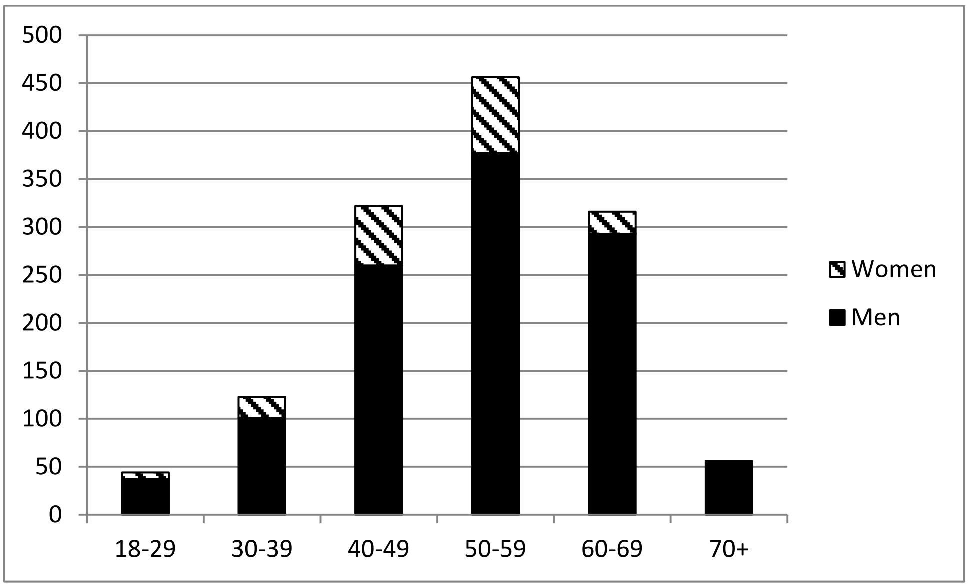


Figure 12. Respondents' Distribution of Age.

Job Field and Income

Respondents were asked to fill in their current job field; these open-ended responses were then classified according to the US Bureau of Labor Statistics' Standard Occupational Classification (SOC) (*70*). Within the fields of education/training/library, installation/maintenance/repair, and sales/related occupations, respondents who noted that they worked with motorcycles and motorcyclists (e.g., motorcycle instructors, dealers, or mechanics) were broken out as sub-groups. The number and percentage of respondents in each of the SOC categories (for the 1204 respondents who answered this question) are listed in Table 10.

Table 10. Survey Responses – Job Field.

Job Field (SOC) (47)	Number of Responses	Percentage of Responses
Architecture/Engineering	86	7.1%
Arts, Design, Entertainment, Sports, Media	16	1.3%
Building and Grounds Cleaning and Maintenance	1	0.1%
Business/Financial	58	4.8%
Community and Social Service	32	2.7%
Computer/Mathematical	31	2.6%
Construction and Extraction	80	6.6%
Education, Training, Library	49	4.1%
Education, Training, Library - motorcycles	16	1.3%
Farming, Fishing, Forestry	6	0.5%
Food Preparation and Service	4	0.3%
Healthcare Practitioners and Technical Occupations	47	3.9%
Healthcare Support	3	0.2%
Installation, Maintenance, and Repair	149	12.4%
Installation, Maintenance, and Repair - motorcycles	2	0.2%
Legal	14	1.2%
Life, Physical, Social Science	15	1.2%
Management	95	7.9%
Military	18	1.5%
Office and Admin Support	17	1.4%
Personal Care and Service	8	0.7%
Production/Manufacturing	21	1.7%
Protective Service	84	7.0%
Sales and Related Occupations	79	6.6%
Sales and Related Occupations - motorcycles	7	0.6%
Transportation and Material Moving	71	5.9%
Retired	180	15.0%
Student	4	0.3%
Not currently employed	11	0.9%
Answered question	**1204**	**100%**

The majority of respondents report an annual of $70,000 or more. Table 11 lists the income categories that were reported by the 1286 survey respondents who responded to this question.

Table 11. Survey Responses – Annual Income.

Annual Income	Number of Respondents	Percentage of Respondents
$0 to $25,000	49	3.8%
$25,001 to $40,000	163	12.7%
$40,001 to $55,000	162	12.6%
$55,001 to $70,000	181	14.1%
$70,001 to $85,000	162	12.6%
Over $85,000	569	44.2%

Race

Eighty-five percent of respondents were Caucasian, 7 percent were Hispanic, 3 percent were African-American, 3 percent identified as belonging to multiple races, and 1 percent were American Indian or Alaskan Native. Slightly less than one-half of respondents were Asian, one respondent (0.1 percent) identified as Pacific Islander, and slightly over one percent of respondents identified their race as "other."

Licensing, Motorcycles Owned, and Riding History

Respondents were asked whether they currently hold a motorcycle license, about the numbers and types of motorcycles they own and ride, and whether they ride primarily for recreation or as primary transportation (i.e., for commuting, errands, and other daily transportation needs).

Licensing

Ninety-five percent of respondents reported having a motorcycle endorsement on their driver's license (out of 1,381 who answered this question), and an additional one percent reported having a motorcycle license only with another half reporting having a motorcycle learner's permit. The remaining 49 (3.5 percent) of respondents reported not having a motorcycle license; Of these respondents, 17 said they are motorcycle passengers only, seven are waiting to take a course and/or the test to obtain a motorcycle license, and four do not currently own a motorcycle. For an additional eight respondents, the cost and/or inconvenience of taking the motorcycle safety course has discouraged them from obtaining a license. One respondent commented, "I have a valid Texas driver's license to operate a motor vehicle. A motorcycle is a motor vehicle." Another commented that he only rides off-road, and a third said that he's been riding for many years without a license ("…call me lucky"). The remaining eight respondents who do not have a motorcycle license did not provide a comment.

Type(s) of Motorcycles

Respondents were asked how many motorcycles they own; the makes, models, and years of up to three motorcycles owned; and the type of motorcycle that they ride most often. The question pertaining to the number of motorcycles participants own was answered by 712 respondents. Of these, 435 own one motorcycle, 161 own two, 51 own three, and 49 own four or more. Thirteen hundred (1300) participants listed the make, model, and year of at least one motorcycle that they currently own; 455 listed information for a second motorcycle, and 176 listed information for a third. Table 12 lists the motorcycle makes/brands that were listed most frequently by participants as motorcycles that they currently own.

Table 12. Most Frequent Makes of Motorcycles Owned by Participants.

Make	Bike #1	Bike #2	Bike #3	Total
Harley Davidson	623	144	30	**797**
Honda	237	86	47	**370**
Suzuki	78	49	16	**143**
Kawasaki	74	39	18	**131**
Yamaha	85	33	8	**126**
BMW	69	35	11	**115**
Triumph	25	14	10	**49**
Ducati	20	8	2	**30**
Victory	18	3	2	**23**
KTM	6	6	5	**17**
Moto Guzzi	7	3	1	**11**
Buell	5	0	2	**7**

When asked the *type* (as opposed to particular make/model) of motorcycle that they most frequently ride, “cruiser” was the most frequently selected answer (520, or 40 percent of those answering this question), followed by “touring” (434, or 33 percent). Complete results for this question are shown in Table 13.

Table 13. Type of Motorcycle Participants Ride Most Often.

What type of motorcycle do you ride most often?	Response Percent	Response Count
Cruiser	39.8%	520
Touring	33.2%	434
Sport	5.0%	65
Sport touring	9.1%	119
Standard/naked	4.1%	53
Dual purpose (on and off-road)	5.7%	74
Three-wheeler	2.8%	37
Off-road/dirtbike	0.4%	5
Moped	0.1%	1
Other	2.2%	29

Riding History and Experience

Of the 1,320 respondents who answered this question, 5 percent reported riding for less than two years; 13 percent for two to five years; 13 percent for six to 10 years; 13 percent for 11 to 20 years; 13 percent for 21 to 30 years; and 43 percent for 31 years or more, as shown in Figure 13.

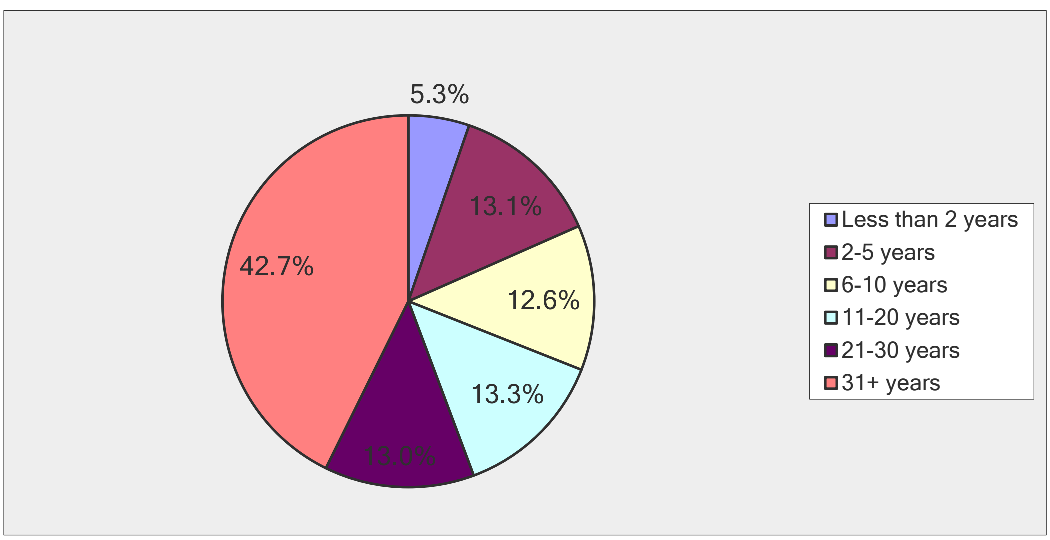


Figure 13. Responses to "How Long Have You Been Riding a Motorcycle?"

The number of miles each participant rode in the last year ranged from 0 to 80,000, with an average of 10,323. Approximately 70 percent of respondents noted they ride primarily for recreation, while the remaining 30 percent use a motorcycle for primary transportation and/or on the job. The question was structured as a one-answer "either-or" response, forcing respondents to choose “recreation” or “transportation” as their primary riding purpose; 75 of the 1,267 respondents to this question added a comment indicating that they ride for both transportation and recreation.

Respondents were also asked, “Where do you most often ride?” in terms of roadway type. Figure 14 displays the responses to this question. The most frequently selected roadway types were “rural roads,” selected by 68 percent of respondents; “US/state highways in rural areas,” selected by 62 percent; and “US/state highways in and around cities,” selected by 57 percent.

“City streets” was selected as one of the top three roadway types by 38 percent of respondents, and “off-road” was selected by just four percent. Three percent of respondents selected “other,” and added a comment to specify their answer; of these, most indicated that they regularly ride a mix of the roadway types.

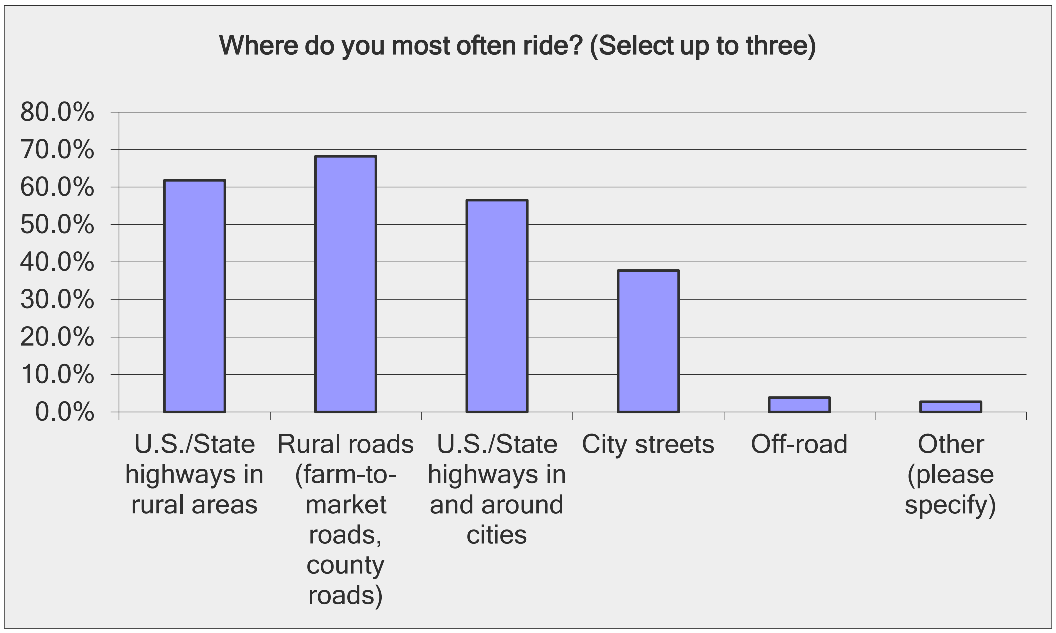


Figure 14. Types of Roadways where Respondents Most Often Ride.

Training

Just under 72 percent of respondents (953 of the 1326 answering this question) have completed one or more motorcycle training course. The participants who have taken at least one training course were asked which course (or courses) they have taken; of the 948 answering this question, 77 percent have taken Texas’ Basic Rider Course, 35 percent have taken Texas’ Experienced Rider Course, 14 percent have taken a similar training course in another state, and 11 percent have taken a course provided by the military. Fourteen percent selected “other”; of these, most specified a training course received at a particular training school that would fall under one of the other course categories listed; several others indicated that they have taken motorcycle training for police officers.

When asked whether they felt their riding skills had improved as a result of the course(s) they have taken, 46 percent of respondents said their skills were "greatly improved" and 36 percent said their skills had "significantly improved." Sixteen percent indicated "slightly improved" skills as a result of the training course(s), while 3 percent felt that their riding skills had not improved following a motorcycle course. A sample of the comments from respondents regarding training courses follows.

Positive comments:

- "Should be mandatory for everyone."
- "After taking my course, it made me feel that everyone should have a course like that to get even a standard driver's license. It makes you so much more aware of your surroundings!"
- "My situational awareness was elevated and I have bettered my maneuvering skills."
- "The skills learned have saved my life numerous times. Absolutely invaluable. Should be mandatory nation-wide to get a license."
- "Didn't take the course until I had crashed my bike after 30 years of riding. Learned why I crashed and what I had forgotten to do as a regular habit."
- "I have been riding and racing motorcycles since I was 7. I am a very accomplished rider already, but the BRC did help me realize some flaws and bad habits related to street riding and allowed me to overcome those to be a better, safer street rider."

Negative or mixed comments:

- "Most safety courses seem out of touch with true riding or possibly written by inexperienced riders."
- "Basic Rider Course training is on small motorcycles in a parking lot, does not give you improved riding skills. It does give you knowledge to improve once you are in the real world on a big bike."
- "Trained on a very small bike that did not teach me how to handle a large bike."

When asked about their potential interest in taking additional motorcycle safety or skills courses in the future, 68 percent answered "yes," 24 percent answered "maybe," and eight percent answered "no." Comments on this question included the following:

- "I have always wanted to take the experienced rider course, and possibly a track-based course."
- "I would like them to be affordable and applicable to my interests and needs."
- "Would like to take a course to improve off road, dual sport, riding skills."
- "More in the aspects of performance riding, cornering, safety, limits of what the bike can do from those who KNOW."

- “Depends on the type of course. For my skill level, I would be more interested in skills like adventure oriented motorcycling (on/off road with an adventure bike). For road it is always good to learn other safe aspects of cornering, with finesse.
- “Interested in learning off-road skills.”
- “If not mandated, and free.”

Helmets, Safety Gear, and Visibility

Of the 1305 respondents who answered this question, 1096 (84 percent) indicated that they wear DOT-approved motorcycle helmets most or all of the time. Table 14 lists the frequency of each of the provided responses to this question.

Table 14. Responses Regarding Helmet Use.

How often do you choose to wear a DOT-approved helmet when you ride?	**Response Count**	**Response Percent**
Always	926	71.0%
Most of the time	170	13.0%
About half the time	57	4.4%
Sometimes	59	4.5%
Rarely or never	93	7.1%
answered question	**1305**	

Helmet usage varied by age group, with respondents aged 30 to 49 being somewhat less likely to state that they wear a DOT-approved helmet “all of the time” and more likely to state that they “rarely or never” wear a helmet. Figure 15 displays the responses to this question by age group.

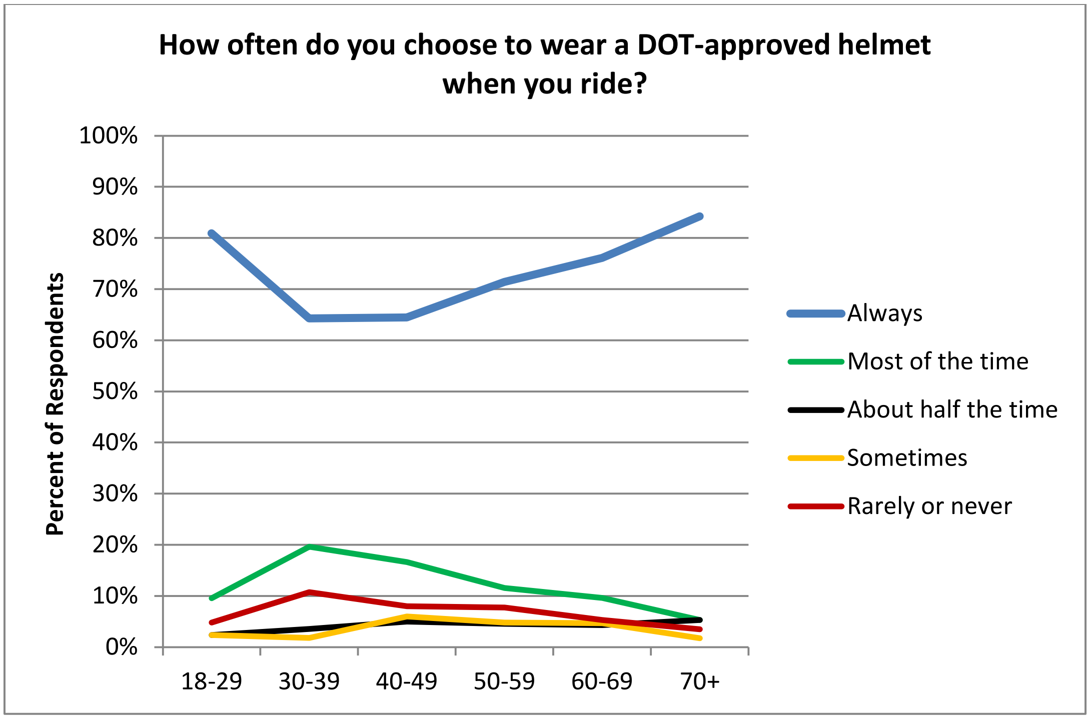


Figure 15. Reported Helmet Use by Age.

The most frequent reason given for wearing a helmet was "protective benefits" (81 percent of those answering this question); the next most frequently-stated reasons include: protection from weather (50 percent of those answering the question), protection from bugs/debris (40 percent), and "habit" (38 percent). Of those that wear a helmet less than half the time, the most frequent reasons stated for not wearing one were: personal choice (58 percent), hot/humid weather (37 percent), discomfort (26 percent), and "more fun to ride without a helmet" (25 percent). Table 15 lists the frequencies of all responses selected for wearing and for not wearing a helmet.

Table 15. Reasons for Wearing or Not Wearing a DOT-Approved Helmet.

Reasons for Wearing a Helmet	#	Percent	Reasons for Not Wearing a Helmet	#	Percent
Protective benefits	963	81.2%	Personal freedom/choice	314	58.3%
Weather (cold/rain/wind)	588	49.6%	Weather (too hot/humid)	197	36.5%
Keeps bugs/debris out of my face	477	40.2%	Uncomfortable	139	25.8%
Habit	454	38.3%	More fun to ride without helmet	136	25.2%
Know someone who was injured riding without a helmet	307	25.9%	See better without helmet	98	18.2%
Comfort	289	24.4%	Hear better without helmet	86	16.0%
Family obligations	288	24.3%	I tend to give my passenger the only helmet	43	8.0%
Hearing protection	266	22.4%	Habit	32	5.9%
Lets me listen to music/ communicate with passenger	176	14.8%	Know someone who was injured because of helmet	31	5.8%
Military requirements	79	6.7%	I'm a cautious rider – helmet not as important	26	4.8%
Style	52	4.4%	Helmet not as important if I'm not in heavy traffic	21	3.9%
Peer pressure	24	2.0%	No protective benefits	20	3.7%
Other (please specify)	115	9.7%	Too expensive	10	1.9%
			Peer pressure	5	0.9%
			The helmet I have doesn't fit	3	0.6%
			Other (please specify)	98	18.2%
Total responses:	**1186**		**Total responses:**	**539**	

Besides the multiple-choice responses for each of these two questions (reasons for wearing a helmet and reasons for NOT wearing a helmet), respondents had the option of selecting "other" and inputting their own answers. Responses that participants provided as other reasons for wearing a helmet included the following:

- "I've been saved by a helmet and know others with similar experience."
- "Face shield keeps my glasses on when looking over my shoulder on the highway."
- "Best eye protection, and over 35 MPH is the best crash preventative device."
- "Part of my commitment as an instructor."
- "Because you are an idiot if you don't wear a helmet."
- "To be a role model for my son."
- "I wear it if I will be riding in downtown traffic."
- "The helmet once saved my life."
- "When the state I'm riding in requires it."
- "Lessens fatigue on long rides."
- "Part of job requirement."

Responses that were provided as other reasons for NOT wearing a helmet included the following:

- "Never, because it will not save your life after 35 mph, and I don't feel safe with one; I can't hear when wearing one."
- "I would choose not to if I were not married and had no kids."
- "Destination is less than 5 minutes away in urban streets."
- "Pulls on my neck and causes pain and chokes me in the wind."
- "I only ride without a helmet if I'm moving less than 10 mph in a situation without traffic (e.g., driving from one end of parking lot to the other)."
- "I wear goggles only if traveling under 40mph and won't be riding on the highway."
- "I've seen too many people killed in motorcycle crashes and the helmet did nothing to prevent their deaths."
- "Wearing a novelty has saved my life. DOT helmets are too thin with padding on half helmets."

Besides a helmet, participants were asked about additional safety gear that they choose to wear when riding. Boots and gloves were indicated most frequently (89 percent and 85 percent of respondents, respectively), followed by goggles/eyewear (73 percent), and protective jackets (57 percent). Figure 4 summarizes the percentages of participants who selected each of the provided options. Additional answers provided by participants (input under other) included the following:

- Ear/hearing protection.
- Long sleeve shirt.
- Leather chaps.
- Back brace.
- Long pants/jeans.
- Balaclava (in cold weather).
- Other winter gear.

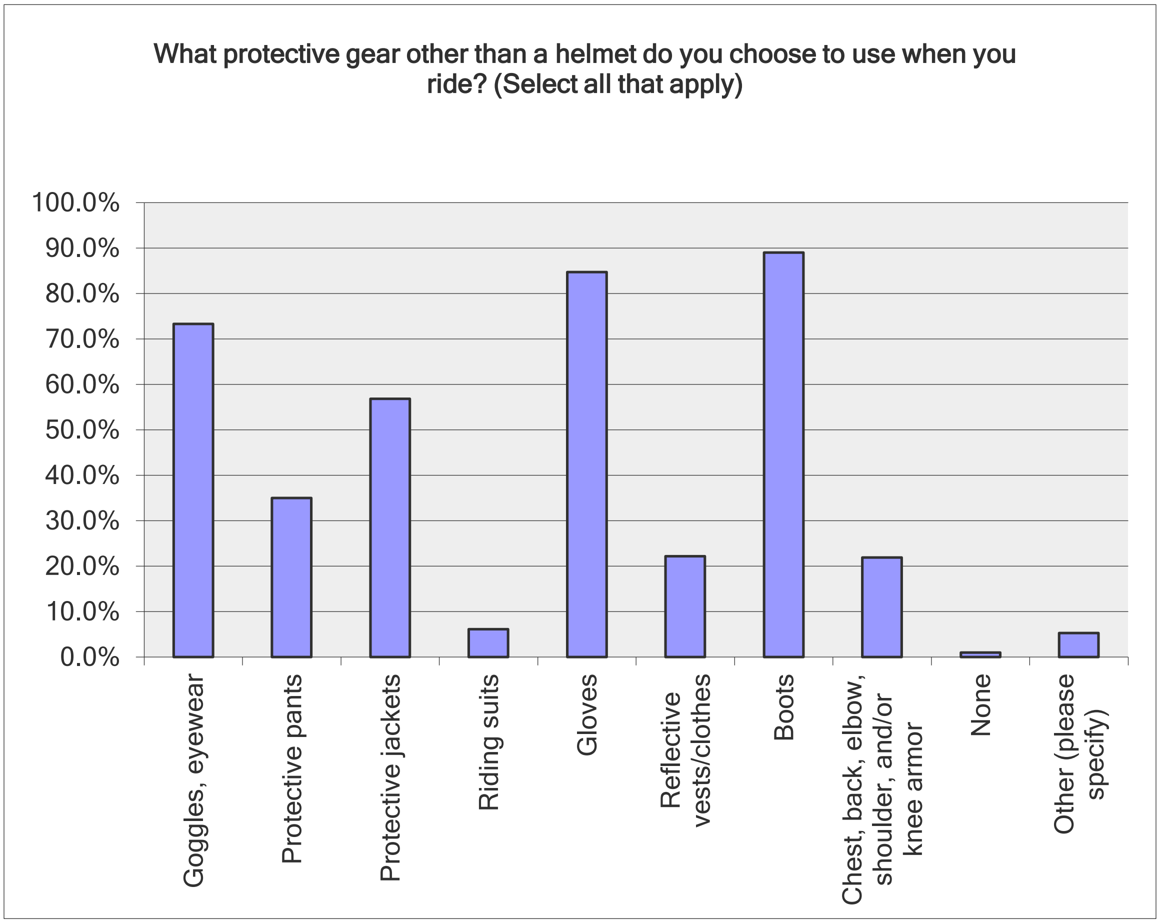


Figure 16. Other Protective Gear Used by Survey Participants.

In addition to protective gear, participants were asked what they use (gear, riding behaviors) to make themselves more visible to other road users. The most frequently selected answer was "strategic lane positioning" (74 percent of those answering this question), followed by "auxiliary driving lights" (57 percent) and "loud pipes" (50 percent). Figure 6 summarizes the percentages of participants who selected each of the provided answers.

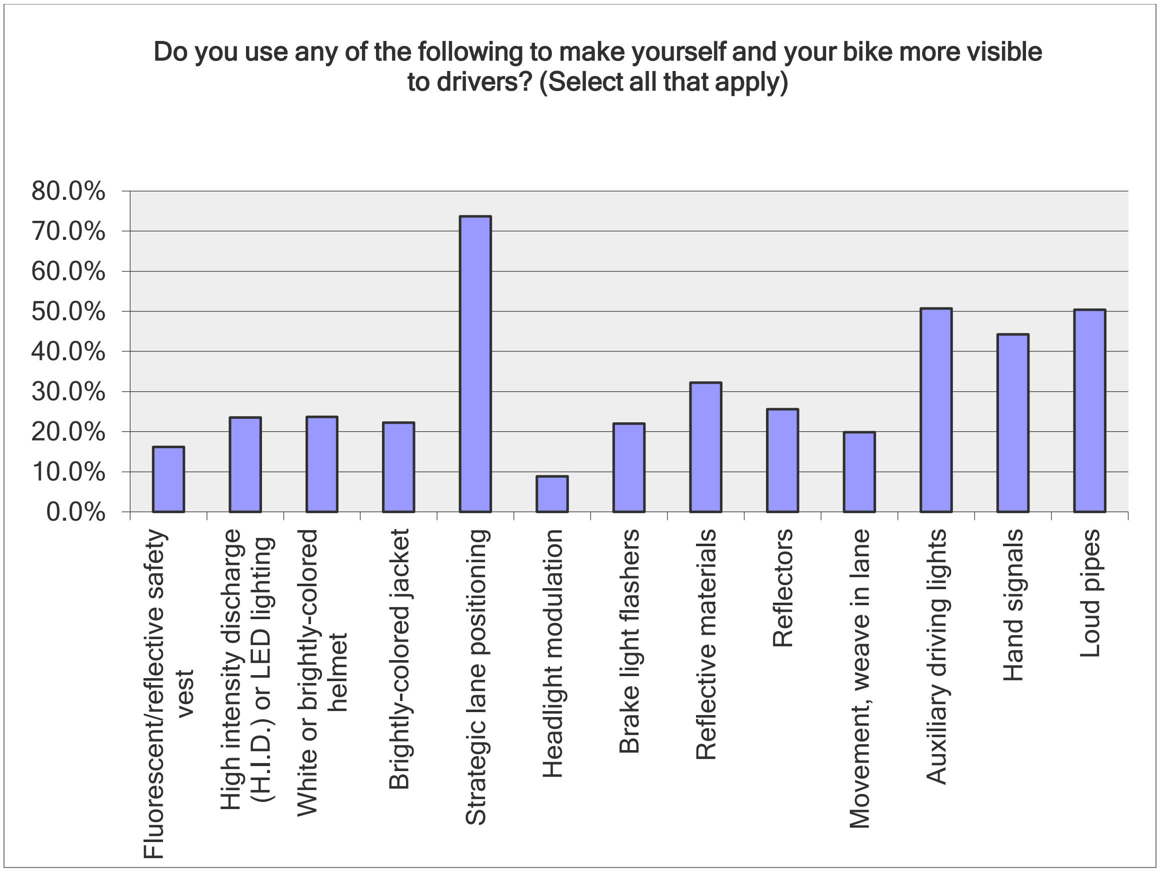


Figure 17. Strategies Used by Riders to Enhance Their Visibility to Drivers.

Motorcycle Maintenance

Two questions addressed motorcycle maintenance. First, respondents were asked "How often do you check your motorcycle's condition (tires/wheels, brakes, controls, lights, oil/fluids, chassis, stands)?" Over 80 percent of respondents reported that they check their motorcycle's condition at least once per week, with 43 percent reporting that they check the motorcycle before each ride. Table 7 lists the responses received to this question.

Table 7. Reported Frequency of Motorcycle Maintenance by Rider.

How often do you check your motorcycle's condition?	**Response Count**	**Response Percent**
Every time I'm going to ride it	552	42.5%
Not every time I ride, but at least once per week	514	39.6%
Once or twice per month	184	14.2%
A few times per year	41	3.2%
Once or twice per year	6	0.5%
Less than once per year	2	0.2%
answered question	**1299**	**100%**

The second question regarding motorcycle maintenance was, "How often do you have your motorcycle serviced by a motorcycle dealer or other professional mechanic/shop?" Of the 1301 respondents who answered this question, nearly two-thirds reported that they have their motorcycle serviced professionally at least once per year. Twenty-five percent reported that they do not have their motorcycle(s) serviced, with the majority of these commenting that they perform all of their own maintenance; some of these respondents also commented that they are professional mechanics themselves. Table 8 lists the responses received to this question.

Table 8. Reported Frequency of Motorcycle Maintenance/Service by Mechanic/Dealer.

How often do you have your motorcycle serviced by a dealer/mechanic?	Response Count	Response Percent
A few times per year	462	35.5%
Once or twice per year	392	30.1%
Less than once per year	119	9.1%
I don't, because (please specify):	328	25.2%
answered question	**1301**	**100%**

Alcohol Use and Physical Condition

Respondents were asked whether, in the past year, they had consumed alcohol within an hour prior to riding a motorcycle. Of the 1301 respondents answering this question, 893 (68 percent) answered "no." Table 16 lists all of the responses received to this question.

Table 16. Reported Alcohol Use.

Within the last year, have you consumed alcohol within an hour prior to riding a motorcycle?	Response Count	Response Percent
Yes, 1 or 2 drinks	367	28.2%
Yes, 3 to 4 drinks	29	2.2%
Yes, more than 4 drinks	12	0.9%
No	893	68.6%
answered question	**1301**	**100%**

The percentage of respondents who answered "no" to this question varied with age. Figure 18 displays responses by respondent age group.

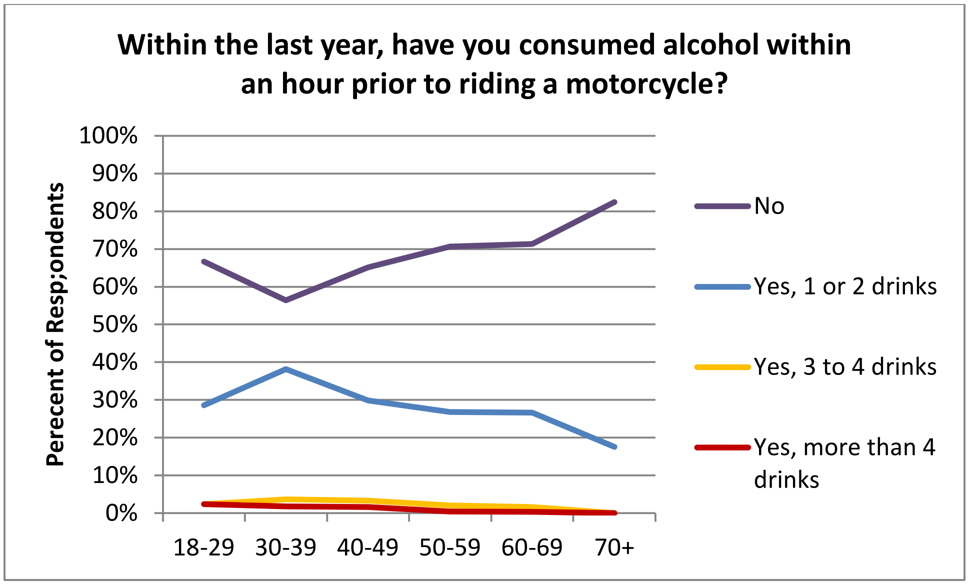


Figure 18. Alcohol Use Prior to Riding - by Age Group.

Respondents were also asked, "Do you consider your own physical and mental condition (for example, fatigue, drowsiness, or illness) before you ride? Of the 1302 respondents who answered this question, 1041 (80 percent) answered "always." Table 17 lists all of the responses received to this question.

Table 17. Physical/Mental Condition Assessment.

Do you consider your own physical and mental condition before you ride?	Response Count	Response Percent
Always	80.0%	1041
Often	14.1%	183
Sometimes	4.3%	56
Rarely	1.2%	16
Never	0.5%	6
answered question	**1301**	**100%**

Crash Experiences

Respondents were asked if they have ever been involved in a crash while on a motorcycle. Of the 1302 respondents who answered this question, 728 (56 percent) reported that they have been in a crash. Those respondents were then asked additional questions about their crash experience.

The vast majority (nearly 98 percent) of respondents who had been in a motorcycle crash were operating the motorcycle at the time of the crash (as compared to just over two percent who were a passenger on the motorcycle).

Crash Location and Time

The largest percentage of crashes (40 percent) occurred on city streets, followed by rural roads such as farm-to-market roads or county roads (20 percent). Table 18 lists the roadway types included as answer choices and the percent of respondents who identified each as the location of their crash. Roadway/location types specified by respondents who selected other included the following:

- Highways/roadways in other countries (Mexico, Germany).
- Parking lots/driveways.
- Closed tracks.
- Highway entrance/exit ramps.

Table 18. Crash Locations – Roadway Type.

Roadway Type on Which Crash Occurred	Number of Respondents	Percent of Respondents
US/state highway in a rural area	89	12.5%
Rural road (farm-to-market road, county road)	143	20.1%
US/state highway in a city/urban area	104	14.6%
City street	282	39.7%
Off-road	45	6.3%
Other (please specify)	48	6.8%
Answered question	**711**	

Thirty-five percent of the described crashes occurred on a straight section of road, 33 percent happened at intersections, and 25 percent on a roadway curve. Seven percent of respondents answered "other"; the locations they input included driveways, parking lots, and roadway construction zones, as well as variations and elaborations on the three location types (straight road, curved road, intersection) that were provided as multiple-choice answers.

The majority of crashes (57 percent) occurred on weekdays, specified as Monday through Thursday in the survey's responses, with 43 percent occurring Friday through Sunday. Respondents reported the highest percentage of crashes during the hours of 3:00 p.m. to 5:59 p.m., 9:00 a.m. to noon, and noon to 2:59 p.m. Table 19 lists the days and time periods of crashes as identified by respondents with the percentages of crashes occurring in each; Figure 19 graphs the percentages.

Table 19. Crash Days and Times as Reported by Respondents.

Time and Day of Crash	Monday-Thursday	Friday-Sunday	Total Monday-Sunday
Between 6:00 and 8:59 a.m.	8.7%	3.6%	12.2%
Between 9:00 and 11:59 a.m.	8.7%	11.8%	20.5%
Between noon and 2:59 p.m.	11.5%	8.1%	19.6%
Between 3:00 and 5:59 p.m.	13.8%	9.8%	23.6%
Between 6:00 and 8:59 p.m.	6.3%	3.3%	9.5%
Between 9:00 and 11:59 p.m.	3.4%	2.3%	5.7%
Between midnight and 2:59 a.m.	0.6%	1.4%	2.0%
Between 3:00 and 5:59 a.m.	4.0%	2.6%	6.5%
Totals	**57.1%**	**42.9%**	**100%**

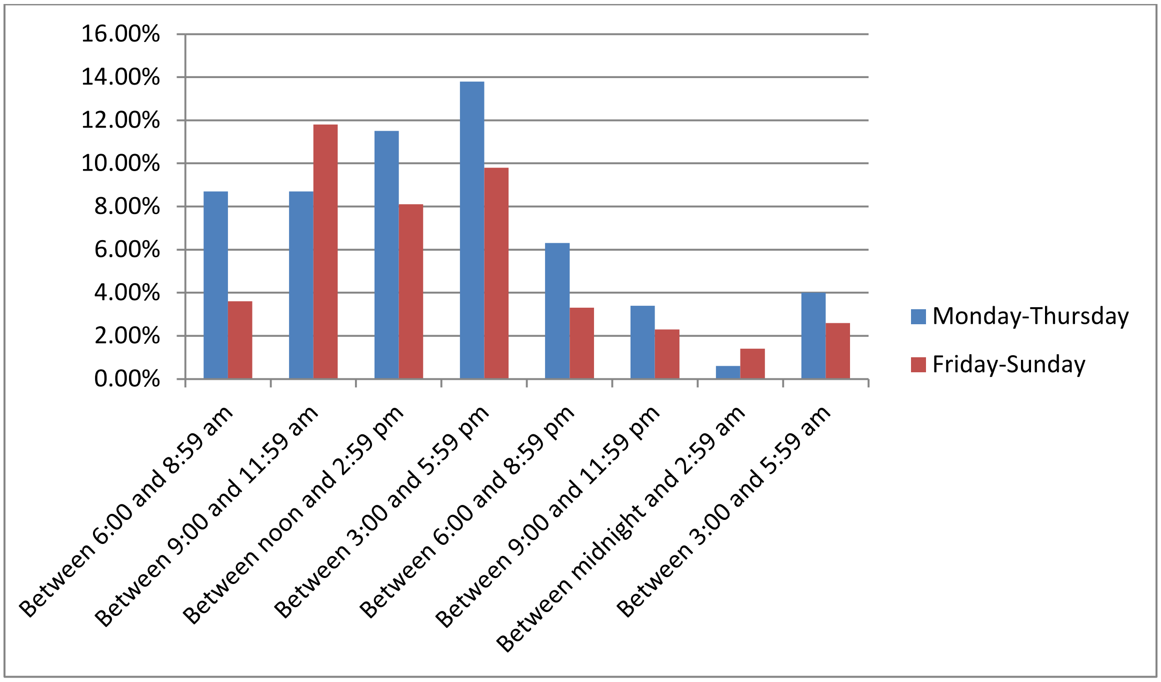


Figure 19. Crash Days and Times Compared.

First Crash Event and Contributing Factors

Respondents were asked, “What happened first in the crash?” This question was intended to categorize the types of crashes according to “first harmful event,” and included the following as multiple-choice response options:

- “Your motorcycle overturned.”
- “Your motorcycle hit an object (such as a rock, debris, animal) on the side of the road.”
- “Your motorcycle left the road without colliding with any other object.”

- “Your motorcycle collided with a pedestrian or bicyclist.”
- “Your motorcycle hit the rear or side of another vehicle.”
- “Another vehicle hit the rear or side of your motorcycle.”
- “There was a head-on collision between your motorcycle and another vehicle.”
- “Other (please specify).”

Nearly 33 percent of respondents selected “other;” however, when their open-ended comments were examined, most of those answers indicated that the first crash event actually fit one of the other seven “first crash event” categories. The explanations provided for most of the crashes described as other described contributing events more often than they described a first crash event. The other responses pertaining to the first crash event have been re-categorized as appropriate to reflect one of the seven named crash events. Table 20 lists the percentage of respondents who identified each type of first crash event. In some cases, it is impossible to determine the crash event from respondents’ comments, and these are also noted in the table. The five other first crash events that did not fit the categories provided included three non-road crashes involving stunt or trick riding, one rider that was knocked over by a flying object, and a rider who stopped suddenly and was thrown over the handlebars.

Table 20. First Crash Event.

What happened first in the crash?	Number	Percent
Your motorcycle overturned	192	27.3%
Your motorcycle hit an object (such as a rock, debris, animal) on the side of the road	105	14.9%
Your motorcycle left the road without colliding with any other object	95	13.5%
Your motorcycle collided with a pedestrian or bicyclist	2	0.3%
Your motorcycle hit the rear or side of another vehicle	115	16.3%
Another vehicle hit the rear or side of your motorcycle	137	19.5%
There was a head-on collision between your motorcycle and another vehicle	14	2.0%
Cannot tell from explanation	39	5.5%
Other	5	0.7%
answered question	**704**	

A later question, answered by 341 respondents, asked if any of the following were contributing factors in the crash:

- “Vehicle driver was talking/texting on a cell phone.”
- “Vehicle driver was talking with passenger.”
- “Vehicle driver said he/she didn't see me.”
- “Vehicle driver was speeding/driving aggressively.”
- “Vehicle driver was tailgating.”
- “I was talking/texting on a cell phone or other hand-held device.”
- “I was talking with the passenger.”
- “I was speeding/riding aggressively.”
- “I was tailgating.”
- “I didn't see the other vehicle.”

The most common contributing factor, cited by 47 percent of respondents who answered this question, was a vehicle driver who did not see the motorcycle prior to the crash. As with the “what happened first” question, many respondents who answered this question (nearly 35 percent) answered other and input a comment to describe a contributing factor. Contributing factors identified under other included drivers running lights or stop signs, drivers who were impaired due to drowsiness, age-related problems such as limited vision and dementia, and mechanical problems either with the rider’s motorcycle or with another vehicle in the roadway. Table 21 shows the percentages of respondents who selected each response pertaining to crash contributing factors. Respondents were able to select more than one response to this question, so percentages do not total 100 percent.

Table 21. Crash Contributing Factors.

Were any of these a factor in the crash?	Response Count	Response Percent
Vehicle driver said he/she didn't see me	160	46.9%
Other (please specify)	118	34.6%
Vehicle driver was speeding/driving aggressively	61	17.9%
Vehicle driver was talking/texting on a cell phone	39	11.4%
Vehicle driver was talking with passenger	30	8.8%
Vehicle driver was tailgating	23	6.7%
I was speeding/riding aggressively	15	4.4%
I didn't see the other vehicle	13	3.8%
I was tailgating	9	2.6%
I was talking/texting on a cell phone or other handheld device	1	0.3%
I was talking with the passenger	1	0.3%
Answered question	**341**	

Respondents were also asked specifically if alcohol use (by the motorcycle rider, by the motorcycle passenger, or by another vehicle driver) played a role in the crash. Of the 709 respondents who answered this question, 87 percent reported that alcohol use was not a factor in the crash. Nineteen respondents (just under three percent) reported that their own alcohol use was a factor in the crash; two respondents who had been passengers on a motorcycle at the time of the crash also indicated alcohol use by the motorcycle operator was a factor in the crash. Another 18 respondents (about 2.5 percent) reported alcohol use by the driver of the other vehicle involved in the crash; the remaining respondents (about 9 percent) did not know if the other driver had been drinking prior to the crash.

Injuries and Protective Gear

Respondents who had experienced a motorcycle crash were asked "what type of injury did you receive?" Of the 708 respondents who answered this question, 73 percent had received some injury as a result of the crash they described. Table 22 provides a breakdown of reported injury severity.

Table 22. Injuries Received by Respondents in Motorcycle Crash.

What type of injury did you receive?	Response Count	Response Percent
Severe injury (severe lacerations, broken arm/leg, head injury, chest injury, abdominal injury, or similar; I was taken from crash scene to hospital in ambulance)	155	21.9%
Minor injury that was treated that day (bruises, abrasions, lump on head, momentary unconsciousness, or similar; I went to doctor/hospital on my own)	135	19.1%
Minor injury that was treated later or did not need medical treatment	227	32.1%
No injury	191	27.0%
Answered question	**708**	

Respondents were also asked if they were wearing safety gear during their crash. Most of the 706 respondents who were asked this question responded that they were wearing one or more pieces of safety gear, with a DOT-approved helmet being the most frequently reported item (81 percent of those responding). Items that were input by respondents who checked other included novelty and full-face helmets, a rain suit, a spine protector, leather race suit, chaps, and vest. One respondent commented that his helmet came off during the crash, and three respondents commented here that they were not wearing any safety gear at the time of the crash. Table 23 lists the safety gear worn by respondents during their reported crashes.

Table 23. Safety Gear Worn by Respondents during Reported Crashes.

Were you wearing protective gear?	Response Count	Response Percent
DOT-approved helmet	571	80.9%
Boots	533	75.5%
Gloves	508	72.0%
Goggles, eyewear	422	59.8%
Protective jacket	320	45.3%
Protective pants	218	30.9%
Chest, back, elbow, shoulder, and/or knee armor	100	14.2%
Reflective vests/clothes	61	8.6%
None	29	4.1%
Riding suit	24	3.4%
Other (please specify)	20	2.8%
Answered question	**706**	

OPINIONS ON MOTORCYCLE SAFETY, COUNTERMEASURES, ITS

Respondents were also asked several questions that were intended to gauge their opinions regarding various aspects of and approaches to motorcycle safety. The first of these questions asked, "How important do you feel each of the following is to your safety when riding a motorcycle?" The list provided included the following:

- Behavior of other motorcycle riders (if I'm riding in a group).
- Experience/time spent riding.
- Maintenance/condition of my bike.
- Maintenance/condition of the roadway.
- My own riding behaviors.
- Traffic/other road users.
- Training (motorcycle skills and/or safety courses).

Respondents were asked to rate each as "extremely important," "fairly important," "neutral/don't know," "not very important," or "not at all important. As shown in Figure 20, the vast majority of respondents rated all of the above elements as fairly to extremely important to their own safety when riding. "My own riding behaviors" was rated as "extremely important" by 87.5 percent of respondents and "fairly important" by an additional 12 percent. "Training" was rated lowest overall by respondents, but only in relative terms; 51 percent of respondents considered motorcycle training to be extremely important, and another 35 percent considered it to be fairly important.

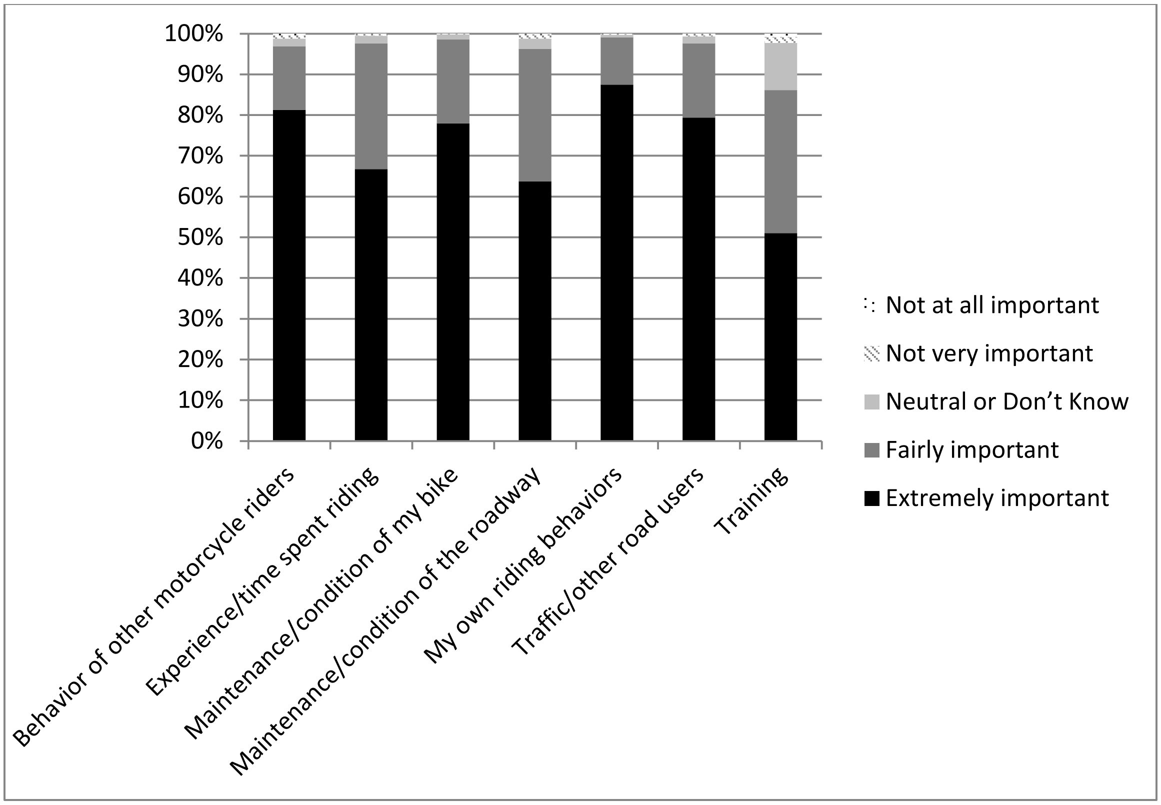


Figure 20. Perceived Importance of Various Factors to Motorcyclist Safety.

The next question addressed various types of countermeasures for preventing or mitigating motorcycle crashes. Again, respondents were asked to rate how effective each of the following is for improving the safety of motorcycle riders:

- Use of DOT-approved helmets.
- Use of other safety gear (gloves, vests, body armor, etc.).
- Use of lights, reflectors, and/or reflective materials to be more visible to drivers.
- Basic training courses on motorcycle safety.
- Advanced training courses on riding technique.
- Public outreach messages to vehicle drivers about watching for motorcycles.
- Public outreach messages to motorcycle riders about ways to prevent crashes.

Most of these safety countermeasures were received positively by most respondents, including helmet use, which was rated "effective" or "very effective" for improving motorcycle rider safety by 85 percent of respondents. Figure 21 shows how each of the countermeasures was rated by respondents.

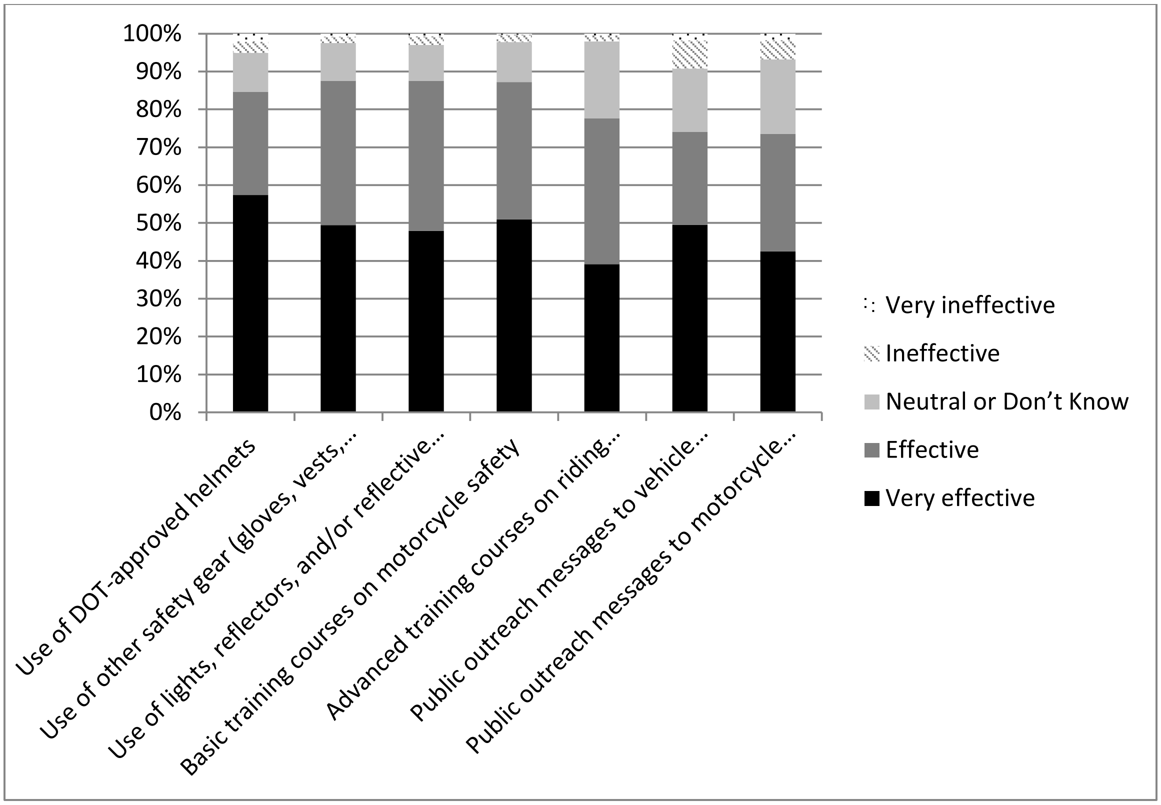


Figure 21. Safety Countermeasures - Effectiveness Ratings.

The final two survey questions presented respondents with a selection of Intelligent Transportation Systems (ITS) and other advanced technologies that are currently available or likely to become available in the future. Some of these technologies are (or would be) specific to motorcycles and/or motorcycle riders, while others are vehicle technologies that could improve other drivers' awareness of nearby motorcycles on the road.

The technologies identified in the survey included the following:

- Airbag on motorcycle.
- "Airbag" vest to protect a rider's body in a crash.
- Alcohol "breathalyzer" attached to motorcycle ignition to prevent a rider from starting a motorcycle when intoxicated.
- Anti-lock brakes (on motorcycle).
- Blind-spot detector incorporated into motorcycle helmet.
- Electronic stability system (for trikes) to help prevent leaning/rolling too far.
- Helmet-mounted rear-view display/camera.
- Blind spot detector for vehicle drivers.
- In-vehicle system to warn drivers if they're getting close to motorcycles.
- Motorcycle headlights that adjust with speed and steering to provide the best night-time view of the road for the rider.

- System on motorcycle to alert riders if they're getting too close to other vehicles, pedestrians, or objects.
- Traction control to reduce wheel lock and slipping.

As shown in Figure 22, the five technologies that were rated highest by respondents (with more than 60 percent of respondents rating them "effective" or "very effective") were anti-lock brakes, an in-vehicle system to warn drivers about nearby motorcycles, a more general blind-spot detector for vehicle drivers, traction control for motorcycles, and adaptable motorcycle headlights.

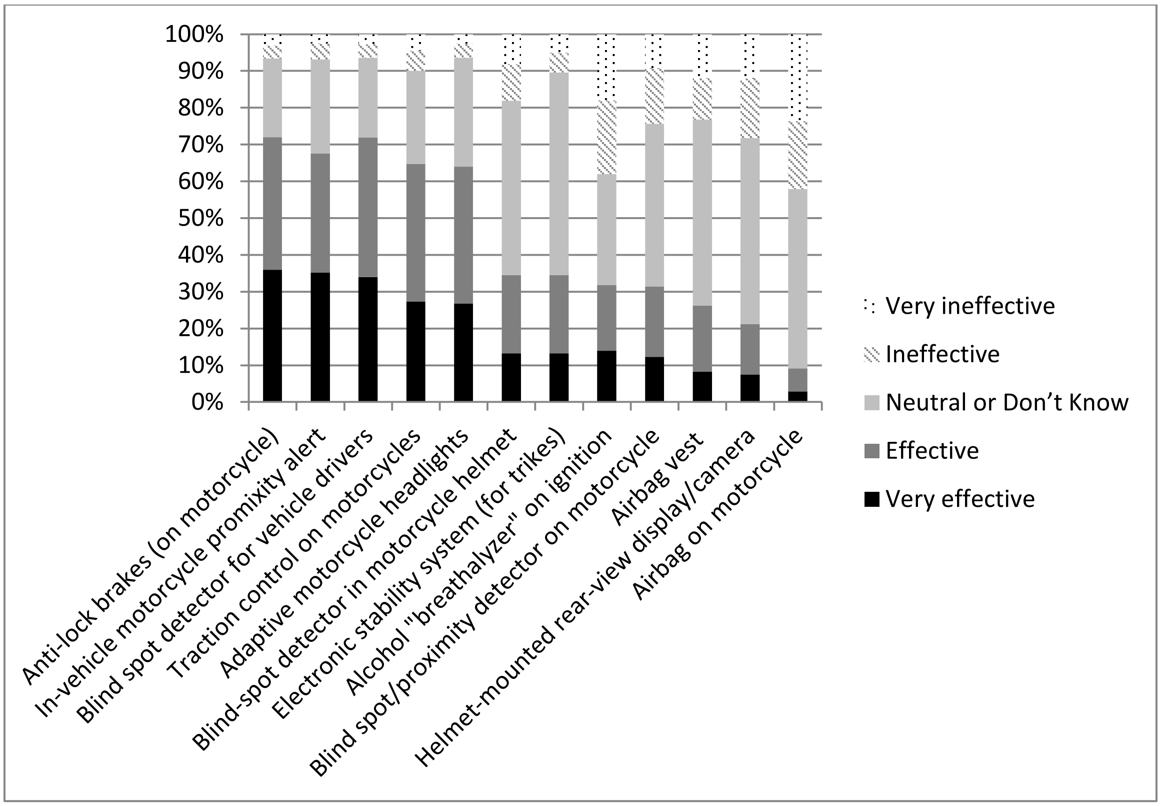


Figure 22. Respondent Ratings for ITS and Other Technologies.

The final question presented nine of these technologies and asked respondents to identify three technologies out of the list that they thought would be the most effective in improving motorcycle safety. The three technologies selected most frequently by respondents are also in the "top five" from the previous survey question: the in-vehicle system to alert drivers of motorcycles on the road, traction control for motorcycles, and adaptive headlights. Additionally, although anti-lock brakes were not included as a response choice for this question, 63 respondents who selected other as an answer choice specified anti-lock brakes as the technology they would choose. One of these respondents specified "anti-lock brakes that work [when the motorcycle is] leaned over."

Table 24. Technologies that Would Be Most Effective in Improving Motorcycle Safety.

Technologies that would be most effective in improving motorcycle safety (select three):	Response Count	Response Percent
In-vehicle system to warn drivers if they're getting close to motorcycles	788	64.1%
Traction control to reduce wheel lock and slipping	720	58.6%
Motorcycle headlights that adjust with speed and steering to provide the best night-time view of the road for the rider	661	53.8%
"Airbag" vest to protect a rider's body in a crash.	219	17.8%
Electronic stability system (for trikes) to help prevent leaning/rolling too far	205	16.7%
Blind-spot detector incorporated into motorcycle helmet	196	15.9%
Alcohol "breathalyzer" attached to motorcycle ignition to prevent a rider from starting a motorcycle when intoxicated	170	13.8%
System on motorcycle to alert riders if they're getting too close to other vehicles, pedestrians, or objects	158	12.9%
Helmet-mounted rear-view display/camera	113	9.2%
Other (please specify)	217	18.3%
answered question	**1229**	

Besides anti-lock brakes, other technology suggestions included the following:

- Lighting systems to increase motorcycle visibility to drivers; suggestions included brighter LED lighting front and rear, emergency strobes/beacons to call attention to motorcycles in certain situations, tail light flashers, and higher brightness levels for taillights and brake lights on motorcycles.
- A GPS position sensor that prevents a motorcycle from leaving the roadway unless its speed is less than 10 mph.
- Loud pipes to make drivers aware you are there.
- Slipper clutch.
- Motorcycle speed governors that cannot be bypassed or eliminated by the rider.
- Chain guard to prevent a broken chain from getting entangled in wheels.
- Proportional braking.
- Ejection seat with a parachute.
- Engine guards.
- Extra loud horns/sirens capable of alerting a driver in a car 500 ft away.

- Since most crashes happen at intersections – something integrated into intersection cameras that flashes some odd colored (purple) light when motorcycles approach the intersection.
- A system to warn drivers making a left turn in front of a motorcycle.

Other suggestions that were input in the other category for this question were not technologies, but other types of safety countermeasures. Twenty-nine respondents recommended improvements to driver training, more stringent licensing standards, and/or stricter enforcement dealing with distracted driving by motorists; 15 respondents similarly suggested more rigorous training and licensing standards for motorcyclists; and 43 respondents commented on the need to promote more situational awareness and reduced distraction among road users. Three respondents recommended changes to roadway engineering and/or maintenance: establishment of a motorcycle-only lane, elimination of longitudinal grooved pavement, and elimination of loose gravel paving on roadways.

Thirty-two respondents recommended against additional safety-related technologies in general. Some of these respondents view the promotion of or potential requirement for these types of technologies as undue governmental interference; some expressed skepticism about the efficacy, cost, and/or distraction potential of the technologies. Several respondents expressed the concern that the use of these types of technologies could create a false sense of security among drivers and riders, and lead to reduced awareness and personal responsibility for safety. One of these respondents commented "the [technologies] for riders have a potential downside—the more a rider is insulated from his own unskilled behavior, the more that behavior is encouraged…without a serious discussion of this trade-off, it could be a more-harm-than-good situation."

CHAPTER 6. CRASH COUNTERMEASURES EVALUATION

The objective of Task 5 was to assimilate and evaluate motorcycle crash countermeasures for potential inclusion into a statewide motorcycle safety plan for Texas. Countermeasures were identified from the Task 1 literature review, including research studies and motorcycle safety plans from other states and countries; from the Task 2 review of ITS technologies; and from the Task 4 motorcycle rider survey. The draft list of countermeasures was then reviewed by a group of motorcycle and highway safety experts during a day-long workshop held on January 24, 2013, at TTI offices in College Station.

ASSIMILATION OF COUNTERMEASURES

Countermeasures were identified from many of the research studies and plans reviewed in Task 1, as well as additional existing motorcycle safety plans and programs that were identified over the course of the project. Motorcycle safety plans that provided some of the countermeasures on the assimilated list included the following:

- State of Arizona Motorcycle Safety Program Technical Assessment, 2007.
- Florida Strategic Motorcycle Safety Plan, 2009.
- State of Illinois Motorcycle Safety Program Assessment, 2005.
- Michigan Motorcycle Safety Action Plan, 2009–2012.
- State of Ohio Traffic Safety Action Plan, 2009.
- Asia-Pacific Economic Cooperation Transportation Working Group's Compendium of Best Practices On Motorcycle and Scooter Safety, 2010.
- National Agenda for Motorcycle Safety Implementation Guide, 2006.
- Victoria's Road Safety and Transport Strategic Action Plan for Powered Two Wheelers, 2009–2013 (Australia).

Countermeasures were organized into categories, based in part on categorization schemes used in the reviewed plans listed above. The following subsections briefly describe the categories and list the countermeasures that were included in each.

Motorcycle/Rider Conspicuity

This category included countermeasures designed to make motorcycles and their riders more conspicuous to motorists on the roadway:

- Educate motorcycle riders in conspicuity products, techniques, and strategies.
- Increase motorcyclists' use of high-visibility clothing, conspicuity products.

- Enhance training on strategic lane positioning for increasing motorcyclist conspicuity in traffic.
- Encourage visibility enhancements for motorcycles, such as auxiliary headlights, auxiliary brake lights, headlight modulators, position lamps, underbody LED lighting, etc.

Motorist Awareness of Motorcycles

This category included countermeasures intended to raise awareness among motorists of the presence of motorcycles on the roadway and associated road safety issues:

- Increase motorists' knowledge about sharing the road with motorcyclists and other vulnerable road users.
- Produce brochure on TxDOT's "Share the Road" sign program and process to request a sign.
- Include up-to-date information on sharing the road and rider conspicuity in the Texas driver's education handbook.
- Add questions about sharing the road with motorcycles on Texas driver's license exam.
- Consider legislation allowing drivers ticketed for right-a-way violations involving a motorcycle to attend a motorcycle safety class for a ticket dismissal.
- Support the use of emerging vehicle technologies (e.g., blind spot and forward collision warning systems, collision avoidance systems) to improve motorists' awareness of motorcycles.

Motorcycle Rider Licensing

This category included countermeasures pertaining to motorcycle licensing requirements, enforcement, and awareness:

- Revise licensing regulations to require specific license for operators of 3-wheel motorcycles.
- Encourage law enforcement to take a zero-tolerance approach regarding unlicensed riders.
- Require proof of motorcycle endorsement before issuing parking permits (large employers, state and local government agencies, university campuses, etc.)
- Engage other groups (i.e., dealerships, insurance, drivers instructors) to provide information or brochures about motorcycle licensing requirements to motorcycle purchasers.

- Increase rider awareness about crash involvement of unlicensed or untrained motorcyclists.
- Implement graduated licensing system for motorcyclists.

Additional countermeasures related to licensing were included under the category "Legislation and Regulation."

Rider Education and Training

This category included countermeasures related to the content, funding, and evaluation of rider training courses, as well as to the relationship between rider education and licensing requirements:

- Expand course availability for three-wheeled vehicles classified as motorcycles.
- Educate riders on potential roadway obstacles (pavement makers, manhole covers, steel plates, etc.) and collision avoidance.
- Integrate rider training with licensing.
- Revise and update motorcycle operator's manual and translate into Spanish.
- Improve type and quantity of motorcycles used for rider training.
- Increase/reallocate funding for motorcycle safety training.
- Update and/or implement better system to monitor training course certificates and end-of-course examinations.
- Update quality assurance plan to increase the number of site and instructor visits and standardizes the review and remediation process.
- Promote (PI&E) importance of rider training to new and experienced motorcyclists.

Impaired Riding

This category contained countermeasures intended to discourage riding a motorcycle while impaired by alcohol consumption:

- Promote peer-to-peer outreach among riders discouraging drinking and riding.
- Reach out to rider group leadership to develop strategies to prevent impaired riding at motorcycle events.
- Engage motorcycle-friendly businesses that serve alcohol to create awareness.
- Explore expanding the use of alcohol interlock devices for motorcycles.
- Require alcohol/drug education as well as rider education for DUI convictions.
- Distribute NHTSA's "Detecting DWI Motorcyclists" guide to law enforcement agencies.
- Develop materials on impaired riding and motorcycle laws for prosecutors, judges, and judicial employees.

Speeding

This category contained countermeasures intended to discourage riders from riding over the posted speed limit and/or riding a motorcycle with speed capabilities that exceed the rider's skill:

- Include motorcycles in speeding enforcement activities.
- Develop outreach/education to riders about dangers of excessive speed.
- Educate riders about selecting a motorcycle compatible with skill level.

An additional countermeasure related to speeding was included under the category "Legislation and Regulation" is to require beginning riders to use motorcycles with speed limiters.

Personal Protective Gear

This category included countermeasures aimed at increasing riders' use of personal protective gear, including DOT-approved helmets:

- Conduct PI&E campaign to promote using motorcycle safety gear (helmets, leg protection, footwear, etc.)—All the Gear All the Time (ATGATT).
- Provide training for law enforcement on identifying non-DOT compliant helmets.
- Work with riders' groups and dealerships to promote the use of protective gear.

Roadway and Infrastructure

This category contained countermeasures pertaining to TxDOT policies and procedures for roadway maintenance and design that impact motorcycle safety:

- Communicate roadway condition information (construction, maintenance, hazardous locations) on DOT websites, social media, and 511).
- Identify pavement markings, surface materials, and other treatments that reduce traction for motorcycles and treat or replace with high-traction materials.
- Establish maintenance policies that require milled surfaces be paved during the same day.
- Post specific warnings for motorcyclists where unavoidable hazardous conditions exist (reduced traction, roadway surface irregularities).
- Consider motorcycles during routine roadway inspections.
- Educate road design and maintenance personnel about conditions that pose hazards to motorcyclists.

- Provide full paved shoulders to accommodate roadside motorcycle recovery and breakdowns.
- Consider motorcycles in the selection and placement of roadside barriers.
- Maintain roadway to minimize surface irregularities and discontinuities that are hazardous to motorcycles.
- Maintain roadway surfaces in work zones to facilitate safe passage of motorcycles.

Legislation and Regulation

This category contained countermeasures that would require changes to existing legislation or regulations in Texas:

- Require mandatory helmet use for all newly licensed riders.
- Implement stricter penalties for riding without a license.
- Implement legislation allowing law enforcement to impound motorcycles if riders are not properly licensed.
- Require motorcycle license/endorsement before motorcycle purchase.
- Implement zero BAC/reduced BAC laws for newly licensed riders
- Require zero BAC/reduced BAC laws for all motorcycle riders.
- Greater penalties for BAC of 0.16 and up.
- Mandatory BAC testing in all death and injury crashes.

Law Enforcement

This category included countermeasures that enable law enforcement actions aimed at reducing motorcycle crashes and injuries:

- Include motorcycles in crash investigation training for law enforcement officers.
- Develop educational materials for justice system personnel on motorcycle-related laws.
- Create a quick reference guide for law enforcement officers specific to motorcycles with statute references.
- Conduct high visibility enforcement (HVE) campaigns in counties with the highest number of motorcycle crashes (Top 10) for speeding and impaired riding.

Program Management

This category included measures for improving the management of statewide motorcycle safety program activities in Texas:

- Increase funding for motorcycle safety by elevating their importance to state highway safety office.
- Focus resources in the top 10 counties for motorcycle fatalities and identify countermeasures that work then develop best practices tools for use statewide.

Evaluation, Data, and Research

This category included measures for improving data collection pertaining to motorcycle crashes and injuries, developing and refining evaluation techniques for motorcycle crash data, and developing motorcycle-safety research initiatives:

- Conduct detailed evaluation of police-reported motorcycle crash reports to determine contributing crash causation factors. Compare findings to existing training materials and adjust curricula to address the issues.
- Use crash location data to help identify needs for additional signage, improved roadway friction, wider shoulders, modification of traffic controls, etc.
- Conduct research to determine why motorcyclists are unlicensed and how to reach out to this group.
- Develop partnerships with trauma centers, health department, insurance agencies, and dealerships for data sharing.
- Add motorcycle specific information to the Texas traffic crash report for increased understanding of motorcycle crashes.
- Promote inter- and intra-agency efforts to link crash, injury, licensing, violation, training, and registration records.
- Determine the impact of funded research and programs on reducing motorcycle crashes, injuries, and fatalities.
- Investigate simulation and computer modeling to better understand motorcycle crash risk and injury.
- Undertake research to examine the role of fatigue in motorcycle crashes.

Motorcycle and Vehicle Technologies

This category included measures for maximizing the use of advanced vehicle technologies that have the potential to improve rider safety:

- Promote availability and benefits of technologies that improve motorcyclist safety and increase rider conspicuity.
- Engage with the motorcycle industry to encourage the development and promotion of motorcycles with safety-related technologies.

CRASH COUNTERMEASURES IMPLEMENTATION WORKSHOP

A crash countermeasures implementation workshop was hosted at TTI offices in College Station on January 24, 2013. Invitations to participate in the workshop were sent to approximately 40 individuals with expertise in various aspects of motorcycle safety, including members of the Texas Motorcycle Safety Coalition (TMSC), TxDOT traffic safety specialists and engineers, motorcycle safety instructors, law enforcement officers (including crash investigators), and TTI researchers; a total of 27 people participated (see Appendix A for a complete list of workshop participants). Dr. R. Quinn Brackett of TTI and Jude Schexnyder, a motorcycle safety instructor and current president of TMSC, acted as workshop moderators.

Participants were given packets (see Appendix B) listing the countermeasures by category, and divided into two groups for the first half of the workshop. Each group reviewed half of the countermeasure categories, evaluating the countermeasures in each category for their potential effectiveness in preventing motorcycle crashes or mitigating injuries as well as identifying potential implementation issues. The evaluation process eliminated some countermeasures from the list, combined some similar or related countermeasures, expanded on some countermeasures, and ranked the revised lists in priority order. The following sections summarize the discussions and results for each of the countermeasure categories reviewed in the workshop.

Motorcycle and Rider Conspicuity

Workshop participants decided to combine the first two countermeasures on the original list, and to add a new countermeasure: encouraging the participation of the motorcycle industry in promoting high-visibility gear. The countermeasure encouraging lighting options for visibility enhancement was modified to include the need to compile information on the legality of lighting and other vehicle enhancements. Table 25 lists the original and the revised, ranked list of countermeasures for this category.

Table 25. Motorcycle and Rider Conspicuity – Ranked Countermeasures.

Original List	Revised and Ranked List
1. Educate motorcycle riders in conspicuity products, techniques, and strategies. 2. Increase motorcyclists' use of high-visibility clothing, conspicuity products. 3. Enhance training on strategic lane positioning for increasing motorcyclist conspicuity in traffic. 4. Encourage visibility enhancements for motorcycles, such as auxiliary headlights, auxiliary brake lights, headlight modulators, position lamps, underbody LED lighting, etc.	1. Educate motorcycle riders in conspicuity products, techniques, and strategies; Increase motorcyclists' use of high-visibility clothing, conspicuity products. 2. Encourage visibility enhancements for motorcycles, such as auxiliary headlights, auxiliary brake lights, headlight modulators, position lamps, underbody LED lighting, etc.; compile and distribute information on legal lighting/technology options in Texas. 3. Enhance training on strategic lane positioning for increasing motorcyclist conspicuity in traffic. 4. Encourage participation of industry.

Motorist Awareness of Motorcycles

Participants combined the first three countermeasures on the original list, and modified the fifth countermeasure to include the option for a modified defensive driving course emphasizing motorcycle awareness for drivers ticketed for right-of-way violations involving motorcycles. Table 26 lists the original and the revised, ranked list of countermeasures for this category.

Table 26. Motorist Awareness of Motorcycles – Ranked Countermeasures.

Original List	Revised and Ranked List
1. Increase motorists' knowledge about sharing the road with motorcyclists and other vulnerable road users. 2. Produce brochure on TxDOT's "Share the Road" sign program and process to request a sign. 3. Include up-to-date information on sharing the road and rider conspicuity in the Texas driver's education handbook. 4. Add questions about sharing the road with motorcycles on Texas driver's license exam. 5. Consider legislation allowing drivers ticketed for right-a-way violations involving a motorcycle to attend a motorcycle safety class for a ticket dismissal. 6. Support the use of emerging vehicle technologies (e.g., blind spot and forward collision warning systems, collision avoidance systems) to improve motorists' awareness of motorcycles.	1. Increase motorist knowledge/awareness about sharing the road with motorcyclists and other vulnerable road users: a. Produce brochure on TxDOT's "Share the Road" sign program and process to request a sign. b. Include up-to-date information on sharing the road and rider conspicuity in the Texas driver's education handbook. c. Increase presence of law enforcement officers riding motorcycles to increase public awareness that a motorcycle could be law enforcement. d. Consider smartphone application (e.g., a game called "Find the Motorcycle!"), YouTube/social media, etc. 2. Support the use of emerging vehicle technologies (add-on or original from manufacturer); difficulty is that currently these are in a small part of the fleet and an expensive option; need to consider age of vehicle fleet and how long it will take to have all vehicles equipped with these technologies. 3. Consider legislation allowing drivers ticketed for ROW violations involving motorcycles to attend a motorcycle safety class, or other modified course emphasizing motorcycle awareness. 4. Add questions about sharing the road on TX DL exam; e.g., (a) about #1 type of collision (turning left in front of a motorcycle); (b) why are motorcycles difficult to see? Add course content about scanning for motorcycles. (legislative change required)

Motorcycle Licensing

Participants discussed safety issues connected with new and returning riders, including new riders beginning to ride with no formal training and without a motorcycle license and returning riders who have not ridden for years and could benefit from re-training. Difficulties and issues pertaining to implementing some of the proposed countermeasures in this category included the following:

- A zero-tolerance law enforcement policy to enforce motorcycle licensing requirements will require a lot of police presence which may not be available.
- Requiring proof of motorcycle endorsements for employer, school, and agency-issued motorcycle parking permits would be difficult to regulate.
- Implementing a graduated licensing system for motorcyclists would be difficult legislation to pass.

No measures were eliminated from the list, and one new measure was added (introduce a legislation requiring a motorcycle license to register a motorcycle in the state of Texas). Table 27 lists the original and the revised, ranked list of countermeasures for this category.

Table 27. Motorcycle Licensing – Ranked Countermeasures.

Original List	Revised and Ranked List
1. Revise licensing regulations to require specific license for operators of 3-wheel motorcycles. 2. Encourage law enforcement to take a zero-tolerance approach regarding unlicensed riders. 3. Require proof of motorcycle endorsement before issuing parking permits (large employers, state and local government agencies, university campuses, etc.). 4. Engage other groups (i.e., dealerships, insurance, drivers instructors, etc.) to provide information or brochures about motorcycle licensing requirements to motorcycle purchasers. 5. Increase rider awareness about crash involvement of unlicensed or untrained motorcyclists. 6. Implement graduated licensing system for motorcyclists.	1. Revise licensing regulations to require specific license for operators of 3-wheel motorcycles. 2. New - Legislative requirement for licensing before motorcycle registration. 3. Encourage law enforcement to take a zero tolerance approach regarding unlicensed riders. 4. Require proof of motorcycle endorsement before issuing parking permits (large employers, state and local government agencies, university campuses, etc.). 5. Engage other groups (i.e., dealerships, insurance, drivers instructors, etc.) to provide information or brochures about motorcycle licensing requirements to motorcycle purchasers. 6. Increase rider awareness about crash involvement of unlicensed or untrained motorcyclists. 7. Implement graduated licensing system for motorcyclists.

Rider Education and Training

Participants combined the fifth and sixth countermeasures, as well as the eighth and ninth. The third countermeasure and the seventh were eliminated from the list, as participants felt these have already been implemented in Texas. Table 28 lists the original and the revised, ranked list of countermeasures for this category.

Table 28. Rider Education and Training – Ranked Countermeasures.

<table>
<tr><th>Original List</th><th>Revised and Ranked List</th></tr>
<tr><td>1. Expand course availability for three-wheeled vehicles classified as motorcycles.
2. Educate riders on potential roadway obstacles (pavement makers, manhole covers, steel plates, etc.) and collision avoidance.
3. Integrate rider training with licensing.
4. Revise and update motorcycle operator's manual and translate into Spanish.
5. Improve type and quantity of motorcycles used for rider training.
6. Increase/reallocate funding for motorcycle safety training.
7. Update and/or implement better system to monitor training course certificates and end-of-course examinations.
8. Update quality assurance plan to increase the number of site and instructor visits and standardizes the review and remediation process.
9. Promote (PI&E) importance of rider training to new and experienced motorcyclists.</td><td>1. Increase/reallocate funding toward safety training (change "may" to "shall"), which would include:
a. Improve type and quantity of motorcycles used for rider training.
b. Update quality assurance plan to increase the number of site and instructor visits and standardizes the review and remediation process.
2. Promote (PI&E) importance of rider training to new and experienced motorcyclists; educate riders on potential roadway obstacles (pavement makers, manhole covers, steel plates, etc.) and collision avoidance.
3. Revise and update DPS motorcycle operator's manual and translate into Spanish.
4. Expand course availability for three-wheeled vehicles classified as motorcycles OR change classification of vehicles</td></tr>
</table>

Impaired Riding

Participants discussed the potential effectiveness of measures in this category, as well as the feasibility of their implementation. It was agreed that the best approach to reducing impaired riding is to implement a reduced legal blood alcohol content (BAC) limit for motorcyclists. While this would be difficult legislation to pass, because it would single out motorcyclists among other road users, arguments can be made (1) that motorcycle riding takes more skill than driving a vehicle and therefore is more severely affected by alcohol use and (2) that a lower BAC limit is already in effect for commercial drivers. The ranked list of countermeasures for reducing impaired riding is shown in Table 29.

Table 29. Impaired Riding – Ranked Countermeasures.

Original List	Revised and Ranked List
1. Promote peer-to-peer outreach among riders discouraging drinking and riding. 2. Reach out to rider group leadership to develop strategies to prevent impaired riding at motorcycle events. 3. Engage motorcycle-friendly businesses that serve alcohol to create awareness. 4. Explore expanding the use of alcohol interlock devices for motorcycles. 5. Require alcohol/drug education as well as rider education for DUI convictions. 6. Distribute NHTSA's "Detecting DWI Motorcyclists" guide to law enforcement agencies. 7. Develop materials on impaired riding and motorcycle laws for prosecutors, judges, and judicial employees.	1. Encourage zero BAC/reduced BAC laws for all motorcycle riders. 2. Promote peer-to-peer outreach among riders discouraging drinking and riding. 3. Reach out to rider group leadership to develop strategies to prevent impaired riding at motorcycle events. 4. Explore expanding the use of alcohol interlock devices for motorcycles. 5. Expand and promote BRI initiative (peer-to-peer). 6. Encourage implementation of zero BAC/reduced BAC laws for beginning motorcycle riders.

Speeding

Participants discussed potential implementation issues connected with the countermeasures listed in this category, including funding limitations for enforcement and the need to avoid singling motorcycle riders out for countermeasures such as speeding enforcement enhancements. The ranked list of countermeasures was unchanged from the original, as shown in Table 30.

Table 30. Speeding – Ranked Countermeasures.

Original List	Revised and Ranked List
1. Include motorcycles in speeding enforcement activities. 2. Develop outreach/education to riders about dangers of excessive speed. 3. Educate riders about selecting a motorcycle compatible with skill level.	1. Include motorcycles in speeding enforcement activities. 2. Develop outreach/education to riders about dangers of excessive speed. 3. Educate riders about selecting a motorcycle compatible with skill level.

Personal Protective Gear

Participants re-ordered the priority of the three countermeasures in this category, and discussed the feasibility of reinstating the helmet law and including a requirement for use of eye protection. Table 31 lists the original and the revised, ranked list of countermeasures for this category.

Table 31. Personal Protective Gear – Ranked Countermeasures.

Original List	Revised and Ranked List
1. Conduct PI&E campaign to promote using motorcycle safety gear (helmets, leg protection, footwear, etc.)—All the Gear All the Time (ATGATT). 2. Provide training for law enforcement on identifying non-DOT compliant helmets. 3. Work with riders' groups and dealerships to promote the use of protective gear.	1. Conduct PI&E campaign to promote using motorcycle safety gear (helmets, leg protection, footwear, etc.)—All the Gear All the Time (ATGATT). 2. Work with riders' groups and dealerships to promote the use of protective gear. 3. Provide training for law enforcement on identifying non-DOT compliant helmets.

Roadway and Infrastructure

Participants combined the second, fifth, sixth, ninth, and tenth countermeasures into a single countermeasure, and deleted countermeasures seven and eight as impractical. A new countermeasure was developed during this discussion to add to the "Evaluation, Data, and Research" category: conducting research on roadway edge drop-off conditions that are safe for motorcycles. Table 32 lists the original and the revised, ranked list of countermeasures for this category.

Table 32. Roadway and Infrastructure – Ranked Countermeasures.

Original List	Revised and Ranked List
1. Communicate roadway condition information (construction, maintenance, hazardous locations) on DOT websites, social media, and 511). 2. Identify pavement markings, surface materials, and other treatments that reduce traction for motorcycles and treat or replace with high-traction materials. 3. Establish maintenance policies that require milled surfaces be paved during the same day. 4. Post specific warnings for motorcyclists where unavoidable hazardous conditions exist (reduced traction, roadway surface irregularities). 5. Consider motorcycles during routine roadway inspections. 6. Educate road design and maintenance personnel about conditions that pose hazards to motorcyclists. 7. Provide full paved shoulders to accommodate roadside motorcycle recovery and breakdowns. 8. Consider motorcycles in the selection and placement of roadside barriers. 9. Maintain roadway to minimize surface irregularities and discontinuities that are hazardous to motorcycles. 10. Maintain roadway surfaces in work zones to facilitate safe passage of motorcycles.	1. Communicate roadway condition information (construction, maintenance, hazardous locations) on DOT websites, social media, and 511). Include info regarding fresh seal-coat, milled surface areas during construction. Add potential for crowd-sourcing roadway condition information. Develop a smartphone app? 2. Educate road design and maintenance personnel about conditions that pose hazards to motorcyclists. a. Identify pavement markings, surface materials, and other treatments that reduce traction for motorcycles and treat or replace with high-traction materials. b. Establish maintenance policies that require milled surfaces be paved during the same day. c. Maintain roadway to minimize surface irregularities and discontinuities that are hazardous to motorcycles. d. Maintain roadway surfaces in work zones to facilitate safe passage of motorcycles. e. Consider motorcycles during routine roadway inspections. 3. Post specific warnings for motorcyclists where unavoidable hazardous conditions exist (reduced traction, roadway surface irregularities).

Legislation and Regulations

Participants eliminated or revised all of the proposed countermeasures in this category; the original countermeasures were judged by the group to be discriminatory toward motorcycle riders, fiscally infeasible, or too limited in scope. Three new countermeasures were proposed: reinstatement of a helmet law, a legal requirement for turn signals on motorcycles, and the establishment of a committee to more thoroughly examine and update all state laws regarding motorcycles. Table 33 lists the original and the revised, ranked list of countermeasures for this category.

Table 33. Legislation and Regulation – Ranked Countermeasures.

Original List	Revised and Ranked List
1. Require mandatory helmet use for all newly licensed riders. [Personal Protective Gear] 2. Implement stricter penalties for riding without a license. [Licensing] 3. Implement legislation allowing law enforcement to impound motorcycles if riders are not properly licensed. [Licensing] 4. Require motorcycle license/endorsement before motorcycle purchase. [Licensing] 5. Implement zero BAC/reduced BAC laws for newly licensed riders. [Impaired Riding, Licensing] 6. Require zero BAC/reduced BAC laws for all motorcycle riders. [Impaired Riding] 7. Greater penalties for BAC of 0.16 and up.[Impaired Riding] 8. Mandatory BAC testing in all death and injury crashes. [Impaired Riding]	1. Legislate mandatory helmet use. 2. Re-examine and update motorcycle laws. a. Review, streamline, and modernize terminology and laws. b. Coordinate among all agencies responsible for motorcycle laws, definitions, and regulations (DPS, DOT, DMV, and other) to develop legislation specifying who is in charge of what regarding motorcycles. c. Review committee comprised of TxDOT, law enforcement, DMV licensing, TMSC. 3. Require motorcycles to have turn signals; currently not required in TX.

Law Enforcement

Participants eliminated two of the countermeasures one and two on the original list because those two efforts (including motorcycles in crash investigation training and developing educational materials for justice system personnel) are already in progress. In place of "conduct high visibility enforcement campaigns" participants suggested advocating for increased funding for existing motorcycle safety campaigns and enforcement efforts (which is also a countermeasure listed under "Program Management"). The group added some detail to the third countermeasure (create a quick reference guide). Table 34 lists the original and the revised, ranked list of countermeasures for this category.

Table 34. Law Enforcement and Regulations – Ranked Countermeasures.

Original List	Revised and Ranked List
1. Include motorcycles in crash investigation training for law enforcement officers. 2. Develop educational materials for justice system personnel on motorcycle-related laws. 3. Create a quick reference guide for law enforcement officers specific to motorcycles with statute references. 4. Conduct high visibility enforcement (HVE) campaigns in counties with the highest number of motorcycle crashes (Top 10) for speeding and impaired riding.	1. Create a quick reference guide for law enforcement officers specific to motorcycles with statute references. Develop a website with this information for print-out. Consider designing as a mobile website or application instead of printing hard copies. 2. Increase funding for motorcycle safety efforts by law enforcement.

Program Management

Participants kept the two countermeasures in this category in the original order, as shown in Table 35. During the discussion, it was noted that under current federal funding regulations, programming funds for certain traffic safety areas (occupant protection, impaired driving, graduated licensing) have new eligibility requirements.

Table 35. Program Management – Ranked Countermeasures.

Original List	Revised and Ranked List
1. Increase funding for motorcycle safety by elevating their importance to state highway safety office. **2.** Focus resources in the top 10 counties for motorcycle fatalities and identify countermeasures that work then develop best practices tools for use statewide.	1. Increase funding for motorcycle safety by elevating their importance to state highway safety office. **2.** Focus resources in the top 10 counties for motorcycle fatalities and identify countermeasures that work then develop best practices tools for use statewide.

Evaluation, Data, and Research

Participants combined the fifth and sixth countermeasures from the original list, and added the need to include research on motorcycle-safe roadway edge drop-off designs. The second measure on the original list was dropped, because the use of crash location data to identify safety needs is already in practice. Table 36 lists the original and the revised, ranked list of countermeasures for this category.

Table 36. Evaluation, Data, and Research – Ranked Countermeasures.

Original List	Revised and Ranked List
1. Conduct detailed evaluation of police-reported motorcycle crash reports to determine contributing crash causation factors. Compare findings to existing training materials and adjust curricula to address the issues. 2. Use crash location data to help identify needs for additional signage, improved roadway friction, wider shoulders, modification of traffic controls, etc. 3. Conduct research to determine why motorcyclists are unlicensed and how to reach out to this group. 4. Develop partnerships with trauma centers, health department, insurance agencies, and dealerships for data sharing. 5. Add motorcycle specific information to the Texas traffic crash report for increased understanding of motorcycle crashes. 6. Promote inter- and intra-agency efforts to link crash, injury, licensing, violation, training, and registration records. 7. Determine the impact of funded research and programs on reducing motorcycle crashes, injuries, and fatalities. 8. Investigate simulation and computer modeling to better understand motorcycle crash risk and injury. 9. Undertake research to examine the role of fatigue in motorcycle crashes.	1. Add motorcycle specific information to the Texas traffic crash report for increased understanding of motorcycle crashes; promote inter- and intra-agency efforts to link crash, injury, licensing, violation, training, and registration records. 2. Conduct detailed evaluation of police-reported motorcycle crash reports to determine contributing crash causation factors. Compare findings to existing training materials and adjust curricula to address the issues. 3. Conduct research to determine why motorcyclists are unlicensed and how to reach out to this group. 4. Develop partnerships with trauma centers, health department, insurance agencies, and dealerships (if possible) for data sharing. 5. Determine the impact of funded research and programs on reducing motorcycle crashes, injuries, and fatalities. a. Fatigue. b. Edge drop-off design. c. Use mileage data (from vehicle inspection data) to normalize crash rates. 6. Investigate simulation and computer modeling to better understand motorcycle crash risk and injuries

Motorcycle and Vehicle Technologies

There was not sufficient time at the workshop to discuss the various motorcycle and vehicle technologies. Participants were provided with a survey to return, which listed the technologies described in Chapter 2 of this report and asked participants to rank each according to its potential effectiveness in reducing crashes or mitigating injuries, anticipated cost, ease of implementation, and probable timeline for implementation/availability. Participants were also asked to rank the two countermeasures associated with vehicle technologies. Ten workshop participants returned completed surveys. The two countermeasures were ranked by eight of the 10 respondents in the same order as originally listed, as reflected in Table 37.

Table 37. Motorcycle and Vehicle Technologies – Ranked Countermeasures.

Original List	Revised and Ranked List
1. Promote availability and benefits of technologies that improve motorcyclist safety and increase rider conspicuity.	1. Promote availability and benefits of technologies that improve motorcyclist safety and increase rider conspicuity.
2. Engage with the motorcycle industry to encourage the development and promotion of motorcycles with safety-related technologies.	2. Engage with the motorcycle industry to encourage the development and promotion of motorcycles with safety-related technologies.

The average participant rating for each of the listed technologies is shown in Figure 23. A rating of "1" equates to "not effective" and a rating of "5" equates to "very effective."

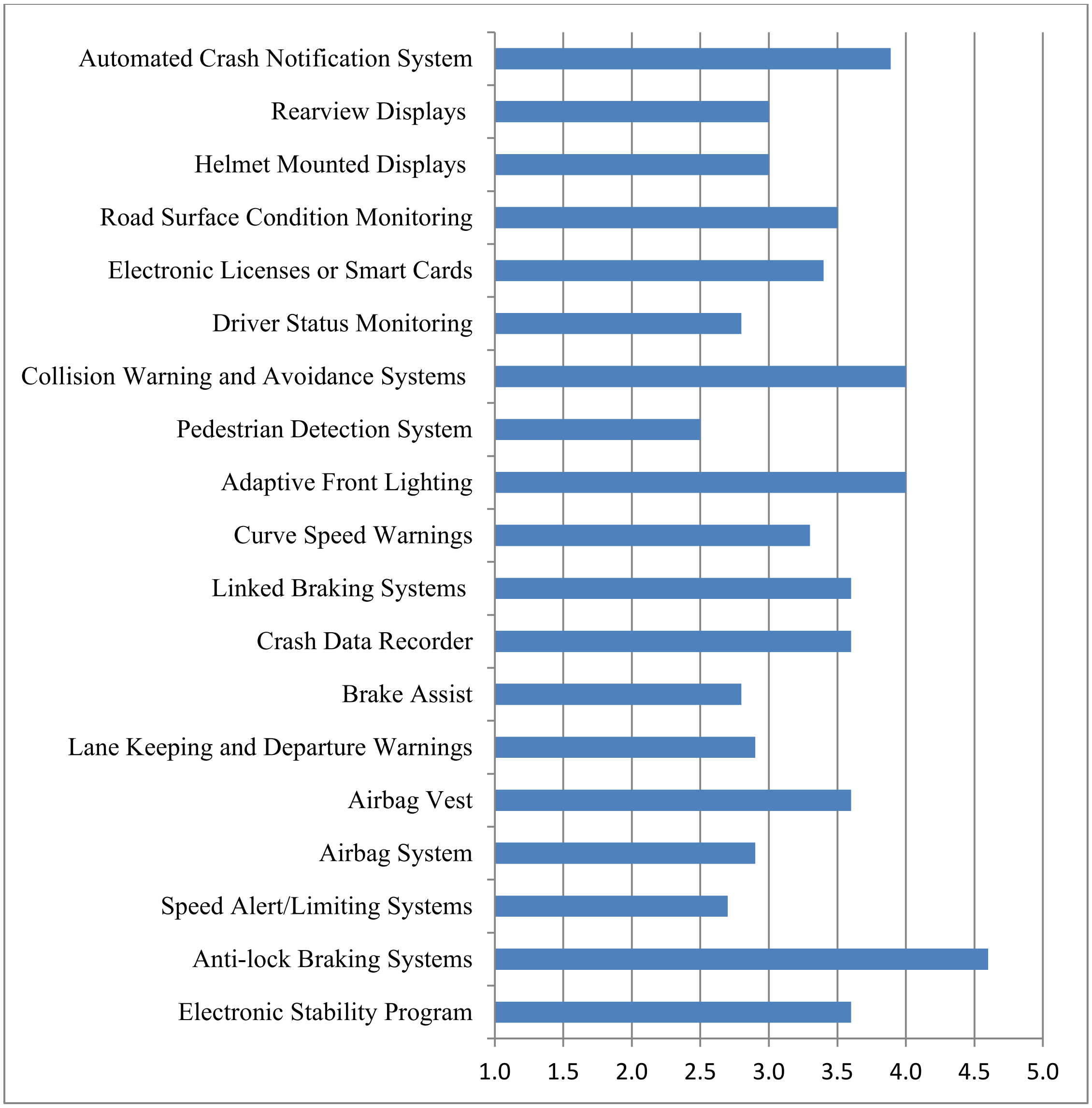


Figure 23. Average Workshop Participant Ratings for Vehicle and Motorcycle Technologies.

Participants were also asked to rank up to five technologies that they feel have the greatest potential for reducing motorcycle crashes and/or injuries. A weighted scoring system assigned each participant's five technology selections point scores of five (for his or her top-ranked selection), four, three, two, and one. Based on the sums of the weighted scores, the vehicle and motorcycle technologies ranked as shown in Table 38 among the nine participants who completed the survey.

Table 38. Weighted Total Scores of Vehicle Technologies by Workshop Participants.

Technology	Weighted Total Score (10 participants)
Anti-lock Braking Systems	37
Electronic Stability Program	18
Adaptive Front Lighting	15
Airbag Vest	15
Airbag System	14
Collision Warning and Avoidance Systems	12
Electronic Licenses or Smart Cards	11
Curve Speed Warnings	10
Brake Assist	8
Linked Braking Systems	8
Crash Data Recorder	7
Helmet Mounted Displays	7
Road Surface Condition Monitoring	7
Lane Keeping and Departure Warnings	6
Pedestrian Detection System	5
Driver Status Monitoring	4
Speed Alert/Limiting Systems	4
Automated Crash Notification System	3
Rearview Displays	2

CHAPTER 7. CONCLUSIONS

This project synthesized information from past motorcycle safety research, a review of current and emerging motorcycle and vehicle technologies, existing motorcycle safety plans and recommendations, motorcycle crash data, and a statewide motorcycle rider survey.

Exploratory and regression analyses were carried out as part of the analysis of motorcycle crash data. The Multinomial Logit model was used for modeling motorcyclists' injury-severity outcomes in urban and rural crashes. The models indicated that various roadway, environmental, and rider characteristics are significant in affecting the probabilities of motorcyclists' crash-severity outcomes in rural and urban areas. The following conclusions were developed based on the research conducted for Task 3.

- Helmet use influences crash injury severity and reduces the chances of fatal and incapacitating crashes.
- Single-vehicle crashes are less likely to result in a fatality or incapacitating injury compared to multi-vehicle crashes.
- Older riders are susceptible to more severe injuries if involved in a crash compared to younger riders.
- Crashes occurring between 8 p.m. and 6 a.m. are more severe than crashes occurring between 6 a.m. and 8 p.m. This may be related to alcohol involvement, difficultly detecting adverse road conditions, higher speeds, etc.
- Roadway curvature (both horizontal and vertical) is correlated with motorcycle crash severity. These features increase the likelihood of more severe crashes. Horizontal curves have a more pronounced effect than the vertical curves on influencing the crash severity.
- Riding under the influence of alcohol or drugs has a strong correlation with crash severity. Rider intoxication significantly increases the probability of a fatality, regardless if the crash occurred in an urban or rural area.
- Crashes involving higher speeds or lane indiscipline (failure to stay within lane of travel) are more severe in comparison to crashes without these two contributing factors.
- Crashes occurring on higher speed limit roads (such as interstate, US, and state highways) are more severe than crashes occurring on other roads (such as city streets and county roads).

Based on Task 3 findings, the following recommendations to reduce motorcyclists' crash-injury severity outcomes for urban and rural crashes are suggested.

- Continue efforts to educate riders about the effects of alcohol and drug use on riding skills and crash injury severity.
- Educate older riders about their increased risk to more severe injuries if involved in a crash.

- Inform riders about the increased crash risks associated with nighttime riding. Encourage riders to use high visibility gear, especially during evening and nighttime hours.
- Increase rider awareness about greater crash risks on roadway segments with horizontal and vertical curves.
- Uniformly enforce speed limit laws for all drivers.
- Reiterate the consequences of speed, alcohol, and unsafe riding in rider training programs. Encourage safe riding.

The rider survey conducted in Task 4 highlighted some additional observations regarding crash risk factors, as well as motorcycle riders' attitudes concerning a variety of motorcycle crash countermeasures.

- While a large majority (84 percent) of responding riders indicate that they wear a helmet most or all of the time, another 9 percent wear a helmet half the time or less, and 7 percent report never wearing a helmet.
- Among respondents who have been involved in a motorcycle crash, 47 percent indicated "the other driver said he/she didn't see me" as a contributing factor in the crash. However, only 30 percent of respondents reported that they regularly wear reflective materials, and just over 20 percent reported that they wear bright-colored clothing or helmets when riding to improve visibility.
- Slightly over one-quarter of respondents reported that they have never taken a motorcycle safety training course. Of the respondents who have taken at least one course, 82 percent report that the training "greatly" or "significantly" improved their riding skills.
- Approximately 28 percent of respondents reported that, during the past year, they have consumed one to two drinks on at least one occasion within an hour of riding a motorcycle. Another 3 percent reported consuming three or more drinks prior to riding.
- Helmets and other safety gear, basic motorcycle training courses, and the use of lights and reflective materials to improve conspicuity were each rated by over 80 percent of respondents as "effective" to "very effective" for preventing crashes and injuries. Advanced rider training, awareness campaigns targeting motorists, and safety awareness campaigns aimed at motorcycle riders were rated "effective" to "very effective" by over 70 percent of respondents.
- Of the advanced motorcycle and vehicle technologies described in the survey, participants most frequently selected anti-lock brakes, traction control, and adaptive headlights as the motorcycle technologies having the most potential for reducing crashes and injuries. Other potentially effective technologies, including airbag vests and airbags on motorcycles, were selected by far fewer participants.

From the results of the research tasks, researchers identified over 70 potential countermeasures with potential for reducing motorcycle crashes and/or mitigating crash-related injuries. The countermeasures were organized into 13 categories that represented particular areas of concern identified by the research: rider conspicuity, motorist awareness, motorcycle licensing, rider training, impaired riding, speeding, personal protective gear, roadway and infrastructure issues, motorcycle-related legislation and regulation, law enforcement activities and education, motorcycle safety program management, program evaluation and data, and emerging motorcycle and vehicle technologies. This list of countermeasures was evaluated and prioritized by workshop participants, and the revised list served as the basis for a statewide motorcycle safety plan for the state of Texas. The plan is available as the *Strategic Action Plan for Motorcycle Safety in Texas: 2013–2018*.

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APPENDIX A. LIST OF CRASH COUNTERMEASURE IMPLEMENTATION WORKSHOP PARTICIPANTS

Name	Affiliation
Jude Schexnyder	TSMC; Motor Pro Training
Quinn Brackett	TTI (retired); TSMC
Maurice Maness	TxDOT
Dan Middleton	TTI
Michael Jedlicka	TxDOT
Keith Rovell	Motorcycle safety instructor
Will Bozeman	TxDOT
Pat Rawlings	Motorcycle rider
Chantal Locke	Austin Police Department
Jay Kimbrough	Department of Public Safety (DPS)
Jeffrey del Castillo	Motorcycle safety instructor
Roy Wright	TxDOT
Nicholas Nemec	TxDOT
Kenneth Smith	College Station Police Department
Lee Ann Bell	TTI
Dave Lund	Bryan Police Department
Kenneth Copeland	NHTSA
Jeff Kaufman	Houston–Galveston Area Council
Michael Kellett	Motorcycle rider
Jeff Milburn	Jeff Milburn Engineering
John Young	TxDOT
Shirley Ashbrook	TxDOT
Nina Saint	Texas Education Agency
Romona Maxim	Driver education instructor
David Metcalf	DPS
Terri Miller	TxDOT

APPENDIX B. WORKSHOP PARTICIPANT MATERIALS

Motorcycle Crash Countermeasures Workshop

The Texas Department of Transportation (TxDOT) contracted with the Texas A&M Transportation Institute (TTI) to develop a 5-year strategic plan for improving motorcycle safety in the State of Texas. The *Texas Strategic Action Plan for Motorcycles: 2013-2018* uses an integrated approach to identify implementable actions to make the road environment and infrastructure safer for motorcyclists and other powered two and three wheelers, and address driver and rider actions that contribute to the number of motorcycle-involved crashes on the roadway system. The plan ensures that motorcycles receive appropriate recognition in future transportation policy and planning in the State of Texas.

Your participation in the workshop will help to shape a new strategic direction for the use of motorcycles and the safety of motorcyclists over the next five years in the State. The plan targets several possible areas for action:

- Motorcycle/rider conspicuity
- Motorist awareness of motorcycles
- Licensing
- Training and Education
- Impaired riding
- Speeding
- Personal protective gear
- Roadway/Infrastructure
- Legislation and regulations
- Law enforcement
- Program management
- Program evaluation and data
- Motorcycle and vehicle technologies/ITS

The materials summarize the literature on countermeasures to improve motorcycle safety. When reviewing each countermeasure, please consider their **effectiveness** in preventing motorcycle crashes, and their **effectiveness** in reducing the severity of injuries to a crash-involved rider. Please add any additional strategies for consideration and/or eliminate those that you consider less effective in achieving the goals of the strategic action plan.

KEY AREA/GOAL (S)	***COUNTERMEASURES***
Motorcycle/Rider Conspicuity	• Educate motorcycle riders in conspicuity products, techniques, and strategies. • Increase motorcyclists' use of high-visibility clothing, conspicuity products. • Enhance training on strategic lane positioning for increasing motorcyclist conspicuity in traffic. • Encourage visibility enhancements for motorcycles, such as auxiliary headlights, auxiliary brake lights, headlight modulators, position lamps, underbody LED lighting, etc.
Motorist Awareness of Motorcycles	• Increase motorists' knowledge about sharing the road with motorcyclists and other vulnerable road users. • Produce brochure on TxDOT's "Share the Road" sign program and process to request a sign. • Include up-to-date information on sharing the road and rider conspicuity in the Texas driver's education handbook. • Add questions about sharing the road with motorcycles on Texas driver's license exam. • Consider legislation allowing drivers ticketed for right-a-way violations involving a motorcycle to attend a motorcycle safety class for a ticket dismissal. • Support the use of emerging vehicle technologies (e.g., blind spot and forward collision warning systems, collision avoidance systems) to improve motorists' awareness of motorcycles.

Licensing

- Revise licensing regulations to require specific license for operators of 3-wheel motorcycles.
- Encourage law enforcement to take a zero-tolerance approach regarding unlicensed riders.
- Require proof of motorcycle endorsement before issuing parking permits (large employers, state and local government agencies, university campuses, etc.)
- Engage other groups (i.e., dealerships, insurance, drivers instructors, etc.) to provide information or brochures about motorcycle licensing requirements to motorcycle purchasers.
- Increase rider awareness about crash involvement of unlicensed or untrained motorcyclists.
- Implement graduated licensing system for motorcyclists.

Other Licensing countermeasures listed under Legislation and Regulations:

- Enact legislation to allow law enforcement to impound motorcycle if operator is not properly licensed.
- Implement stricter penalties for riding without a license.
- Require motorcycle license or endorsement prior to purchasing a motorcycle.

Rider Education/Training

- Expand course availability for three-wheeled vehicles classified as motorcycles.
- Educate riders on potential roadway obstacles (pavement makers, manhole covers, steel plates, etc.) and collision avoidance.
- Integrate rider training with licensing.
- Revise and update motorcycle operator's manual and translate into Spanish.
- Improve type and quantity of motorcycles used for rider training.

- Increase/reallocate funding for motorcycle safety training.
- Update and/or implement better system to monitor training course certificates and end-of-course examinations.
- Update quality assurance plan to increase the number of site and instructor visits and standardizes the review and remediation process.
- Promote (PI&E) importance of rider training to new and experienced motorcyclists.

Impaired Riding

- Promote peer-to-peer outreach among riders discouraging drinking and riding.
- Reach out to rider group leadership to develop strategies to prevent impaired riding at motorcycle events.
- Engage motorcycle-friendly businesses that serve alcohol to create awareness.
- Explore expanding the use of alcohol interlock devices for motorcycles.
- Require alcohol/drug education as well as rider education for DUI convictions.
- Distribute NHTSA's "Detecting DWI Motorcyclists" guide to law enforcement agencies.
- Develop materials on impaired riding and motorcycle laws for prosecutors, judges, and judicial employees.

Additional Impaired Riding countermeasures listed under Legislation and Regulations:

- Encourage implementation of zero BAC/reduced BAC laws for beginning motorcycle riders.
- Encourage zero BAC/reduced BAC laws for all motorcycle riders.
- Encourage enhanced penalties for BAC of

0.16 and up.

- Require mandatory BAC check in all death and injury crashes.

Speeding

- Include speeding enforcement
- Develop outreach/education to riders about dangers of excessive speed.
- Educate riders about selecting a motorcycle compatible with skill level.

Additional Speeding countermeasure listed under Legislation and Regulations:

- Require beginning riders to use motorcycles with speed limiters.

Personal Protective Gear

- Conduct PI&E campaign to promote using motorcycle safety gear (helmets, leg protection, footwear, etc.). All the Gear All the Time (ATGATT)
- Provide training for law enforcement on identifying non-DOT compliant helmets.
- Work with riders' groups and dealerships to promote the use of protective gear.

Roadway/Infrastructure

- Communicate roadway condition information (construction, maintenance, hazardous locations) on DOT websites, social media, and 511).
- Identify pavement markings, surface materials, and other treatments that reduce traction for motorcycles and treat or replace with high-traction materials.
- Establish maintenance policies that require milled surfaces be paved during the same day.
- Post specific warnings for motorcyclists where unavoidable hazardous conditions exist (reduced traction, roadway surface irregularities).
- Consider motorcycles during routine

roadway inspections.

- Educate road design and maintenance personnel about conditions that pose hazards to motorcyclists.
- Provide full paved shoulders to accommodate roadside motorcycle recovery and breakdowns.
- Consider motorcycles in the selection and placement of roadside barriers.
- Maintain roadway to minimize surface irregularities and discontinuities that are hazardous to motorcycles.
- Maintain roadway surfaces in work zones to facilitate safe passage of motorcycles.

Legislation and Regulations

- Require mandatory helmet use for all newly licensed riders. [Personal Protective Gear]
- Implement stricter penalties for riding without a license. [Licensing]
- Implement legislation allowing law enforcement to impound motorcycles if riders are not properly licensed. [Licensing]
- Require motorcycle license/endorsement before motorcycle purchase. [Licensing]
- Implement zero BAC/reduced BAC laws for newly licensed riders [Impaired Riding, Licensing]
- Require zero BAC/reduced BAC laws for all motorcycle riders. [Impaired Riding]
- Greater penalties for BAC of 0.16 and up.[Impaired Riding]
- Mandatory BAC testing in all death and injury crashes. [Impaired Riding]

Law Enforcement

- Include motorcycles in crash investigation training for law enforcement officers.

- Develop educational materials for justice system personnel on motorcycle-related laws.
- Create a quick reference guide for law enforcement officers specific to motorcycles with statute references.
- Conduct high visibility enforcement (HVE) campaigns in counties with the highest number of motorcycle crashes (Top 10) for speeding and impaired riding.

Program Management

- Increase funding for motorcycle safety by elevating their importance to state highway safety office.
- Focus resources in the top 10 counties for motorcycle fatalities and identify countermeasures that work then develop best practices tools for use **statewide.**

Evaluation, Data & Research

- Conduct detailed evaluation of police-reported motorcycle crash reports to determine contributing crash causation factors. Compare findings to existing training materials and adjust curricula to address the issues.
- Use crash location data to help identify needs for additional signage, improved roadway friction, wider shoulders, modification of traffic controls, etc.
- Conduct research to determine why motorcyclists are unlicensed and how to reach out to this group.
- Develop partnerships with trauma centers, health department, insurance agencies, and dealerships for data sharing.
- Add motorcycle specific information to the Texas traffic crash report for increased understanding of motorcycle crashes.
- Promote inter- and intra-agency efforts to link crash, injury, licensing, violation,

training, and registration records.

- Determine the impact of funded research and programs on reducing motorcycle crashes, injuries, and fatalities.
- Investigate simulation and computer modeling to better understand motorcycle crash risk and injury.
- Undertake research to examine the role of fatigue in motorcycle crashes.

Motorcycle/Vehicle Technologies

- Promote availability and benefits of technologies that improve motorcyclist safety and increase rider conspicuity.
- Engage with the motorcycle industry to encourage the development and promotion of motorcycles with safety-related technologies.

Motorcycle and Vehicle ITS Technologies

Technology	Definition	Status
Electronic Stability System	Enables the stability of the car to be maintained during critical maneuvering and to correct potential under-steering or over-steering	Existing
Curve Speed Warnings	Warns riders about upcoming curves by using GPS and digital mapping	Emerging
Lane Keeping and Departure Warnings	Uses forward-facing cameras to scan roadway and determine if the vehicle is migrating toward to the lane markings. All systems vibrate the wheel to ensure the driver is awake, while others also lightly apply the brakes to keep the vehicle in line	Existing in passenger vehicles
Adaptive Front Lighting	Uses steering wheel angle and vehicle speed to ensure that headlight illuminates the roadway in front of the vehicle operator	Emerging
Anti-lock Braking Systems	Monitors wheel speed and adjusts braking pressure evenly among wheels to ensure that brakes do not lock when applied to avoid a crash	Existing
Brake Assist	Applies maximum pressure under sudden braking conditions	Existing in passenger vehicles
Linked Braking Systems	Applies pressure to both brakes simultaneously to ensure balance	Existing for MC
Pedestrian Detection System	Uses radar sensors and data from an on-board camera to automatically brake to reduce or mitigate the risk of hitting a pedestrian	Emerging
Collision Warning and Avoidance Systems	Uses radar to monitor the forward roadway and warn the driver audibly and visibly that they are nearing an object or vehicle in their lane. As the object gets closer, the warning becomes more intense	Emerging
Driver Status Monitoring	Uses facial detection technology to analyze driver facial features to ensure driver alertness	Emerging
Electronic Licenses or Smart Cards	Requires smart card be placed into the ignition to operate the motorcycle to prevent unlicensed riding. This would also allow the ability to monitor drivers who are inexperienced or deemed at-risk	Emerging
Road Surface Condition Monitoring	Laser linked to ABS or speed-limiting systems, scans road and alerts drivers to potential road hazards. System can be combined with information from roadside beacons or other sources of data	Emerging
Helmet Mounted Displays	Projects information from the instruments to a display inside the operator's helmet, reducing the need to fully take their eyes off the road and look at the panel.	Emerging
Rearview Displays	Helmet or vehicle based, rearview displays use backward facing cameras to project real time images of the road environment behind the motorcycle to increase visibility over traditional rear-view mirrors	Emerging
Speed Alert/Limiting Systems	System warns drivers when they have exceeded the posted speed limit or exceed the maximum limit set by the motorcycle operator in order to minimize the role that excessive speed plays in motorcycle crashes	Existing

Technology	Definition	Status
Airbag System	Airbag systems deploy upon impact at a certain intensity level and can assist in reducing injuries to riders involved in crashes	Existing
Airbag Vest	Vest protects front and back of the body if rider is ejected from the motorcycle	Existing
Automated Crash Notification System	System automatically notifies emergency personnel of a crash so that help can arrive more quickly; advanced systems also collect crash severity data from sensors, airbag deployment and other cues	Emerging
Crash Data Recorder	Located in the airbag control or powertrain control on vehicles, crash data recorders can record information such as driver's pre-impact speeds, seatbelt use, driver's brake or throttle position pre-crash and crash severity	Existing in some passenger vehicles