Instrumented On-Road Study of Motorcycle Riders
Supporting Statement for Information Collection Request

TABLE OF CONTENTS

B. Collections of Information Employing Statistical Methods

The proposed information collection will employ statistical methods to analyze the data collected from respondents. The following sections describe the procedures for respondent sampling and data tabulation.

The objective of this study is to collect data on motorcyclists' real-world riding behavior using the *naturalistic driving* methodology. Volunteers will be recruited to have their motorcycles outfitted for one year with instrumentation such as cameras, GPS, and accelerometers that will capture data on normal riding behavior whenever their motorcycles are ridden.

Participating motorcycle riders will be asked to complete questionnaires during the time when their motorcycles are being instrumented that will ask about their demographics, riding history, sensation- and thrill-seeking propensity, personality, and self-reported riding style. After completing the on-road study, participants will complete a short debriefing questionnaire that will ask them to provide feedback on their subjective experience while riding with the instrumentation, to recollect behavior that could not be recorded with the instrumentation, and to rate their own riding safety and skills. This subjective data will be combined with the objective data from the instrumentation on actual riding behavior to help NHTSA develop a better understanding of if a rider's demographic characteristics, riding history, sensation- and thrill-seeking propensity, personality, self-reported riding style, and other subjective factors are linked to his or her observed behavior on the road.

B.1. Describe the potential respondent universe and any sampling or other respondent selection to be used.

Participants in this study will be a non-representative convenience sample of volunteers. The sample will include 160 motorcycle riders. Operational considerations dictate that we draw the sample of volunteers from a single metropolitan area. We acknowledge that drawing volunteers from a single metropolitan area means that our sample will not be representative of American motorcycle riders and that we will not be able to generalize findings to the American motorcycle riding population. However, in spite of this limitation, we expect to uncover useful information on motorcycle riding behavior similar to what has been found in past naturalistic driving studies such as the 100-Car Naturalistic Driving Study (Dingus et al., 2006) and the Naturalistic Teenage Driving Study (Lee, Simons-Morton, Klauer, Ouimet, & Dingus, 2011), which were also conducted with a sample of volunteers drawn from a single metropolitan area.

Factors that were considered in selecting a site from which to draw study volunteers include:

- Have sufficiently large populations to support recruitment,
- Include high traffic densities,
- Include multi lane unrestricted access roadways,
- Include exposure to controlled and uncontrolled intersections,
- Have crash types found in urban areas,
- Include other currently uncharacterized factors present in urban riding,
- Have minimal geographic separation between urban and rural areas,
- Include restricted access highways/interstates,

- Include two lane roads,
- Include hills and curves,
- Have crash types found in rural areas,
- Include other currently uncharacterized factors present in rural riding, and
- Have a long motorcycle riding season.

Bearing the above factors in mind, we have chosen San Diego, CA as the study site area. As of January 2011, there were 82,110 registered motorcycles in San Diego County, CA (California Department of Motor Vehicles, 2012), which is sufficiently large for recruitment.

There will be several criteria for participation for riders in the study site, based on the experimental design and practical issues. The major criteria include age, motorcycle riding experience, and motorcycle type. We will seek participants for this study to fit an age distribution that approximates the age distributions of motorcycle operators involved in fatal crashes and of motorcycle owners. This distribution will balance representing the age distribution of the American motorcycle riding population with maximizing the number of crashes and near-crashes that will be captured for analysis. Table 1 reports the age distribution of motorcycle operators involved in fatal crashes in 2010 from NHTSA's Fatality Analysis Reporting System (NHTSA, 2011c), the age distribution of American motorcycle owners as reported in the Motorcycle Industry Council's 2008 Motorcycle/ATV Owner Survey (Motorcycle Industry Council, 2009), and the desired age distribution of participants in the sample. Motorcycle riders ages 18-29 are overrepresented in fatal motorcycle crashes and will be oversampled in this study.

Table 1. Age distribution of motorcycle operators in fatal crashes, motorcycle owners, and of participants in study design.

	Age				Total
	18-29	30-39	40-49	50+	
% of motorcycle operators in fatal crashes, 2010	25%	18%	22%	34%	
% of motorcycle owners, 2008	19%	19%	28%	29%	
Number of participants	40 (25%)	32 (20%)	40 (25%)	48 (30%)	160

Source: NHTSA's Fatality Analysis Reporting System (FARS), 2010 data; Motorcycle Industry Council 2008 Motorcycle Owner Survey

Twelve percent of motorcycle owners in 2008 were female (Motorcycle Industry Council, 2009), and 4% of motorcycle operators involved in fatal crashes in 2010 were female (0.5% age 18-29, 0.7% age 30-39, 1.3% age 40-49, and 1.3% age 50+; NHTSA, 2011c). Because female riders are underrepresented in fatal crashes, NHTSA will seek to fill approximately 10% of the sample (16 participants) with females, which is slightly less than the percentage of motorcycle owners who are females. The Motorcycle Industry Council Statistical Annual reports the overall percentage of motorcycle owners by sex but does not break sex down by age from the Motorcycle/ATV Owner Survey (Motorcycle Industry Council, 2009). Because there is no accurate report of the distribution of American motorcycle riders by sex and age available, and because females are a

small percentage of American motorcycle riders, we do not include a distribution of participants by sex within each age cell of our study design.

Prior motorcycle riding experience is an independent variable of interest for this study. Half of riders in each age category will be experienced riders, and half of riders in each age category will be new or newly returning riders. Criteria for these experience categories will include:

Novice

- 2 or fewer years of riding experience,
- Have ridden 2,000 or fewer miles in the past year,
- And 2 or fewer years of off-road riding experience.

Newly Returning

- Returned to motorcycle riding in the past 2 years
- After taking a break from riding that lasted 5 years or more (i.e., rode when they were younger, and stopped riding for 5+ years),
- And have ridden 2,000 or fewer miles in the past year.

Experienced

- 5 or more years of continuous riding experience, and
- Ride 8 or more days a month during their riding season.

For riders in the 30-39, 40-49, and 50+ age ranges, 25% of participants will be novices, 25% will be newly returning, and 50% will be experienced. It would not be practical to include newly returning riders in the 18-29 age range. Therefore, for riders age 18-29, 50% will be novices, and 50% will be experienced. The distribution of riders in the age and experience riders in the sample design appears in the Table 2.

Table 2. Age and experience distribution of participants in study design.

	Age				Total
	18-29	30-39	40-49	50+	
Novice	20	8	10	12	50
Returning	Not Applicable	8	10	12	30
Experienced	20	16	20	24	80
Total	40	32	40	48	160

Because custom instrumentation must be developed for each make and model of motorcycle involved in the study, it is necessary for us to limit the number of models that will be included. Models to be included in the study will be chosen among cruisers and sports bikes, which comprised 71% of registered motorcycles in 2008 for which type was known (Teoh & Campbell, 2010). This is similar to the procedure of 100-Car Naturalistic Driving Study, in which participants also were required to drive one of six specified car models for inclusion (Neale et al., 2002.)

Participants must report that they ride a minimum of three days a month during their riding to ensure that they will ride often enough to produce a sufficient amount of data over one year. For liability and privacy considerations, participants additionally must own their motorcycle, must report that another person will not ride regularly during the study, must be licensed, and must carry liability insurance. Finally, to receive payment and communicate with study personnel, participants must be eligible to work in the United States and must be comfortable reading and speaking English. Participants' motorcycles must also not be in poor operating condition.

Because we will recruit a convenience sample that will respond to advertisements and not a probability sample, it is not possible to estimate nonresponse. However, data collected during the pilot project for this study indicates that motorcycle riders' interest in participating may be high. A survey sponsored by the National Surface Transportation Safety Center for Excellence during the pilot project asked motorcycle riders to rate on a scale of 0 to 5 how willing they would be to participate in an instrumented motorcycle study (0 being "unwilling," and 5 being "very willing"). Seventy-five percent of the 229 survey respondents indicated that they would be very willing to participate, and only 1% indicated that they would be unwilling to participate (McLaughlin, Doerzaph, & Cannon, 2011; see Appendix A). Because less-willing candidates may have declined to complete the survey, the results of this survey do not assure that the response rate to the current study will be as high as 75%; nevertheless, they do indicate that there is high enthusiasm among the motorcycle community to participate in this type of study.

Though a stratified participant sampling approach will be pursued, the final participant sampling strategy in this study will be more similar to a convenience sample. For this reason, the naturalistic study does not lend itself to weighting approaches that might be appropriate in crash record database analyses, for example. However, using weighting techniques to translate findings to the larger population may be possible and informative when applied to certain measures. Measures based on large quantities of data may be relatively stable and weighting approaches may provide guidance about the larger population. Exposure to different road categories or conditions would be candidates for weighting, because it is expected that a large amount of data will be collected for these variables. Wherever applied, it will be important to carefully match the participant demographic measures to the known characteristics of the larger populations (e.g., age).

Resulting publications will include a caveat that data were collected from a convenience sample of volunteers, and that the results cannot be generalized to the population of American motorcycle riders. We will not attempt to characterize American motorcycle riders with the results. We will instead use the findings as a foundation from which to generate ideas for the development of novel behavioral- and vehicle-based countermeasures for motorcycle safety.

B.2. Describe the procedures for the collection of information.

Procedure

Multiple methods will be used to recruit participants. Examples of methods, ranging roughly from targeted to broad include: traditional mailings generated from owner data (e.g., from State Department of Transportation databases of registered motorcycle owners), placing flyers on motorcycles of specific types, posting notices with online forums, placing advertisements in

newspapers, and word-of-mouth. The contractor for this study, Virginia Tech Transportation Institute (VTTI) will organize a candidate participant database and use it for coordinating distribution of these types of materials as well as managing reporting of success rates and tracking status of a contact. Mailings will be drafted that include phone numbers and e-mail addresses that potential participants can use to get more information and/or enroll. VTTI will also host a recruiting website where interested potential participants can read more information about the study before choosing to contact VTTI to express interest.

Interested respondents will contact VTTI if they want to volunteer to participate. These potential participants will be screened with the screener provided in Appendix C and will be told that they will be contacted later if selected for the study. Categories for demographic and experience characteristics (age, gender, experience level) will continue to be recruited until filled.

The participants who are selected based on demographic and experience characteristics will ride their motorcycles to the instrumentation facility and undergo informed consent procedures. Their motorcycles will then be outfitted with the data acquisition system. During the instrumentation process, participants will be asked to complete four questionnaires. These questionnaires include (see Appendix D):

- Demographics and riding history questionnaire,
- Sensation- and thrill-seeking questionnaire,
- NEO Five Factor Inventory (NEO-FFI) personality inventory,
- and Motorcycle Rider Behavior Questionnaire (MRBQ).

Section B.4 contains more information on how these questionnaires were selected for inclusion, how they compare to individual difference assessments used in previous naturalistic driving studies, and how they were developed and validated.

If the expected instrumentation time is longer than the time it takes the participant to complete questionnaires, the participant will be shuttled home and back to the facility when his or her motorcycle is ready for pick-up. Instrumentation is expected to last up to 8 hours. Participants will be instructed to ride as they normally do once their motorcycles are instrumented.

Motorcycles will be instrumented for one year each. During this time, the data acquisition system will record data from its sensors and cameras continuously, whenever the motorcycle is ridden. The data acquisition system will communicate via cellular reporting to VTTI for periodic checking that the system is operational and data are being collected. If a malfunction is detected or when the hard drive nears capacity, a technician will be dispatched to correct the problem or to swap the hard drive for a new one. The hard drive is expected to have an 8-12 month capacity, depending on the frequency of riding. It is expected that participants may require one appointment over the course of the study to swap hard drives. These appointments will typically take about 15 minutes, but could take up to one hour depending on what needs to be done. They will be scheduled to take place at a location that is convenient for the participant such as their home, work, school, or at a local shopping mall.

After 12 months, the participant will return to the instrumentation facility to have the data acquisition system removed from their motorcycle. During this time, the participant will also complete the debriefing questionnaire (Appendix E). This questionnaire will ask respondents to

provide feedback on their subjective experience while riding with the instrumentation, to recollect behavior that could not be recorded with the instrumentation, and to rate their own riding safety and skills.

Sample Size

The sample size of 160 riders was chosen to balance statistical power and cost considerations. We assumed that crashes would be the least-frequent behavior of interest, and thus used the potential number of crashes as the primary consideration when determining sample size. Because crashes occur infrequently, we also plan to analyze the frequency of crashes combined with the surrogate measure of *near-crashes*. Near-crashes are defined as circumstances that require a rapid, evasive maneuver by the participant vehicle to avoid a crash (Guo, Klauer, McGill, & Dingus, 2010). Near-crashes have been used as surrogates for crashes in prior naturalistic driving studies such as the 100-Car Naturalistic Driving Study and the Naturalistic Teenage Driving Study (e.g, Dingus et al., 2006; Lee et al., 2011).

The number of potential crashes and near-crashes in this study were estimated based on the number of crashes and near-crashes per mile driven that occurred during the 100-Car Naturalistic Driving Study. In the 100-Car Naturalistic Driving Study, there were 82 crashes and 761 near-crashes that occurred over the approximately 1.8 million miles traveled. McCartt, Balanr, Teoh, and Strouse (2011) estimated from a survey of American motorcycle riders that riders ride an average of 5,383 miles per year. Half of the riders we recruit will have low riding experience (i.e., novice riders who rode fewer than 2,000 miles over the past year) and half will have high riding experience (i.e., experienced riders who ride more than 8 days a month during the riding season); thus, we estimate that the average mileage of the overall sample will approximate this mean. Estimates for the number of crashes and near crashes for the 160 motorcycles in this study appears below in Table 3, alongside the actual crash and near-crash numbers from the 100-Car Naturalistic Driving Study and Naturalistic Teenage Driving Study.

Table 3. Crashes and Near-Crashes in Naturalistic Driving Studies

	Instrumented On-Road Study of Motorcycle Riders (projected)	100-Car Naturalistic Driving Study	Naturalistic Teenage Driving Study
Number of Vehicles	**160**	100	42
Miles	**861,280**	1.8 million	500,000
Crashes	**40**	82	40
Crash Rate Per 100,000 Miles	***4.6***	*4.6*	*8*
Near Crashes	**364**	761	279
Near Crash Rate Per 100,000 Miles	***42.3***	*42.3*	*55.8*

These estimates are conservative, given that the injury crash rate was 20 times higher for motorcycles than that for passenger vehicles in 2009 (NHTSA, 2011b). Furthermore, novice drivers have higher-than-average crash rates per mile driven, and we thus expect that the novice

riders recruited for this study will also have a higher-than-average crash rate (Williams, 2003). As can be seen in Table 3, the crash- and near-crash rate per mile driven was higher for the Naturalistic Teenage Driving Study, where half of the drivers were novice drivers, than for the 100-Car Naturalistic Driving Study.

Based on the distribution of riders in fatal motorcycle crashes by age from NHTSA's Fatality Analysis Reporting System (FARS; NHTSA, 2011c), and how that compares to the distribution of motorcycle owners by age (Motorcycle Industry Council, 2009), the projected distribution of crashes and near-crashes that may occur by age group appear in the Table 4 below. Riders in the age groups that are overrepresented in fatal crashes compared to ownership numbers (18-29 and 50+) are also overrepresented in our sample to increase the number of near-crashes and crashes we will have available for analysis; thus, we anticipate that the largest percentages of crashes and near-crashes will come from riders of these age groups.

No data currently exist on how crash rates differ among American novice riders, experienced riders, and returning riders. As noted above, we expect that novice riders will have a higher crash rate than experienced riders based on the difference in crash rates between novice and experienced passenger car drivers. This study will collect data on how crash rates differ between these groups, which will be one of the study's novel contributions.

Table 4. Projected Crashes and Near-Crashes by Age

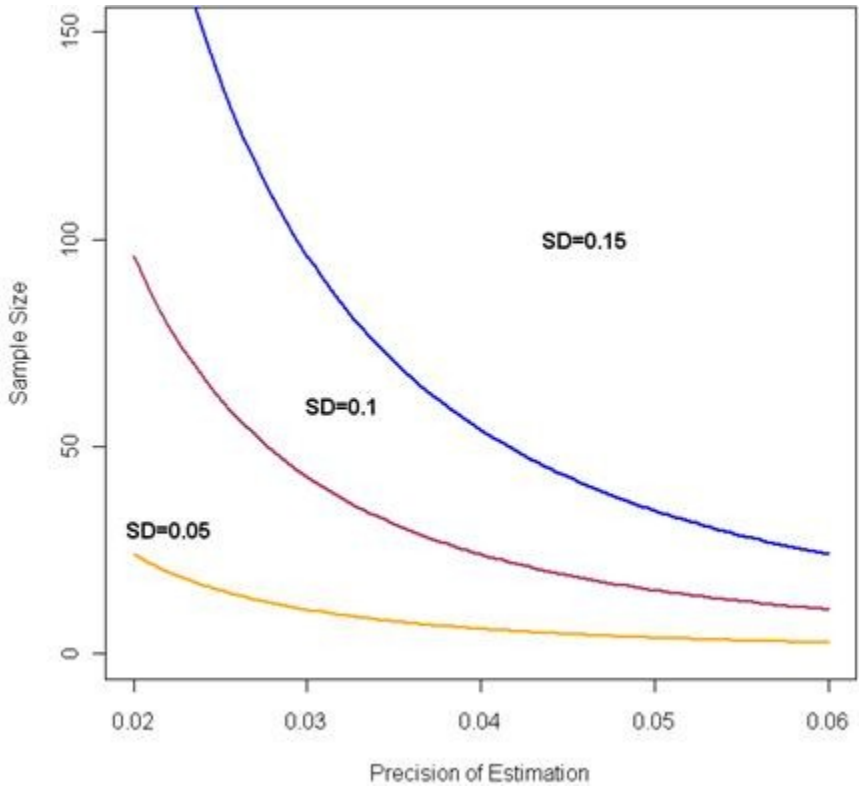
	Age			
	18-29	30-39	40-49	50+
% of motorcycle operators in fatal crashes, 2010	25%	18%	22%	34%
% of motorcycle owners, 2008	19%	19%	28%	29%
% of study participants	25%	20%	25%	30%
% of projected crashes and near-crashes	30.8%	17.8%	18.4%	33.0%
Number of projected crashes	13	7	7	13
Number of projected near-crashes	112	65	67	120

Source: NHTSA's Fatality Analysis Reporting System (FARS), 2010 data; Motorcycle Industry Council 2008 Motorcycle Owner Survey

The number of crashes and near-crashes we expect to see approximates what was found in the Naturalistic Teenage Driving Study. The 40 crashes and 279 near-crashes in that study provided sufficient power to address numerous questions on driver performance and exposure, many of which are similar to the questions of interest in the current study. Additionally, survey data from 100 primary drivers in the 100-Car Naturalistic Driving Study provided sufficient power to determine relationships between personality characteristics and crash/near-crash involvement (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2009).

Available power to detect effects will vary, depending on the research question and the measures being used. For research questions relying on infrequent events, the power will be low. Detecting specific effects related to these measures will likely not be possible. Because of this, we plan to not rely on infrequent events in our analyses (e.g., will use more common events such as near-crashes as surrogates for infrequent events such as crashes). For questions that use rider exposure, there will be quite a lot of data, and so identifying differences in groups should be possible. Results of a power analyses are provided in Figure 1 that follows for measures of exposure to interstate travel (that is, research question regarding how often motorcyclists ride on interstate roads). The analysis relates the precision of estimation available to the number of participants that would be required.

Figure 1. Precision of Estimation Required for Research Question on Interstate Exposure



As can be seen in the figure, the sample size from which the study will be collecting exposure data provides reasonable precision.

B.3. Describe methods to maximize response rates.

Several methods will be used to maximize response rates. Potential participants will be assured that the technicians working on their motorcycles are knowledgeable about motorcycles and will not harm their motorcycles in any way. They will also be directed to a project website that will show pictures of instrumented motorcycles to illustrate the unobtrusive appearance of the instrumentation. Project staff will ensure that the instrumentation, data retrieval, and de-instrumentation processes are as convenient as possible for participants by shuttling participants

to work or home if instrumentation or de-instrumentation takes longer than the time required to complete questionnaires and paperwork, and by scheduling data retrieval to occur at a location convenient to participants.

One hundred participants will be compensated $300 for their participation. The motorcycles of sixty participants will be outfitted with a more complex data acquisition system (i.e., more cameras and sensors) that will take longer to install, and these participations will be compensated $500 for their participation. These compensation amounts are similar to what has been used in other naturalistic driving studies. For example, the Strategic Highway Safety Research Plan 2 Naturalistic Driving Study initially compensated participants $300 for one year of driving an instrumented vehicle and later increased compensation to $500 for one year of driving an instrumented vehicle.

B.4. Describe any tests of procedure or methods to be undertaken.

NHTSA sponsored a pilot study to determine the feasibility of developing a data acquisition system small and durable enough to collect naturalistic data from motorcycle riders. During the pilot study, naturalistic data were collected from three instrumented motorcycles that were each ridden on the road for several weeks. A report on the pilot study was published in 2011 and contains details on the data acquisition system, instrumentation procedure, demonstration analyses performed on the pilot data, and a report from an independent evaluator (McLaughlin et al., 2011). The report from the pilot study is attached to this package in Appendix A.

Questionnaires will be administered to participants in this study to examine if individual differences in demographics, riding history, sensation- and thrill-seeking propensity, personality, and self-reported riding behavior correlate with observed riding behavior on the road as measured with the data acquisition system. All of these questionnaires are modeled on or are identical to individual difference questionnaires that have been completed in conjunction with past naturalistic driving studies. Because risk taking, sensation seeking, and thrill seeking have been especially theorized to correlate with risky motorcycle riding behavior, we chose assessments from previous naturalistic driving studies that examine these individual differences in particular.

The demographics and riding history questionnaire is designed to collect information on the demographics and prior riding experience of participants. This questionnaire will allow us to examine if individual differences in these factors are correlated with on-road performance, and will also allow us to group riders into high-experience and low-experience groups for analysis. Past and ongoing naturalistic driving studies, such as the 100-Car Naturalistic Driving Study (Dingus et al., 2006), Naturalistic Teenage Driving Study (Lee et al., 2011), and Strategic Highway Research Plan 2 Naturalistic Driving Study (Antin, Lee, Hankey, & Dingus, 2011) have asked similar questions on demographics and experience, tailored to the population sampled. For example, novice teenage drivers in the Naturalistic Teenage Driving Study were asked different types of questions about driving experience than drivers from a variety of age and experience levels in the 100-Car Naturalistic Driving Study and the Strategic Highway Research Plan 2 Naturalistic Driving Study.

The sensation- and thrill-seeking questionnaire is drawn from three instruments. Eight questions constitute the Brief Sensation Seeking Scale (BSSS), which was adapted from Form V of the Sensation Seeking Scale (SSS-V) developed by Zuckerman, Eysenck, and Eysenck (1978) and was validated in its shorter form as the BSSS by Hoyle, Stephenson, Palmgreen, Lorch, and Donohew (2002). Sensation seeking has been shown to be related to crashes, traffic violations, self-reported risky driving behavior, and risky driving in a simulator (e.g., Jonah, 1997; Schwebel, Severson, Ball, & Rizzo, 2006). In this study, we will examine if it also related to observed on-motorcycle riding behavior. Sensation seeking was measured in the Naturalistic Teenage Driving Study and is currently being measured in the Strategic Highway Research Plan 2 Naturalistic Driving Study.

Four of the questions on the sensation- and thrill-seeking questionnaire were administered to participants in the Naturalistic Teenage Driving Study and were derived from Akers' Social Learning Theory (Akers, 1977). The final eight questions on the sensation- and thrill-seeking questionnaire constitute eight of the nine questions of the thrill-seeking scale of the Driver Stress Inventory, which was developed and validated by Matthews, Desmond, Joyner, Carcary, and Gilliland (1997). These eight questions have been shown to be related to speeding behavior in a driving simulator (Stradling, Meadows, & Beatty, 2004). The Driver Stress Inventory was administered to participants in the 100-Car Naturalistic Driving Study.

The NEO-FFI is validated measure of the personality characteristics of neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness developed by Costa and McRae (1992). This inventory has been widely used to assess what are considered to be the five major personality constructs, and the personality constructs measured by this scale have been shown to be associated with crash involvement (e.g., Arthur & Graziano, 1996). The NEO-FFI was administered to participants in the 100-Car Naturalistic Driving Study and is currently being administered to participants in the Strategic Highway Research Plan 2 Naturalistic Driving Study, and was used to demonstrate the relationship between personality characteristics and driver involvement in inattention-related crashes and near-crashes in the 100-Car Naturalistic Driving Study (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006).

The Motorcycle Rider Behavior Questionnaire (MRBQ) is a validated self-report measure of motorcycle riding behavior and errors that predict crash risk. The MRBQ was developed by Elliot, Baughan, and Sexton (2007) and was adapted for motorcycle riders from the Driver Behavior Questionnaire, or DBQ (Reason, Manstead, Stradling, Baxter, & Campell, 1990). The DBQ is being administered to participants in the Strategic Highway Research Plan 2 Naturalistic Driving Study.

The questions asked in the debriefing questionnaire that will be administered at the conclusion of the study are similar to those administered after the 100-Car Naturalistic Driving Study and the Naturalistic Teenage Driving Study.

B.5 Provide the names and telephone numbers of individuals consulted on statistical aspects of the design.

Jessica Cicchino, Ph.D.

Research Psychologist
National Highway Traffic Safety Administration
1200 New Jersey Ave SE, W46-491
Washington, DC 20590
(202) 366-2752
jessica.cicchino@dot.gov

Shane McLaughlin, Ph.D.
Research Scientist/Group Leader, Motorcycle Safety Research Group
Virginia Tech Transportation Institute
Virginia Tech
3500 Transportation Research Plaza
Blacksburg, VA 24061
(540) 231-1077
SMclaughlin@vtti.vt.edu

Feng Guo, Ph.D.
Assistant Professor
Department of Statistics
Virginia Tech
Blacksburg, VA 24061
(540) 231-7933
feng.guo@vt.edu