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Connected and Automated Vehicle (CAV) Data Infrastructure and Access – Phase 1 and 2

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Dr. Carol A. Flannagan





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AND AUTOMATED
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Connected and Automated Vehicle (CAV) Data Infrastructure and Access

Phase 1 and Phase 2

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DISCLAIMER

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15. Supplementary Notes Conducted under the U.S. DOT Office of the Assistant Secretary for Research and Technology's (OST-R) University Transportation Centers (UTC) program.			
16. Abstract This project developed a system for data access to UMTRI data by creating formal paperwork and guidance. Many researchers wanted access to connected and automated vehicle (CAV) data collected over three decades by UMTRI and its partners. Each data collection has unique personal identifiable information (PII) to protect. A data management committee was established in Phase 1 to create forms and define an initial pilot process. CAV data includes real-world driver video and kinematic data collected from vehicles equipped with specialized equipment for Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication to analyze safety benefits of connected vehicle technologies and driver warning systems. Also known as naturalistic driving data (NDD), the four data collection projects are: the Safety Pilot Model Deployment (SPMD); the Ann Arbor Connected Vehicle Test Environment (AACVTE); the Integrated Vehicle-Based Safety Systems Light Vehicle Field Operational Tests (IVBSS LVFOT); and the Heavy Truck Field Operational Tests (IVBSS HTFOT). The data owner is the Principal Investigator (PI) of the study the data originated from. There are many secondary uses (i.e. lane-change behavior analysis) for this complex data. Phase 2 led to smoother data access and four codebooks for new users to understand data with less technical guidance. The new process provided access to 39 different requestors. These included provision of 16 different datasets (counting subsets such as bicyclists and bus datasets, as well as separate extracts). The data requestors had 13 different advisors and at least 12 publications.			
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Final report submitted by:

Helen K. Spradlin and Dr. Carol A. C. Flannagan

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Introduction

Over the past three decades, the University of Michigan Transportation Research Institute (UMTRI) has collected large amounts of data via Field Operational Tests (FOTs) and Naturalistic Driving Studies (NDS). The primary purpose of the naturalistic driving study sequence is to analyze the safety benefits of connected vehicle technologies and driver warning systems. These data, especially more recent data, have been used in research projects as secondary datasets by numerous researchers both inside and outside of UMTRI. UMTRI and Mcity were challenged with managing multiple requests to use their innovative and unique naturalistic driving data (NDD) data which includes personal identifiable information (PII). An efficient, equitable process was needed for data access in a secure manner.

Regardless of the high demand for secondary use, there had been no standard method of requesting and obtaining access to these data prior to this project. Researchers and students desiring access had to reach out to the data holder and ask permission. If their use was allowed, there was some process of providing a data extract or direct access to the data. It was an arduous process with no criteria for who was or wasn't granted access; no tracking of requests; and no standard agreement or policy for data use. This project aspired to find and create processes to allow researchers appropriate access to archived NDD while protecting all interests. The focus was on protecting existing NDD already collected, this project did not collect or generate new data.

The project access process was conducted in two phases. During Phase 1 a system for data access to UMTRI data came about through a series of meetings and implementation of a data management committee which included most of the Principal Investigators (PIs) for the relevant research. With few best practices available, internal driving data release forms were created to serve as guiding documents. The forms and approval steps by the management committee were piloted internally. In Phase 2, the process was implemented more broadly and became routine. Codebooks were developed for the data, enabling easier sharing of metadata. The contents of this report describe the results of these efforts.

Findings

Datasets

While the primary purpose of the naturalistic driving studies is to analyze the safety benefits of connected vehicle technologies and warning systems, there are numerous secondary uses for the data collected. Secondary uses include lane change behavior analysis; Global Positioning System (GPS) position accuracy analysis; trip needs (timing and location) and congestion; driver behavior; driver posture and position; and correlation between windshield wiper use and actual weather. There are many more potential secondary uses. Four studies were identified as the most requested data from UMTRI. These datasets were the focus of the access process and documentation in this project. These datasets are described briefly below.

Connected Vehicle Safety Pilot Model Deployment (SPMD)

The SPMD tested connected vehicle safety applications based on vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications systems using dedicated short-range communications (DSRC) technology in real-world driving scenarios to test their effectiveness in reducing crashes. There was a need to ensure that the devices were safe and did not distract



motorists or cause unintended consequences. It was a successful deployment utilizing 29 infrastructure sites. It led to the United States Department of Transportation (USDOT) to initiate rulemaking that would propose to create a new Federal Motor Vehicle Safety Standard (FMVSS) to require V2V communication capability for all light vehicles (passenger cars and light truck vehicles) and to create minimum performance requirements for V2V devices and messages. The light vehicles were driver-owned sedans. Fleet vehicles in the study included transit buses and other medium and heavy vehicles.

The SPMD study included driving data for over 3,000 vehicles. Participants' personal vehicles were equipped with either an Aftermarket Safety Device (ASD) or an ASD and Data Acquisition System (DAS). The ASD sends and receives data on Basic Safety Messages (BSMs) and issues audible warnings to the driver. The BSMs included a GPS trace, so the trajectories and speeds of participants could be traced.

There were 120 DAS-equipped vehicles included, with the same components as the ASD vehicles which added cameras with exterior and interior views as well as accelerometers and a camera-based system that could measure range, range-rate, and classification of forward targets (e.g., cars, motorcycles, pedestrians, etc).

Road Side Equipment (RSE) was installed within an area encompassing the northeast and a portion of the southeast corners of Ann Arbor, Michigan. Six RSEs were located at the entrance and exit of three road curves (two per curve), and these curve speed warning safety applications could issue speed advisories to a sub-set of the drivers in the SPMD. The remaining 23 RSEs were installed at signalized intersections along two major Northeast Ann Arbor corridors. The majority of these devices did not broadcast messages, but they received and recorded BSM messages broadcast by all equipped vehicles in the SPMD. Three RSEs were equipped to broadcast Signal Phase and Timing and map (geographical intersection geometry description) messages.

Vehicle Awareness Devices (VADs) are communication-only devices which do not contain safety applications, and the majority of vehicles were equipped with VADs. VADs transmit the vehicle's speed and GPS location ten times per second as the vehicle is driven. Other vehicles equipped with ASDs can hear these transmissions, and potentially warn a driver if they are about to collide with the transmitting vehicle. They also transmit this information to RSEs. They were included to increase the number of interactions that integrated light vehicles and ASDs would experience, enabling researchers to better evaluate the performance of safety applications in providing alerts to drivers during conflicts. A device for the commercial truck sector, a Retrofit Safety Device (RSD) is like the ASD, but it is connected to a vehicle data bus, and can provide information from in-vehicle sensors. It had a display for visual cues in addition to an audible alert. Additional detail can be found in the *Safety Pilot Model Deployment Test Conductor Team Report*, DOT HS 812 171 at: <https://www.nhtsa.gov/sites/nhtsa.gov/files/812171-safetypilotmodeldeploymenttestcondrtmrep.pdf>

Ann Arbor Connected Vehicle Test Environment (AACVTE)

The AACVTE study was an extension of the successful SPMD study, emphasizing ASDs. The number of ASD-equipped vehicles was increased and data collection was extended for the vehicles in the original study (with permission). The data-collection equipment on vehicles was the same as it was in the SPMD study.



Led by UMTRI and several partners, the infrastructure footprint expanded from Northeast Ann Arbor to the entire 27 square miles of the City of Ann Arbor. The number of RSEs increased from 29 to 75. It was the world's largest operational real-world deployment of connected vehicles and connected infrastructure, and it is the standard for a nation-wide implementation.

The AACVTE environment has deployed both Vehicle-to-Everything (V2X) and V2I application testing which include Forward Collision Warning, Emergency Electronic Brake Light, Emergency Vehicle Approach, Intersection Movement Assist, Curve Speed Warning, Ice Warning, Red Light Violation Warning and Pedestrian in Crosswalk Warning. Transitioning from a government-funded project to a self-sustaining operational deployment was the goal. Further detail on AACVTE is available at: <https://aacvte.umtri.umich.edu>.

Integrated Vehicle-Based Safety Systems (IVBSS) Light-Vehicle Field Operational Test (LVFOT)

The IVBSS study goal was to assess the safety benefits and driver acceptance associated with a prototype integrated crash warning system designed to address rear-end, road departure, and lane change/merge crashes on light vehicles and heavy trucks. The IVBSS light-vehicle study was conducted using a fleet of 16 Honda Accord LX sedans equipped with both a set of integrated safety systems and a data acquisition system. The data acquisition system included accelerometers, GPS, cameras with interior and exterior views and radars for range-sensing to forward targets. For the light-vehicle component, there were 108 participants and each participant used the study vehicles as their own for a 40-day period. The first 12 days of use was a baseline period with the safety system disabled, and the remaining 28 days were completed with the system enabled. The participants drove approximately 175,000 miles total. At the end of their use of the test vehicle, drivers were debriefed and invited to participate in focus groups with other drivers. For additional IVBSS information refer to the *Integrated Vehicle-Based Safety Systems Field Operational Test Final Program Report*, DOT HS 811 482: <https://deepblue.lib.umich.edu/bitstream/handle/2027.42/84378/102747.pdf?sequence=1&isAllowed=y>

Integrated Vehicle-Based Safety Systems (IVBSS) Heavy-Truck Vehicle Field Operational Test (HTFOT)

The heavy-truck portion of the IVBSS involved ten ProStar 8600-series trucks owned and operated by Conway Freight, Inc. of Ann Arbor, MI. Twenty participants who worked for Conway trucking in either pickup and delivery or line-haul routes, volunteered to drive the experimental trucks as part of their regular job activities. Over 600,000 miles of driving data were collected, including 140,000 miles of baseline and 510,000 miles with the integrated system enabled.

Personal Identifiable Information (PII) and Consent

The NDD data collection is overseen by several Principal Investigators (PIs) with ongoing responsibility to protect the data because it includes PII such as face video and home location. Federal and university requirements for data protection apply since data was collected working with the U.S. Department of Transportation (U.S. DOT). Furthermore, certain data elements are proprietary for the project sponsors, and proprietary elements vary by dataset. The PIs are the formal data owners, and as such they need to approve very specific uses of the data in every instance, so unfettered data access cannot be granted. For each of the studies, the consent form is provided in Appendix A.



The original Institutional Review Board (IRB) approvals for these data collection projects expired. Therefore, a current IRB approval including secondary use of the data is one of the protections UMTRI requires from users requesting access. Secondary use of the data means the existing data is reused for something specific with no intention to contact or identify the original subjects. UMTRI has concerns about the entire NDD being released to other entities due to the inherent risk of losing control over the datasets, so it has never been done. When UMTRI allows access, in return it requests credit for the use of the NDD data by the inclusion of a citation in resulting published research. The NDD is important to UMTRI's ongoing research, but there is little funding to support curation and sharing. When access is granted to this data it is temporary, cannot be shared with others, and access may be revoked at any time.

Codebooks & Codebook Development

One of the major challenges of sharing data is conveying metadata information to the user so that they can determine what to ask for and how to use it when their access or extract is provided. Metadata includes the subject-sampling strategy, the data-collection procedure, the variables in the dataset including variable names and units, missing-data codes, and database table structure, among other things. Prior to this project, sharing this information had been done by requestors discussing it with UMTRI faculty or staff who knew the dataset contents and structure. This created a significant time burden for UMTRI faculty and staff, and it is a barrier to sharing.

In Phase 2 of this project, four codebooks were developed for portions of the SPMD data and for the IVBSS light vehicle datasets. This documentation allows requestors to access information on their own to help them determine definitions for the variables they need. The codebooks are a key aspect of enabling others to use the data with much less interaction with UMTRI staff and faculty.

Processes

Data Acquisition Procedure

A major challenge in supplying data access while ensuring privacy protection for participants is to set up processes around data governance, requests, decisions, and providing the access. Much of the effort in Phase 1 went into developing these processes, while in Phase 2, the processes were implemented. Details on specific elements of the process are in the subsections below.

Governance

Data access policies were set by the UMTRI data management committee which met as needed. The data management committee members are Dr. Jim Sayer, Dr. David LeBlanc, Debby Bezzina, PMP, Dr. Carol Flanagan, and Helen Spradlin. Dr. Henry Liu was also consulted as needed. Helen Spradlin served as the UMTRI data liaison, ensuring that the new process was implemented and tracked. The data liaison routinely brought issues related to data access to the data management committee for discussion, and a determination as to whether to grant access was made on a case-by-case basis. The user pledge was written in these meetings and it became a component of the form that data requestors submit to UMTRI (Part D of Appendix B). There was emphasis on the importance of abiding by the pledge and data requestors taking primary responsibility for data stewardship. The University requires online training for faculty, staff and





students which is foundational instruction and certification known as the Program for Education and Evaluation in Responsible Research and Scholarship (PEERRS). Verification that the PEERRS requirements were met was incorporated into our process.

Process Overview

The overall process of data management and sharing involve: an inquiry; a current IRB certification from the University; permission for access from the UMTRI data management committee; server access or delivering a data subset extraction; tracking of the end of the project period; and finally, removing server access. The order of these detailed steps of the process varies and some steps may be concurrent:

1. Student or Researcher Inquiry
2. Database(s) of Interest Identified
3. Student or Researcher Form Requested
4. Student or Researcher Advised of Need for PEERRS Training
5. Student or Researcher Form Returned, Signed by Advisor if Student Involvement
6. PEERRS Training Confirmed
7. Advisor or Researcher Informed of IRB Requirement
8. Advisor Form Returned Only if Students are Involved
9. IRB Approval Returned
10. Confirm Secondary Use of Data Issue Addressed Within IRB
11. Signature Packet Assembled of Student or Researcher and Advisor Forms; PEERRS Certifications; and IRB Approval Detail
12. Ascertain University Relationship
13. Technical Request Detail Identified
14. Technical Communications Considered/Implemented
15. Data User Meeting
16. Request Reviewed Within Data Management Committee Meeting
17. Data Liaison Informs Requestors If Access Denied
18. If Requestors Appeal, Meeting with UMTRI Director Scheduled
19. UMTRI/Mcity Staff Effort Identified and Assigned If Approved
20. UMTRI Signatures Obtained by Liaison from the PI/Owner of the Specific Data
21. Access Message Sent to ESG (Engineering Systems Group) Staff with Server Oversight
22. Server Access Granted by ESG Staff
23. Student or Researcher and Advisor Informed of Access to ESG server
24. Final Packet Assembled of IRB Approval Number; Student Form; Advisor Form; PEERRS Forms; and Other Relevant Write-ups and Communications
25. Server Data Access End Date Tracked by Data Liaison
26. Access Removal Messages Sent to ESG Upon Research Completion (ensures data users are routinely removed from the ESG server)
27. Track and Record Research Publications Resulting from Data Use

Data Access Request

Data access requests were formalized through development of a data access form that was used for all requests. One form is required from the student(s) or researcher and another



form is required from the Advisor. The form is provided in Appendix B. It includes details about the applicant and their request, an UMTRI proper-use pledge, and signature lines for the requestor and their advisor if the requestor is a student. The data liaison offered students a guide to help them learn about the IRB process (U-M Health Sciences and Behavioral Sciences IRB, 2016).

Evaluation of Request

If a request could be served through a pre-existing available public-use data extract, requestors were directed to that source first. For research requiring server access or custom extracts, requests were evaluated by the data management committee. Permission for simple requests with no privacy issues could be granted by the data owner or by the committee via email. More complex issues were brought to the committee for discussion. In most cases, the request was granted, but in some instances, there was further iteration to limit the requested access in specific ways to protect data privacy.

Providing Data Access

After receiving the signed paperwork, the liaison contacted the staff in the Engineering Systems Group (ESG) who are allowed to provide access to datasets on their secure ESG server. After confirmation that the requestor's access had been granted, she informed the requestor of their access. The preferred method of accessing the data after approval was by using a computer within UMTRI. For video data, a video viewer program developed within ESG was usually used. UMTRI had information technology assistance available to have the viewer installed if it wasn't already on the computer used for access. Using computers within UMTRI was not always possible and during the COVID-19 pandemic data access was restricted entirely for a short period of time. Remote access was restored, but it was after this project ended. When direct access was infeasible, a custom data extract could be provided, which was often created by a CMISST staff member.

In some cases when data access was approved, staff extracted relevant authorized portions of the NDD for the specific research use. Since these subsets of the data were sanitized to protect PII, at times they were able to be reused for future requests. An example of one subset contained left turn data. Another filtered dataset available on Flux through Globus Connect represents the Basic Safety Messages transmitted by each vehicle to the Road Side Equipment. To protect PII such as a driver's home location, a sanitized subset of the data was created by applying an algorithm to randomly remove a portion of each trip from the beginning and end of each trip. The size of this portion of the dataset is about 5.4 TB uncompressed. It is located here:

<https://github.com/caocscar/ConnectedVehicleDocs/blob/master/BSMdocumentation.md>

Follow-Up

Two critical aspects of the process are follow-up to ensure that access was turned off after the requestor's time period for access ended and follow-up on proper attribution in research reports. Both of these were handled by the liaison during the project period. The first is easy because it is a one-time process with a specific timeframe. However, tracking attribution was harder since papers might be published at any time, and students and faculty often forget



to send UMTRI their publications, even if they remembered to attribute the data source. This follow-up would need to be repeated over time.

The need for an appeal step became evident. When it was necessary, the potential data users were offered an in-person meeting with UMTRI's Director and the data liaison. In one case, requestors were refused use of the NDD for their research because they did not include secondary data access within the approved IRB they submitted. They were clearly informed that excluding secondary data access was the reason they were denied access. The advisor and his students still wanted an opportunity to discuss the reasons for denial. The meeting did not guarantee access or change the outcome of the denial in this case, but it was an opportunity to air grievances. The protection afforded to UMTRI by inclusion of secondary data access was reiterated. It was unclear whether secondary data access was excluded intentionally or inadvertently. The meeting was a productive education about why the IRB protections are necessary and why privacy issues dictate our inability to offer the NDD data to the broader University or the public at no cost. Alternative options for their research objectives were suggested such as using a commercial vehicle dataset which is publicly available.

Recommendations

One of the significant challenges to providing data access after the original project was over, is the lack of funding to support this effort. That said, the naturalistic driving data are valuable and still used. In this project, we did not explore the possibility of charging users for the time to manage paperwork and provide access or extracts. However, if a robust data access process were to be implemented in the future, funding would have to be considered. This might come from the College of Engineering as a general service to the community, or it would have to come from individual users. It is unclear how much of a deterrent a user fee would be.

Another challenge is in ensuring that data were attributed appropriately and obtaining the references in which the data were used. The University of Michigan unit named the Inter-University Consortium for Political and Social Research (ICPSR), for example, has staff who search for attributions in the literature. However, this is a time-consuming process and they are a much larger operation (ICPSR, 2012). It might be possible to have students do this as part of a larger work-study experience (since the number of publications is likely to be fairly small).

Finally, the data access process involves a great deal of effective communication. While the forms and process and points of contact were standardized and greatly streamlined, there is no way to completely eliminate questions about data use, data elements, etc. Experienced staff and faculty understand the datasets in ways that are difficult to convey to someone else. In general, requests could be granted with minimum technical assistance, but a robust system would need to have some support for this as well.

Outputs, Outcomes and Impact

Outputs and Outcomes

The key results of this project are a complete, well-structured process for granting and tracking access to naturalistic driving data at UMTRI. This includes standard forms for requesting access, codebooks for the datasets, a governance data management committee, and documentation of the process and the requests granted and denied. The UMTRI pledge has been incorporated into data use agreements for different research projects.





The form used by requestors for data use is included in Appendix B. The codebooks generated are available on the CCAT website [here](#).

Impact

From Sept 1, 2017 through March 15, 2020, when the pandemic interrupted operations, the data access process provided access to 39 different requestors. These included provision of 16 different datasets (counting certain data subsets such as the bicyclists and bus datasets, as well as separate extracts). The data requestors had 13 different advisors and their research led to at least 12 publications. Four approved requestors were external to the University of Michigan: Michigan Tech, Chalmers (Sweden) University, Morgan State University and University of Washington. The remaining 35 were from University of Michigan entities, primarily in the College of Engineering. There were also two requests refused and eight inquiries that did not end in access.

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Appendix A Consent Forms

Study ID: HUM00063435 IRB: Health Sciences and Behavioral Sciences Date Approved: 10/17/2012

Safety Pilot Model Deployment Integrated Vehicle (IV) – Transit Informed Consent

Researchers:

James R. Sayer, Ph.D., UMTRI; Dillon Funkhouser, M.S.E, UMTRI

Description of research:

The University of Michigan Transportation Research Institute (UMTRI) and the United States Department of Transportation (U.S. DOT) are conducting a study of the potential safety benefits of connected vehicle safety technology. Connected vehicle safety technology allows vehicles to communicate wirelessly with other, similarly equipped vehicles, and to communicate wirelessly with portions of the infrastructure—such as traffic signals. The Safety Pilot Model Deployment is a scientific research study that features a real-world implementation of connected vehicle safety technologies utilized by everyday drivers in, and around, Ann Arbor. The study was designed to test the performance of connected vehicle technology, evaluate its usability, and collect data for analysis in order to better understand the potential safety benefits. To collect the necessary data, UMTRI, working with the U.S. DOT and a variety of other organizations, is equipping over 2800 vehicles, and a section of roadway, in northeast Ann Arbor with a variety of connected vehicle devices and technologies.

The majority of the devices that will be installed in vehicles will only transmit/broadcast information about that vehicle's location and speed, while some devices in vehicles will both transmit and receive location and speed information. The devices that receive location and speed information from other vehicles are designed to provide warnings to the driver when there is the potential for a crash. It is one of these devices, a crash warning system, which has been installed in a transit bus that we will be asking you to drive for up to the next 12 months.

Description of your involvement:

You have qualified to participate in this research study and therefore you are being asked to regularly drive a transit bus with a warning system installed on it. Participation in this study





requires instruction and training on use of the warning systems (approximately 1 hour). At the end of the study you will also be asked to complete a survey regarding your experience (approximately half an hour).

Study ID: HUM00063435 IRB: Health Sciences and Behavioral Sciences Date Approved: 10/17/2012

The following is additional information about the safety/warning applications that you will have on-board the transit vehicle with connected vehicle technology you are being asked to drive:

• **Emergency Electronic Brake Lights (EEBL):**

The EEBL application allows an equipped vehicle to broadcast an emergency braking event to surrounding vehicles. Upon receiving the information, equipped vehicles can use the information to determine if a warning to the driver should be provided in order to lessen the chance of a rear-end collision. This warning is particularly useful when the driver's line of sight is obstructed by other vehicles, or in bad weather conditions such as fog or heavy rain.

• **Forward Collision Warning (FCW):**

The FCW application warns drivers of a potential rear-end collision with an equipped vehicle ahead that is in the same lane and direction of travel.

• **Curve Speed Warning (CSW):**

The CSW application warns drivers that they may be traveling too fast for an upcoming curve, and that they should reduce their speed.

• **Pedestrian in Crosswalk Warning (PCW):**

The PCW application warns drivers that a pedestrian may be located in a signalized crosswalk their bus is about to cross.

• **Vehicle Turning Right in Front of Bus Warning (VTRW):**

The VTR application warns drivers that another vehicle is passing on the left and turning in front of the bus, either to re-enter the right-hand lane or to complete a right-turn in front of the bus.

If you chose to participate in this study, you will receive explicit instruction on use of the crash warning systems. You may be asked to watch an instructional presentation, and receive instruction from a researcher. The researcher will also answer any questions you may have at that



time.

During this study you will be asked to follow your normal driving routine (operating the bus as an employee of the University, along regular bus routes). At no time will you be asked to perform any unsafe driving actions. If you choose to participate, you will be expected to obey all applicable motor vehicle laws, codes, and regulations including: wearing your seat belt and not texting while driving.

You may not remove, modify, or tamper with any components of the equipment, or allow others to do so. You will also be asked to report as soon as possible any problems you notice with the equipment.

Study ID: HUM00063435 IRB: Health Sciences and Behavioral Sciences Date Approved:
10/17/2012

The data to be collected:

The connected bus continuously transmits speed and position data to other, similarly equipped vehicles. This information can also be recognized by research equipment located along the roadside and at intersections. While the data broadcast by connected bus includes a unique identifier that is associated with that bus, for the study only UMTRI will know your personal information (i.e. name, phone number, address, etc.). UMTRI will not share your personal data with any outside 3rd party.

A computer on-board the connected bus continuously records data including the speed of the vehicle, the distance to vehicles in front of you and dozens of other pieces of information about the state of the vehicle. Throughout your participation video cameras installed as part of a data acquisition system (DAS) will be used to record images of you, including your face, the roadway, and other traffic near your vehicle. It will not record images of any passengers on the bus. In addition, detailed information about how you drive will be collected (speed, lane keeping, braking events, etc.). This data is important because it allows researchers to understand when and how the connected vehicle technologies help drivers avoid crashes. You may place some restrictions on how the video data is used (i.e. only the researchers directly involved in this research study are allowed to view video that includes your likeness—your face or other directly identifying content), but the collection of video is required.

Confidentiality of records/data:





During the study, we are gathering information on the performance of the connected vehicle technology. We are not evaluating your skill or performance as a driver. Your personal information (name, phone number, address, email address, etc.) will not be released to anyone outside of UMTRI, except potentially under subpoena as discussed below. Your name will not appear in any project reports or published papers. Most importantly, no data will be shared with management or supervisors from University of Michigan Transportation Services.

The data gathered in this experiment is confidential. One year after the study is complete, your name and all other personal information will be separated from your driving data and your personal information will be destroyed/deleted. A coding scheme will be used to identify the collected data by participant number only (e.g. Participant No. 1). All personal data will be removed prior to any data release to Volpe National Transportation Systems Center, Federal Transit Administration, Research and Innovative Technology Administration, or the Federal Highway Administration (U. S. DOT), all of whom are affiliated with, and contributing to, this project. While these researchers have access to the video data of you, at no time will these researchers have access to your personal contact information (name, phone number, address, email address, etc.), and at no time will video of you be shared with anyone else without your express written consent. Finally at no time can anyone other than the UMTRI researchers contact you.

Data will be stored on a secure server located maintained by the University of Michigan Transportation Research Institute, and at similarly secure facilities at Volpe and the Federal Transit Administration. The data will be retained indefinitely by the research team, as it represents a unique and irreplaceable dataset, and as such can be used long-term for exploratory analyses of driver behavior and the benefits of connected vehicle technology. Even if you withdraw from the study prematurely, your data will be retained and may be the subject of analyses.

Insurance and what to do in the event of a crash:

In the unlikely event of physical injury resulting from participating in this study, the University will provide medical treatment in accordance with the determination by the University of its responsibility to provide such treatment. If a crash occurs, the standard procedure should be to remove yourself and others from harm's way, and then call for emergency services (police and EMS, as necessary). Only after you and any passengers are out of harm's way should you contact





researchers at UMTRI. The research team at UMTRI will be available on a 24 hour-a-day basis to answer questions or assist you should a need arise.

You, the transit vehicle, as well as any other persons or property involved, are covered under an insurance policy held by The University of Michigan. However, that does not preclude other insurance coverage from involvement: including your personal injury protection (PIP) insurance, otherwise referred to as no-fault insurance, and your personal health insurance. The specifics of a claim cannot be stated beforehand because it is a coordination of benefits issue involving various insurance carriers. The University insurance coverage is coordinated with other insurances, the priorities being determined to a large extent by the insurance laws of the State of Michigan. You may want to consult your personal automotive insurance provider(s) with any additional questions regarding insurance coverage.

Study ID: HUM00063435 IRB: Health Sciences and Behavioral Sciences Date Approved: 10/17/2012

Only trained participants may operate the equipped buses:

You will be trained to use the research vehicle. As such, only trained drivers are allowed to operate the equipped buses.

To participate in this study, you must also agree to abide by the following:

1. You may not, or allow others to, remove, modify, or tamper with any components of the research vehicle, the on-board warning systems, cameras, or the data collection system.
2. You must not operate the research vehicle while under the influence of alcohol or any medications that may impair your ability to drive.
3. You should not rely solely on the crash warning systems being tested, and instead exercise normal caution when operating the vehicle.
4. You agree to report as early as possible to UMTRI any problems, malfunctions, or crashes with the research vehicle.

Length of your participation:

Your participation will last up to 12 months, and require approximately 1.5 hours of your time to receive instruction and complete a survey regarding your experience.

Risks and discomforts of participation:





While driving in this study, you will be subject to all risks that are normally present. Additionally, there may be risk associated with using prototype crash warning technology. The vehicle's features are designed to provide warnings about certain crash threats; however, risks still exist and malfunctions could occur. When operating any system you are not familiar with, caution should be exercised and you should never rely solely on the crash warning system to alert you to the threat of a crash.

In the event that you are involved in a crash with your vehicle during the study, UMTRI could potentially be forced to release data on your driving in response to a court order.

Expected benefits to you or to others:

The results of this study will provide U.S. DOT, and the other research partners, with valuable information in support of deploying future connected vehicle safety systems. It will also provide important information about driver acceptance of these types of systems. While there are no direct benefits to you, by participating in this study you are lending your experience as a driver to support safety research.

Cost to you resulting from participation in the study:

UMTRI and the U.S. DOT will bear all costs associated with the execution of this study.

Payment for participation in the study:

Participation in this study is voluntary. Should you choose to participate, you will be paid a total of \$50 for completing your participation. Even after you have agreed to participate, you may still withdraw from this study at any time, and for any reason. You will be entitled to \$25 simply for receiving the training on the connected bus. Upon completion of the study, you will receive another \$25 for the time it takes to complete a survey about your experience.

UMTRI researchers retain the right to terminate the study at any time. Should your participation in the study be terminated by the researcher prior to its planned completion you will receive full compensation.

Contact information:

The person in charge of this testing is:

James R. Sayer
Research Scientist
The University of Michigan Transportation Research Institute





Human Factors Division
2901 Baxter Rd., Ann Arbor, MI 48109-2150
Phone: (734) 936-0410

Should you have questions regarding your rights as a research participant, please contact the person named above or the Institutional Review Board, 540 E. Liberty St. Suite 202, Ann Arbor, MI 48104-2210, 734.936.0933, email: irbhsbs@umich.edu.

Privacy Act Statement (5 U.S.C. § 552a, as amended): AUTHORITY: Section 5306 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, (P.L.10959, Title V, 2005) authorizes DOT to conduct operational tests of intelligent vehicles as part of its intelligent transportation system research. PURPOSE(S): DOT will use the information provided to, determine participant eligibility, evaluate technologies used by drivers during the study, and identify driver behaviors, and for other purposes as described in the DOT Privacy Act Notice. ROUTINE USE(S): In accordance with DOT's system of records notice, DOT/RITA 001 – Vehicle and Driver Research, Test, and Evaluation Records, the information provided may be disclosed to, parties conducting research on behalf of DOT, government officials in order to determine the suitability of an individual to participate in the research activity, members of the DOT workforce including contractors, consultants and others performing work on behalf of the Department, and for other uses as described in the "Prefatory Statement of General routine Uses" (available at http://www.dot.gov/privacy/privacy). DISCLOSURE: Provision of the requested information is voluntary; however failure to furnish the requested information may result in an inability of the Department to include you in the research activity.

Consent:

I have read (or been informed of) the above information given above. James Sayer has offered to answer any questions that I may have concerning the study. I hereby consent to participate in the study.

YES, I consent to participate in the study_____

NO, I do not consent to participate in the study_____

Name (Print) Signature Date

Address

()

Phone





Study ID: HUM00063435 IRB: Health Sciences and Behavioral Sciences Date Approved: 10/17/2012

Optional use of video images: I agree to permit the unrestricted use of the video recordings of my driving (continuous or single framed) to be used for scientific, educational, and outreach purposes. I am aware that these recordings will contain images of my face. I am aware that I may decline to permit the unrestricted use of the recordings without penalty or compromise to my participation in this study.

YES, I consent to allow unrestricted use of my video recordings_____

NO, I do not consent to allow unrestricted use of my video recordings _____

Signed: _____ Date: _____

Permission to be contacted for follow-up related to this project: I agree to allow UMTRI researchers to contact me with follow-up questions related to my participation in this research project (example: to ask questions that the researchers forgot to ask while I was still a participant or to ask if I would be interested in participating in a focus group).

YES, I consent to allow UMTRI researchers to contact me with follow-up questions_____

NO, I do not consent to allow UMTRI researchers to contact me with follow-up questions_____

Signed: _____ Date: _____





Study ID: HUM00063435 IRB: Health Sciences and Behavioral Sciences Date Approved: 8/28/2015

**Ann Arbor Connected Vehicle Test Environment (AACVTE)
Aftermarket Safety Device (ASD) w/ Data Acquisition System (DAS)
New AACVTE Participants
Informed Consent**

Researchers:

Principal Investigator: James R. Sayer, Ph.D., UMTRI; Dillon Funkhouser, M.S.E, UMTRI

Description of research:

The University of Michigan Transportation Research Institute (UMTRI) and the United States Department of Transportation (U.S. DOT) are conducting a study of the potential safety benefits of connected vehicle safety technology. Connected vehicle safety technology allows vehicles to communicate wirelessly with other, similarly equipped vehicles, and to communicate wirelessly with portions of the infrastructure—such as traffic signals. The Ann Arbor Connected Vehicle Test Environment (AACVTE) is a real-world implementation of connected vehicle safety technologies utilized by everyday drivers in, and around, Ann Arbor. This effort was designed to test the performance of connected vehicle technology, evaluate its usability, and collect data for analysis in order to better understand the potential safety benefits. To collect the necessary data, UMTRI, working with the U.S. DOT and a variety of other organizations, is equipping over 5000 vehicles, and a section of roadway, in northeast Ann Arbor with a variety of connected vehicle devices and technologies.

The majority of the devices that will be installed in vehicles will only transmit/broadcast information about that vehicle's location and speed, while some devices in vehicles will both transmit and receive location and speed information. The devices that receive location and speed information from other vehicles are designed to provide warnings to the driver when there is the potential for a crash. Thus, we are requesting permission to install one of these crash warning systems in your personal vehicle. *Description of your involvement:*

You have qualified to participate in this research study and therefore we are requesting permission to install an Aftermarket Safety Device (ASD) and a Data Acquisition System (DAS) in your personal vehicle for up to 1 year. Participation in this study requires traveling to UMTRI





on several occasions; for the initial device installation (8 hours, during which time we will loan you a vehicle to use), training (approximately 30 minutes), returning to UMTRI roughly every 6 months for a data download

Study ID: HUM00063435 IRB: Health Sciences and Behavioral Sciences Date Approved: 8/28/2015

(approximately 20 minutes each visit), and returning to UMTRI at the end of your participation to have the equipment removed from your vehicle (4 hours) and to complete a survey on your experience (approximately 10 minutes).

The ASD installation includes the following: a small box (in the trunk, under the dash, or under the driver's seat), an antenna (installed near the rear windshield) and a small display mounted where it is visible to the driver. The ASD is designed to warn you, the driver, about potential crash situations involving other vehicles with similar equipment. The DAS is a small box which will be installed in your trunk or the rear of your vehicle. Additional data collection equipment, such as sensors and cameras will be installed in your vehicle. All of the data collected is stored in the DAS. You will be shown photographs of a sample installation before you complete this form. The equipment installed in your car will not affect the operations of your car or permanently alter its appearance.

Prior to your participation in this study you will be instructed on how to use the Aftermarket Safety Device's crash warning system. You will receive instruction from a researcher, and will have the opportunity to take a vehicle for a demonstration drive with a researcher present who will be able to answer any questions you may have.

During this study you will be asked to follow your normal driving routine (with the exception of scheduled visits to UMTRI outlined above). At no time will you be asked to perform any unsafe driving actions. If you choose to participate, you will be expected to obey all applicable motor vehicle laws, codes, and regulations including; wearing your seat belt and not texting while driving.

During your participation, you may not remove, modify, or tamper with any components of the equipment, or allow others to do so. We ask that you notify us about any planned mechanical work on your car that might affect the equipment. You will also need to report as soon as possible any problems you notice with the equipment. If at any time the researchers deem it necessary that you return with your car to UMTRI, you must do so or make arrangements with UMTRI



personnel to meet at an alternate location. When your participation has concluded, you and your vehicle will be required to return to UMTRI so that all equipment can be removed from your vehicle.

If at any time during the study you cease to drive the vehicle in which the equipment is installed (either because it will be sold, or because it was damaged and is no longer drivable) you are required to contact UMTRI researchers so that we can make arrangements us to remove the equipment.

The data to be collected:

The ASD continuously transmits speed and position data from your vehicle to other, similarly equipped vehicles. This information can also be recognized by research equipment located along the road side and at intersections. While the data broadcast by your vehicle includes a unique identifier that is associated with your vehicle, for the study only UMTRI will be able to link the unique identifier with your personal information (i.e. name, phone number, address, etc.). UMTRI will not share your personal data with any outside 3rd party.

The DAS continuously records data including such information as the speed of the vehicle, whether the windshield wipers are on, the distance to the car in front of you and hundreds of other pieces of information about the state of the vehicle.

Throughout your participation video cameras installed on your vehicle as part of the DAS will be used to record images of you, including your face, the roadway, and other traffic near your vehicle. In addition, detailed information about how and where you drive will be collected (speed, lane keeping, braking events, etc.). This data is important because it allows researchers to understand when and how the connected vehicle technologies help drivers avoid crashes. You may place some restrictions on how the video data is used (i.e., only the researchers directly involved in this research study are allowed to view video that includes your likeness—your face or other directly identifying content), but the collection of video is required.

Confidentiality of records/data:

During the study, we are gathering information on the performance of the connected vehicle technology. We are not evaluating your skill or performance as a driver. Your personal information (name, phone number, address, email address, etc.) will not be released to anyone outside of UMTRI, except potentially under subpoena as discussed below. Your name will not



appear in any project reports or published papers.

The data gathered in this experiment is confidential, although for the duration of your participation, and one year after, UMTRI researchers will maintain a link between your contact information and your driving data. One year after the study is complete, your name and all other personal information will be separated from your vehicle data and your personal information will be destroyed/deleted. A coding scheme will be used to identify the collected data by participant number only (e.g., Participant No. 1), but your email and phone number will not be associated with the data. Finally at no time can anyone other than the UMTRI researchers contact you.

Data will be stored on a secure server located at UMTRI. The data will be retained indefinitely by UMTRI, as it represents a unique and irreplaceable dataset, and as such can be used long-term for exploratory analyses of driver behavior and the benefits of connected vehicle technology. Even if you withdraw from the study prematurely, your data will be retained and may be the subject of analyses.

Insurance Coverage

Throughout your participation you will be covered by your normal state of Michigan automobile insurance relating to both property and injury claims. The University of Michigan will not supply additional coverage.

Length of your participation:

Your participation will last approximately 1 year.

Risks and discomforts of participation:

While driving in this study, you will be subject to all risks that are normally present.

While UMTRI is confident in its ability to install and remove the equipment without damage to your vehicle, any such damage as a result of UMTRI's operations installing, uninstalling or through a problem with the installation will be remediated by UMTRI.

The ASD is designed to provide warnings about certain risky driving situations; however, risks still exist and malfunctions could occur. When operating any system you are not familiar with, caution should be exercised and you should never rely solely on the ASD to alert you to the threat of a crash. Malfunctions should be limited to false alarms. Any other malfunction should be reported to UMTRI researchers immediately.

In the event that, you may be involved in a crash with your vehicle during the study, UMTRI





could potentially be forced to release data on your driving in response to a court order.

Expected benefits to you or to others:

The results of this study will provide UMTRI and the U.S. DOT with valuable information for the development of future vehicle-to-vehicle communication safety systems. It will also provide information about driver acceptance of these types of systems. While there are no direct benefits to you, by participating in this study you are lending your experience as a driver to support safety research.

Cost to you resulting from participation in the study:

UMTRI and the U.S. DOT will bear all of the costs associated with installation and removal of the equipment. You will be responsible to pay for gasoline and your vehicle's maintenance while participating in this study. However, you are not responsible for maintenance or repair of the ASD or DAS devices.

Payment for participation in the study:

Participation in this study is voluntary. Should you choose to participate, you will be paid \$200 for your participation. Even after you have agreed to participate, you may still withdraw from this study at any time, and for any reason. You will be compensated for your participation according to how long you remain in the study. You will be entitled to \$25 simply for coming to UMTRI and having the ASD and DAS installed on your vehicle. If you withdraw at any time within the first three months of your participation, this amount will be your compensation. After three months, you will be entitled to \$50, after 6 months, \$100, after 9 months, \$150 and after 1 year and the uninstallation; you will be entitled to full compensation, \$200.

UMTRI researchers retain the right to terminate the study at any time prior to its scheduled completion. In this event you will receive full compensation.

Contact information:

The person in charge of this testing is:

Dillon Funkhouser
Engineer in Research Senior
The University of Michigan Transportation Research Institute
Human Factors Division
2901 Baxter Rd., Ann Arbor, MI 48109-2150
Phone: (734) 936-0410





**CENTER FOR CONNECTED
AND AUTOMATED
TRANSPORTATION**

YES, I consent to have an ASD and DAS installed on my personal vehicle _____

NO, I do not consent to have an ASD and DAS installed on my personal vehicle _____

I have had the equipment installation explained to me, and I agree to allow UMTRI technicians to install the ASD and DAS equipment in my personal vehicle. I understand that UMTRI will be responsible for any damage to my vehicle, or its operations, that are a direct result of the installations of the ASD and the DAS equipment.

Signed: _____ Date: ____/____/____

Optional use of video images: I agree to permit the unrestricted use of the video recordings of my driving (continuous or single framed) to be used for scientific, educational, and outreach purposes. I am aware that these recordings will contain images of my face. I am aware that I may decline to permit the unrestricted use of the recordings without penalty or compromise to my participation in this study.

YES, I consent to allow unrestricted use of my video recordings _____

NO, I do not consent to allow unrestricted use of my video recordings _____

Signed: _____ Date: _____





**CENTER FOR CONNECTED
AND AUTOMATED
TRANSPORTATION**

IVBSS Light Vehicle Field Operational Test Informed Consent

Researchers:

James R. Sayer, Ph.D., UMTRI; Mary Lynn Buonarosa, B.S.E., UMTRI; Dillon Funkhouser, M.S.E, UMTRI

Description of research:

The University of Michigan Transportation Research Institute (UMTRI) and the U.S. Department of Transportation (U.S. DOT) are conducting a study of an integrated, collision warning system for passenger vehicles. This warning system addresses four crash types; forward crashes, curve over speed crashes, lane departure crashes, and lane change/merge crashes. We are examining the impact of this warning system on driving safety, driver comfort, and driver convenience.

Description of your involvement:

You have qualified to participate in a research study in which you are being asked to drive a research vehicle that is equipped with an integrated crash warning system on public roadways. Participation in this study requires traveling to UMTRI, participating in training on use of the system (approximately 2 hours), use of the research vehicle as your personal vehicle for approximately six weeks (40 days), completing questionnaires, and taking part in a debriefing session when you return the vehicle (approximately 2 hours).

In addition, we would like to use information contained in your State of Michigan driving record to examine how accident history and driver behavior correlate. With your permission, and through an agreement between the University of Michigan and the Michigan Secretary of State, your driving record in the State of Michigan would become part of this study.

In this study you will be instructed on how to use the integrated crash warning system prior to testing. You will be asked to watch an instructional video, receive instruction from a researcher, and take the vehicle for a demonstration drive with a researcher present. During the demonstration, a researcher will instruct you on where to drive. The researcher will also be present to answer any questions you may have.





Throughout your participation video cameras will be used to record images of you (your face and over your shoulder), the roadway, and other traffic near the research vehicle. In addition, very detailed information about how you drive will be collected (speed, lane keeping, braking events, etc.).

At no time during this study will you be asked to perform any unsafe driving actions. The existence of the integrated warning system on the vehicle will not eliminate the possibility of an accident occurring, and therefore you should avoid becoming too reliant on the integrated crash warning system. If you choose to participate, you will be expected to obey all applicable motor vehicle laws, codes, and regulations including wearing your seat belt.

In the unlikely event of physical injury resulting from participating in this study, the University will provide medical treatment in accordance with the determination by the University of its responsibility to provide such treatment. If an accident occurs, the standard procedure should be to remove yourself and others from harms way and call for emergency services (police and emergency medical technicians). The research vehicle is equipped with a fire extinguisher and first aid kit. Only after you and any passengers are out of harms way should you contact researchers at UMTRI. The research team at UMTRI will be available via pager on a 24 hour-a-day basis to answer questions or assist you should a need arise.

You, the test vehicle, as well as any other persons or property involved, are covered under an insurance policy held by The University of Michigan. However, that does not preclude other insurance coverage from involvement: including your personal injury protection (PIP) insurance - otherwise referred to as no-fault insurance, and your personal health insurance. The specifics of a claim cannot be stated beforehand because it is a coordination of benefits issue involving various carriers. The University insurance coverage is coordinated with other insurances, the priorities being determined to a large extent by the insurance laws of the State of Michigan. You may want to consult your personal automotive insurance provider(s) with any additional questions regarding insurance coverage. A participant may be held liable for damages resulting from an accident if afterwards it is determined that the participant knowingly misrepresented his/her eligibility to take part in the study.

You alone will be trained to use the research vehicle. As such, no one other than you is permitted to drive the vehicle during your participation. While there are no limitations on where



you chose to drive the research vehicle within the continental United States, you are not permitted to take the research vehicle outside of the continental United States for any reason. In addition, to participate in this study you must also agree to abide by the following:

1. The research vehicle cannot be used to tow any form of trailer, or haul any material greater than what the vehicle was designed to accommodate.
2. You may not, or allow others to, remove, modify, or tamper with any components of the research vehicle, the integrated warning system, or data collection system. You must receive verbal permission from the researchers prior to allowing any mechanical work to be performed on the research vehicle.
3. The research vehicle cannot be used to transport flammable materials (e.g., gasoline).
4. You are responsible for purchasing fuel for the research vehicle for the duration which it is assigned to you.
5. You are solely responsible for all tickets and violations for the duration which the research vehicle is assigned to you.
6. You must not operate the research vehicle while under the influence of alcohol or any medications that may impair your ability to drive.
7. You agree to report as early as possible to UMTRI any problems, malfunctions, or accidents with the research vehicle.
8. If at any time, and for any reason, the researchers deem it necessary that the research vehicle be returned to UMTRI, you must either return the vehicle or make arrangements for UMTRI personnel to retrieve it.
9. You must return the research vehicle at the specified date and time your participation is scheduled to end.

Length of your participation:

Your participation will last 40 days and require approximately four hours of your time to receive instruction, complete questionnaires and review selected video events of your driving experience. Additionally, you may be contacted after you have returned the vehicle to see if you are interested in participating in a focus group to discuss your experiences with, and impressions





of, the crash warning system.

Risks and discomforts of participation:

While driving in this study you will be subject to all risks that are normally present while driving. The use of the integrated warning system is intended to make driving safer and more comfortable. However, caution should be exercised when operating a vehicle with which you are not familiar.

Expected benefits to you or to others:

The results of this study will provide UMTRI and the U.S. DOT with valuable information for the development of future driver assistance and safety systems for passenger vehicles. It will also provide information about driver acceptance of these types of systems.

While there are no direct benefits to you, by participating in this study you are lending your experience and expertise as a driver to support safety research.

Cost to you resulting from participation in the study:

UMTRI and the U.S. DOT will bear nearly all of the costs associated with performing this study. You will be responsible to pay for gasoline while participating in this study.

Payment for participation in the study:

Participation in this study is voluntary. Should you choose to participate, you will be paid \$200 for your participation. Even after you have agreed to participate, you may still withdraw from this study at any time, and for any reason. If you withdraw from the study before the completion of the study, you still will be paid the entire amount.

UMTRI researchers retain the right to terminate the study at any time. Should your participation in the study be terminated by the researcher prior to its planned completion you will receive full compensation.

Confidentiality of records/data:

UMTRI is gathering information on driver assistance systems for passenger vehicles, and not





testing your skill or performance. Your name will not be released to anyone who is not working on the project. Your name will not appear in any reports or papers written about the project. However, it is possible that, should you be involved in an accident during testing, that UMTRI will have to release data on your driving in response to a court order.

Because video of you as the driver is part of the dataset, complete confidentiality cannot be offered. UMTRI and the U.S. DOT will use video (with your consent) and driver performance data from your driving experience for scientific, educational, and outreach purposes (e.g., scientific conferences, public safety commercials). This video is critical to understanding the context in which warnings are provided, how drivers respond, and general driver behavior.

Data will be stored indefinitely, as it represents a unique and irreplaceable dataset. The U.S. DOT has stated publically that it does not intend to ever fund a study of this type and magnitude again, and as such the data set needs to be retained for long-term exploratory analyses of driver behavior and the effects of collision warning systems by UMTRI, U.S. DOT and other researchers. Even if you withdraw from the study, your data will be retained, however, it will not be analyzed.

Contact information:

The experimenter in charge of this testing is:

Mary Lynn Buonarosa
Engineering Research Associate
The University of Michigan Transportation Research Institute
Human Factors Division
2901 Baxter Rd., Ann Arbor, MI 48109-2150
Phone: (734) 763-3583

Should you have questions regarding your rights as a research participant, please contact the Institutional Review Board, 540 E. Liberty St. Suite 202, Ann Arbor, MI 48104-2210, 734.936.0933, email: irbhsbs@umich.edu.

Consent:

I have read (or been informed of) the information given above. Mary Lynn Buonarosa has offered to answer any questions that I may have concerning the study. I hereby consent to





participate in the study.

Name (Print) Signature Date

Address

Phone

Optional use of video images: I agree to permit the unrestricted use of the video recordings of my driving (continuous or single framed) to be used for scientific, educational, and outreach purposes. I am aware that these recordings will contain images of my face and audio recordings of my voice. I am aware that I may decline to permit the unrestricted use of the recordings without penalty or compromise to my participation in this study.

Signed: Date:

Permission to be contacted for follow-up related to this project: I agree to allow UMTRI researchers to contact me with follow-up questions related to my participation in this research project (example: to ask questions that the researchers forgot to ask while I was still a participant).

Signed: Date:





IVBSS Heavy Truck Field Operational Test Informed Consent

Researchers:

James R. Sayer, Ph.D., UMTRI; Dillon Funkhouser, M.S.E, UMTRI; Mary Lynn Buonarosa, B.S.E., UMTRI; Joel Devonshire, B.S, UMTRI

Description of research:

The University of Michigan Transportation Research Institute (UMTRI) and the U.S. Department of Transportation (U.S. DOT) are conducting a study of an integrated, collision warning system for heavy trucks. This warning system addresses three crash types; rear-end, lane departure, and lane change/merge crashes. We are examining the impact of this warning system on driving safety, driver comfort, and driver convenience.

Description of your involvement:

Participation in this research study involves driving a Con-way tractor that is equipped with an integrated collision warning system as part of your normal responsibilities at Con-way. You will be asked to drive the same routes you drive normally, and your participation will last ten (10) months. Twenty drivers from Con-way's Romulus terminal are being asked to participate in this study.

Should you choose to participate, you will be instructed about how the integrated warning system works prior to taking the tractor on your normal routes. Throughout your participation video cameras will be used to record images of you (your face and over your shoulder), the roadway, and other traffic around the truck. In addition, very detailed information about how you drive will be collected (speed, lane keeping, braking, etc.).

At no time during this study will you be asked to do any unsafe driving. If you choose to participate you will be expected to comply with all normal Con-way operating requirements, including wearing your safety belt and obeying applicable motor vehicle laws, codes, and regulations.

You will have an opportunity to experience and practice the use of the collision warning system prior to testing. At the conclusion of testing you will be asked to complete a questionnaire regarding your impressions of the system. Completion of this questionnaire will take approximately one hour.



IRB: Behavioral Sciences

IRB Number: HUM00024529

**IRB Project Approval Date:
12/3/2008**

A researcher will provide you with hands-on instruction on the use of the new tractor and the integrated warning system, and will also take part in a demonstration drive in which you will be able to drive with this system while a researcher is present to answer questions.

The existence of the integrated warning system on the vehicle will not eliminate the possibility of an accident occurring, and therefore you should avoid becoming too reliant on the integrated crash warning system.

In the event of an accident, you should contact your dispatcher, who will in turn contact researchers at UMTRI. The research team at UMTRI will be available via pager on a 24 hour-a-day basis to answer questions or assist you should the need arise.

Length of your participation:

Your participation will last ten (10) months during your regular work hours and one additional hour to complete the questionnaire.

Risks and discomforts of participation:

While driving in this study you will be subject to all risks that are normally present while driving as part of your normal job responsibilities at Con-way. The use of the integrated warning system is intended to make driving safer and more comfortable. However, caution should be exercised when operating a vehicle with which you are not familiar.

Expected benefits to you or to others:

The results of this study will provide UMTRI and the U.S. DOT with valuable information for the development of future driver assistance and safety systems for commercial trucks. It will also provide Con-way with information about driver acceptance of these types of systems, which will be used in making future decisions regarding their purchase and use.





While there are no direct benefits to you, by participating in this study you are lending your experience and expertise as a commercial truck driver to support safety research for the commercial trucking industry.

IRB: Behavioral Sciences

IRB Number: HUM00024529

**IRB Project Approval Date:
12/3/2008**

Cost to you resulting from participation in the study:

UMTRI and Con-way will bear all costs associated with performing this study. There will be no costs to you associated with participating in this study.

Payment for participation in the study:

Participation in this study is voluntary, and in no way will affect your employment at Con-way. Even after you have agreed to participate, you may still withdraw from this study at any time, and for any reason, without penalty. Should you choose to participate and complete the study, as a token of appreciation you will receive 15,000 Safety Points from Con-way and \$300 from the University of Michigan. If you withdraw from the study before the end of the 4th month (16 weeks), you will only receive 2,500 safety points and \$50. If you withdraw from the study before the end of the 8th month (32 weeks), you will only receive 7,500 safety points and \$150.

UMTRI researchers retain the right to terminate the study at any time. Should your participation in the study be terminated by the researcher prior to its planned completion you will receive full compensation.

Confidentiality of records/data:

UMTRI is gathering information on driver assistance systems for heavy trucks, and not testing your skill or performance. Your name will not be released to anyone who is not working on the project, although Con-way management will, by virtue of having to assign you a tractor and routes, know you are participating.

While Con-way supports, and is participating in the conduct of this study, the only data that will be shared with Con-way is aggregate data reporting driver responses to the questionnaire regarding impressions of the collision warning system. Your individual responses will be kept





strictly confidential. In addition, we will not share any specific driving performance data or video with Con-way without your explicit permission to do so. However, it is possible that, should you be involved in an accident during testing, that UMTRI will have to release data on your driving to law enforcement and/or Con-way in response to a court order. This risk of this occurring is rare.

You have the option to allow UMTRI to share video and driving performance data with Con-way. You may still participate in the study without allowing Con-way to see your data. Should you permit us to share your video and driving performance data, the only data that would be shown to Con-way management would be strictly limited to events surrounding warnings provided by the collision warning system. This would include what events led up to the warning and how you as the driver responded.

Certificate of Confidentiality

UMTRI has obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researcher cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

The Certificate cannot be used to resist a demand for information from personnel of the United States Government that is used for auditing or evaluation of Federally-funded projects or for information that must be disclosed in order to meet the requirements of the federal Food and Drug Administration (FDA).

You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information.

The Certificate of Confidentiality does not prevent the researchers from disclosing voluntarily, without your consent, information you provide on current child/elder abuse is given to the researchers, or if there are threats to harm yourself or others, the researchers will report this to the authorities.



Long-Term Use of the Data

Data will be stored indefinitely, as it represents a unique and irreplaceable dataset. The U.S. DOT has stated publically that it does not intend to ever fund a study of this type and magnitude again, and as such the data set needs to be retained for long-term exploratory analyses of driver behavior and the effects of collision warning systems. This will include use of the data by a wide range of researchers studying trucking driving behavior and safety. However, at no time will your name or contact information be shared with anyone outside of UMTRI.

Contact information:

The experimenter in charge of this testing is:

James R. Sayer. Ph.D.
Associate Research Scientist
The University of Michigan Transportation Research Institute
Human Factors Division
2901 Baxter Rd., Ann Arbor, MI 48109-2150
Phone: (734) 764-4159

Should you have questions regarding your rights as a research participant, please contact the Institutional Review Board, 540 E. Liberty St. Suite 202, Ann Arbor, MI 48104-2210, 734.936.0933, email: irbhsbs@umich.edu.

Consent:

I have read (or been informed of) the information given above. Dillon Funkhouser has offered to answer any questions that I may have concerning the study. I hereby consent to participate in the study.

_____/_____/_____
Name (Print)

Signature

Date

Address





() _____

Phone

Optional Sharing of Identifiable Data with Con-way: Providing your signature below indicates that you agree to permit UMTRI to share video of you and information on your driving performance with Con-way. You may still participate in the study without allowing Con-way to see data which is specifically linked to you. Should you permit us to share your video and driving performance data with Con-way, the only data that would be shown to Con-way management would be strictly limited to events that would result, or resulted, in a collision warning. This would include what events led up to the warning and how you as the driver responded. You may decline to permit the sharing of this identifiable video and performance data without penalty or compromise to your participation in this study. Even if you agree to this optional sharing portion, you may still choose to withdraw data from specific trips or brief periods of time which you prefer not to share.

Signed: _____

Date: _____





Appendix B Data Request Form



Internal Driving Data Release Advisor Form

Integrated Vehicle-Based Safety System (IVBSS) Data
Safety Pilot Model Deployment (SPMD) / Ann Arbor Connected Vehicle Test Environment (AACVTE) Data

Please submit completed form to Helen Spradlin sparkyo@umich.edu.
Update form annually for continued data access (based on Submission Date of Request).
Form Number (UMTRI Internal Use) _____

PART A: APPLICANT INFORMATION

Submission Date of Request _____

Study Name

Principal Investigator (PI) / Faculty Advisor Name

PI / Faculty Advisor Unique Name _____





____ U-M Ann Arbor Campus ____ U-M Dearborn Campus ____ U-M Flint Campus

PI / Faculty Advisor Department or College

PI / Faculty Advisor ORCID Identifier (See <https://orcid.org/> for details)

Each person requesting data access must complete this form.

Data User Name _____

Unique Name _____

Phone _____

Data User/Student Major

Student level

Freshman ____ Sophomore ____ Junior ____ Senior ____

Graduate ____ Year ____ Post-doctorate ____ Year ____

Data User/Student ORCID Identifier (if user has one) _____

PART B: DATA ACCESS SPECIFICS

Will data be made public from the final report? _____

Proposed Time Period Required for Data Access

(month & year to begin and month & year to end)

Project End Date _____

Clearly describe project goals and the specific data elements required on an additional page with details on datasets under consideration.





Relevant course # _____

Person primarily responsible for data stewardship (insert the name of the person completing this form) _____

IRB approval submitted to Helen Spradlin sparkyo@umich.edu ____ Yes ____ No

Please list name(s) if you are collaborating with or have identified UMTRI / Mcity internal data expert(s) for assistance

PART C: PEERRS TRAINING

PEERRS is the *Program for Education and Evaluation in Responsible Research and Scholarship* offered online by the University of Michigan. PEERRS courses provide training required per university, state and federal regulations regarding responsible conduct of research. PEERRS certification may be required, depending on your role (e.g., Principal Investigator), the funding source (e.g., NSF), and/or the type of research (e.g., human subjects). PEERRS certifications are valid for three (3) years from the last complete data.

UMTRI requires the following PEERRS course. Additional courses are optional. **Human Subjects Research Protections** is required for PIs, Co-Investigators, Faculty Advisor, Research Staff and Study Coordinator.

Visit the *Welcome to PEERRS* page:
http://my.research.umich.edu/peerrs/?_ga=2.197101804.134964638.1507906263-1741286639.1483731843

Your PEERRS Certification will be verified within the University of Michigan system.

PART D: USER PLEDGE

- I understand I am granted only the temporary use of these research data and am not granted the rights to copy the data for myself or others. This is granted by the original research team, which controls access to the data. There are no dedicated staff to the data, so the original research team may or may not be able to donate their time for assistance with the data. The data user needs to be patient and considerate.





- I will not allow anyone else to use my passwords or use the data.
- I will not capture Personally Identifiable Information (PII) data and I will not share it with others, unless approved by the IRB and the UMTRI naturalistic driving data use agreement.
- I will never seek to identify any of the human participants from these data, unless approved by IRB and the UMTRI data team. The driving data set team retains the right to immediately suspend my access or use, which is a necessary right in order to honor IRB commitments.
- I understand that others are on the same servers and promise to use good manners, such as making sure queries don't run too long.
- I agree to uphold the standard defining permitted and restricted uses of university-owned data, including the IT environments in which these data are maintained by university faculty and staff. This link references Sensitive Regulated Data: Permitted and Restricted Uses: <http://cio.umich.edu/policy/sensitive-regulated-data.php>
- I will acknowledge the UMTRI driving data by referencing them in publications and/or presentations.

User Signature _____ Date _____

Print User Name _____

PART E: FACULTY ADVISOR SIGNATURE

I'm aware that _____
[data user/student name]

Is requesting access to the data referenced herein and I will support appropriate use of the data.

Advisor Signature _____

Print Advisor Name _____

Date _____





PART F: UMTRI \ MCITY APPROVAL (For Internal Use Only)

Type of Access Granted

___ Access only from computers within UMTRI

___ Remote read-only access

Approval Signature

_____ Date _____

Print Approver Name _____

Questions or comments? Contact Helen Spradlin sparkyjo@umich.edu (734) 845-0317



**Appendix C Publications As An Outcome Of Naturalistic Driving Data
Access As Of Summer 2019****Appendix C Publications As An Outcome Of Naturalistic Driving Data Access As Of
Summer 2019**

Bartos, M., Park, H., Zhou, T., Kerkez, B., Vasudevan, R. (2019). Windshield wipers on connected vehicles produce high-accuracy rainfall maps. *Scientific reports*, 9(1), 170. <https://doi.org/10.1038/s41598-018-36282-7>

Huang, X., Zhang, S., & Peng, H. (2019). Developing Robot Driver Etiquette Based on Naturalistic Human Driving Behavior. *IEEE Transactions on Intelligent Transportation Systems*.

Yu, B., Bao, S., Feng, F., & Sayer, J. (2019). Drivers' Reaction Analysis and Prediction with V2I-Communication-Based Energy-Related Strategies. *Transportation Research Board*, 19-04240.

Yu, B., Bao, S., Feng, F., & Sayer, J. (2019). Examination and prediction of drivers' reaction when provided with V2I communication-based intersection maneuver strategies. *Transportation Research Board, Part C: Emerging Technologies*, 106, 17-28. doi:10.1016/j.trc.2019.07.007

Breg, A. N. (2018) *Neural Network Predicting Remote Vehicle Movement with Vehicle-to-Vehicle Data* (<https://deepblue.lib.umich.edu/handle/2027.42/146791>) [Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Engineering (Electrical Engineering) University of Michigan Dearborn]. University of Michigan Deep Blue.

Chen, Y., Sohani, N., & Peng, H. (2018). Modelling of uncertain reactive human driving behavior: A classification approach. *IEEE Conference on Decision and Control (CDC)*. doi:10.1109/CDC.2018.8619568

Huang, X., & Peng, H. (2018). Eco-routing based on a data driven fuel consumption model. *ArXiv*, 1801(08602).

Huang, X., & Peng, H. (2018). Efficient Mobility-on-Demand System with Ride-Sharing. *2018 21st International Conference on Intelligent Transportation Systems (ITSC)*. IEEE.

Oh, G., & Peng, H. (2018). Eco-driving at signalized intersections: What is possible in the real-world? *2018 21st International Conference on Intelligent Transportation*



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TRANSPORTATION**

Systems (ITSC). *IEEE*, 3674–3679. doi:10.1109/itsc.2018.8569588

Zhang, S., Peng, H., Zhao, D., & Tseng, H. E. (2018). Accelerated Evaluation of Autonomous Vehicles in the Lane Change Scenario Based on Subset Simulation Technique. *2018 21st International Conference on Intelligent Transportation Systems (ITSC)*, 3935-3940. doi:10.1109/itsc.2018.8569800

Huang, X., Zhao, D., & Peng, H. (2017). Empirical study of DSRC performance based on safety pilot model deployment data. *IEEE Transactions on Intelligent Transportation Systems*, 18(10), 2619-2628. doi:10.1109/tits.2017.2649538

Wang, X., Zhao, D., Peng, H., & Leblanc, D. J. (2017). Analysis of unprotected intersection left-turn conflicts based on naturalistic driving data. *2017 IEEE Intelligent Vehicles Symposium (IV)*. doi:10.1109/ivs.2017.7995723





Appendix D Acronyms & Abbreviations

APA	American Psychological Association
AACVTE	Ann Arbor Connected Vehicle Test Environment
ASD	Aftermarket Safety Device
BSM	Basic Safety Message
CCAT	Center for Connected and Automated Transportation
CMISST	Center for the Management of Information for Safe and Sustainable Transportation within UMTRI
CAV	Connected and Automated Vehicle
CSW	Curve Speed Warning
DAS	Data Acquisition System
DSRC	Dedicated Short-Range Communications
EEBL	Emergency Electronic Brake Lights
ESG	Engineering Systems Group within UMTRI
FMVSS	Federal Motor Vehicle Safety Standard
FOT	Field Operational Test
FCW	Forward Collision Warning
GPS	Global Positioning System
HTFOT	Heavy-Truck Field Operational Test
IT	Information and Technology
IVBSS	Integrated Vehicle-Based Safety Systems
IRB	Institutional Review Board
LVFOT	Light-Vehicle Field Operational Test
MEDC	Michigan Economic Development Corporation
NDD	Naturalistic Driving Data
NDS	Naturalistic Driving Studies
OST-R	Office of the Assistant Secretary for Research and Technology
ORCID	Open Researcher and Contributor Identifier



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PCW	Pedestrian in Crosswalk Warning
PII	Personal Identifiable Information
PI	Principal Investigator
PEERRS	Program for Education and Evaluation in Responsible Research and Scholarship, online at University of Michigan
RSE	Roadside Equipment
RSD	Retrofit Safety Device
SPMD	Safety Pilot Model Deployment
UMTRI	University of Michigan Transportation Research Institute
UTC	University Transportation Center
U.S. DOT	United States Department of Transportation
VAD	Vehicle Awareness Device
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
VTRW	Vehicle Turning Right in Front of Bus Warning

