CrIS | Crash Imminent Safety UTC

THE OHIO STATE UNIVERSITY

Program Progress Performance Report

Project Title: "Human Factors for Crash Imminent Safety in Intelligent Vehicles"

April 30, 2014

Federal Agency: US Department of Transportation (USDOT)

Organization: Research and Innovative Technology Administration (RITA)

Program Director/PI: Ümit Özgüner
UTC Center Director
Professor, Department of Electrical and Computer Engineering
Transportation Research Center (TRC) Inc. Chair on
Intelligent Transportation Systems (ITS)
Crash Imminent Safety (CrIS) University Transportation Center (UTC)
The Ohio State University
ozguner.1@osu.edu
614-292-5940

Submitting Official: Tamar Forrest, UTC Program Manager
forrest.97@osu.edu
614-746-9893

Submission Date: April 30, 2014

DUNS Number: 832127323, EIN Number: 31-6025986

Recipient Organization: US Department of Transportation (USDOT)
1200 New Jersey Avenue, SE; Washington, DC 20590

Recipient Identifying Number or Account Number: DTRT13-G-UTC47

Project/Grant Period: 9/30/13 – 9/30/17

Report Term or Frequency: semi-annual

Signature of Submitting Official:

CENTER FOR AUTOMOTIVE RESEARCH

PPPR Overview

The Crash Imminent Safety UTC has had a strong start since our kick-off on December 6, 2013. Research teams have done a number of important preliminary tasks that have set the stage for accomplishing year one goals. The UTC research team now includes over 30 faculty and student researchers working at OSU and our partner Universities (IUPUI, NCA&T, UMass, UW), in addition to ~10 individuals that provide administrative support. Administrative resources and structure have been developed. A Program Manager was hired in December 2013. She schedules and facilitates team meetings between research partners and universities, which take place anywhere from once a week to once a month depending on the project. The new UTC website is up and running (http://citr.osu.edu/CrIS). Publicity materials (e.g., CrIS UTC flyer) have been developed and dispersed. Additionally, our Internal Technical Advisory Board has formed and will meet for the first time in May. We are finishing up recruitment for our External Advisory Board. We have also applied, with the support of Vice-president for Research at OSU, to join the Council of University Transportation Centers (CUTC).

Early UTC research efforts have included selecting three candidate pre-crash scenarios from a list of 37 given in the NHTSA taxonomy – 1) "lead vehicle stopped," 2) "vehicle(s) turning at non-signalized intersections," and 3) "Vehicle(s) changing lanes – same direction." The selection of these scenarios was done considering both the real-life severity of the scenarios and the overall variety of the selected scenarios so that they cover a range of situations. These scenarios have been reviewed by all UTC Project leads and university partners. Projects 2 (Driver Models for Both Human and Autonomous Vehicles with Different Sensing Technologies and Near-crash Activity) and 4 (Bio-Injury Implications of Pre-Crash Safety Modeling & Intervention) are adopting these scenarios for their research, while Project 3 is moving forward with the selection of different scenarios more applicable to driver reengagement. Some or all of these scenarios will be utilized when networking simulators (Project 1, Pre-crash Multi-vehicle Experimental Analysis Using a Networked Multiple Driving Simulator Facility). Additionally, Project 5 (Pre-Crash Interactions between Pedestrians and Cyclists and Intelligent Vehicles) is in the process of developing a driving simulation model of a pedestrian forward collision imminent braking (CIB) system that will also be utilized when networking simulators.

In preparation for networked simulators, universities (e.g., Wisconsin and UMass) have begun to share and utilize the same scenarios with which they are running independently on their respective simulators.

Project and university leads have been working together to brainstorm solutions to methodological and theoretical challenges surrounding model development – both the "Driver Models" being developed in Project 2 and "Cognitive Models" in project 3. At times, research teams have decided to attempt the same tasks utilizing different approaches (e.g., NCA&T utilizing Support Vector Machines and OSU utilizing Hidden Markov Models and Hierarchical Hidden Markov Models), develop models utilizing different scenarios, and access to the driving simulator environment is being planned for those who have not developed models using these methods (e.g., David Woods, OSU). Researchers from all UTC partner universities are seeking out and acquiring datasets containing either recorded naturalistic driving or accident/incident reports and statistics needed for model development and are developing a culture of data sharing from the onset.

New researchers are already being introduced to the UTC (e.g., David Good, Sean O'Connor, Matt Roberts) and forums are being created to introduce universities to new methods and tools that can be used in their research. For example, representing the UTC, Dr. O'Connor has begun a dialog with the President of RealTime Technologies, the manufacturer of the driving simulators employed in the UTC grant, discussing methods to facilitate transfer of CAIS (Computer-assisted Alcohol Infusion System) technology to users of simulators throughout the country.

Those not historically involved in technology transfer and policy and are beginning to think about the implications of their work and these conversations are being facilitated by those with both engineering and policy experience (Beth Anne Schuelke-Leech, David Good). UTC researchers are beginning to clarify the policy and regulatory issues associated with safety, crashes, and intelligent vehicle systems, employing both big data analytics on unstructured data and econometric models, in addition to primary research using semi-structured interviews with stakeholders. The UTC has applied for external dollars that we hope will support more extensive policy discussions and technology transfer. Initial discussions with industry leaders during the process of proposal development have resulted in letters of support for UTC projects written by, for example, Ford Motor Company and Nissan Technical Center. UTC partners also continue to supplement their work, both conceptually and through the enhancement of facilities, with projects supported by Denso, DURA, Faurecia Emission Control Technologies , NASA, RealTime Technologies, TASS International, Toyota, among others.

Examples of recent enhancement of resources and facilities (coordinated by Keith Redmill) include completing the development of a V2X laboratory (funded by the Denso Foundation) providing DSRC radio hardware as well as robots and diagnostic equipment that can be used for testing and implementing wireless communication based safety, sensing, and autonomous systems. Construction has also begun on a 1,300 square foot garage, along with a paved securely fenced area, located behind the UTC site for vehicle preparation and maintenance and experiment development. We have also acquired, and will soon take possession of, a new experimental vehicle platform (a Toyota Prius). This was not purchased using UTC funds, but will be used in UTC research and demonstration activities. Additional, TASS International is providing the PreScan vehicle simulation software to IUPUI for the development of the simulation model and pedestrian CIB and V2V simulation and Faurecia Emission Control Technologies, USA, LLC is providing vehicle test track to IUPUI for pedestrian CIB data collection.

The UTC is also moving toward achieving education and workforce development goals -- transferring the knowledge gained through CrIS research efforts to the next generation of ITS engineers. Students work with real data, commercial simulation software and hardware, and/or actual vehicles. This includes the development of 1) a STEM summer program for female high school students involving transportation and robotics for the OSU Women In Engineering organization, 2) "hands on" labs that introduce undergraduate students to AVs and the simulator environment, and 3) big data analytics workshops with industry leaders (and data analysis results that consider implications of AV technology). Materials, such a lab manuals and datasets, resulting from these activities are being shared with all UTC partners, allowing for larger scale adoption and implementation of education activities.

Another activity that CrIS researchers have been involved in is the organization of the IEEE Intelligent Vehicles Symposium, IV'14 (http://www.ieeeiv.net/). The general Co-Chairs are Yaobin Chen and Ümit Özgüner. Arda Kurt is the Publication Co-Chair, Tamar Forrest is the Registration Chair, and Keith Redmill is the Demonstration Co-Chair. The symposium will be held from June 8-11, 2014 and will bring together over 300 researchers on topics relevant to CrIS.

Project 1: Pre-crash Multi-vehicle Experimental Analysis Using a Networked Multiple Driving Simulator Facility

Project Lead: Janet Weisenberger (OSU)

Accomplishments

Progress toward stated objectives and goals:

The primary goal/objective for Year 1 for Project 1 is the networking of driving simulators across the institution in the CrIS UTC. We have made progress toward this goal, but much remains to be done. Initially, it was determined that the simulators would be added to the network one at a time, and an order for adding simulators was created. At the present time, two simulators (one desktop, one motion platform) are networked and communicating in a common scenario, with the driver in each simulator able to see a representation of the other vehicle. Several problems still need to be overcome, most involving phantom representations in one of the simulations that had not been programmed. We are proceeding at this point with adding a third simulator to the network.

This effort has required the establishment of VPN connections across laboratories to allow safe and secure access among the universities and laboratories in the CrIS UTC. Navigating the VPNs has created some challenges in ensuring adequate speed and bandwidth for common simulations. Additional challenges involve differences in hardware and software across laboratories that impact the degree of transferability of scenarios.

Plans for next reporting period:

We will continue to add additional simulators to the network over the next six months, and will address challenges to timing and bandwidth limitations as they arise. Collaborations with OARnet and the UTC Coordinator for Facilities and Experiments (Keith Redmill) will assist with network troubleshooting as needed.

Products: Nothing to Report

Collaborations

All of the partner universities in the CrIS UTC are part of this project. Primary work on the networking issues has been done by Thomas Kerwin (Research Scientist) and Patrick Veith (undergraduate student). No external partners have yet been brought into this project.

Impact

No impact has as yet been demonstrated. Upon completion, the existence of a network of driving simulators will provide a testing resource that does not currently exist elsewhere in the country. This will be a significant output of the center, which will contribute to outcomes by improving our understanding of driver interactions in crash-imminent scenarios, and ultimately to a broader impact in increasing safety for drivers of cars with autonomous vehicle systems.

Changes or Problems: There has been no change in overall goals or objectives.

Project 2: Driver Models for Both Human and Autonomous Vehicles with Different Sensing Technologies and Near-crash Activity

Project Lead: Ümit Özgüner (OSU)

Accomplishments

Progress toward stated objectives and goals:

Project 2 researchers are investigating different ways of capturing driver behavior in computational and functional models. The purpose of developing these models is to provide a means of understanding and quantifying human driving behavior for the computational aspects of current and future transportation systems, ranging from Advanced Driver Assistance Systems (ADAS) to partial/full automation applications.

Early stages of project work (also relevant to Project 3) have included extensive literature reviews, concentrating on 1) Hybrid State Systems for Autonomous Vehicle Control, 2) Probabilistic Modeling of Mobile Agents, and 3) Discrete-State Encoding in Hierarchical Hybrid-State Systems.

There are multiple viable methodologies in modeling the decision-making and low-level driving aspects of the various tasks that are undertaken by human drivers. Earlier studies in cognitive driving models mostly utilized the division of various subtasks such as perception, implementation and decision-making that operate concurrently during regular human driving. One example illustration of such a cognitive model can be seen below.

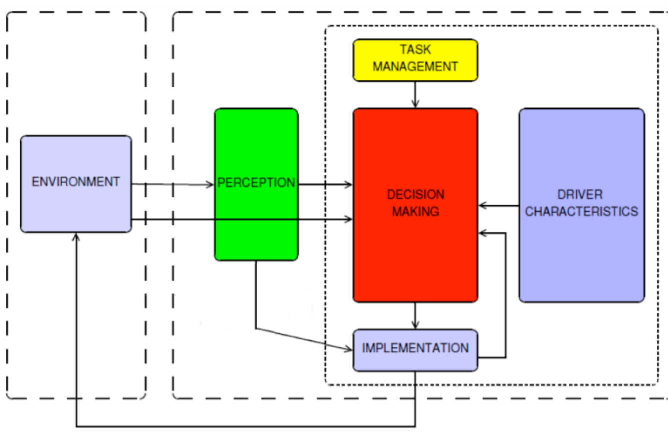

Figure 1. Human Driver Model

This project is a continuation of the earlier efforts on capturing parts of this driver model in Hybrid-State Systems (HSS) and probabilistic state machines. These earlier models dealt specifically with intersection approach scenarios, as illustrated below, and involved ad-hoc models tested and verified with real driving data.

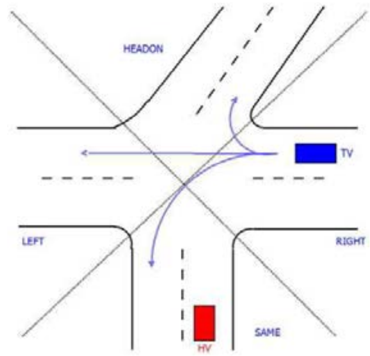

Figure 2. Intersection approach decisions

Currently the driver modeling effort of Project 2 is being carried out in two parallel tracks. OSU researchers are investigating probabilistic models of decision for crash-imminent scenarios through Hidden Markov Models (HMM) and Hierarchical Hidden Markov Models (HHMM), which have shown promise in both capturing driver modes/intents, and also factoring in stochastic nature of such decisions. On the other hand, NCAT researchers are investigating Support Vector Machines (SVM) for a similar purpose.

Common to both of the above-mentioned research tracks is a need for real or realistic driving data covering relevant scenarios. So far, a number of larger-scale data collection efforts such as VTTI 100-Car Naturalistic Driving Study and NHTSA SHRP2 are explored as candidate data sources. Since the publicly available portion of the 100-Car study is de-identified (GPS locations and other pieces of information stripped off), and the SHRP2 data is still being processed, our initial attempts at identifying useful driving data has focused on our internal resources. For this purpose, data collected with an instrumented OSU research vehicle for an earlier project is being examined to pinpoint near-crash situations. Even though this data set is not extensive as the above-mentioned naturalistic driving studies, it will provide a starting point for the initial model-building efforts and help get our group of researchers from multiple institutions onto the same page.

Teaching or Professional Development Activities:

Human driver models and decision-making structures were included in the extended syllabus of OSU Electrical and Computer Engineering course “Autonomy in Vehicles” (ECE5553) for the first time. The course focuses on analyzing autonomy in the context of modern road vehicles and developing design approaches for such systems in cars, use of CAD packages to analyze advanced system design techniques, and understanding evaluation of 'futuristic' technologies. The inclusion of human driver models in this course reflects our previous and ongoing efforts in this field.
The students were able to both learn the theoretical foundations of driver modeling and its application in Intelligent Transportation Systems during the lectures of the course; and also test their understanding with newly-designed laboratory experiments utilizing Control and Intelligent Transportation Research (CITR) Laboratory Driving Simulator (seen in Figure 3 below). Collecting realistic driver data from a simulator and processing the data to help driver-model development, alternative driving-data sources such as naturalistic driving studies, and traffic scenario selection methods were both discussed in class and illustrated through examples and lab experiments (which involves implementing safety systems, such as intersection safety or left turn safety systems, using DSRC radios), transferring the knowledge gained through CrIS research efforts to the next generation of ITS engineers.

Figure 3. OSU CITR Driving Simulator

Products

Arda Kurt & Umit Ozguner developed a report detailing three potential crash scenarios for evaluation by UTC projects: 1) Lead vehicle stopped, 2) Vehicle turning at non-signalized junctions and 3) Vehicles changing lanes.

A laboratory manual (shared with all UTC partners and universities) for ECE 5553- Autonomy in Vehicles, utilizing the driving simulator available at the UTC. Students collect driving data as various team members interact with a simulated road environment, including other vehicles, pedestrians, and surprise events. They analyze this data and use the results to tune and validate their software driver model that they then use in the simulation of autonomous vehicles and vehicular safety systems.

Publications:

Kurt, A., Ozguner, U. "Probabilistic Modeling, Estimation and Prediction of Hybrid-State Systems for Driver-Vehicle Interactions," submitted to *IEEE Transactions on Intelligent Transportation Systems*.

Data Sources and Databases:

The driver-model design and development efforts include using real or realistic driving data to train or generally shape the models through stochastic methods. For this reason, both internal data sources on relevant driving data is continuously being investigated. The major data sources being examined and considered are listed below:

- *OSU Intersection Approach data*: This dataset was collected for an earlier research effort focusing on possible intersection-approach scenarios. The dataset includes vehicle-centric data such as recorded CAN bus data and high-precision GPS coordinates, as well as limited environment information through recorded video, shown in Figure 4. As the data set includes various approaches to different intersections and the travel between the intersections, it contains a range of scenarios that are not limited to the immediate intersection areas. Currently, this dataset is being processed and the video records are being watched to identify relevant near-crash cases to be used in pre-crash scenarios.

Figure 4 – Snapshot from the video data included in OSU Intersection Access dataset.

- *VTTI 100-Car data*: This is a larger dataset collected for a 100-car naturalistic driving study, and it includes both vehicle and video data similar to our relatively smaller dataset. Examples extracted from this dataset are also being investigated by watching the corresponding video recordings, and if relevant scenarios are identified in the extracts, access to the full data set including GPS tracks, which were removed by VTTI for de-identification purposes before the information was made public, will be pursued in the near future. Full access to this dataset will require submitting a Data Sharing Agreement form to VTTI stating our data-related scope of analysis, project, and members, and it also requires IRB certifications. Due to these secondary requirements, the internal dataset mentioned above has priority over these external datasets.

- *SHRP2 Naturalistic Driving data*: This most recent dataset is still being processed by the VTTI and NHTSA researchers and portions are being made available on the SHRP2 website. As we get a more complete picture for this largest and most recent data set, the CrIS group will consider the inclusion of the data to our pre-crash scenario-model training set.

Collaborations

We have been developing a number of national and international collaborations that have included visits to the CrIS UTC. This includes a visit from a Brazilian contingent through Ohio State's Brazil Gateway Program.

Impact

Changes or Problems

Project 3: Driver Models for Both Human and Autonomous Vehicles with Different Sensing Technologies and Near-crash Activity

Project Lead: John Lee (Wisconsin)

Accomplishments

To improve pre-crash safety in future more automated vehicles with some autonomous capabilities, the responsible human in the care (human driver) will need to shift from other activities to re-engage with the driving situation. This is called the re-engagement problem and is part of achieving "bumpless" transfers of control in human-automation systems. The objective of one part of Project 3 is to look at the re-engagement problem. The work to date on this subtask has focused on developing an experimental plan for the first round of studies to evaluate the critical factors that determine whether re-engagement is smooth or bumpy.

The first round of envisioned studies addresses looking ahead at changing driving conditions and how changes in the traffic and weather change the relationship between the autonomous capabilities and the human driver on-board. We plan to assess how we can simulate situations where (1) the human driver on-board has delegated control to the autonomous capabilities, (2) the traffic situation ahead changes, (3) the autonomous capabilities begin to signal for the human driver on-board to shift from other activities to re-engage with the traffic situation ahead.

In this family of scenarios, there are several characteristics which are important for understanding coordination between human drivers and on-board automated capabilities.

- There is an explicit act of delegation of control from the human driver to the vehicle's autonomous capability.
- The on-board automation has to be able to monitor the situation ahead and recognize changes from a baseline which is based on the act of delegation.
- The on-board automation has to be able to begin to signal the human driver that their reengagement with the driving situation is needed and to vary the type and strength of the signals to the driver to dis-engage from other activities. The signaling should lead the human driver (a) to re-orient to the driving situation, (b) to prepare to take over portions of control of the vehicle, or (c) to provide new instructions/guidance to the autonomous systems.

The work to date has developed an initial plan to study re-engagement in the above family of scenarios. To date the study plan includes:

- Two driving situations have been identified where the human would delegate control to the automation, changes would then occur in the driving situation ahead, leading the automation to signal the driver to begin re-engagement, including re-orienting, re-directing, and takeover depending on the specific changes that occurred.
- Two families of signals have been identified: perceptual re-orienting cues to look out and ahead; human-assistant like communication about the changing situation (verbal auditory).
- Two timing conditions are essential--early and late: one where the signaling begins when the driving situation ahead first changes relative to the act of delegation, and a second

where the signaling begins when the driving conditions have deteriorated and the automation is starting to have difficulty handling the situation.

- Two agent coordination conditions can be studied: compare and contrast human automation interaction with a condition where a person signals another person about the changed situation ahead.

- To assess the feasibility of simulation studies of re-engagement with the above characteristics, the basic plan is being analyzed with Project 3 team members and with specialists who run the simulation capabilities. The planned line of inquiry will provide results on how to re-engage human drivers in less critical situations and assess how quickly effective re-engagement can occur. This will provide inputs on how to support reengagement in more critical crash imminent situations.

Products

Nothing to Report

Collaborations

Nothing to Report

Impact

Nothing to Report

Changes or Problems

Nothing to Report

Project 4 – Bio-Injury Implications of Pre-Crash Safety Modeling & Intervention

Project Lead: John Bolte (OSU)

Accomplishments

Progress toward stated objectives and goals:

The goal of this project is to use Bio-Injury data from given crash scenarios to suggest evasive action/driver position best suited to reduce injury.

- Selection of crash scenarios

Arda Kurt & Umit Ozguner submitted a report on February 26th detailing three potential crash scenarios for evaluation: 1) Lead vehicle stopped, 2) Vehicle turning at non-signalized junctions and 3) Vehicles changing lanes. These three scenarios were redefined in terms of principal direction of impact forces to the autonomous vehicle along with potential impact velocities.

- National Automotive Sampling System – Crashworthiness Data System (NASS-CDS)

The NASS-CDS database search variables have been defined for all three crash scenarios defined above. The variables selected to date include (subject to change): 1) NASS-CDS Data: 1998-2011 (14 years), 2) Vehicle model years: 1985 onwards, 3) Occupant Age: ≥ 16 years old; no pregnant occupants, and 4) Occupants: driver & right front passenger only. The statistics from the searchers are currently being run and will not be finalized until the end of April.

- Crash Injury Research & Engineering Network (CIREN)

We have applied for full access to the CIREN files through NHTSA, which include radiology images and reports. We currently have access to the public database and are looking at the 3 defined scenarios. The findings from the public version of the CIREN analysis will be completed by May 15, 2014.

Training or professional development

We have introduced two students (Tim Gocha & Tanisha Kashikar) to database mining and statistical analysis. These students do not typically receive this as part of their education in our research center.

Dissemination of results: Nothing to report -- not applicable until results are determined.

Plans for next period: NASS-CDS and Public CIREN findings will be analyzed and reported.

Products

Publications: Initial database mining has just begun so there are no publications ready at this time. This analysis should result in at least two publications.

Data: This research will result in crash and injury databases that will be useful to better understand injuries which occur during the three defined crash scenarios.

Collaborations

We have been collaborating with the National Highway Traffic Safety Administration (NHTSA) for access to the full CIREN database, which includes radiology images and reports. We also have been discussing correct use of the database.

Impact

On the development of disciplines: The techniques being developed for mining both databases will help further the role of epidemiology in analyzing autonomous vehicle crash scenarios. These techniques will be published and could also be taught to future researchers in the Injury Biomechanics course (Anat 7892).

On society beyond science and technology: Having a better knowledge of injuries that occur in common crash scenarios will lead to safer vehicles and thus reduce fatalities and injuries in future crashes.

Project 5: Pre-Crash Interactions Between Pedestrians and Cyclists and Intelligent Vehicles

Project Lead: Yaobin Chen (IUPUI)

Accomplishments

Progress toward stated objectives and goals

Major activities, including milestones and dates:

The Transportation Active Safety Institute (TASI) at Indiana University-Purdue University Indianapolis (IUPUI) has been working on three parallel activities under the OSU-led UTC program since the start of the program.

Activity 1: Create a driving simulation model of a pedestrian forward collision imminent braking (CIB) system using actual mannequin-based CIB testing data. The purposes of this activity are as follows:

a. Since no automotive companies provide pedestrian CIB models for public research, we try to treat the CIB system as a black box and develop a method and process to model pedestrian CIB system based on vehicle pedestrian CIB test data. This method can be used to develop pedestrian CIB braking models for different vehicles.
b. Use this method to identify the set of data essential for developing a pedestrian CIB model.
c. Use the pedestrian CIB model in a driving simulator environment to evaluate a realistic pedestrian CIB performance.
d. Use the pedestrian CIB model to evaluate the improvement of CIB operations in a V2V communication enabled environment.

This activity is conducted in two phases, the first phase is to use the PreScan vehicle simulator provided by TASS International to create the pedestrian CIB model. The model describes the CIB performance based on the vehicle speed, pedestrian speeds, pedestrian sizes, the pedestrian motion direction relative to the vehicle motions, and lighting conditions. The model development in the PreScan environment is more time efficient since the result can be animated and be checked easily. The work in the first phase will be completed in end of May 2014. The second phase is to transfer the pedestrian CIB model generated from PreScan environment to the Realtime Technology driving simulator. A Realtime Technology desk driving simulator has been ordered and will be available before the end of May 2014. The second phase will be completed in September 2014. The resulting model will be shared with all partners in our UTC program consortium for the proposed V2V simulation using multiple Realtime Technology driving simulators located at these partner universities. One Master's student in the Electrical and Computer Engineering Department is working on this.

Activity 2: Integrate the active safety sensing information in V2V study. Traditional V2V studies concentrate on the exchange of vehicle operation information among vehicles. Since more vehicles are equipped with pedestrian CIB capabilities, these vehicles already have pedestrian crash sensing capability. Our idea is that if these vehicles can exchange the pedestrian sensing information in real-time, a vehicle can get potential crash information before it can sense the potential crash itself and, hence, have more lead time to respond to a potential crash and improve safety. Therefore, researchers at TASI are in the process of developing a practical method that can incorporate the useful pedestrian motion information in the V2V messaging and enable a vehicle to use the received pedestrian information in conjunction with its own CIB sensing information to determine the potential pedestrian crash. The theoretic study of the problem for simple scenarios will be completed in the end of May 2014. The simulation using PreScan will be conducted from June to the end of September 2014. More complex scenarios will also be studied between June and September 2014. After successful PreScan simulation, all scenarios will be simulated in the multi-driving simulators environment.

Activity 3: Transfer the technology of the Computer-assisted Alcohol Infusion System (CAIS). The CAIS apparatus combines a physiologically based pharmacokinetic (PBPK) model of alcohol distribution and elimination with computer control of infusion pump rate to enable precise control of breath alcohol concentration over time. The precise alcohol level control and driving simulation provide ideal environment for various types of drunk driving studies. The device has been designed and successfully tested. TASI is actively pursuing the collaborative research in drunk driving using CAIS and driving simulators, and technology transfer opportunities of CAIS with our UTC program partners.

Major findings or results:

Activity 1: A PreScan model of a Pedestrian CIB system is currently being developed. The pedestrian CIB model that matches the CIB braking performance of a vehicle in terms of speed and time to collision has been successfully implemented. The model with additional variables, such as cloth color, lighting condition, pedestrian size, and performance variations is currently being developed on the PreScan vehicle simulator.

Activity 2: The study has categorized the types of vehicles that have different V2V and active sensing capabilities, and identified the type of information to be transferred between vehicles. The study also specified what potential crash data to be communicated between vehicles and how the data is to be transformed and utilized on each vehicle. A PreScan simulation is being developed to demonstrate the potential safety gain by using this approach.

Activity 3: A report of the pilot study performed in the IUPUI TASI simulator using CAIS was prepared. That study demonstrated the ability to perform 'stepped BrAC clamping' in the driving simulator setting -- implementing prescribed intervals of constant BrAC at investigator-specified levels of BrAC (0.06 and 0.10 gldL (60 and 100 mg/dL) in this case). The report will be turned into a manuscript for submission this summer.

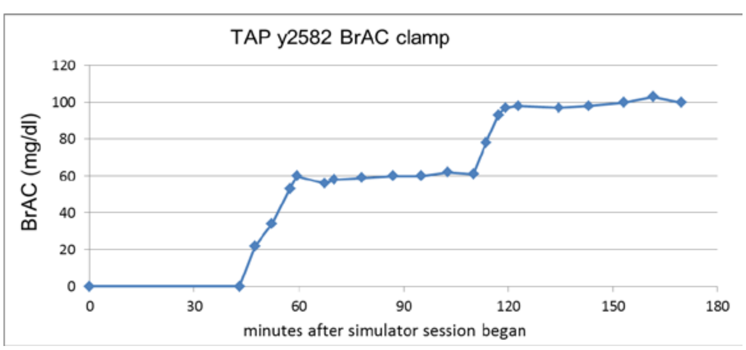

Figure 5 – TAP y2582 BrAC Clamp.

Dissemination of results -- Outreach Activities

Activity 3: Representing the UTC, Dr. O'Connor has begun a dialog with the President of RealTime Technologies, the manufacturer of the driving simulators employed in the UTC grant. Dr. O'Connor will visit RTI headquarters in Royal Oak Michigan in May or June to discuss methods to facilitate transfer of CAIS tecnology to users of RTI simulators throughout the country.

Plans for next reporting period:

Activity 1: The development of the pedestrian CIB models of two vehicles on PreScan vehicle simulator and Realtime Technology driving simulator will be completed. A technical paper describing the model and its development process will be submitted to an intelligent transportation conference for presentation and publication.

Activity 2: A protocol for the exchange of CIB sensing information will be defined. The V2V simulation with the exchange of CIB sensing information will be conducted. A technical paper describing the protocol development and the CIB performance improvement based on the simulation results will be submitted to an intelligent transportation conference for presentation and publication.

Activity 3: Dr. O'Connor visited the Ohio State University on April 1, 2014 to meet with UTC principals and staff, in order to discuss the transfer of CAIS technology to the OSU driving simulator. He familiarized OSU investigators with CAIS capabilities and propoposed a formal study on the effect of drunken driving as part a multi-driver/multi-simulator study in the UTC renewal application.

Products: Nothing to Report

Collaborations:

- *In-kind Support*
  TASS International is providing the PreScan vehicle simulation software to IUPUI for the development of the simulation model and pedestrian CIB and V2V simulation.

- *Facilities*
  Faurecia Emission Control Technologies, USA, LLC is providing vehicle test track to IUPUI for pedestrian CIB data collection.

Impact:

On the development of the discipline(s): The limitation of the CIB technology is the short sensing range that can provide the reliable potential crash information. The integrated V2V and CIB sensing has the potential to improve the performance of CIB greatly since a vehicle can receive potential collision information from other vehicles so that the potential collision can be detected early (such a pedestrian darts out from behind of a vehicle). The cost for this improved safety for vehicles with V2V capability is low since the CIB already gathered the information. This is a new field that enables intelligent and cooperative CIB systems.

On the base of knowledge, theory, or methods: The activities performed at TASI and IUPUI will have great impact to the transportation safety. The pedestrian CIB modeling activity provides a pedestrian collision imminent braking model for real vehicles, which can be used by public for transportation safety research and technology development. This simulation model provides a realistic reference for evaluating the safety improvement for V2V related pedestrian safety studies.

On the development of transportation workforce development: Three IUPUI Master's students in the Department of Electrical and Computer Engineering are working on this project as part of their graduate degree requirements under the guidance of faculty PI's in the UTC program. Potential involvement by senior students in this project will also contribute to training of next generation engineers needed by transportation and automotive industry in this new field.

On technology transfer: IUPUI is actively pursuing the transfer and dissemination of the CAIS technology to Driving simulator company and driving simulation community. The CAIS technology enables more accurate and consistent infusion of alcohol for testing subjects in terms of BrAC, hence making the drunk driving study more precise and reliable.

Changes or Problems: Nothing to Report

Project 6: Safety Policy Implications and Information Dissemination

Project Lead: Beth-Anne Schuelke Leech

Accomplishments

Progress toward stated objectives and goals:

There are several goals and objectives with this project.

1. Develop an understanding of the policy and regulatory issues of pre-crash scenarios and technologies. This understanding is to be integrated into the early stages of R&D projects undertaken at the UTC to improve the knowledge transfer and use by policymakers and regulators.
2. Bridge the technical-non-technical divide with respect to intelligent vehicle systems. This requires finding and leveraging educational and outreach opportunities, either by holding in person forums and meetings, or by preparing videos or virtual meetings to be shared online.
3. Undertake research relevant to this project that will identify important factors affecting technology and innovation adoption. This research is to lead to publications in academic journals and translated into at least one policy brief for wider dissemination.

Several important activities have been undertaken in support of these grant goals and objectives.

1. Several collaborations were undertaken, which are described below under collaborations. These collaborations will support the research and outreach activities.
2. Preparations were begun to host several forums over the next year, bringing together different stakeholders to discuss the different technical and policy components of safety, crashes, and vehicle systems. The purpose of these forums is to both disseminate and gather information from policymakers, engineers, automotive manufacturers, suppliers, and drivers. A grant application was submitted to support this activity.
3. Research was begun to understand the policy and regulatory issues associated with safety, crashes, and intelligent vehicle systems. This research employs both big data analytics on unstructured data and econometric models. This research will be supported by primary research using semi-structured interviews with stakeholders.

Preliminary findings:

Research thus far revealed that there was a significant shift in focus by policymakers between the 1990s and 2000s. In the 1990s, safety discussions were focused on how to minimize property damage resulting from crashes. In the 2000s, the focus has shifted to crash avoidance. This may indicate that the dominate stakeholders shifted or it may be reflective of development and adoption of advanced technologies.

***Opportunities for training and professional development*:** Currently, we are looking to hold the first forum in the Fall of 2014.

***Dissemination of results*:** Nothing to Report

Plans for next reporting period: In the next reporting period, we are planning to get two papers prepared for submission for publication with my collaborators. We are also planning on continuing with preparations for the fall forum, including identifying speakers and invitees. We will begin interviewing stakeholders on safety, crashes, and intelligent vehicle systems.

Products**:** Nothing to report

Collaborations**:**

There are three collaborators working on this project: Betsy Barry, Clayton Darwin, and Suzanne Smith. These three collaborators are visiting scholars at the Center for Automotive Research at the Ohio State University for 3 months. These collaborators are helping Dr. Schuelke-Leech to look at the policy discussions around safety, vehicle crashes, and intelligent vehicle systems using Federal government documents from 1990 through 2014. The goal of this collaboration is an academic publication and support of knowledge creation, education, and outreach.

Also, Matt Roberts has begun collaborating with Beth-Anne Schuelke-Leech and Tamar Forrest on a project looking at the safety divide and the potential socio-economic disparities of safety technologies. The goal of this collaboration is an academic publication and support of knowledge creation, education, and outreach.

Impact: Nothing to Report

Changes/Problems: Nothing to Report

Project 7: Technology and Enhancements to Improve Pre-Crash Safety

Project Lead: Ümit Özgüner (OSU)

Accomplishments

This project covers a number of smaller sub-topics relevant to technology and enhancements to improve pre-crash safety with the possibility of future expansion. The topics initiated in the first year have been on:

- Topic I: Testing bio-monitors and their value in improving crash safety and predict, using behavior models, and clarifying the extent to which monitoring information can be effective in improving pre-crash safety.
- Topic II: Utilizing simulator studies and field tests to clarify the value of V2I and V2V communications for improving pre-crash safety.
- Topic III: Utilizing behavioral models resulting from other UTC projects to study the impact of both intra-vehicle and inter-vehicle communication cybersecurity on pre-crash scenarios.

In each of these a student has been supported to investigate theoretical and practical aspects of the problem. In the second year, we expect at least one of the topics to expand, with the possibility of adding one or more topics,

In Topic I, preliminary investigations have been performed in the use of EEG monitoring for possible driver intent detection. In Topic II, hardware has been purchased to investigate imbedded processor architecture. We expect cybersecurity issues to become more relevant and worth attention in CrIS.

Products

Publications

Ozbilgin, G., Kurt, A., & Ozguner, U. (July 2014). "Using Scaled Down Testing to Improve Full Scale Intelligent Transportation," to appear in *Proceedings of 2014 IEEE Intelligent Vehicles Symposium*. Dearborn, MI.

Collaborations: Nothing to report

Impact: Nothing to report

Changes or Problems: There has been no change in overall goals or objectives.