CENTER FOR CONNECTED AND AUTOMATED TRANSPORTATION

Program Progress Performance Report

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Center Director:	Henry Liu CCAT Director Professor of Civil and Environmental Engineering Phone: (734) 647-4796 Mobile: (651) 260-5876 Email: henryliu@umich.edu
Submitted By:	Debby Bezzina CCAT Managing Director Phone: (734) 763-2498 Mobile: (734) 751-1778 Email: dbezzina@umich.edu
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UMTRI · The University of Akron · Illinois Center for Transportation · Purdue University · Washtenaw Community College · Central State University

1. Accomplishments

The University of Michigan at Ann Arbor (UM), in partnership with Purdue University, University of Illinois at Urbana-Champaign (UIUC), University of Akron (UA), Central State University (CSU), and Washtenaw Community College (WCC), established the USDOT Region 5 University Transportation Center: Center for Connected and Automated Transportation (CCAT). The FAST Act research priority area for CCAT is promoting safety and CCAT will focus its efforts in the field of comprehensive transportation safety and congestion management by taking advantage of connected vehicles, connected infrastructure, and autonomous vehicles. This report documents the progress for the reporting period June 1, 2017 through March 31, 2018.

1. A Research Progress

CCAT research targets six areas: (1) Control and Operations; (2) Infrastructure Design and Management; (3) Human Factors; (4) Policy and Planning; (5) Modeling and Implementation; and (6) Enabling Technology. As CCAT entered year 2, several new projects were selected and several existing projects were approved for phase 2 funding. The following are the active research projects:

University of Michigan

1. ***Driving Etiquette.*** Apply deep learning techniques to establish standards and serve as basis to ensure autonomous vehicles drive "like safe human drivers." This project will collect a large amount of naturalistic driving video data from the Ann Arbor CV deployment and selected partner organizations' areas (equip 50 volunteers' cars with a smart phone). The data will be used to train algorithms to learn about "what is appropriate" (use a combination of machine learning and Monte Carlo tree search techniques).
   PI: H. Peng
   Status: The team has queried naturalistic data from the Safety Pilot Model Deployment (SPMD) project lead by the University of Michigan Transportation Research Institute (UMTRI). The focus over the past quarter has been on the car following, free-flow driving and lane change behaviors. Detailed statistics of vehicle acceleration in highway and local driving, free flow speed (in comparison with posted speed limit), range/time headway selection, and starting of brake vs. time to collision, brake vs. range, lane change gap acceptance and duration of lane change are analyzed. The team is planning to submit a conference paper in June of 2018.
   Research Thrust: Enabling Technologies
   CCAT Funds: $150,000
   Cost Share: None
2. ***CAV Data Infrastructure and Access.*** Develop process for general access to CAV data generated by researchers at UM. Also, develop code books for data deposits.

PI: H. Liu, Carol Flannagan
Status: Phase 1 is nearly complete. The data release form is finished and the process developed. Several students and faculty members have used the new system. Any lessons learned were incorporated into the process and/or data use agreement. The next step is to migrate the process to an on-line format. Phase 2 will focus on creating codebooks for the data, establishing a metadata repository, and instituting a data oversight committee. Phase 2 will begin in September of 2018.
Research Thrust: Infrastructure Design and Management
CCAT Funds: $33,559 (Phase 1), $63,299 (Phase 2)
Cost Share: Contribution may be provided by other UM organizations that are heavy data users (Mcity, UMTRI)

3. ***AV IQ Test (Design an evaluation system to determine the intelligence of AVs***). Testing and evaluation is a critical step in the development and deployment of connected and automated vehicles (CAVs). It is essential to identify appropriate testing scenarios to evaluate the "intelligence" of the vehicle, similar to a driver's license test, which indicates whether a CAV can drive safely and efficiently without human intervention. The objective of this project is to design a testing scenario library that can evaluate a CAV in terms of safety, efficiency, and functionality.
   PI: H. Liu, Y. Feng
   Status: A hierarchical structure is designed to construct the scenario library, namely functional scenarios, logical scenarios and specific scenarios. The functional scenarios and logic scenarios are summarized by analyzing the crash typologies from national crash databases. The parameters of logic scenarios are sampled from the driving behaviors analyzed from naturalistic driving data (NDD). To determine the parameters of specific scenarios (i.e., background vehicle trajectory profile), an optimization problem is formulated with time to collision (TCC) as the objective function. The constraints includes vehicle dynamics (maximum acceleration and deceleration), vehicle behaviors (car following and lane changing), and environment factors (visible distance, speed limit).
   Research Thrust: Modeling and Implementation
   CCAT Funds: $150,000
   Cost Share: None
4. ***Development of an Augmented Reality Environment for Connected and Automated Vehicle Testing.*** Using real vehicles as background traffic for CAV testing in a closed test facility is not only costly, but also difficult to coordinate and control. To address the limitation, in this project we develop an augmented reality testing environment, in which background traffic is generated in microscopic simulation and provided to testing CAVs to augment the functionality of the test facility. The augmented reality combines the real-world testing facility and a simulation platform, in which movements of testing CAVs and

traffic signals in the real world can be synchronized in simulation, while simulated traffic information can be provided to testing CAVs' communication system.
PI: H. Liu
Status: Augmented reality framework complete and operating at Mcity. Two scenarios have been developed: (1) red light violation where a virtual vehicle is generated and will run the red light, the CAV under test will detect the virtual vehicle and stop to avoid the collision, even though the CAV has the right of way; and (2) railway crossing where a simulated train will be detected by the CAV and the CAV will stop and wait for the train. A communication test was conducted to test the latency of the proposed system. The average message delay with 10 simulated vehicles was only about 32ms and the delay with 100 simulated vehicles was about 102ms, which guarantees the real-time performance.
Research Thrust: Modeling and Implementation
CCAT Funds: $150,000
Cost Share: None

5. ***CAV-Based Intersection Maneuver Assist Systems and Their Impact on Driver Behavior, Acceptance, and Safety (CAVIMAS).*** The objective of this project is to conceptualize, prototype, and evaluate an intersection maneuver assistance system in a simulated driving environment to empirically examine driver behaviors and mental models. The goal is to study driver behaviors related to use of (1) in-vehicle driver interfaces for warning, (2) automated intersection maneuver assistance controls, and (3) integrated driver display warning and vehicle control systems, including drivers' perception and acceptance of these systems.
PI: A.K. Pradhan, S. Bao, J. Sullivan
Status: Conceptualization & design of the CAVIMAS concept, including human-machine interface, alerts/warnings modalities, and operational concept have been completed. An experimental design for evaluation of the system has been completed as well, with identification of intersection types and scenarios, of risk categories, and of driver responses. Prototyping of the system on the driving simulator is underway, after which the experimental evaluation will take place.
Research Thrust: Enabling Technologies
CCAT Funds: $150,000
Cost Share: None
6. ***Enhancing Network Assignment Models for Capturing Emerging Shared-Use Mobility Services.*** Develop a simulation model for shared mobility that explicitly models the behaviors of both service operators and travelers.
PI: N. Masoud, Y. Yin
Status: The modeling of decentralized (in which vehicles choose which areas to serve based on their individually defined utility functions) and centralized (in which a shared-use mobility service provider optimally assigns vehicles to requests based on a system-level

objective function) systems have been 90% completed. The study area for numerical experiments has been identified and the data from this area has been pre-processed. The remaining task are completing the modeling efforts, and implementing both approaches in the study area to enable comparisons.
Research Thrust: Modeling and Implementation
CCAT Funds: $35,044
Cost Share: $121,182

7. ***An Investigation of User Responses to Connected and Autonomous Vehicles Using Prompted Choice Experiments.*** Introduce users to CAV technologies utilizing Mcity properties. Gather responses and analyze. Also compare these responses of users with CAV experience/knowledge, with previous studies that benchmarked the response of users without direct experience.
PI: T. Bills
Status: Completed a literature review on the current state on research methods for modeling the expected impacts of CAV technologies on transport-disadvantaged communities. This review shows that no studies have considered how exposure to CAV technologies may influence CAV adoption patterns. Further, new (utility-based) performance measures are necessary in order to compare potential CAV related impacts across income classes and other disadvantaged groups. The next stage of this project aims to leverage UM surveys of CAV shuttle users to investigate how riders' potential adoption patterns will differ from the general population, using conjoint stated preference analysis.
Research Thrust: Human Factors
CCAT Funds: $21,600
Cost Share: None
8. ***Trajectory Based Traffic Control with Low Penetration of Connected and Automated Vehicles.*** This project aims at developing new science and technology of vehicle trajectory based traffic control, especially under lower penetration of CAVs. A two-stage research plan is proposed with corresponding key research questions. The first stage corresponds to the period that human-driven vehicles start to become connected vehicles (CVs). The key research question is how to utilize a limited number of CV trajectories to perform detector-free real-time adaptive traffic control at a corridor and network level. The second stage corresponds to a mixed traffic condition. The critical research question at this stage is how to control CAV trajectories and traffic signals jointly to further improve the intersection operations regarding safety, mobility, and sustainability.
PI: H. Liu, Y. Feng
Status: Planned start date May 2018.
Research Thrust: Control and Operations
CCAT Funds: $150,000
Cost Share: None

9. ***Adapting Land Use and Infrastructure for Automated Driving.*** Develop quantitative modeling frameworks to analyze the impacts of automated vehicles on land use and infrastructure
   PI: Y. Yin (UM), S. Peeta (Purdue)
   Status: Started in February 2018. In the process of conducting a literature review on modeling the impacts of automated vehicles on land use and infrastructure, and infrastructure adaptation planning.
   Research Thrust: Modeling and Implementation
   CCAT Funds: $127,810 UM
   Cost Share: None.
10. ***Machine Learning, Human Factors and Security Analysis for the Remote Command of Driving: A Mcity Pilot.*** Both human drivers and autonomous vehicles are now able to drive relatively well in 'typical' (frequently- encountered) settings, but fail in exceptional cases. Worse, these exceptional cases often arise suddenly, leaving human drivers with a few seconds at best to react—exactly the setting that people perform worst. This work proposes methods for leveraging groups of remote operators to provide assistance on- demand. Unlike prior work, we introduce collective workflows that enable groups of operators to significantly outperform any of the constituent individuals on control and correction tasks. We propose to develop a software platform for Mcity that enables a group of remote operators to command the autonomous test vehicles at Mcity. A pilot study will be conducted at the Mcity Test Facility.
    PI: R. Hampshire, W. Lasecki, S. Bao
    Status: Planned start date September 1, 2018.
    Research Thrust: Enabling Technology, Human Factors, Control and Operations
    CCAT Funds: $178,371
    Cost Share: None.
11. ***Supporting People with Vision Impairments in Automated Vehicles: Challenge and Opportunities.*** Autonomous and automated vehicles (AVs) will provide many opportunities for mobility and independence for people with vision impairments (PwVI). This project will provide insights on the challenges and potential barriers to their adoption of AVs. We will examine adoption and use of ridesharing services, which are similar means of single-rider transportation for PwVI, by conducting observations and interviews. In addition, we will investigate social receptiveness of sighted people and PwVI towards the use of AVs through focus groups. From these studies, we will be able to provide recommendations to AV manufacturers and suppliers for how to best design vehicles and interactive systems that mitigate barriers that PwVI face.
    PI: R. Brewer, N. Ellison
    Status: IRB for Phase 1 submitted and approved. Conducted review of existing literature. Established partnerships with National Federation of the Blind and Greater Detroit Agency

for the Blind and Visually Impaired for recruiting participants. In process of hiring a graduate student research assistant. Planned start term of human subject research is Summer 2018.
Research Thrust: Human Factors
CCAT Funds: $168,337
Cost Share: None.

12. ***Design and Operation of Efficient and Budget-Balanced Shared-Use Mobility Systems.*** Shared-use mobility systems allow individuals traveling along the same routes to share (parts of) their trips. Routing/scheduling and pricing of shared-use mobility services are often considered as two separate problems due to the high computational complexity of solving the joint problem. This approach disregards the fact that both agent types (i.e., riders and drivers) in ridesharing systems are utility maximizers, and therefore the operational feasibility of a joint trip does not necessarily translate into the agents' willingness to participate. In this project we devise a mechanism that solves the allocation and pricing problems jointly, guaranteeing individually rational and incentive compatible (within bounds) ridesharing proposals, while seeking a budget-balanced solution that does not require the system to be subsidized.
PI: N. Masoud
Status: We have completed about 30% of our modeling efforts. A VCG-based model with individual rationality and incentive compatibility constraints has been developed. We are working towards obtaining limits on the budget-balanced property. In parallel, we have selected a study area for our experiments, and are in the process of preparing the data.
Research Thrust: Planning and Policy
CCAT Funds: $108,049
Cost Share: None.

University of Akron

1. ***Access Control at Major-Minor Intersection through CAV in Mixed Traffic.*** This research studies gap characteristics and utilization at intersection entrances when CAV is mixed with ordinary vehicles (non-CAV) to improve intersection operations. The impact of data communication between the experimental vehicle and the RSU will be investigated on the reliability and effectiveness of the control logic implementation. The expected benefits on intersection efficiency improvements at different levels of CAV market penetration will be summarized.
PI: P. Yi
Status: The first part of work was to conduct traffic flow analysis and develop the basic models for applications. During this reporting period, the first part of work was completed and the next steps on hardware system and field testing has been started.
Research Thrust: Control and Operations

CCAT Funds: $150,000
Cost Share: $150,000

Purdue University

1. ***Development of a Dynamic Network Traffic Simulator for Mixed Traffic Flow under Connected and Autonomous Vehicles.*** Develop a unified car-following modeling framework that models mixed-traffic streams under different market penetration rates of CAVs. It will also perform stability analyses to explore implications for safety and mobility.
   PI: S. Peeta
   Status: Started January 2018. The vehicle topology combinations of the mixed flow platoon (including CAV, AV, CV and HDV) were investigated and the models proposed which describe the interaction between any two kinds of models. The impact of information topology dynamics to the CAV control performance was analyzed. A mixed flow multi-lane cell-transmission model is being developed to describe the mixed traffic flow characteristic by considering both longitudinal and lateral improvement by CAV technology.
   Research Thrust: Human Factors, Control and Operations, and Modeling and Implementation
   CCAT Funds: $143,004
   Cost Share: $117,468
2. ***Develop In-Vehicle Information Dissemination Mechanisms to Reduce Cognitive Burden in the Information-Rich Driving Environment.*** Understand the impacts of real-time information characteristics and multiple dissemination sources on driver cognition, and its effects on the driver decision-making process and ability to comprehend information safely.
   PI: S. Peeta
   Status: Started January 2018. Several tasks are complete; design and prepare driving simulator environments; pilot testing and preparing IRB application; and recruitment of participants and perform experiment. The final task, data analysis and research reporting and dissemination, is in progress.
   Research Thrust: Human Factors
   CCAT Funds: $129,096
   Cost Share: $120,000
3. ***Non-Connected Vehicle Detection Using Connected Vehicles.*** Develop a model to identify non-CV locations/trajectories that will be integrated with a cooperative situation awareness framework to analyze real-world vehicle trajectory data to aid the situational awareness of CVs under low market penetration rates.
   PI: S. Peeta
   Status: Started January 2018. Work to date focused on Task 3: Integrate the proposed HMM model for the unequipped vehicle location estimation. The mathematical structure

for implementing the HMM model was developed and verified by HDV trajectories from NGSIM data.
Research Thrust: Enabling Technology, Control and Operations, and Modeling and Implementation
CCAT Funds: $138,505
Cost Share: $117,468

4. ***Cooperative Control Mechanism for Platoon Formation of Connected and Autonomous Vehicles.*** Design cooperative control mechanisms for a CAV platoon under realistic vehicle-to-vehicle (V2V) communication environments to maximize platoon performance.
PI: S. Peeta
Status: Started January 2018. Work to date focused on developing mathematical models characterize the dynamics of a platoon under the proposed consensus for vehicles in a platoon. Work also focused on designing an algorithm to solve the model predictive control problem for CAV platoon.
Research Thrust: Control and Operations, Modeling and Implementation
CCAT Funds: $138,518
Cost Share: $140,000
5. ***Design of Urban Landscape and Road Networks to Accommodate CAVs.*** Analyze and develop urban landscape and road network designs to accommodate CAVs that can maximize safety and comfort for all road users, including motorists, public transit users, cyclists and pedestrians.
PI: S. Peeta
Status: Started January 2018. Created four types of roadway designs for a downtown one-one-way street with different foci on mobility, safety, accessibility, and sustainability. Designed a survey to capture people's attitude towards different roadway designs and how these designs can affect their willingness to pay for CAVs. IRB application is in progress.
Research Thrust: Policy and Planning, Controls and Operation, Infrastructure Design and Management
CCAT Funds: $139,148
Cost Share: $95,386
6. ***Pedestrian-Vehicle Interaction in a CAV Environment – Explanatory Metrics.*** Measure the interaction between pedestrians and motorists in order to document the variety of expected interactions between pedestrians and autonomous vehicles.
PI: J. Fricker
Status: Started January 2018. Established the shortage of published work on the interaction of pedestrians and motorists at unsignalized crosswalks. Assembled methods commonly used to observe and measure the interactions. Built an inventory of behavioral characteristics that will confirmed or refuted in our videos. Converted data from 5 hours of video of pedestrians crossing one-way streets into digital databases. Now that weather has

improved, videos are being made for the same places and times one year later – only now the one-way streets have been converted to two-way operation. Databases containing measureable characteristics of pedestrian and motorist interactions have been created from the "one-way" videos. Several analyses using the "one-way" data have been conducted, with follow-up analyses underway. The analyses will be repeated with the two-way data. A white paper has been prepared to summarize the preliminary findings to date. "A Methodology for the Analysis of Pedestrian Behavior in Semi-Controlled Crosswalks", by David Villarreal and Jon Fricker, Purdue University, Lyles School of Civil Engineering.
Research Thrust: Human Factors
CCAT Funds: $66,280
Cost Share: $66,280

7. ***Autonomous Vehicle's Impacts on Energy Use and GHG Emissions.*** Examine the potential effects of autonomous vehicles on energy demand and GHG emissions by improving projections of future travel demand and patterns in response to using a behavioral experiment (survey), and estimating the energy and carbon intensity of vehicle travel.
PI: K. Gkritza
Status: Started January 2018. Designed the survey instrument, submitted to IRB, and received approval. Data collection will begin in April and last three to four weeks.
Research Thrust: Planning and Policy
CCAT Funds: $63,450
Cost Share: $65,000
8. ***Design and Management of Highway Infrastructure to Accommodate CAVs.*** Examine how the various maturity levels of connected and autonomous vehicle (CAV) implementation will influence the design and management of highway infrastructure.
PI: S. Labi
Status: Started January 2018. Conducted Literature review on the following topics: (a) the concept and evolution of autonomous vehicles (b) the concept of connected vehicles, (c) any discussions in research literature or in the print and electronic media regarding infrastructure preparedness for CAV. After much deliberation, the team decided to use three levels of autonomy for the impact assessment: levels 1, 3, and 5. Recognizing that demand is a critical input factor in the analysis, the research team designed and administered a questionnaire survey to assess the expected levels of CAV demand. Identified a highway section in Indiana to serve as a possible case study for the project. An inventory of the physical infrastructure features of these highways is in progress.
Research Thrust: Planning and Policy
CCAT Funds: $70,000
Cost Share: $70,000
9. ***Public Acceptance and Socio-Economic Analysis of Shared Autonomous Vehicles: Implications for Policy and Planning.*** Investigate public acceptance towards SAVs by

assessing the intention to switch from public transportation to ride-sharing SAV services using data from two Midwest cities (Indianapolis, IN and Chicago, IL). Also, inform policy and planning decisions by conducting a socio-economic analysis using the results of market segmentation analysis for the two study areas.
PI: N. Gkritza
Status: Project approved but not started.
Research Thrust: Planning and Policy
CCAT Funds: $75,941
Cost Share: $70,000

University of Illinois at Urbana-Champaign

1. ***Operations of Connected and Autonomous Freight Trucks under Congestion and Infrastructure Cost Considerations.*** This proposal aims at developing an integrated connected and autonomous truck routing model that simultaneously considers interdependency between traffic lane/"track" use, platooning, and pavement deterioration and rehabilitation, such that the total life-cycle societal costs due to infrastructure investment, traffic delay, and pavement life-cycle costs are minimized.
PI: I. Al-Qadi, Y. Ouyang, J. Roesler, H. Ozer, H. Meidani
Status: Autonomous vehicle technologies allow precise control of truck fleets, which leads to enhanced truck platooning that increases traffic flow, reduces congestion, improves safety at high speeds, and reduces emissions. Yet, such precise platooning operations, if implemented without caution, may cause more damage to pavement structures because the lateral position of successive autonomous and connected trucks (ACTs) within a lane is similar (i.e., channelized traffic) while it is more scattered for human-driven trucks (HDTs). Therefore, this study develops a platooning control strategy for a fleet of ACTs such that trucks' lateral shifts within a lane can be explicitly optimized to minimize damage to the pavement as well as significantly reduce energy consumption from aerodynamic resistance. The obligatory prior step to perform such optimization is to simulate the cases where the trucks in a platoon have different lateral positions. Therefore, the research team has developed a new pavement design framework that takes the lateral position of wheel loads as a direct input. In this framework, inherent randomness of lateral position for HDTs is also considered to simulate the mixed traffic scenarios where the truck traffic is composed of different percentages of ACTs and HDTs. Additionally, the research team has developed Finite Element (FE) models to analyze the change in aerodynamic drag forces as the ACTs in a platoon are laterally shifted. These models allow developing surrogate models that input relative lateral position of ACTs and output increase in aerodynamic drag, consequently fuel consumption. The research team has integrated FE truck models with developed pavement design framework to optimize truck platooning which in turn will lead more sustainable

infrastructure systems where pavement damage and fuel efficiency are optimized. By the end of spring semester, an optimization problem to identify the position of trucks in a platoon will be studied. The optimization will consider the aerodynamic factors, as well as the pavement damage, and will incorporate in its first stage a probabilistic wind model. In addition, the research team is currently drafting the literature review of AV sensing roadway/roadside features. The main sensors used in AV have been identified, along with their corresponding working principle, advantages, and disadvantages. The literature review serves as starting point for the research team to proposed road infrastructure adjustments that can enhance the performance of AV and its sensors.
Research Thrust: Modeling and Implementation
CCAT Funds: $232,060
Cost Share: $232,060

Central State University

1. ***CAV Systems Incorporating Air Pollution Information from Traffic Congestion.*** Through CCAT center, CSU proposes to study air pollutants under different traffic congestion scenarios along selected freeways in Ohio. The study captures pollution intensities in different seasons of the year representing different atmospheric stabilities and concentration of pollutants as a function of hold up times and traffic densities. Our prior work has determined typical hot spots in Ohio along freeways that are prone to high traffic densities and possible congestion. MOVES will be used to generate these scenarios to determine emissions from vehicles in a simulated traffic congestion scenario. ODOT traffic data will be used these scenarios. Resulting air pollution from emissions will be determined using a dispersion model and compared with NAAQS. A model will be developed to assess severity of air pollution, which will be used to forecast air quality index for the congested areas on freeways. CAV technology will then be deployed to communicate the information to travelers on freeways on radio channels approaching congested areas.
   PI: K. Nedunuri and R. Kandiah
   Status: Not yet started. Planned start date is June 11, 2018
   Research Thrust: Modeling and Implementation.
   CCAT Funds: $49,938
   Cost Share: $49,938 (UM)
2. ***CAV Developed Vehicles as Real-Time Sensors for Assessing Greenhouse Gases.*** CSU proposes to study air pollutants under different traffic congestion scenarios along selected freeways in Ohio. The study captures pollution intensities in different seasons of the year representing different atmospheric stabilities and concentration of pollutants as a function of hold up times and traffic densities. MOVES will be used to generate several scenarios to determine emissions from vehicles in a simulated traffic congestion scenario. ODOT traffic

data will be used in these scenarios. Resulting air pollution from emissions will be determined using a dispersion model and compared with GHG standards for emissions. A model will be developed to assess severity of air pollution, which will be used to forecast air quality index for the congested areas on freeways. CAV technology will then be deployed to communicate the information to travelers on freeways on radio channels approaching congested areas.

PI: K. Nedunuri and R. Kandiah
Status: An inventory of priority Pollutant and greenhouse gas emissions from On-Road Vehicles in Franklin County was conducted.
Research Thrust: Enabling Technology
CCAT Funds: $49,938
Cost Share: $49,938 (UM)

1. B Outreach, Education, Leadership Development, and Workforce Development

This period, CCAT organized and hosted the first annual Global Symposium for Connected and Automated Vehicle and Infrastructure on March 7-8, 2018. Industry, government, academia, and media attended this 2-day event. The keynote speaker was Bob Zhang, Co-Founder and CTO, Didi Chuxing. CCAT research was also highlighted at the event:

- Ping Yi (University of Akron) – Access Control at Major-Minor Intersection in Mixed Traffic Flow with CAV
- Srinivas Peeta (Purdue) – Cooperative Control Mechanism for Platoon Formation of Connected and Autonomous Vehicles
- Yafeng Yin (University of Michigan) – Adapting Transportation Infrastructure Systems for Automated Driving
- Imad Al-Qadi (University of Illinois Urbana-Champaign) – Leveraging Autonomy in Truck Platooning to Improve Freight Transportation Sustainability

ITS Michigan sponsored the student poster competition and awarded two (2) $500 Scholar Awards for outstanding entry in the CCAT student poster competition. Undergraduate students, graduate students, doctoral candidates and post-doctoral researchers from Purdue, University of Illinois, and the University of Michigan participated. The two winners were:

- Purdue graduate student Dongyoon Song “Effects of Cognitive Load on Driver Satisfaction under Real-Time Travel Information” (https://engineering.purdue.edu/CE/AboutUs/News/Transportation_Features/dong-yoon-song-wins-its-michigan-scholar-award-for-best-student-poster).

- UM doctoral candidate Shihong Huang "Adaptive Signal Control for Arterials Using Online Connected Vehicle Data"

The full agenda and speaker presentations can be found at ccat.umtri.umich.edu.

In addition to the symposium, CCAT consortium members completed the following outreach, education, leadership development, and workforce development activities during this reporting period:

Washtenaw Community College

- Develop a certificate of completion training program for the field of transportation technicians and other job functions related to the skilled technician work in the Connected and Automated Vehicle and Transportation industry cluster [CAV/CAT].
- Develop Credit Education Programs to address the growing demand for talent in STEM-oriented occupations in the emerging Connected and Automated Transportation industry cluster.
- Foster K-12 STEM career pathways in Connected and Automated Transportation fields and student dual enrollments in related certificate and degree programs.
- A WCC staff member presented at the National Operating Center of Excellence (NOCoE) sponsored forum on November 8, 2017. The forum is dedicated to identifying the core considerations for a pre-employment workforce development strategy aimed at producing both TSM&O generalists and specialists with key support capabilities.
- A monthly WCC On the Record [OTR] Newsletter and two internal WCC- ATC newsletters [Nov. '17/Feb. 18] were issued highlighting recent events and activities of the CCAT Grant. The target audience included faculty, administrators and students.
- In addition to the WCC OTR Newsletter and internal ATC newsletters, additional efforts were taken to develop information about emerging career pathways in the field of Connected and Autonomous Vehicles.
- Began an internship program with the University of Michigan Transportation Research Institute (UMTRI) for WCC Automotive Service Technology students to install connected vehicle equipment on vehicles that are being deployed as part of the Ann Arbor Connected Vehicle Test Environment (AACVTE).

University of Michigan

- Distinguished Lecture Series (two per year): Presentations were held live at UMTRI and shared via WebEx for remote attendees.

  - Dr. Chris Hendrickson, Carnegie Mellon. October 4, 2017. Transformational Transportation Technologies: Research at Carnegie Mellon University.
  - Dr. Hani Mahmassani, Northwestern. April 11, 2018. Autonomous Vehicles and Connected Urban Mobility: Rethinking Public Transit.
- Education: Developed course curriculum for Connected and Automated (CAT) Professional Practice
- Leadership Development: Supported MiTSO (Michigan Transportation Student Organization)
  - Worked with ITS Michigan to establish a student chapter under MiTSO
  - Arranged for speakers and provided lunch for the ITE Student Chapter Speaker Series:
    - Scott Shogan, Vice President, WSP
    - Robert Caster, Engineering Technical Expert, Bosch
  - Provided travel for five students to attend TRB
- Published CCAT Newsletter November 2017 edition
- Maintained CCAT website (ccat.umtri.umich.edu)
- Participated in conferences:
  - PI Neda Masoud gave an invited talk titled “P2P Ridesharing: Using the Existing Capacity to Serve Transportation Demand” in the ASCE speaker series at University of Michigan
  - PI Yafeng Yin gave an Invited Seminar titled “Modeling and Analysis of Ride-Sourcing Markets“ at Tongji University, Shanghai, China, March 29, 2018.
  - CCAT Managing Director Debby Bezzina gave invited talks:
    - ASCE National Conference October 11, 2017
    - ITS World Congress, Montreal, October 30, 2017
    - Mcity Congress, November 15, 2017
  - UMTRI Director Jim Sayer gave invited talk titled “University-City Coordination for Smart Transportation Infrastructure in Ann Arbor, MI” at Smart Cities Week, Washington, DC, October 5, 2017.
- In this reporting period, twenty (20) academia, sixteen (16) government, twenty-two (22) industry, and fourteen (14)media outreach engagements occurred plus eleven (11) technical exchanges. Because of space limitations, full details of the engagements are not provided, but are available upon request.

Purdue

- Established connections with Indiana University–Purdue University Indianapolis (IUPUI) researchers who have carried out a “naturalistic” study of pedestrians in crosswalks.

Central State University

- Dr. Ramanitharan Kandiah presented "Advancing Mobility in the Connected World" at the Ohio Transpiration Engineering Conference on October 11, 2017.
- Moses Vines and Ramanitharan Kandiah. 2017. Inventory of Priority Pollutant and Greenhouse Gas Emissions from On-Road Vehicles in Franklin County, OH. *Ohio Transportation Engineering Conference (OTEC) 2017*. October 11, 2017 (Poster)

1. C Deliverables

The main deliverables for this reporting period were:

- PPPR #1 for 11/30/16 through 5/31/17
- Performance Indicators for 11/30/16 through 9/30/17
- All approved research projects' UTC forms were posted to the CCAT website and entered into RiP

Deliverables planned for next reporting period are:

- Continue to update the CCAT website to include planned outreach events, news research, etc.
- 2nd edition CCAT newsletter
- Conclude research project selection for year 2 funding (Purdue)
- Complete product submissions, as applicable
- Update all UTC forms to current status, post to CCAT website, and update RiP

2. Products

In this reporting period, the CCAT consortium created the following products:

University of Michigan

- Masoud, Neda, and Yuexi Tu. Trip-Based Graph Partitioning in Peer-to-Peer Ridesharing. Transportation Research Board conference, No. 18-06119. 2018
- Data Release Form for accessing and using research data from several UMTRI/Mcity research projects.

Washtenaw Community College

- The ITS Field Technician open enrollment course modules.

- Technology demonstration "Go-Cart" and CAV equipment for use with middle/high school project teams as an education aid to show principles and functions of CAV/CAT technology hardware. Procured LiDAR sensors, DSRC transmitter/receivers and other components.

Purdue University

- A cooperative adaptive cruise control (CACC) model considering dynamic Information Topology for the CAV platoon was established. The paper was submit to the 21st IEEE International Conference on Intelligent Transportation Systems.
- Taxonomies and models that describe interactions between pedestrians and motorists at unsignalized crosswalks.

Central State University

- MOVES model customized to estimate NAAQS and GHG.

3. Participants and Other Collaborating Organizations

One of the CCAT goals is to collaborate with other organizations within the CCAT consortium, within Region 5, and nationally. In year 2 of the CCAT grant, the University of Michigan and Purdue University developed a joint research project "Adapting Land Use and Infrastructure for Automated Driving." Additionally, the following tables summarize the collaborations that occurred during this reporting period.

CCAT Org.	Org.	Location	Contribution
WCC	MDOT	Lansing, MI	Collaborative activities and support on the development of CAV Infrastructure and talent requirements.
WCC	Center for Automotive Research (CAR)	Ann Arbor, MI	Collaborative research and work groups focused upon CAV and Infrastructure developments and talent requirements, including quarterly CAV workshops of regional partners.
WCC	Ann Arbor SPARK	Ann Arbor, MI	Community and industry collaboration on CAV and Infrastructure developments, talent requirements, and economic talent development initiatives.
WCC	MICHauto- The Detroit Regional Chamber	Detroit, MI	Collaborative on advocacy, awareness, business attraction and talent requirements for all aspects of the automotive and transportation industries.
WCC	Integral Blue	Madison Heights, MI	Collaborative research on job skills and descriptions. Reference projects include: MDOT RSU Deployment, MDOT SEMTOC Sys. Integration, MDOT Metro Region Wireless Path.

WCC	WSP (formerly Parsons Brinckerhoff)	Detroit, MI	Collaboration research on job skills and descriptions. Reference projects include Mcity, Ann Arbor Connected Vehicle Safety Pilot, Connected Corridor Initiative, and American Center of Mobility CAV Test Center.
WCC	Michigan Academy of Greater Mobility Advancement [MAGMA] – part of Workforce Intelligence Network for SE MI	Southeast, MI	As a convener organization, MAGMA convenes automotive Mfg. companies, MDOT, education, and workforce development to ensure the automotive & transportation industries obtain engineering & technical talent needed to support CAV's, hybrid, electric, lightweight, alternative fuel, & other advanced vehicle & transportation technologies.
WCC	Wayne County Community College District	Detroit and Wayne County, MI	Workforce training cooperative at the American Center for Mobility.
WCC	Center for Advancing Transportation Leadership and Safety (ATLAS Center) at UMTRI	Ann Arbor, MI	Published a report "Connected and Automated Vehicles Skills Gap Analysis" jointly with the Workforce Intelligence Network for Southeast Michigan, dated February 2017
WCC	Ypsilanti Community Utilities Authority	Ypsilanti, MI	Contributed field subsurface staking technician skill sets for laying cable infrastructure.
WCC	City of Ann Arbor	Ann Arbor, MI	The City of Ann Arbor sent job descriptions, credentials, etc. for the 5- levels of positions in its Transportation Division.
WCC	MITA	Okemos, MI	Collaboration on workforce training and creating a pre-apprenticeship program for K-12.
WCC	Danlaw	Novi, MI	Contracted with an Engineer-in-Residence to collaboration with faculty instructors on upgrading CIS/IT and Automotive Technology curricula and courses aligned with emerging CAV/CAT technologies.
WCC	Planet M, an initiative of the State of Michigan	Lansing, MI	Planet M, the epicenter for mobility initiatives, sponsored WCC for various vehicle and transportation technology events including the Automobili-D educational exhibits at the January 2017 North American International Auto Show in Detroit.
WCC	Ypsilanti Community Schools	Ypsilanti, MI	A partnership with WCC that identifies high school students interested in STEM careers to participate in key college learning activities, and who may be eligible for dual enrollment to earn an Associate's Degree in their 5th year.
WCC	General Motors Corporation (Warren Tech Center)	Warren, MI	Staff Researcher in the Connected Vehicle Systems Group at the General Motors Research & Development Center: Presentation for education and faculty professional development: Enabling Next Generation Automated Vehicles through Connectivity.

WCC	Scarlett Middle School	Ann Arbor, MI	A partnership with WCC that identifies middle school students interested in STEM careers to participate in key college learning activities, and who may be eligible for dual enrollment to earn an Associate's Degree in their 5th year.
WCC	Lear Corporation (Lear Cybersecurity)	Ann Arbor, MI	Staff Vice President of Cyber Security visited WCC to present "Automotive Cybersecurity- Next Challenges & Approaches"
WCC	Square One Education Network (SOEN)	Waterford, MI	Square One's "Signature Series" of STEM projects enable high school students to incorporate innovation and engineering into their project designs. This family of Innovative Vehicle Design projects provides students with a real world, authentic learning opportunity, including connected and autonomous technologies.
WCC	Washtenaw Technical Middle College	Ann Arbor, MI	Students and teachers to participate in project activities.
WCC	Greater Ann Arbor Prosperity Region Consortium [State of MI organized]	Ann Arbor and surrounding communities, MI	Economic and talent development program coordination in the consortium communities.
UM	Mcity	Ann Arbor, MI	Funding for additional projects including a pedestrian detection deployment and the transportation control room. Collaboration on joint project selection process.
Akron	City of Akron (Traffic Engineering Department)	Akron, OH	The Traffic Engineering Department of the city of Akron collaborates with the University of Akron in the project by providing test sites (intersections) and technical staff to facilitate field investigation and system testing
Akron	Pathmaster, Inc.	Aurora, OH	Pathmaster provides technical guidance in signal equipment adjustment and system integration.
Purdue	Chongqing University of Posts and Telecommunications	Chongqing, China	Funding for projects on cooperative adaptive cruise control for CAV platoon. Collaboration on joint project selection process.
Purdue	University of Michigan Transportation Research Institute (UMTRI)	Ann Arbor, MI	Dr. James R. Sayer, Director of UMTRI, has offered the assistance from some of his staff to assist the PI in areas where they themselves have already performed pedestrian safety research and can offer guidance and share lessons learned.
CSU	Transportation Research Board (TRB) and FHWA	Washington, DC	Facilitates recognition of CCAT research by students through Minority Student Fellows Program

4. Impact

University of Michigan

The use of augmented reality for CAV testing will save automobile manufacturers millions of dollars in development and validation costs.

Washtenaw Community College

The announcement of WCC opening an office at the American Center for Mobility has big impact upon the project goal to certificates of completion and talent development in CAT sectors. In collaboration with Wayne County Community College District, the colleges will focus attention on developing skills and competencies for new hires and incumbent workers needing skill development in V2V/V2I/V2X communications, advanced vehicle design and manufacturing, cybersecurity, data analytics and supply chain logistics.

Additionally, the announcement of WCC opening an office at the American Center for Mobility for workforce development are expected to precede employer demand for credit education certificates and degree programs. These programs for new hires and incumbent workers will likely focus upon skill development in V2V/V2I/V2X communications, advanced vehicle design and manufacturing, cybersecurity, data analytics and supply chain logistics.

Lastly, K-12 Students and teachers gained awareness of WCC's educational resources during the Square One Education Network [SOEN] Innovative Vehicle Design Mobility Challenge event at Mcity, May 6, 2017. With approximately sixty high schools competing, sixteen WCC staffers promoted its Advanced Transportation Center of educational programs, especially to high school juniors and seniors. It was observed many of the high school project teams had difficulty with their vehicles during the competition. Failures occurred with sensors and other vehicle parts. WCC will add repair materials/equipment to the workshops and competition event to allow the project teams to incorporate repairs and fixes.

5. CHANGES/PROBLEMS

There were no significant program changes or problems to report. However, two actions required prior written approval from OST-R grants official:

- International travel authorization for ITSA World Congress in Montreal.
- Approval to purchase a driving simulator ($8,405) as equipment that was not originally included in the CCAT budget. WCC used existing funds for the approved purchase.