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Bumper to Bumper: The Need for a National Surface Transportation Research Agenda

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Good afternoon Chairwoman Stevens, Ranking Member Baird and Members of the House Committee on Science, Space, and Technology Subcommittee on Research and Technology. Thank you for the opportunity to participate in today's hearing entitled, "Bumper to Bumper: The Need for a National Surface Transportation Research Agenda."

My name is Henry Liu and I am a Professor in the Department of Civil and Environmental Engineering at the University of Michigan and a Research Professor at the University of Michigan Transportation Research Institute. I am also the Director of the U.S. Department of Transportation's (DOT's) Region 5 University Transportation Center (UTC), Center for Connected and Automated Transportation, or as we call it,

CCAT. My research has been focused on transportation systems modeling and control with emphasis on the development of connected and automated vehicle (CAV) applications. In the past, my students and I have filed and obtained a number of U.S. patents, some of which have been funded by CCAT and have been implemented in the real world. In my role I am fully aware of the U.S. leadership in the evolution of transportation and mobility. I believe it is because of the ongoing support from the U.S. government in funding research and specifically funding UTCs like CCAT that gives us this advantage. However, without increased funding - that advantage is ours to lose.

Transportation is integral to society. However, there are increasing concerns with the existing transportation system: fatalities/injuries, congestion, and pollution. Every day on average in the United States, 100 people lose their lives on our roadways. In 2017, U.S. drivers spent an average of 41 hours a year in traffic during peak hours, which cost an average of $1,445 per driver. Congestion also produced 56 billion pounds of carbon dioxide (CO2) pollution and contributed to 3.1 billion gallons of wasted fuel in 2015. In addition, at least two societal trends, urbanization and the aging population, demand a fundamental reassessment of the future transportation system. CAV technologies hold the potential to substantially improve traffic safety and reduce traffic congestion, fuel consumption and emissions.

Today's hearing takes place at an important time. Driven by the rapid development of CAV technologies, we are on the cusp of a new revolution in transportation safety and mobility on a scale not seen since the introduction of automobiles a century ago. Although CAV technologies will continue their steady advance towards incorporation into public roadway systems, there exist a variety of

open questions and issues on technology development, policy and planning, and system design and operations that require answers and resolution.

My testimony today will be focused on the following three topics:

1. An overview of CCAT.
2. The impacts of the FAST Act on the UTC program and recommendations for improvements to the UTC program.
3. Needs and challenges to developing a national surface transportation research agenda.

Let me state at the outset, that the opinions I express are my own and do not necessarily represent those of the University of Michigan.

Overview of Center for Connected and Automated Transportation

CCAT was selected for funding by USDOT under the FAST Act which required that one Regional UTC address the field of comprehensive transportation safety, congestion, connected vehicles, connected infrastructure, and autonomous vehicles [49 U.S.C. 55-5(c)(3)(E)]. CCAT is a regional consortium of universities comprised of the University of Michigan at Ann Arbor (U-M), Purdue University, University of Illinois at Urbana-Champaign (UIUC), University of Akron (UA), Central State University (CSU), and Washtenaw Community College (WCC).

Located at the focal point of the U.S. auto industry, CCAT plays a unique regional role in promoting connected and automated transportation research, education, workforce development and technology transfer activities, which are of critical importance to the future of the region’s economy. CCAT aims to provide national and

regional leadership for connected and automated transportation research, education, training, and deployment. The CCAT team's extensive and substantive collaborations with stakeholders such as the region's state DOTs, local governments and the CAV industry ensure that our research translates to practical outcomes through prototypes, field tests, technology transfer, implementation, and policies.

CCAT's research focuses on overarching issues related to connected and automated transportation system (CATS) planning, design, and operations that affect transportation agencies and the general public. CCAT research thrusts include CATS' enabling technologies, CATS' modeling and implementation, CATS' control and operations, CATS' infrastructure design and management, CATS' policy and planning, and CATS' human factors. Sample research topics include traffic flow characteristics and operations for mixed streams of CAVs and regular vehicles; travel behavior under CAVs and implications for shared mobility; transportation infrastructure design and planning for CAVs; CAV data collection, management, dissemination and safe-keeping; cybersecurity management of CAVs and infrastructure; and societal impacts of CAVs in terms of safety, efficiency, and environmental sustainability. A central feature of CCAT's approach is to test and demonstrate emerging technologies and concepts by leveraging the Ann Arbor Connected Vehicle Test Environment, a unique 'living laboratory' that has instrumented urban streets and highways, thousands of connected vehicles, motorcycles, bicycles, and smartphones; and Mcity, a state-of-the art off-roadway test facility for CAV testing and evaluation developed at the University of Michigan.

Let me give you one example of CCAT funded research projects titled "Connected Automated Vehicle Testing Scenario Design and Implementation Using

Naturalistic Driving Data and Augmented Reality". Testing and evaluation is a critical step in the development and deployment of CAVs, yet there is no systematic way to design representative scenarios for validating CAV systems. In this project, researchers investigated how to design representative testing scenarios for CAVs systematically by mining and examining crash and naturalistic driving databases. A small set of critical scenarios were chosen from the entire scenario space to generate the scenario library, by considering both the maneuver challenge and exposure frequency of the scenario occurring in the real-world. The proposed framework is theoretically proven to obtain accurate evaluation results with much fewer number of tests, compared with public road test methods. The results of the project can be used as a guideline to create a comprehensive testing scenario library; thus, increasing the body of knowledge and understanding amongst lawmakers and transportation professionals as they develop CAV testing regulations and standards. The automakers can also utilize the library to accelerate their CAV testing procedure to ensure the safety and efficiency necessary to make driverless technology viable. Ultimately, the project lays a foundation for generating a complete and comprehensive set of scenarios that can systematically evaluate the "intelligence" of CAVs. At the moment, the research results generated from this project are being integrated with the augmented reality testing environment and being deployed in Mcity.

The pace of CAV technology development is unprecedented. This is powered not only by the traditional transportation industry, such as automakers, but also by the investment put forward by the IT industry such as Google, Microsoft, Uber, etc. Advance transportation is a rising industry, and the need for a skilled workforce trained in these

new technologies is rapidly emerging. This need exists for technicians as well as engineers. Current curriculum in traditional transportation engineering programs, however, cannot meet the needs of the future workforce. Students must be equipped with modernized course offerings and hands-on training to accommodate new technologies and provide them with forward-looking technical skills.

In 2014, U-M has reestablished the transportation program in the Civil and Environmental Engineering Department. CCAT takes advantage of the newly established transportation engineering program in U-M's Civil and Environmental Engineering Department. Unlike most programs, this transportation program focuses on next-generation transportation systems. Surrounded by top-notch engineering programs at U-M and having access to industry partners involved with Mcity, the new transportation program, as it will be built from the ground up, has the potential to be an exemplary program that cultivates future transportation leaders and innovators equipped with the necessary skills.

CCAT has also assisted the Michigan Transportation Student Organization (MiTSO), which include the student chapters for ITE, ITS America, and WTS, etc., to grow with the aim of attracting more students to the field of connected and automated transportation. To this end, experts from industry, academia, and government have been invited to give talks at the student chapters. Moreover, CCAT has organized tours for the student chapters to Mcity, UMTRI, and auto manufacturers to provide students with field learning experiences. Activities like this attract attention from industrial and academic entities across the region, but also help to cultivate future leaders in this field.

CCAT provides graduate students with opportunities to advance their academic knowledge in the classroom and through participation on research teams. We have also provided travel awards to technical meetings and conferences such as the Transportation Research Board Annual Meeting so that students can present research findings, network with professionals, and learn from experts from around the world.

Another unique feature of the CCAT consortium is the inclusion of Washtenaw Community College (WCC) as a partner institution. Located in Ann Arbor, WCC is a leader in preparing technicians for advanced vehicle technologies. The college recently established the Advanced Transportation Center to address one of the most important challenges facing the national deployment of connected vehicle technologies: qualified, job-ready employees trained in the latest intelligent transportation systems. Located within a mile of the largest connected vehicle deployment test bed in the world, WCC faculty and students will benefit from the test sites, the experts and the technology that will play a part in transforming the current transportation system, as well as playing a critical role in the revitalization of the economy of the State of Michigan.

In addition, with the support of CCAT, WCC is developing a credentialing program for technicians to address the skills necessary to work within the rapidly advancing field of CATS. WCC will create a blended learning approach consisting of extensive online learning and resources coupled with campus-based sessions that highlight critical thinking and problem-solving related to real world case studies from industry based partners. WCC will also utilize engineering professionals to serve as project managers of students placed in embedded systems test engineering practicums and/or other experiential learning practicums. Course credit will be awarded for these

practicums. The university grant partners may also serve as internship hosts for student interns who wish to work on CAV related research projects.

CCAT consortium universities/colleges provide a full-spectrum of educational programs, ranging from non-credit incumbent worker training to upscale engineering-concentrated programs, from 2- and 4-year degree programs to advanced education. This extensive educational structure provides students in this region a complete spectrum of workforce education. Training the future workforce with the necessary skill set is critical to the regional economy concentrated within the auto industry.

Since 2017, we have held two global symposiums on CAV's, and are already planning another for 2020 (April 14-15). Our symposium brings together industry and academia to discuss the path towards a national deployment. We host a quarterly colloquium with students, academia and industry that dive into specific topics such as efficient freight movement, the state of our infrastructure, and smart communities. We believe that a truly smart livable, economically vibrant future is one with performance and resilience, vision and leadership and with a culture of service and inclusion -- not just cars that drive themselves!

Recommendations for improvements to the UTC program

The UTC Program has provided funding to a wide variety of UTCs since the late 1980s. USDOT initiated the UTC Program in 1988 as authorized by the Surface Transportation and Uniform Relocation Assistance Act of 1987 to fund transportation curricula and research at universities nationwide. Since then, UTCs are awarded based on a competitive process following every transportation authorization. There are currently 37

UTCs collaborating with more than 120 universities throughout the country. In addition to federal funds, UTCs leverage funding from private, state, and local sources to conduct research, develop the workforce of tomorrow, and test innovations which make our transportation safer, more efficient, and more secure.

To better integrate technology transfer into the transportation research process, the UTCs are now required to develop Technology Transfer Plans (referred to as T2 Plans). The change from an optional to a mandatory T2 Plan for each UTC was a game changer and I believe that this will strengthen the UTCs' technology transfer efforts by making research results available to potential users. This will also stimulate more private investment that will extend UTC research projects.

In the 2016 UTC competition, the Department of Transportation received more than 200 highly qualified responses. As such, funding was not available for a significant number of applications which were deemed 'highly recommended' by the department's staff. To enhance innovation, expand workforce development, and leverage public private partnerships from UTCs, I recommend that the UTC program be fully reauthorized at no less than $150 million per year. Additional funding should be equally used to increase the investments made into UTCs, as well as to increase the number of 'national' and 'Tier-1' centers. The recommended increase is incumbent upon a much-needed increase in funding authorized as part of a FAST-Act reauthorization.

Additionally, I urge Congress to:

- Change match requirements to allow for Federal funds to be used as match, akin to other research programs.

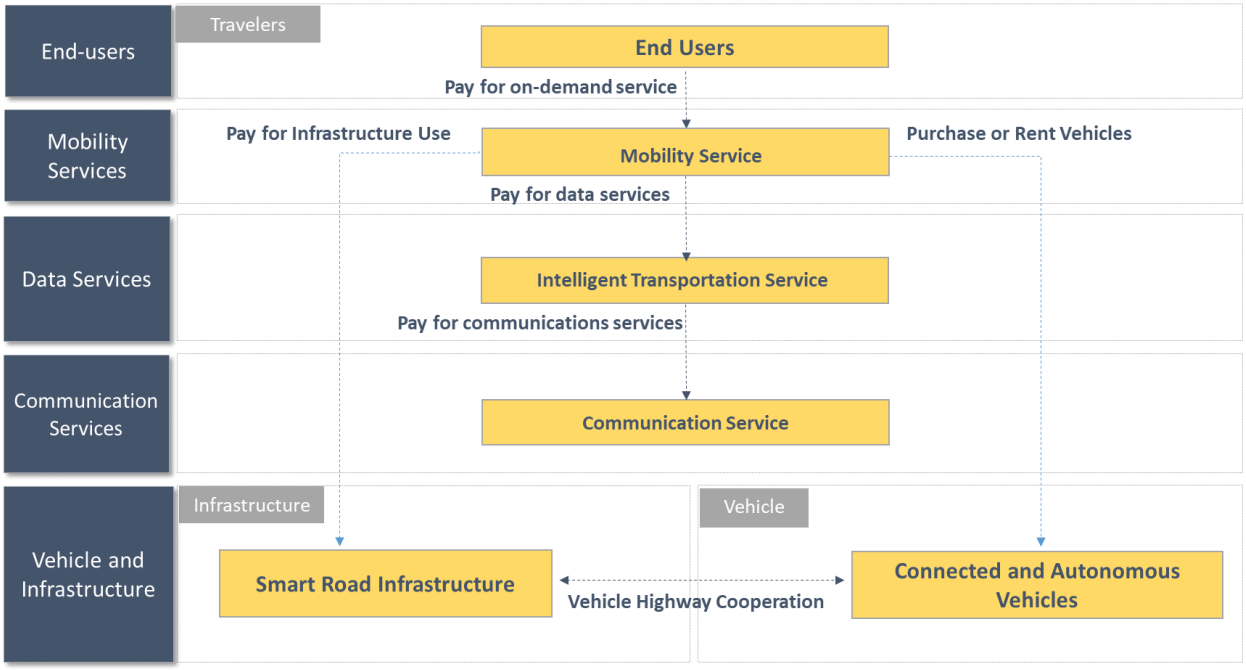
- Require submissions to include self-selected performance measures and metrics vs. all-encompassing metrics which are too broad to be useful.
- Creation of workforce development programs which utilize and leverage UTCs, including community colleges.
- Establish an annual open-unsolicited research program that UTCs can play a role in and submit projects ideas.

UTCs are where transportation innovation begins, and it is where we are training a transportation workforce for the 21st century. In order to ensure the US leadership in this wave of transportation revolution, it is more important than ever for Congress to reauthorize the UTC program with increased funding.

Needs and challenges for a national surface transportation research agenda

Before I describe the needs and challenges for a national surface transportation research agenda, let me offer my view on how the transportation systems will evolve in the future, as shown in the following figure. With the rapid development of communication, artificial intelligence, and cloud computing technologies, transportation systems are experiencing a revolutionary time because all three major elements of transportation systems are changing. End users are changing from owning a vehicle for transportation to using mobility as a service, vehicles are changing from human-driven to connected and automated, and road infrastructure are changing from static and independent from vehicles to digital and connected with vehicles. More importantly, transportation services are changing. Mobility services connect transportation demand and supply, communication services enable vehicle-to-vehicle communication and

vehicle-highway cooperation, and intelligent transportation services not only provide necessary information (including adverse traffic conditions, events, and potential crash objects, etc.) to vehicles, but also manage traffic flow so that both temporal and spatial resources can be allocated optimally. In short, our surface transportation system is becoming a complex social cyber-physical system that deserves extensive research involving not only scientists and engineers but also social, legal, and political experts.



Therefore, more research work needs to be done for a connected and automated transportation system and more support needs to be available. And we need a national transportation research agenda.

- We need to continue to invest in advanced technology development, particularly pre-competitive technologies that enable large scale CAV deployment, for example, testing and evaluation of CAVs, cyber-security, privacy protection, CAV traffic modeling and control, etc.

- We need to focus on infrastructure - beyond just fixing the roads and bridges, we need to deploy a connected infrastructure network that will accelerate vehicle automation.
- We need to better understand consequences of vehicle automation, such as affects on employment, social equity, and accessibility, even population distribution, property values, and other aspects of the economy.

The United States has led two waves of transportation revolution in the 20th Century. The first is in 1910s with Ford's massive production of Model-T cars that change people's concept on time and space, one can live in suburb and work in city center. The second is in 1950s with the construction of interstate highway systems that enable inter-city travel by car. The economic competitiveness so far achieved by the United States in the global marketplace is in no small part because it had led the last two waves of transportation evolution and developed the best transportation system in the world. The U.S. must lead the third wave of transportation revolution with connected and automated vehicle technologies, through further investment in research and development, in order to ensure international economic leadership.

University Transportation Centers, like the CCAT, are funded through the FAST Act. The FAST Act is critical to ensuring that the nation continues to recognize the added value of research, in infrastructure development and for the rapid deployment of these technologies across the nation and I look forward to continuing to work with the subcommittee as you work on the reauthorization of this important legislation.

Thank you again for the opportunity to testify today, and I am happy to answer any questions you may have.