Michigan State University Campus Pilot Mobility Proving Ground Designation

In response to DOT-OST-2016-0233: Solicitation of Proposals for Designation of Automated Vehicle Proving Grounds Pilot

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Designated Safety Officer: Mr. John Prush, Deputy Director of Management Service Bureau
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Application Type: University Campus
Institution: Michigan State University, East Lansing, MI, 48824-1226

Abstract:
A pilot mobility proving ground designation for the campus of Michigan State University (MSU) is proposed. The designation will enable MSU researchers to participate in the national development of technologies and processes for mobility, including connected, autonomous vehicles, pedestrians, and cyclists. As a major university campus with over 60,000 personnel and a contiguous campus-managed transportation network covering an area of over 15 square miles with a land utilization profile ranging from rural to suburban to high-density urban, MSU is an ideal place to develop mobility technologies for vehicles, infrastructure, and optimization and management tools. Coincident with plans to upgrade campus infrastructure to enhance safety and efficiency, researchers will be involved in developing vehicle technologies, infrastructure technologies, and system integration technologies that enable real time optimization and management of routine and emergency mobility on campus. The proposed pilot proving ground designation will enable MSU to participate in bidirectional sharing of technologies, data, processes, and policies with other campuses and urban centers to improve safety and efficiency of urban mobility systems nationwide. This coordinates well with ongoing research activities on campus.

1 Introduction

The field of transportation engineering seeks to develop innovative and practice-ready solutions that improve both mobility, accessibility, and safety while doing so in a manner that is economical and sustainable. To that end, it is crucial to study the impacts that autonomous vehicle system (including connected vehicles) technologies will have on accessibility, mobility, and safety, of transportation systems, while using the results to guide proper infrastructure planning and design. The transportation area group housed within the Department of Civil and Environmental Engineering at

Michigan State University has been extensively involved in research on transportation safety, mobility, and infrastructure planning, within Michigan and elsewhere. The following paragraphs provide brief summaries of how the transition from human operated vehicles to autonomous vehicles will impact traffic related research in these areas.

Safety Impacts. Each near, more than 32,000 people die on our nation's roadways. Although this number remains unacceptably high, life-saving progress is clearly being made (more than 40,000 persons were killed a decade ago) through various nationwide policy initiatives, including the federal *Toward Zero Deaths* initiative. Nevertheless, numerous transportation safety issues persist. Transportation safety researchers at MSU have been working for decades to identify and address such issues, creating a safer environment for all users of the transportation network. However, the safety impacts that will result from an increasing presence of autonomous (and connected) vehicles remains unknown.

Highway Safety Studies. Several recent projects by MSU researchers have considered the safety-related impacts of transportation policies involving speed limits, roadside safety devices, highway rumble strips, traffic signalization techniques, roundabouts, and pedestrians and bicyclists. However, none of these projects considered the impacts of connected or autonomous vehicles. Although connected and autonomous vehicles are expected to improve efficiency and safety by reducing the human influence from vehicle operation, there are still other human factors and behaviors that will remain within the transportation network, such as non-motorized travel modes, including both pedestrians and bicyclists, which are particularly vulnerable. Therefore, future research is needed to determine the impacts that autonomous vehicles will have on traffic safety, particularly during the transition period from a fully-human to fully-automated driving environment.

Traffic Control Devices. Traffic control devices, including pavement markings, traffic signs, traffic signals, and work zone delineation devices are another area where the transition from human to autonomous will have substantial impacts. This means that all plans, designs, and strategies will gradually need to consider increasing penetration rates of connected vehicles and later automated vehicles with varying levels of automation. For example, to assist with lane positioning of an autonomous vehicle, pavement markings will need to be interpretable and consistent across all jurisdictions and during all weather conditions and times of day. Deterioration of these devices must be considered, as degraded markings will inherently provide less luminance contrast for machine-vision systems to interpret. Similarly, highway guide signs, which are notorious for being inconsistently applied throughout the United States, must also undergo a full review for consistency and readability by autonomous vehicles. Traffic signal timing, particularly during the change

(yellow) and clearance (red) intervals will also be impacted, as the reliance on human reaction and response to these signals are diminished.

Highway Work Zones. Perhaps the most challenging traffic control device aspect related to autonomous vehicles involves highway work zones due to the dynamic nature of the work zone environment. All work zone traffic control devices (channelizers, pavement markings, signs, barricades, etc.) must be designed to accommodate both humans and vehicle sensor technology. For example, queue warning messages, which when used in work zones with connected vehicles, may provide users in connected vehicles with congestion warning messages to slow down and/or reroute. However, connected and especially autonomous vehicles present unique challenges when presented with the unique characteristics of work zones, including unusual traffic routing patterns, and the presence of workers, work vehicles/equipment, and traffic control devices all within very close proximity to travel lanes. As a result, work zones may require specific devices and instruments to facilitate application of connected and autonomous vehicles. Roadside infrastructure for vehicle-to-infrastructure communication will need to be strategically placed both in advance of and within the work zone. Because work zones likely present conditions that would require transfer of autonomous control back to the driver, it will be necessary to alert the vehicle and driver far ahead of the work zone such that control can be safety transferred in advance of the work zone. Finally, for automated vehicles that work with exact GIS data, it will be necessary to update the modified GIS information for the work zone area and provide driverless vehicles with the updated information. Future research is needed to explore different methods and strategies to accommodate the transition period from human to connected/autonomous vehicle networks, in addition to work zone design for the fully autonomous system of vehicles.

Mobility Impacts. For decades, the dynamics of traffic congestion in urban areas has been modeled and using a variety of network traffic simulation tools. Although simulation has long been used to model network travel patterns, connected vehicles will not only change the fundamental input parameters for simulation models (spacing, capacity, reaction time, acceleration performance, braking performance, etc.), the vehicles will also provide input data for use in the computer models. Furthermore, the influx of connected and autonomous vehicles will greatly impact the algorithms used in network modeling software, since these vehicle systems will allow for a network optimization approach (through systems connectivity), versus the traditional route optimization at the individual user level. Thus, consideration of connected and autonomous systems will require re-calibration and re-validation of these mobility models to account for this shift away from user optimization to network optimization.

In addition to congestion, travel time uncertainty is also present in transportation networks. Traffic incidents, work zones, weather conditions, special events, traffic control devices, fluctuations in demand, and inadequate base capacity are the source of these uncertainties. Different users have different responses to this travel time uncertainty based on their personality and risk acceptance. On the other hand, the data collected by connected and autonomous vehicles will provide important travel time distributions for these models. Also the real-time information on congestion pattern and special events can be used to improve network reliability performance.

Another area where connected and autonomous vehicles may play a major role relates to minimizing the disruptive effect of inclement weather on traffic congestion and delay, that occurs due to reduced capacity, diminished network reliability, and greater crash. To mitigate the impacts of adverse weather on highway travel, the FHWA Road Weather Management Program (RWMP) has been involved in research, development, and deployment of weather responsive traffic management (WRTM) strategies and tools. Connected and autonomous vehicles will decrease the weather disruptive effects significantly and these effects will need to be considered in Traffic Estimation and Prediction Systems (TrEPS) to improve the capabilities of WRTM systems.

Transportation Infrastructure Planning. With increasing market share of connected and autonomous vehicles, planning for the infrastructure to communicate with these vehicles has attracted more attention. Connectivity of vehicles along with the availability of infrastructure affects the market acceptance of these vehicles. Thus, optimization of the level of this connectivity or the level of information send/received, while considering the tradeoffs between cost, safety and market share is necessary. During the recent years the focus of the MSU transportation area group has been on optimizing policies affecting various types of alternative fuel vehicles, specifically electric vehicles. The tool developed by the researchers of this group has the ability to predict market evolution of different vehicles' sales. This Infrastructure Planning Tool (IPT) gathers the information on users, vehicle type, fuel and maintenance cost, availability of infrastructure, and the expected growth rate. The IPT analyzes the data and proposes an optimum policy which includes improving and expanding current infrastructure and/or diverse pricing scenarios.

IPT can be used to test various pricing and planning scenarios. The outputs of this tool include, cost and emissions from each policy, an optimum policy with minimum cost and emission, and market share evolution of these vehicles through the life time of the study. It will be necessary to modified this tool to incorporate connected and autonomous vehicles, their characteristics, including the level of information disseminated to predict market acceptance and revenue generated from these vehicles.

Recent developments in the field of mobility include the development of connected autonomous vehicles (CAVs), smart infrastructure, and hardware and software mobility management tools to integrate the technologies into a system capable of optimization and management of urban mobility. Mobility optimization and management can enhance both efficiency and safety by managing the interactions between vehicles, and between vehicles, pedestrians, and cyclists. Optimization may include reduction of time to destination, maximization of fuel economy, minimization of emissions, and reduction in interactions with cross traffic, pedestrians, and cyclists using a centrally managed combination of vehicle, infrastructure, and personal electronics technologies. For example, platooning vehicles and pedestrians using smart traffic signals, so that cross traffic arrives at intersections out of phase, can result in fewer stops and less time waiting for both, with resulting benefits to safety and efficiency. These techniques, scaled for large urban areas, can also have measureable effects on emissions, so that urban areas that are smog-prone can recognize improved air quality as well as reduction of fines for violations. Management of peak mobility events including large sports or other entertainment events or emergencies, is also possible with a system approach.

Mobility interactions are a particular challenge on University campuses, where cyclic classes and vehicle traffic peaks at the start and end of the work day as well as during the lunch hour result in significant variability. MSU has started to reimagine pedestrian and vehicular traffic optimization with an eye on improving traffic safety, enhancing vehicular flow, and reducing pedestrian commute time between classes and between buildings. Certain campus initiatives are already underway in this regard, as MSU has initiated plans to upgrade key features of the transportation network, including traffic signal controllers, sensors, and data collection devices.

MSU has more than 50 acres of parking lots, which are used for commuter and student parking. These parking lots are on campus and connected to the teaching and research parts of campus via regular bus lines. The same bus system also has an on-campus hub, which was established one decade ago, and which connects the university to the regional public transportation system. This is a partnership with CATA, the Capitol Area Transportation Authority. Connecting the various commuter parking lots to central campus and the public transportation terminals is one of the projects MSU envisions as a future use of autonomous vehicles on campus.

MSU also benefits strongly from having its crash data included in the award-winning Michigan Traffic Crash Facts (MTCF) website, which provides convenient public access to the official annual crash data (sanitized to remove personal identifiers) for all public roadways in Michigan.

2 Mobility Studio

Michigan State University has recently developed a system approach to mobility, called Mobility Studio. Mobility Studio includes three key components: Connected Autonomous Networked Vehicles for Active Safety (CANVAS), smart infrastructure, and mobility optimization and management. Mobility Studio research is underway in each of these areas within the College of Engineering, and plans to study and deploy technologies to enhance campus safety and efficiency are underway using a combination of developed and commercial technologies in collaboration with industry, other academic institutions, and the Michigan Department of Transportation (MDOT).

Key areas of research, such as cybersecurity and connectivity, are common across the component areas of Mobility Studio. Integration of these technologies with existing commercial technologies for CAVs and smart infrastructure, as well as personal electronics such as mobile phone technologies, can be used to enhance safety and improve mobility services.

2.1 CANVAS

Connected and Autonomous Networked Vehicle Active Safety (CANVAS) comprises a comprehensive and integrated initiative that can enhance state-of-the-art and key sensor, data fusion, and deep learning technologies at MSU. More specifically, the CANVAS vision is centered around three areas of research where CoE faculty members have been making key contributions:

1) EM-based sensing and analysis
2) Visual and Lidar sensing and analysis
3) Connected vehicle networking & cybersecurity

By integrating MSU's strengths and expertise in the aforementioned areas, MSU can position itself to take a clear leadership in an area that is becoming increasingly critical and impactful for the automotive industry. The proposed CANVAS center-level activities can be divided into multiple strategic efforts:

Enhancing state-of-the-art active safety solutions. It is clear that many leading automotive manufacturers have developed advanced technologies for active safety in support of their collision warning and avoidance systems. Some ongoing research at MSU can make key contributions toward helping the automotive industry further enhance their state-of-the-art systems. Evidence of such contributions includes close interactions of ECE faculty with key players of the auto industry, and more importantly, recent support that ECE faculty have received from major players in the area of active safety.

Taking the lead in networked connected-vehicle active safety. A crucial aspect of the CANVAS initiative is the integration of visual scene analysis, radar and EM-based sensing with efficient, real-time, and secure connected vehicle networking. The vision for this integration is to move active safety to a new level of performance that is beyond what can be offered based on current state-of-the-art solutions. In principle, current active safety technologies primarily focus on the particular, individual vehicle that is being supported and whose environment being sensed and monitored, but with minimal communication or sharing of vital information with surrounding vehicles. Such framework although may provide adequate safety for individual vehicles, it can't guarantee the best optimal safety scenario for all of the vehicles, pedestrians, and cyclists within a given scene. CANVAS will move toward sharing and exploiting, in real-time, the collective data sensed and captured by multiple nearby vehicles to paint a more robust and safer picture for all vehicles and people within a given situation. This networked-based approach to active safety will represent a cornerstone for CANVAS research at MSU. More importantly, development of cybersecurity mechanisms for connected vehicles will be crucial for the viability of these networked vehicles.

Developing key technologies and establishing a foundation for autonomous vehicle research and development. It is well known that autonomous cars represent a crucial and strategic direction for the automotive industry. Furthermore, technologies developed for active safety are inherently related to autonomous vehicles. Consequently, the CANVAS related activities could play a major role in positioning MSU as a key player in autonomous vehicle R&D. This could lead to strategic relationships not only with traditional industry manufacturers, but also with emerging key players such as Google.

CANVAS Related Education and Outreach. Establishing a center-level activity around the CANVAS initiative can include an important education and outreach component with the automotive industry, government agencies and other players. This includes offering specialized and online courses on specific topics of an interest to engineers, managers and researchers within the auto industry. Such topics may include antenna design, electromagnetic interference and compatibility, mobile and sensor networks, image processing and computer vision, and advanced signal processing.

2.2 Smart Infrastructure

Recent technology advances are rapidly transforming transportation infrastructure, and enabling new capabilities that can impact CAVs and conventional vehicles alike. As one of the leading academic institutions in machine vision, pattern recognition, and deep learning, development of smart infrastructure provides many opportunities for application. The development of cameras on traffic

signals enables moving from timed signals to smart signals that adjust for actual traffic conditions in order to minimize wait times, or that can recognize vehicles by type and determine trajectories which will exceed stopping capabilities, mitigating accidents by holding lights slightly longer.

One of the key advantages of an MSU Designated Proving Ground is testing in four seasons, with rain, snow, ice, sand, leaves, and water to obscure lane markings and interfere with signals, visual sensing via cameras, and lidar, as well as interfering with radar. Overcoming these challenges is required for full autonomy, and will require technological advances in infrastructure. Furthermore, deployment in the vast majority of US roads that lack access to power requires new technologies for providing lane markings in poor visibility. MSU has developed networked vibration-harvesting accelerometers for measuring vibrational modes on bridges, with ongoing research on major Michigan bridges. Adapting this technology to provide lane markings, for example in pairs to provide position and directionality can provide additional information for CAVs in rural areas.

MSU has one of the top groups in electromagnetics, from sources to antennas to electromagnetic interference. These technologies will be key elements in mobility infrastructure where directionality, range, and low power may be important features in connected infrastructure.

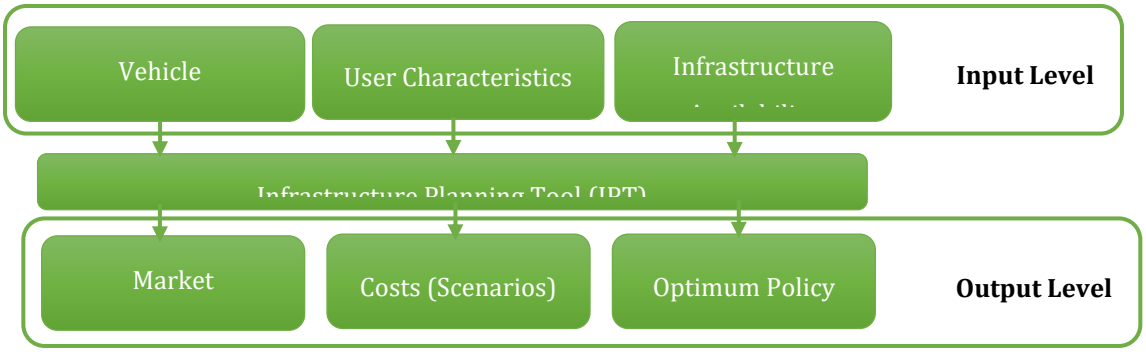
2.3 Mobility Management

Transportation infrastructure planning foci is on providing mobility and accessibility through various land uses and communities. Urban planning studies and the businesses in the area have mutual effects on one another. Therefore, each business especially production units need to consider infrastructure planning for their success. The transportation infrastructure planning team at MSU has conducted advanced research in policy optimization to move people and goods through the network. The overarching goal of this section includes, but is not limited to maximizing market acceptance, increase mobility, increase the environmental benefits, and maximize safety; while minimizing cost and emissions of different types of vehicles and infrastructure. The costs are both the user cost and manufacturing cost, considering supply chain delays and transportation costs. Market acceptance is affected by the features of the vehicle, availability of infrastructure and maintenance costs and hassles.

These planning studies consider the tradeoffs within the system, which are the results of conflicting interests in the system. Among the most important tradeoffs, maximizing the coverage while minimizing the cost is worth investigating. These tradeoffs have been studied to some extent in some recent research studies of the MSU's transportation infrastructure planning team for alternative fuel

vehicles. We are currently investigating these tradeoffs in emerging connected and autonomous vehicles.

With increasing market share of connected and autonomous vehicles, planning for the infrastructure of these vehicles has attracted more attention. Thus, taking the lead in planning for infrastructure of connected and autonomous vehicles has become crucial. These infrastructures include in vehicle and on-road infrastructure. As the on-road infrastructure propagates the market acceptance of these vehicles grows. However, the safety concerns rise when there is a mixed fleet of conventional and autonomous vehicles on road. These concerns can be addressed by the amount of information transferred among the vehicles and between vehicles and infrastructure. Connectivity of vehicles along with the availability of infrastructure affects the market acceptance of these vehicles. Thus, optimization of the level of this connectivity or the level of information send/received, while considering the tradeoffs between cost, safety and market share is necessary. Producing these vehicles with various communication capabilities affects the supply chain of the production line through time. With a mixed fleet of vehicles on road, the supply chain of conventional and autonomous vehicle parts should also be combined and designed to minimize the total production cost, while



Components of the Infrastructure planning tool

maximizing the production pace and the market acceptance of the produced vehicles.

During the recent years the focus of this research group has been on optimizing policies affecting various types of alternative fuel vehicles, specifically electric vehicles. The tool developed by the researchers of this group has the ability to predict market evolution of different vehicles' sales. This Infrastructure Planning Tool (IPT) gets the users' information and types of vehicles as inputs. The other inputs are fuel and maintenance cost, availability of infrastructure, and the expected growth rate. IPT proposes an optimum policy which includes improving and expanding current infrastructure and/or diverse pricing scenarios.

IPT can be used to test various pricing and planning scenarios. The outputs of this tool include, cost and emissions from each policy, an optimum policy with minimum cost and emission, and market

share evolution of these vehicles through the life time of the study. This tool can be modified to incorporate autonomous vehicles, their characteristics, including the level of information disseminated to predict market acceptance and revenue generated from these vehicles.

Michigan State University is studying campus mobility and existing commercial smart infrastructure along with developing technologies and processes, with plans to upgrade campus infrastructure with two key performance goals. The first goal is safety, in which reduction in vehicle-cycle-pedestrian encounters, as well as elimination of human error, are the key drivers. The second goal is efficiency, which may be defined as tenability among time to destination, fuel economy, or greenhouse gas or other emissions for combustion powered vehicles. For electric vehicles, the goals include time to destination, battery range, and battery lifetime. These goals may be achieved by an integrated system approach, in which vehicle and infrastructure are monitored and controlled by a central system designed for tunable optimization.

3 Selection Criteria

3.1 Mandatory Criteria

Michigan State University has established its own Department of Public Safety with more than 80 officers, currently under the direction of Chief Jim Dunlap. This department has police authority on the grounds of Michigan State University's more than 15 square miles of contiguous campus area. The Designated Safety Officer for the proposed pilot mobility proving ground will be Mr. John Prush, Deputy Director of Management Service Bureau. His team will also be in charge of storing and appropriately sharing data on testing and operating autonomous vehicles on campus.

MSU is committed to developing and sharing data and approaches to enhancing safety developed at the proposed Proving Ground, including data obtained in controlled tests as well as operational data. As one of the largest university campuses in the US, with mobility density varying from high-density pedestrian intensive sectors to low density agricultural sectors on a contiguous campus with train tracks, a power plant, and one of the largest campus-run food and dormitory systems in the nation, MSU can offer unique data on many types of interaction, with a population able to accept new technologies, and the benefit of four seasons, and all the varied equipment required to manage the large and diverse facilities.

3.2 Proposed Contributions

The proposed MSU Proving Grounds will enable contributions in a number of key areas, including unique areas not presently covered by other proving grounds, to our knowledge. With the wide range of mobility densities from rural to pedestrian intense urban, and its four seasons, MSU will offer

unique opportunities not available on corporate test tracks. Along with MSU-developed CAV and infrastructure technology, and integrated mobility monitoring and management software, the MSU Proving Ground can support advanced situational testing opportunities. MSU intends to be a leader in the area of system integration, and hosting CAV and infrastructure testing will provide the basis for system architecture research and development.

MSU has its own CAV program (Sec. 2.1), and will also review applications for corporate and academic institutions requesting use of the facility. In particular, testing of heterogeneous components is of particular interest.

MSU will participate in the Mobility Community of Practice, including data and process sharing, and hosting workshops bringing together top researchers with companies developing large scale mobility solutions. MSU has a strong record as a national leader in the area of pavement preservation, as the site of the National Center for the Preservation of Pavement (NCPP), as well as the site of a DOT University Transportation Center on pavement research. The NCPP provides workshops on best practices and methods, a methodology that will serve well in dissemination of mobility information. MSU anticipates increased ties to the Michigan DoT as well as the US DoT, both through R&D activities, and through sharing of best practices through publications, workshops, and conferences at MSU and externally.

3.3 Commitment to Safety

MSU has established a standing committee on safety and security with regularly scheduled quarterly meetings, which unifies communications between the Department of Public Safety, the Department of Information and Technology Services, emergency responders, and various interested campus units. Co-PI Dr. Bauer currently chairs this committee. The safety officer for the Autonomous Vehicle Proving Grounds will be a member of this standing safety and security committee, thus providing effective two-way communication between the project and the campus community at large.

Dr. Richard Enbody of Computer Science and Engineering leads a team of undergraduates, graduates, and MSU staff working on developing cyber-defense skills in the automotive domain. Scoring vulnerabilities proved to be critical for developing defenses to cyber-attacks on networks and servers. Consequently, our team developed a protocol allowing the system-focused CVSS scoring system that can be applied to cyber-attacks on vehicles. In addition, we have been analyzing a Ford-supplied instrument cluster to develop cyber-attack skills for the group while probing for vulnerabilities.

3.4 Research, Application and Data Sharing

MSU is capable of hosting cloud acquired from data from mobility testing, and making that data available to collaborators. Data ranging from the training data for deep learning modules in CAVs or smart infrastructure can be acquired in operations, and post-processed to improve algorithms for decisions making both internally and externally, MSU is also a planned collaborator in MCity in Ann Arbor, as well as the planned American Center for Mobility, and will seek to fuse the data from the varied experiences at all these sites, as well as participating in efforts to make the data available nationally.

3.5 Demonstrated Investments

In the last few years MSU has invested more than $15 million in campus transportation to enhance emergency vehicle access and remove possible collision points with railroad traffic by building underpasses. During the previous year MSU has begun installing cameras at intersections and set up the process of utilizing a traffic management software system to create an adaptive, connected traffic control system.

MSU has a campus master plan for locating new buildings, roads, and parking lots. This master plan provides a flexible framework for guiding the physical organization of the campus. It is updated periodically in response to new initiatives. The campus mobility plan, which is under current discussion, will interface with the master plan and provides a framework to improve campus mobility for all.

MSU has invested in a fully instrumented Lincoln MKZ autonomous vehicle outfitted by AutonomouStuff. In addition, Dr. Radha leads a team of faculty and students developing improved sensors, acquiring data for deep learning to train the vehicle, and developing data fusion capabilities to improve performance.

3.5 Readiness

MSU's campus mobility planning consists of three sub-committees, mobility source management, infrastructure, and mitigation & optimization. It is part of these committees' responsibility to ensure readiness planning for the proposed starting date of Jan 1, 2018 for the Designated Pilot Mobility Proving Grounds. MSU's Department of Public Safety will take the lead in designating areas that can be considered part of these Proving Grounds. They can initially be closed tracks, but can also be expanded to the entire campus once sufficient safety protocols are in place. Significant portions of campus can be utilized for pedestrian-infrastructure interactions immediately, which entail a lower technological challenge for safety since these will entail changes in infrastructure timing and

responsiveness which follows existing pedestrian rules. In addition, data gathering via monitoring technology described in Section 3.4 is already active.

3.6 Adherence to Laws, Regulations, and Federal Policy

The responsibility to assure that the facility will adhere to current Michigan and federal laws lies within the MSU Department of Public Safety.

4.0 Personnel

John Verboncoeur is Professor of Electrical and Computer Engineering, Professor of Computational Mathematics, Science, and Engineering, and the Associate Dean for Research in the College of Engineering at Michigan State University. In the latter role, he oversees the research enterprise of the College of Engineering, including research strategy and operations, fee for service activities, compliance, and other aspects. His role in the proposed Pilot Mobility Proving Ground will include oversight of the researchers, interface to state and federal government agencies on policy, interface to companies in the connected and autonomous vehicle and smart infrastructure areas, and development of funding for projects utilizing the facility. He is also leading a campus committee to study and plan implementation of campus upgrades to mobility infrastructure to improve safety and efficiency, reporting to the Executive Vice President for Administrative Services.

Wolfgang Bauer is a University Distinguished Professor in physics at Michigan State University. He has been the chair of the Department of Physics and Astronomy from 2000 to 2013. In 2009 he founded the MSU Institute for Cyber-Enabled Research and served as its director until 2013. Since 2013 he has been working as a Senior Consultant to the Executive Vice President for Administrative Services. He is leading the campus mobility planning effort, and will serve as the Designated Point of Contact for the Proving Ground

Hayder Radha is Professor of Electrical and Computer Engineering at Michigan State University. He serves as Director of the CANVAS Center within the College of Engineering, with oversight of the research and development activities for connected autonomous vehicles. His technical expertise is in communications; image and video compression; image processing; multimedia communications over packet networks; video coding and communications over the Internet and wireless networks; modeling and analysis of the stochastic behavior of communication networks; wavelet, subband, and multiresolution coding. Hayder will lead the autonomous vehicle component of the efforts.

Timothy Gates is an Associate Professor of transportation within the Department of Civil and Environmental Engineering at MSU. He has extensive research experience in traffic engineering,

traffic operations, traffic safety, and driver behavior. During his more than nine years as faculty at MSU and Wayne State University, he has served as PI or co-PI on greater than $9.0 million worth of externally funded research through competitive grant awards from agencies including the FHWA, state DOTs, SHRP2, and NCHRP.

John Prush is Deputy Director of Management Service Bureau at Michigan State University. He will serve in the role of Designated Safety Officer for the pilot mobility proving ground. His team will also be in charge of storing and appropriately sharing data on testing and operating autonomous vehicles on campus.

MICHIGAN STATE
UNIVERSITY

December 19, 2016

Office of the Secretary
U.S. Department of Transportation

Subject: Michigan State University Campus Pilot Mobility Proving Ground Designation
In response to DOT-OST-2016-0233: Solicitation of Proposals for Designation of Automated Vehicle Proving Grounds Pilot

Dear Review Committee Members:

I write to strongly endorse the Michigan State University (MSU) Campus Pilot Mobility Proving Ground Designation proposal to the Department of Transportation's (DOT).

The designation will enable MSU researchers to participate in the national development of technologies and processes for mobility, including connected, autonomous vehicles, pedestrians, and cyclists. As a major university campus with over 60,000 personnel and a contiguous campus-managed transportation network covering an area of over 15 square miles with a land utilization profile ranging from rural to suburban to high-density urban, MSU is an ideal place to develop mobility technologies for vehicles, infrastructure, and optimization and management tools.

MSU already has many mobility initiatives underway on campus including the College of Engineering's Mobility Studio which takes a system approach to mobility, and upgrades to campus traffic signals to utilize a traffic management software system and create an adaptive, connected traffic control system. However, many campus mobility challenges exist and our Office of the Executive Vice President for Administrative Services is taking the lead on a Campus Mobility Plan. This plan will engage stakeholders across campus, connect existing mobility initiatives, interface with the Campus Master Plan, and work to create a forward looking framework for campus mobility. We commit that it will also be the responsibility of this effort to ensure readiness planning for the proposed starting date of Jan 1, 2018 for the Automated Vehicle Proving Grounds.

Michigan State University approaches mobility as an opportunity to create future-oriented solutions for a better world. I applaud Drs. John Verboncoeur, Wolfgang Bauer, Hayder Radha and Tim Gates for their vision and am pleased to offer our support to the designation of MSU's Campus as a Pilot Mobility Proving Ground.

Yours sincerely,

Satish Udpa
University Distinguished Professor

OFFICE OF THE
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