

## NTC Program Progress Performance Report (PPPR) Information Form

### For P.I.'s Use

On a semi-annual basis the NTC sponsored P.I. must report Program Progress Performance Report (PPPR) using the format specified in this PPPR Information Form. The form must be submitted electronically to the corresponding NTC Associate Director by **9/16/2016**.

**Cover Period: 4/01/2016 – 9/30/2016**

NTC Funded Project Information (Round/Year 2, 2014-2015)	
University Name	Arizona State University
Project Title	Distributed Traffic Monitoring and Prediction with Vehicle-to-Vehicle Communications
Principal Investigator	Yingyan Lou, Ph.D.
PI Contact Information	<a href="mailto:Yingyan.lou@asu.edu">Yingyan.lou@asu.edu</a> 480-965-6361

The form includes the following six parts:

- Part I – Performance Indicators
- Part II – Accomplishments: What was done? What was learned?
- Part III – Products: What has the program produced?
- Part IV – Participants & Collaborating Organizations: Who has been involved?
- Part V – Impact: What is the impact of the program? How has it contributed to transportation education, research and technology transfer?
- Part VI – Changes/Problems

*Supplementary documents/materials can be attached to this form with the submission.*

<b>Part I – Performance Indicators</b>	
<b>Reporting Period</b>	<b>4/01/2016 – 9/30/2016</b>
<b>1. Transportation-related courses offered during the reporting period that were taught by faculty and/or teaching assistants who are associated with the UTC</b>	
Undergraduate courses	CEE 384 Numerical Methods for Engineers CEE 372 Introduction to Transportation Engineering
Graduate courses	
<b>2. Students supported by this grant</b>	
Undergraduate students	[Student Name] [Supervisor]
Masters students	[Student Name] [Supervisor]
Doctoral students	Mr. Peiheng Li, Ph.D. Student in Civil Engineering Dr. Yingyan Lou
<b>3. Students participating in transportation research projects funded by this grant (but not supported by this grant)</b>	
Undergraduate students	[Student Name] [Supervisor]
Graduate students	[Student Name] [Supervisor]
<b>4. Students supported by this grant who received degrees</b>	
Undergraduate degrees	[Student Name]
Masters degrees	[Student Name]
Doctoral degrees	[Student Name]

**Part II – Accomplishments: What was done? What was learned?**

The information provided in this section allows the OST-R grants official to assess whether satisfactory progress has been made during the reporting period.

**Reporting Period**

**4/01/2016 – 9/30/2016**

**1. What are the major goals of the program?**

The National UTC aims to promote strategic transportation policies, investment, and decisions that bring lasting and equitable economic benefits to the U.S. and its citizens. The Center is concerned with the integrated operations and planning of all modes serving the nation’s passenger and freight transportation system, including the institutional issues associated with their management and investments. A balanced multi-modal approach will be used that considers freight and passenger travel mobility, reliability, and sustainability, as well as system operations during periods of both recurring and non-recurring incidents, including response to major emergencies. The modes in this theme include highway, transit, rail, and inter-modal interfaces including ports, terminals and airports. In particular, the center focuses on research, education, and technology transfer activities that can lead to (1) Freight efficiency for domestic shipping and for our international land, air, and sea ports; (2) Highway congestion mitigation with multi-modal strategies; and (3) Smart investments in intercity passenger travel facilities such as high speed rail. Major center activities are as following:

- **Advanced & Applied Research Promoting Economic Competitiveness:**  
Our research activities are multimodal/intermodal and multidisciplinary in scope, with the aims of addressing nationally and regionally significant transportation issues pertinent to economic competitiveness and providing practice-ready solutions.
- **Education, Workforce Development, Technology Transfer, & Diversity**  
The consortium is committed to providing high-quality transportation education and workforce development programs for a broad and diverse audience. Center’s efforts will support the development of a critical transportation knowledge base and a transportation workforce that is prepared to design, deploy, operate, and maintain the complex transportation systems of the future.

<p><b>2. What was accomplished under these goals?</b></p>	<p><b><i>Goal 1: Advanced &amp; Applied Research Promoting Economic Competitiveness</i></b></p> <p>The overarching goal of this research is congestion mitigation during extreme events (such as major disasters or special events), a subject that directly supports the first research focus area (congestion mitigation) of the National Transportation Center (NTC) @ Maryland.</p> <p>The objective of this project is to develop innovative distributed traffic monitoring protocols as well as localized and area-wide traffic estimation algorithms, sustained by vehicle-to-vehicle (V2V) communications alone, to support coordinated transportation operations.</p> <p><b>Scheduled Activities for This Period</b></p> <ol style="list-style-type: none"> <li>1. Task 2.3: Develop area-wide traffic state estimation / prediction algorithm</li> <li>2. Task 2.4: Validate and evaluate proposed approach via simulation</li> </ol> <p><b>Work Performed in This Period</b></p> <p><b><i>Task 2.3: Develop area-wide traffic state estimation / prediction algorithm</i></b></p> <p>The team has developed an algorithm for area-wide traffic state estimation based on the fundamental diagram (FD) in traffic flow theory. The algorithm is run by a selected vehicle (could be the lead or the anchor vehicle, or selected through voting mechanism) in the identified platoon. Given the FD and MPR, we are able to adjust the underestimated traffic density of each identified platoon. The algorithm is able to provide a more accurate estimation on traffic density.</p> <p>For traffic state prediction, the team developed two different algorithms with respect to different traffic conditions. The classic shock-wave analysis is adopted for light traffic. The average speed and density of an identified platoon are used for computing its potential interaction(s) with its adjacent platoon(s). The distributed platoon identification framework developed in Task 1 allows us to apply shock-wave analysis on a meso-scopic scale without the a priori knowledge of the FD of a roadway section.</p> <p>For heavy traffic, a localized cooperative algorithm that runs on individual vehicles is developed. It will be trigger once the value of <math>\Delta</math> (metric of micro-discontinuity) is above a predefined threshold. The algorithm considers individual movements of vehicles within the platoon as inputs, and predicts whether the platoon will stay together or split into multiple ones and thus the corresponding</p>

	<p>traffic state(s) in a given prediction horizon.</p> <p><b>Task 2.4: Validate and evaluate proposed approach via simulation</b></p> <p>The team has started the validation process of the algorithms developed in task 2.3 using simulated data from the microscopic simulation platform VISSIM. So far the estimation algorithm is shown to be able to give more accurate estimation at a low MPR. For the two prediction algorithms, they are shown to be able to predict traffic states of platoons at a signalized intersection with the priori signal timing plans. The team is currently analyzing the numerical results and assemble them into the final report.</p> <p><b>Goal 2: Education, Workforce Development, Technology Transfer, &amp; Diversity</b></p> <p>This project has supported one PhD student, Peiheng Li, at ASU. Mr. Li plans to graduate in May 2017.</p>
<p><b>3. How have the results been disseminated?</b></p>	<ul style="list-style-type: none"> <li>• A full paper has been published by Transportation Research Part C</li> <li>• An abstract was accepted by INFORMS 2016</li> </ul>
<p><b>4. What do you plan to do during the next reporting period to accomplish the goals?</b>  <b>(10/1/2014 – 3/10/2016)</b></p>	<p><b>Scheduled Activities for This Period</b></p> <ol style="list-style-type: none"> <li>1. Task 3: Assemble the final report and report writing</li> </ol>

**Part II – Products: What has the program produced?**

Publications are the characteristic product of research projects funded by the UTC Program. OST-R may evaluate what the publications demonstrate about the excellence and significance of the research and the efficacy with which the results are being communicated to colleagues, potential users, and the public, not the number of publications. Many research projects (though not all) develop significant products other than publications. OST-R may assess and report both publications and other products to Congress, communities of interest, and the public.

<b>Reporting Period</b>	<b>4/01/2016 – 9/30/2016</b>
<b>1. Journal publications:</b>	Lou and Li (2016) A Distributed Framework for Network-wide Traffic Monitoring and Platoon Information Aggregation Using V2V Communications, <i>Transportation Research, Part C</i> , 69, 356-374
<b>2. Books or other non-periodical, one-time publications</b>	Li and Lou (2016) A Distributed Framework for Network-wide Traffic Monitoring and Platoon Information Aggregation Using V2V Communications [Abstract], <i>2016 INFORMS Annual Meeting</i> , Nashville, TN (Accepted)
<b>3. Other publications, conference papers and presentations</b>	Li and Lou (2016) Impacts of Traffic Controls on Distributed Traffic Monitoring [podium presentation], <i>2016 ITS Arizona Annual Conference</i> , Mesa, AZ
<b>4. Website(s) or other Internet site(s)</b>	None.
<b>5. Technologies or techniques</b>	<ul style="list-style-type: none"> <li>• A distributed framework for network-wide traffic monitoring and platoon information aggregation using V2V communications</li> <li>• Evaluation methodology of the impacts of market penetration rate on the performance of the monitoring system</li> <li>• Traffic state estimation algorithm</li> <li>• Traffic state prediction algorithms for different traffic conditions</li> </ul>
<b>6. Outreach activities</b>	<ul style="list-style-type: none"> <li>• The PI reached out to the traffic engineer at the City of Glendale to discuss the research.</li> </ul>

	<ul style="list-style-type: none"><li>• A proposal submitted by the PI to the SOLARIS UTC extending the ideas developed in this project has been approved and funded.</li></ul>
<b>7. Courses and workshops</b>	None.
<b>8. Inventions, patent applications, and/or licenses</b>	None.
<b>9. Other products</b>	None.

**Part III – Participants & Collaborating Organizations: Who has been involved?**

**OST-R needs to know who has worked on the project to gauge and report performance in promoting partnerships and collaborations.**

**Reporting Period**

**4/01/2016 – 9/30/2016**

**1. What organizations have been involved as partners?**

The PI held a few meetings with the traffic engineer at the City of Glendale in Arizona to discuss the research, the preliminary results from the funded SOLARIS project and the potential to pursue collaborative research.

**2. Have other collaborators or contacts been involved?**

Dr. Xiaoyan Hong from the Computer Science department at The University of Alabama has been involved in several discussions and has provided valuable inputs. They were incorporated into the journal paper published by Transportation Research Part C

The PI has made contacts with some vendors of DSRC equipment and is working to acquire some devices for field testing purposes.



**Part IV – Impact: What is the impact of the program? How has it contributed to transportation education, research and technology transfer?**

**DOT uses this information to assess how the research and education programs:**

- increase the body of knowledge and techniques;
- enlarge the pool of people trained to develop that knowledge and techniques or
- put it to use; and,
- improve the physical, institutional, and information resources that enable those people to get their training and perform their functions.

<b>Reporting Period</b>	<b>4/01/2016 – 9/30/2016</b>
<b>1. What is the impact on the development of the principal discipline(s) of the program?</b>	The project is the first step towards the envisioned transportation operation system that relies on V2V communications to support coordinated traffic operation algorithms and does not require any fixed infrastructure. The envisioned system is particularly suitable for mobility applications in situations where the capability of existing fixed infrastructure is limited due to damage, power outage, or work overload, such as during the immediate or extended aftermath of major disasters or special events. The envisioned system is self-sustained through V2V communications alone, and thus will provide desired redundancy when existing infrastructure and standard capabilities suffer damage. It could also open up new possibilities for a variety of transportation applications and could enable a new paradigm of a safer and more efficient transportation infrastructure.
<b>2. What is the impact on other disciplines?</b>	The data elements identified as necessary to support the envisioned vehicle-to-vehicle communication system as well as the new protocols developed from this research may have an impact on vehicle communication technologies.
<b>3. What is the impact on the development of transportation workforce development?</b>	This project has supported one PhD student at ASU. It has provided research opportunity as well as an enhanced education experience to the student. The student will gain more knowledge in intelligent transportation systems, and improve research, programming, and technical writing skills.
<b>4. What is the impact on physical, institutional, and information resources at the</b>	None.

<b>university or other partner institutions?</b>	
<b>5. What is the impact on technology transfer?</b>	None at the moment, but the team is excited about potential future work to transfer the framework and protocols developed in this study into products.
<b>6. What is the impact on society beyond science and technology?</b>	The proposed approaches could also open up new possibilities for a variety of transportation applications such as real-time traffic-responsive route guiding system and instant user feedback platform for dynamic value-added road pricing systems. It could enable a new paradigm of a safer, more efficient and cost-effective transportation infrastructure.
<b>7. Additional impacts</b>	None.

**Part V – Changes/Problems**

If not previously reported in writing to OST-R through other mechanisms, provide the following additional information or state, “Nothing to Report, if applicable:

<b>Reporting Period</b>	<b>4/01/2016 – 9/30/2016</b>
<b>1. Changes in approach and reasons for change</b>	Nothing to report.
<b>2. Actual or anticipated problems or delays and actions or plans to resolve them</b>	Nothing to report.
<b>3. Changes that have a significant impact on expenditures</b>	Nothing to report.
<b>4. Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards</b>	Nothing to report.
<b>5. Change of primary performance site location from that originally proposed</b>	Nothing to report.