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 3/10/2015.

Cover Period: 10/1/2014 – 3/10/2015

NTC Funded Project Information (Round/Year 2, 2014-2015)	
University Name	University of Maryland
Project Title	Advanced Volatility Models for Improving Travel Time Prediction
Principal Investigator	Ali Haghani, Professor
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The form includes the following six parts:

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

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

Part I – 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	**10/1/2014 – 3/10/2015**
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.

2. What was accomplished under these goals?	The objective of this research is to identify and model uncertainties associated with travel time prediction and develop models for short term forecasting of the traffic state. Most existing travel time prediction methods only provide a point value as the prediction result which does not represent the uncertainty issues. Instead of providing a point value (an average of travel time during a certain time interval), a prediction interval based approach is proposed. The prediction interval represents likeliness of capturing true value of the future travel time. In other words, a prediction interval is an estimated range that captures the future observation, with a prescribed probability, given the current available observations. The project encompasses six tasks of which three are completed and we are currently working on the fourth one. These are: 1. Data Processing: both Bluetooth and INRIX freeway travel ti data will be used in this project. Bluetooth sensor only repo the identification number of the devices along with a timestar Converting sensor data into travel time and traject information requires matching, filtering and aggregation. IN reports data on segments of different length called TMC (Tra Message Channel). In order to accurately obtain travel time c path that consists of several TMC segments, a backtrack algorithm must be applied to generate new records. 2. Data Modeling: this task investigates the characteristics of tra time data collected from Bluetooth sensors and probe vehic and will particularly focus on the seasonality and variability data during different time intervals. 3. Prediction Interval Analysis: apply the concept of predict intervals in modeling uncertainties associated with travel ti prediction. 4. Volatility Models Development: develop innovative statist volatility models that provide more reliable prediction throu consideration of the changing behaviors of travel time variati Both stochastic and seasonal characteristic of traffic data will addressed.
3. How have the results been disseminated?	Several papers have been submitted to archival journals to disseminate the results of the work of those some have been accepted and some are still under review.
4. What do you plan to do during the next reporting period to accomplish the goals? (4/1/2015 – 9/30/2015)	We will continue working on completing task 4 and the remaining tasks to complete the project. For the next reporting period the focus will be tasks 4 and 5. Task 4 is explained above and task 5 is comparison of the models developed.

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.	
Reporting Period	**10/1/2014 – 3/10/2015**
1. Journal publications:	Zhang, Y. R., A. Haghani, and X. S. Zeng, 2014, "Component GARCH models to account for seasonal patterns and uncertainties in travel time prediction," IEEE Transactions on Intelligent Transportation Systems, Vol. PP, No. 99, pp. 1-11.
2. Books or other non-periodical, one-time publications	None
3. Other publications, conference papers and presentations	Zhang, Y., M. Hamedi, A. Haghani, S. Mahapatra, and X. Zhang, 2015, "How data affect travel time reliability measures: empirical study," 94th Annual Meeting of the Transportation Research Board Compendium of Papers, Washington DC. Zhang, Y. R., Q. Wang, and A. Haghani, 2015, "Innovative hybrid freeway travel time prediction method: wavelet denoising with echo state neural network and ARIMA model," 94th Annual Meeting of the Transportation Research Board Compendium of Papers, Washington DC.
4. Website(s) or other Internet site(s)	None
5. Technologies or techniques	None
6. Outreach activities	None
7. Courses and workshops	None

8. Inventions, patent applications, and/or licenses	None
9. Other products	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	**10/1/2014 – 3/10/2015**
1. What organizations have been involved as partners?	[Describe partner organizations – academic institutions, other nonprofits, industrial or commercial firms, state or local governments, schools or school systems, or other organizations (foreign or domestic) – that have been involved with the program. Partner organizations may provide financial or in-kind support, supply facilities or equipment, collaborate in the research, exchange personnel, or otherwise contribute.] [Provide the following information for each partnership: Organization Name: Location of Organization: (if foreign location list country) Partner's contribution to the project (identify one or more) • Financial support; • In-kind support (e.g., partner makes software, computers, equipment, etc., available • to project staff); • Facilities (e.g., project staff use the partner's facilities for project activities); • Collaborative research (e.g., partner's staff work with project staff on the project); and • Personnel exchanges (e.g., project staff and/or partner's staff use each other's • facilities, work at each other's site).] Nothing to Report.
2. Have other collaborators or contacts been involved?	[Some significant collaborators or contacts within the lead or partner universities may not be covered by "What people have worked on the project?" Likewise, some significant collaborators or contacts outside the UTC may not be covered under "What other organizations have been involved as partners?" For example, describe any significant:

	• Collaborations with others within the lead or partner universities; especially • interdepartmental or interdisciplinary collaborations; • Collaborations or contact with others outside the UTC; and • Collaborations or contacts with others outside the United States or with an international organization. • Country(ies) of collaborations or contacts.] Nothing to Report.

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.**

Reporting Period	**10/1/2014 – 3/10/2015**
1. What is the impact on the development of the principal discipline(s) of the program?	[Describe how findings, results, techniques that were developed or extended, or other products from the program made an impact or are likely to make an impact on the base of knowledge, theory, and research and/or pedagogical methods in the principal disciplinary field(s) of the program. Summarize using language that an intelligent lay audience can understand (Scientific American style).] [How the field or discipline is defined is not as important as covering the impact the work has had on knowledge and technique. Make the best distinction possible, for example, by using a "field" or "discipline", if appropriate, that corresponds with a single academic department (i.e., physics rather than nuclear physics).] Travel time effectively measures freeway traffic conditions. Easy access to this information provides the potential to alleviate traffic congestion and to increase the reliability in road networks. Accurate travel time information through Advanced Traveler Information Systems (ATIS) can provide guidance for travelers' decisions for departure time, route, and mode choice, and reduce travelers' stress and anxiety. In addition, travel time information can be used to present the current or future traffic state in a network and provide assistance for transportation agencies in proactively developing Advanced Traffic Management System (ATMS) strategies. Despite its importance, it is still a challenging task to model and estimate travel time, as traffic often has irregular fluctuations. These fluctuations result from the interactions among different vehicle-driver combinations and exogenous factors such as traffic incidents, weather, demand, and roadway conditions. Travel time is especially very sensitive to the exogenous factors when operating at or near the roadway's capacity, where congestion

	occurs. Small changes in traffic demand or the occurrence of an incident can greatly affect the travel time. As it is impossible to take into consideration every impact of these unpredictable exogenous factors in the modeling process, travel time prediction problem is often associated with uncertainty. This research uses innovative data mining approaches such as advanced statistical and machine learning algorithms to study uncertainty associated with travel time prediction. The developed models can help manage traffic better and alleviate congestion faster which result in economic benefits in terms of time, cost and energy savings for the users and the society as a whole.
2. What is the impact on other disciplines?	[Describe how the findings, results, or techniques developed or improved, or other products from the program made an impact or are likely to make an impact on other disciplines.] More efficient traffic management will also benefit private sector transportation companies such as urban delivery, trucking and logistics firms to manage their fleet in a more efficient and economical way.
3. What is the impact on the development of transportation workforce development?	[Describe how the program made an impact or is likely to make an impact on transportation workforce development. For example, how has the program: • Provided opportunities for research and teaching in transportation and related disciplines; • Improved the performance, skills, or attitudes of members of underrepresented groups that will improve their access to or retention in transportation research, teaching, or other related professions; • Developed and disseminated new educational materials or provided scholarships; or provided exposure to transportation, science and technology for practitioners, teachers, young people, or other members of the public?] The dissemination of research outcomes and their publications can help in developing a more informed and better educated workforce.
4. What is the impact on physical, institutional,	[Describe ways, if any, in which the program made an impact, or is likely to make an impact, on physical, institutional, and information

and information resources at the university or other partner institutions?	resources that form infrastructure, including: • Physical resources such as facilities, laboratories, or instruments; • Institutional resources (such as establishment or sustenance of societies or organizations); or • Information resources, electronic means for accessing such resources or for scientific communication, or the like.] None
5. What is the impact on technology transfer?	[Describe ways in which the program made an impact, or is likely to make an impact, on commercial technology or public use, including: • Transfer of results to entities in government or industry; • Instances where the research has led to the initiation of a start-up company; or • Adoption of new practices.] The results and the methods of this project will be disseminated to the traffic management personnel in various states. It can help them in developing better strategies for traffic management and congestion mitigation.
6. What is the impact on society beyond science and technology?	[Describe how results from the program made an impact, or are likely to make an impact, beyond the bounds of science, engineering, and the academic world on areas such as: • Improving public knowledge, attitudes, skills, and abilities; • Changing behavior, practices, decision making, policies (including regulatory policies), or social actions; or • Improving social, economic, civic, or environmental conditions] More efficient traffic management and congestion mitigation has significant societal economic and other user benefits. Economic benefits include travel time and cost reduction and reduction in

	energy use. Other benefits include travelers' peace of mind and reduction in the frustration levels that are due to long delays in traffic queues.
7. Additional impacts	[NTC encourages to consider identifying program results by outcomes or impacts, as suggested by the examples below. Impacts should be linked to National goals expressed in the Secretary's Strategic Goals.] [Outcomes are broader changes that are expected to result from the products, such as: • Increased understanding and awareness of transportation issues; • Improved body of knowledge; • Improved processes, techniques and skills in addressing transportation issues; • Enlarged pool of trained transportation professionals; • Greater adoption of new technology; • Other impacts. Impacts are the longer-term, fundamental changes intended as a result of your activities, such as: • Safer driver behavior; • Increased travel time reliability; • Increased intermodal transportation operations; • Reduction in carbon and other harmful emissions from transportation sources; • Other impacts.] Nothing to Report.

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:	
Reporting Period	**10/1/2014 – 3/10/2015**
1. Changes in approach and reasons for change	[If there is nothing significant to report during this reporting period, state "Nothing to Report."] [Describe any changes in approach during the reporting period and reasons for these changes. Remember that significant changes in objectives and scope require prior approval of the OST-R grant administrator.] Nothing to Report.
2. Actual or anticipated problems or delays and actions or plans to resolve them	[If there is nothing significant to report during this reporting period, state "Nothing to Report."] [Describe problems or delays encountered during the reporting period and actions or plans to resolve them.] Nothing to Report.
3. Changes that have a significant impact on expenditures	[If there is nothing significant to report during this reporting period, state "Nothing to Report."] [Describe changes during the reporting period that may have a significant impact on expenditures, for example, delays in hiring staff or favorable developments that enable meeting objectives at less cost than anticipated.] Nothing to Report.

4. Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards	[If there is nothing significant to report during this reporting period, state "Nothing to Report."] [Describe significant deviations, unexpected outcomes, or changes in approved protocols for the use or care of human subjects, vertebrate animals, and/or biohazards during the reporting period. If required, were these changes approved by the applicable institution committee and reported to the agency? Also specify the applicable Institutional Review Board/Institutional Animal Care and Use Committee approval dates.] Nothing to Report.
5. Change of primary performance site location from that originally proposed	[If there is nothing significant to report during this reporting period, state "Nothing to Report."] [Identify any change to the primary performance site location identified in the proposal, as originally submitted.] Nothing to Report.