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

<table>
<thead>
<tr>
<th>NTC Funded Project Information (Round/Year 3, 2015-2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>University Name</td>
</tr>
<tr>
<td>Project Title</td>
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<tr>
<td>Principal Investigator</td>
</tr>
<tr>
<td>PI Contact Information</td>
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</tbody>
</table>

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.
## Part I – Performance Indicators

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<tr>
<th>Reporting Period</th>
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</table>

### 1. Transportation-related courses offered during the reporting period that were taught by faculty and/or teaching assistants who are associated with the UTC

<table>
<thead>
<tr>
<th>Undergraduate courses</th>
<th>CE 305 Traffic Engineering (NCSU)</th>
</tr>
</thead>
</table>
| Graduate courses      | CEE 776/876: Transportation Operations II (ODU)  
                        | CEE 772/872: Intelligent Transportation Systems (ODU)  
                        | CE 707 Transportation Policy and Funding (NCSU)  
                        | CE 595 Railroad Engineering (EOL-NCSU)  
                        | CE 504 Airport Planning and Design (OS&EOL-NCSU)  
                        | CE 795 Transportation Logistics (OS&EOL-NCSU)  
                        | EOL = Engineering On Line; OS&EOL = on-site and EOL |

### 2. Students supported by this grant

| Undergraduate students | [Student Name]  
                        | [Supervisor] |
| Masters students       | [Student Name]  
                        | [Supervisor] |
| Doctoral students      | Elizabeth Williams (Advisor: George List from NC State)  
                        | Ehsan Beheshtitabar (Advisor: M. Cetin from ODU)  
                        | Reza Vatani Nezafat (Advisor: M. Cetin from ODU) |

### 3. Students participating in transportation research projects funded by this grant (but not supported by this grant)

| Undergraduate students | [Student Name]  
                        | [Supervisor] |
| Graduate students      |                     |

### 4. Students supported by this grant who received degrees

| Undergraduate 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.

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<tr>
<th>Reporting Period</th>
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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? | [For this reporting period describe: 1) major activities; 2) specific objectives; 3) significant results, including major findings, developments, or conclusions (both positive and negative); and 4) key outcomes or other achievements. Include a discussion of stated goals not met. As the program progresses, the emphasis in reporting in this section should shift from reporting activities to reporting accomplishments.]  

[Generally, the activities and expected outputs, outcomes and impacts should not change from one reporting period to the next. However, if there are changes, please list the revisions and explain the reason(s) for the changes.]  

This project aims to investigate how Connected Vehicles (CVs) technology can be used to control traffic flows for sag curves, road segments where a downgrade is followed by a relatively steep upgrade. The capacity of sag curves tends to be considerably lower than that for flat road segments. Through vehicle-to-infrastructure (V2I or I2V) communications, system operators can relay messages to CVs, instructing them to slow down, increase their gaps, change lanes, divert to other routes, etc., so that overall system operation is improved. The field study site will be the Hampton Roads Bridge Tunnel (HRBT). It includes a sag curve inside the tunnel. Based on the empirical observations from HRBT, it is shown that the tunnel throughput for the eastbound HRBT can be 25% higher if a bottleneck is not allowed to form inside the tunnel. However, during peak hours, bottlenecks do form inside the tunnel causing a reduction in capacity. To avoid formation of such bottlenecks, the approaching traffic on the mainline can be regulated by variable speed limit.  

The following are the main objectives:  

- **Explore how data from CVs can be used to observe the traffic flow pattern in real-time such that critical levels of volume can be detected effectively.** This real-time data will be used as input to the control algorithm that regulates the upstream traffic.  

- **Develop a control strategy (e.g., proportional feedback control) for regulating traffic in the upstream of the sag curve via suggested**
advisories to the CVs.

- Investigate the impact of market penetration of the CV-equipped vehicles on the effectiveness of the control strategies.

The following activities are completed:

- A microscopic simulation model for the HRBT corridor is created in VISSIM. Using VISSIM’s COM interface, an optimization framework is developed to calibrate the simulation parameters based on the field data.
- Field data are assembled/colllected that include (i) per-vehicle records from VDOT’s continuous count site located at the tunnel exit; (ii) video from 3 VDOT’s surveillance cameras at the tunnel; (iii) floating-car data that include vehicle’s speed measured via an OBD device; and (iv) LIDAR data collected by a vehicle equipped with a Velodyne’s VLP-16 sensor.

### 3. How have the results been disseminated?

[Describe how the results have been disseminated. Include any outreach activities that have been undertaken to reach members of communities who are not usually aware of these program activities, for the purpose of enhancing public understanding and increasing interest in learning and transportation careers.]

None to report.

### 4. What do you plan to do during the next reporting period to accomplish the goals? (10/1/2014 – 3/10/2016)

[Describe briefly what you plan to do during the next reporting period to accomplish the goals and objectives.]

- Complete simulation calibration and compare outputs from simulation to the field data.
- A control strategy (e.g., proportional feedback control) for regulating traffic in the upstream of the tunnel sag curve via suggested advisories to the CVs will be developed and tested in the simulation environment.
- Discuss the results of the simulation with VDOT or HRBT traffic control operators to get their feedback.
<table>
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<tr>
<th>Part II – Products: What has the program produced?</th>
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<tbody>
<tr>
<td>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.</td>
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<tr>
<th>Reporting Period</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Journal publications:</strong></td>
<td>[List peer-reviewed articles or papers appearing in scientific, technical, or professional journals. Include any peer-reviewed publication in the periodically published proceedings of a scientific society, a conference, or the like. A publication in the proceedings of a one-time conference, not part of a series, should be reported under “Books or other non-periodical, one-time publications.”]</td>
</tr>
<tr>
<td>[Identify for each publication: Author(s); title; journal; volume: year; page numbers; status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).]</td>
<td>None to report.</td>
</tr>
<tr>
<td><strong>2. Books or other non-periodical, one-time publications</strong></td>
<td>[Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like.]</td>
</tr>
<tr>
<td>[Identify for each one-time publication: Author(s); title; editor; title of collection, if applicable; bibliographic information; year; type of publication (book, thesis or dissertation, other); status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).]</td>
<td>None to report.</td>
</tr>
<tr>
<td><strong>3. Other publications, conference papers and presentations</strong></td>
<td>[Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication as noted above.]</td>
</tr>
<tr>
<td>One paper submitted to the TRB 2017 Annual Meeting: “Calibration</td>
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</tbody>
</table>
4. Website(s) or other Internet site(s)

[List the URL for any Internet site(s) that disseminates the results of the research and/or program activities. A short description of each site should be provided. It is not necessary to include the publications already specified above in this section.]

http://www.tri-odu.org/autonomous--connected-vehicles.html

5. Technologies or techniques

[Identify technologies or techniques that have resulted from the research activities. Describe the technologies or techniques and how they are being shared. Such as Technologies or technology assessments]

A MATLAB program was developed which constructs trajectories of vehicles inside the tunnel based on LIDAR and GPS data as inputs.

A MATLAB program was developed that enables the calibration of VISSIM car-following parameters via meta-heuristic algorithm(s) in MATLAB.

6. Outreach activities

None to report.

7. Courses and workshops

None to report.

8. Inventions, patent applications, and/or licenses

[Identify inventions, patent applications with date, and/or licenses that have resulted from the research. Submission of this information as part of an interim research performance progress report is not a]
substitute for any other invention reporting required under the terms and conditions of an award; as of the date of this document, UTC Program inventions may not be submitted to the Federal government’s Interagency Edison (iEdison) invention-reporting system, but OST-R is working to make that available and will notify UTCs. For additional requirements pertaining to Patents and Copyrights, refer to General Provisions of Grants for University Transportation Centers, Section III, 14.]

None to report.

9. Other products

[Identify any other significant products that were developed under this program. Describe the product and how it is being shared. Examples of other products are:

- Databases
- Physical collections
- Audio or video products
- Software or NetWare
- Models
- Educational aids or curricula
- Instruments or equipment
- Data & Research Material
- Other]

The trips recorded in the HRBT with the LIDAR remote sensing device can provide a database of trajectories, headways and driving behavior within the studied tunnel.
### 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.

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#### 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).]

ODU is going to provide in-kind financial support. The team will ask VDOT to help with field testing after the simulation study is completed.

#### 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...]

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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.]
### 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.

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</table>
| **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). ]

It is anticipated that this project will have the following impacts on traffic flow theory and control:  
- New methodologies to model and evaluate CV technologies for active bottleneck management through speed control.
- New algorithms for CV systems to control upstream traffic to avoid capacity drop phenomena at the downstream sag curves.

| **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.] |
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 technology for practitioners, teachers, young people, or other members of the public?]

   3 PhD students (2 from ODU and one female student from NCSU) are working on this project as graduate research assistants. The project is providing valuable experience to these students to learn advanced simulation modeling techniques, data processing and analytics, vehicle tracking methods based on LIDAR data, etc. They are also acquiring new professional skills including leadership, collaboration, organization, etc.

4. **What is the impact on physical, institutional, and information resources at the university or other partner institutions?**

   [Describe ways, if any, in which the program made an impact, or is likely to make an impact, on physical, institutional, and information 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]
It is anticipated that this project will help enhance the relationships and collaboration between ODU and VDOT since the proposed methods are going to be applied to the HRBT corridor, one of the most congested corridors in Hampton Roads.

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.]

If proved effective, the proposed bottleneck management strategies could be implemented in the field by VDOT to reduce congestion at tunnels in Hampton Roads and by others.

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]

The overall goal of this study is to reduce traffic congestion by maximizing the bottleneck throughput. If implemented in the field, congestion and negative environmental impacts of traffic would be reduced.
### 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. ]
### 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:

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<tr>
<th>Reporting Period</th>
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<tbody>
<tr>
<td>1. Changes in approach and reasons for change</td>
<td>[If there is nothing significant to report during this reporting period, state “Nothing to Report.”]</td>
</tr>
<tr>
<td></td>
<td>[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.]</td>
</tr>
<tr>
<td></td>
<td>Nothing to Report.</td>
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<tr>
<td>2. Actual or anticipated problems or delays and actions or plans to resolve them</td>
<td>[If there is nothing significant to report during this reporting period, state “Nothing to Report.”]</td>
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<tr>
<td></td>
<td>[Describe problems or delays encountered during the reporting period and actions or plans to resolve them.]</td>
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<tr>
<td></td>
<td>Nothing to Report.</td>
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<tr>
<td>3. Changes that have a significant impact on expenditures</td>
<td>[If there is nothing significant to report during this reporting period, state “Nothing to Report.”]</td>
</tr>
<tr>
<td></td>
<td>[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.]</td>
</tr>
<tr>
<td></td>
<td>Nothing to Report.</td>
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</tbody>
</table>
| **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. |