Program Progress Performance Report
University Transportation Centers
Cover Page TranLIVE

Submitted to: Office of the Assistant Secretary for Research and Technology

Federal Grant Number: DTRT12-G-UTC17

Project Title: TranLIVE (Transportation for Livability by Integrating Vehicles and the Environment

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Submission Date: 7/30/15

DUNS and EIN Numbers: 075746271 and 82-6000945

Recipient Organization: University of Idaho, Office of Sponsored Programs, 875 Perimeter Dr., MS 3020, Moscow, ID 83844-3020

Recipient Account Number: KLK900

Grant Period: January 1, 2012 to January 31, 2016

Reporting Period End Date: June 30, 2015

Report Frequency: Semi-annual

Signature of Submitting Official:

SEMI-ANNUAL REPORTING CATEGORIES
TranLIVE DTRT12GUTC17
January 1, 2015 to June 30, 2015

1. ACCOMPLISHMENTS:

A. University of Idaho:

i. ***Developing and Testing Eco-Traffic Signal System Applications***

Provided guidelines on using advanced controller settings to optimize traffic operation at signalized intersections operating in an isolated mode.

ii. ***Calibration of Multi-Scale Energy and Emissions Models***

Used vehicle-emission and fuel consumption data to develop and optimize a rule-based energy management strategy for fuel economy improvements in Hybrid Electric Vehicles.

iii. ***Direct Drive AC Rim Motor for Responsive Energy Control of Alternative Electric Vehicle***

Nothing to report

iv. ***Daily Travel Feedback to Encourage Eco-Routing***

a. Presented work at the annual meeting of the Transportation Research Board.
b. Wrote the final report.

v. ***Eco-driving Modeling Environment***

Developed a Java-based application to estimate fuel consumption for a center engine configuration under different driving cycles based on driver simulator output.

B. Old Dominion University:

i. ***Reducing Energy Use and Emissions through Innovative Community Designs: Methodology and Application***

a. A report that covers relevant literature was written. Key portions of the reviewed literature are contained in research papers presented and published based on the project. This information is being integrated into the final report.
b. Intelligent technologies: eco-friendly traveler information. Several papers related to the project were presented at the 2015 TRB annual meeting. A paper discussing generating emissions information for route selection was published in the *Journal of Intelligent Transportation Systems*.
c. Modeling alternative fuel vehicle data. One paper on this topic was published in *Transportation Research*.

C. Syracuse University:

i. ***Enhancing TSM&O Strategies through User Cost Analysis and Life Cycle Assessment***

The final report had to be removed and will be sent for peer review after some of the assumptions made in the study are re-visited and the outputs adjusted accordingly. The substantial effort placed on re-evaluating the procedures and assumptions will result in improving the final report considerably.

ii. ***Assessing Social and Environmental Impacts of Work-Zones in Arterial Improvement Projects***

Project completed.

iii. ***Assessing Environmental Impacts of Traffic Congestion and Vehicular Emissions on Groundwater and Fresh Water Supplies***

a. Efforts in the first half of 2015 focused on developing methods for analysis of vehicle-emitted trace metals on both the OnCenter green roof and the War Memorial control roof. The methods were used to analyze runoff from both roofs as well as fresh precipitation. Initial samples collected in May 2015 showed small but measureable

concentrations of Ni, Cu, and Pb in fresh precipitation. Concentrations of these three metals in runoff from the green roof were considerably greater than concentrations in precipitation. This suggests that either atmospheric deposition of metals onto the green roof or else trace metals in the growth medium of the green roof are adding trace metals to the runoff. Analysis of the control roof samples is currently underway and will be reported shortly, as is analysis of dry deposition samples and airborne concentration filters.

b. Dr. Cliff Davidson presented a seminar on the use of green infrastructure for stormwater management at the Center for Science, Technology and Policy in Bangalore, India, on June 25, 2015 (approximately 20 attendees).

iv. ***A Sustainable Asset Management Framework for Transportation System Management and Operation Systems***

The research team has completed reviewing literature on inspection and management of various components of TSM&O systems. Currently, the team is focusing on development of a risk based prioritization tool for efficient management of TSM&O deployments.

v. ***Sustainability Workshops***

a. Dr. Cliff Davidson organized three international sustainability workshops in January 2015 that included transportation components as part of the Center for Sustainable Engineering. The workshops were offered at TERI University in New Delhi on January 12, 2015 (approximately 20 attendees), India Institute of Technology Gandhinagar on January 14, 2015 (approximately 25 attendees), and India Institute of Technology Bombay on January 16, 2015 (approximately 25 attendees).

b. Dr. Cliff Davidson was a co-organizer of a workshop in June 2015 that included transportation components as part of the Center for Sustainable Engineering. The workshop was held at the National Meeting of the Association of Environmental Engineering and Science Professors, Yale University, on June 14, 2015. There were approximately 50 attendees.

c. Dr. Cliff Davidson organized an international sustainability workshop in June 2015 that included transportation components as part of the Center for Sustainable Engineering. The workshop was offered at India Institute of Science in Bangalore on June 26, 2015. There were 29 attendees.

D. <u>Texas Southern University</u>:

i. ***A Systematic Evaluation of the Impacts of Traffic Condition Information on the Reduction of On-road Mobile Emissions***

a. What we have done:
   1) Reviewed more literature.
   2) Working on draft of the final report.

b. What we have learned:
   The frame developed in this study needs to be in a more general way for practitioners to use to carry out similar evaluation studies in the future. More data needs to be collected to further verify the collected field data for improving the model results.

ii. ***Education and Outreach Activities***

a. Supported faculty and student travels to present research papers in academic conferences such as:
   1) The 2015 Transportation Research Board Annual Meeting, Washington DC, January 11-15, 2015.

2) The 28th International Conference of Transportation Professionals Association (ICTPA), May 14-16, 2015, Los Angeles, California.
3) The 108th Air & Waste Management Association (AWMA) Annual Meeting, June 22-25, 2015, Raleigh, North Carolina.

iii. ***Develop an Integrated Data Management System at the Microscopic, Mesoscopic, and Macroscopic Levels to Assess the Environmental Impacts of Transportation System***

a. Further tested part of the database for sample use of emission estimation for different purposes, especially for vehicle-to-infrastructure communications.
b. Incorporating with a project from Texas Department of Transportation (TxDOT), vehicle emissions have been tested in junction with the records of pavement roughness information. Vehicle emissions on 11 roadway segments in El Paso, Texas, 14 roadway segments in Houston, Texas, and 1 segment in College Station, Texas have been tested.

iv. ***Use the Driving Simulator to Synthesize the Related Vehicle Specific Power (VSP) for Emission and Fuel Consumption Estimations***

The driving simulator is capable of testing driving performance in work zones when the Drivers' Smart Advisory System (DSAS) message is provided.

v. ***Develop Multi-scale Energy and Emission Models for Arterial Traffic Systems***

Developed a kNN model to estimate vehicle emissions in relationship with vehicle activity information.

vi. ***Improve the Environment for a Livable Community: Advance the AERIS Program by Developing and Testing Eco-traffic Signal System Control Applications***

a. The impacts of foggy weather conditions on driver behavior at yellow intervals were characterized, and how driver behavior is influenced by the advanced warning message from the Drivers Smart Signal System (DSSS) at high-speed signalized intersection approaches was discussed using driving simulator test.
b. Tested impacts of weather condition (fog) on emissions due to changed drivers' reactions during yellow change interval.

vii. ***Developing Short Range Vehicle-to-Infrastructure Communication Systems***

Designed smartphone applications and tested in work zone (advance warning area and activity area) and signalized intersections using the driving simulator.

E. <u>Virginia Tech</u>:

i. ***Develop Mesoscopic Fuel Consumption and CO_2 Emission Models***

Developing mesoscopic modeling framework.

ii. ***Develop Macroscopic Fuel Consumption and CO_2 Emission Models***

a. Characterized vehicle power distributions along freeway weaving sections.
b. Reviewing naturalistic data to characterize typical vehicle power distributions for different facility types depending on the type of intersection control.

iii. ***Develop Multi-scale Energy and Emission Models***

a. Extending VT-CPFM to model heavy-duty truck fuel consumption and CO, HC, and NOx emissions.
b. Extending VT-CPFM to model hybrid electric light-duty vehicles.

F. <u>Multi-institution</u>:

i. ***Developing and Field Implementing a Dynamic Eco-routing System*** **–Virginia Tech, lead; University of Idaho and Old Dominion University, partners**

a. Develop a simulation environment for testing the eco-routing system.
b. Study the dynamics of driver routing behavior.

c. Develop algorithms to enhance the minimum path search.
d. Conduct simulation/field tests.

ii. ***Smartphone-based Solutions to Monitor and Reduce Fuel Consumption and Co_2 Footprint – Old Dominion University, lead; Virginia Tech and Texas Southern University, partners***

a. New algorithms based on support vector machines (SVMs), neural networks, and clustering techniques were developed to estimate whether the vehicle is in motion or stopping. The performance of the algorithms was tested on large datasets collected by the research team. Overall, the algorithms were found to be effective in detecting when the vehicle stops and for how long.
b. A module for estimating vehicle speed from accelerometer data was developed. The core algorithm for this module utilizes the Principal Component Analysis (PCA) technique to map the accelerometer readings from smartphones to the orientation/direction of travel of the vehicle. The performance of the module was evaluated offline on the collected data by the research team. Overall, the algorithms were found to be good in estimating vehicle speed independent of the phone orientation. Currently, we are integrating this module with GoGreen App for online speed estimation as well as improving the algorithm performance under different driving scenarios.
c. Algorithms have been developed and finalized to predict the mode of travel based on sensor data from smartphones. The performance of the algorithms was tested and the results were published in a journal paper.
d. Shorthest path algortims are being developed to detemine the eco-friendly shortest paths whicle considering both travel time and fuel consumption in the path cost function.

iii. ***Eco-traffic Signal System*** **– University of Idaho, lead; Virginia Tech and Syracuse University, partners**

a. Developed connected-vehicle lab integrating DSRC receivers and road side units.
b. Validated the data exchange mechanics between the DSRC units, road side units, a microprocessor interface, and the traffic controller.

iv. ***Studying the impact of accelerated construction methods in work zones using micro-simulation, on vehicle emissions and the environment*** **– Syracuse University, lead; Virginia Tech and University of Idaho, partners**

In order to achieve the project objectives, a comprehensive literature review was completed on the MRR activities and accelerated construction techniques to get familiar with the construction methods, construction sequencing, contracting requirements and traffic management plans (TMPs) used by various transportation agencies. During this reporting period, case studies related to highway construction, maintenance or repair activities were identified. Data on these case studies were collected from New York State's Online Data Repository (data.ny.gov). More specifically, the databases accessed are "Transportation Projects in your Neighborhood", "Capital Projects by NYS Thruway Authority" and "511 NY Events". Work zones for different MRR activities were identified and their corresponding traffic management plans (TMPs) are listed. As a part of this research project, Mr. Sudipta Ghorai spent two days at the Virginia Tech Transportation Institute and worked with Dr. Rakha and Dr. Du on work-zone traffic modeling. Dr. Rakha provided Syracuse University with licenses for the software INTEGRATION (large) and QueensOD, which can be used to model complex networks and generate origin-destination matrix for simulating traffic around the work-zones. The research team is now in the process of modeling this information in INTEGRATION and obtaining the emission impact results.

2. PRODUCTS:

A. University of Idaho:

i. ***Developing and Testing Eco-Traffic Signal System Applications***

a. Sherief Elbassuoni, "Guidelines for Eco-Traffic Signal System Operations in Small and Medium Size City Environments", Doctoral Student Research in Transportation Operations and Traffic Control, TRB 94th Annual Meeting, Transportation Research Board, National Research Council, Washington, D.C., January 2015, Presentation # P15-7006.

b. Jacob W. Preston, Richard W. Wall, and Ahmed Abdel-Rahim, "Real-Time Traffic Signal System Instrumentation using National Electrical Manufacturers Association TS2 Synchronous Data Link Control Networks", CD-ROM, Proceedings of the TRB 94th Annual Meeting, Transportation Research Board, National Research Council, Washington, D.C., January 2015, Paper # 15-3047.

c. Sherief Elbassuoni, Christopher Davidson, and Ahmed Abdel-Rahim, "Guidelines for Eco-Traffic Signal System Operations for Isolated Actuated Intersections", Paper submitted for publication in ASCE Journal of Transportation Engineering.

d. Sherief Elbassuoni completed his PhD May 15, 2015 with his Doctoral Dissertation entitled "Guidelines for Eco-Traffic Signal System Operations in Small and Medium Size City Environments."

ii. ***Calibration of Multi-Scale Energy and Emissions Models***

Final report being drafted.

iv. ***Direct Drive AC Rim Motor for Responsive Energy Control of Alternative Electric Vehicle***

Final report being drafted.

v. ***Daily Travel Feedback to Encourage Eco-Routing***

a. Chang, K. Lowry, M., Seely, B., and Cook, R. (2015). "Using a Responsive Interactive Program to Enhance Daily Travel Feedback" Presented at the 94th Annual Transportation Research Board, Washington, D.C. January 11-15, 2015.

b. Final report completed - http://tranliveutc.org/engr/niatt/tranlive/projects/2013/daily-travel-feedback-to-encourage-eco-routing.

vi. ***Eco-driving Modeling Environment***

Java-based application to estimate fuel consumption for a center engine configuration under different driving cycles.

B. Old Dominion University:

i. ***Reducing Energy Use and Emissions through Innovative Community Designs: Methodology and Application***

a. Wang, X., & A. Khattak, Is smart growth associated with reductions in CO2 emissions? Published in Transportation Research Record, 2375, 2013, pp. 62-70.

b. Wang X., A. Khattak, J. Liu, G. Amoli, S. Son, What is the Level of Volatility in Instantaneous Driving Decisions? Forthcoming in Transportation Research-Part C, DOI: 10.1016/j.trc.2014.12.014.

c. Liu J., A. Khattak, X. Wang, The Role of Alternative Fuel Vehicles: Using Behavioral and Sensor Data to Model Hierarchies in Travel, Transportation Research Part C: Emerging Technologies, Issue 55, 2015, 379-392.

d. Wang X, J. Liu, and A. Khattak, Generating Fuel Economy Information to Support Cost Effective Vehicle Choices: Comparing Standard and Customized Driving Cycles, TRB paper # 15-4548, Presented at the Transportation Research Board, National Academies, Washington, D.C., 2015.

e. Khattak A. & J. Liu, Supporting Instantaneous Driving Decisions through vehicle trajectory data, TRB paper # 15-1345, Presented at the Transportation Research Board, National Academies, Washington, D.C., 2015.
f. Liu J., A. Khattak, & L. Han, What is the Magnitude of Information Loss When Sampling Driving Performance Data? TRB paper # 15-0968, Presented at the Transportation Research Board, National Academies, Washington, D.C., 2015.
g. Liu J., A. Khattak & X. Wang, Creating Indices for How People Drive in a Region: A Comparative Study of Driving Performance, TRB paper # 15-0966, Presented at the Transportation Research Board, National Academies, Washington, D.C., 2015.

C. <u>Syracuse University</u>:

i. Salem, O., and Ghorai, S. (2015). "Environmental Life-Cycle Assessment of Pavement Maintenance, Repair and Rehabilitation Activities." TRB 94th Annual Meeting. Washington, D.C., January, 2015 in Washington, DC.

ii. Salem, O., Ghorai, S., and Salman, B. (in review). "Socio-Environmental Impacts of Pavement Maintenance, Repair and Rehabilitation Activities", International Journal of Sustainable Transportation, Taylor and Francis.

iii. Johnson, Alex, Cliff I. Davidson, and Mario Montesdeoca, Analysis of trace metals in stormwater runoff from two building roofs, Poster Presentation, AEESP Conference, New Haven, CT, June 13-16, 2015.

iv. Johnson, Alex and Cliff Davidson, Influence of Urban Aerosols on the Chemistry of Stormwater Runoff from Building Roofs, accepted for oral presentation at the National Meeting of the American Association for Aerosol Research, Minneapolis, MN, October 12-16, 2015.

v. Sudipta Ghorai presented a posted titled "Environmental Life-Cycle Assessment of Pavement Maintenance, Repair and Rehabilitation Activities" at the TRB 94th Annual Meeting. Washington, D.C., January, 2015 in Washington, DC.

vi. Sudipta Ghorai, Song He, and Sharareh Pirzadeh attended the poster session on the Nunan Lecture and Research Day organized by Syracuse University on April 6th, 2015. The titles of their posters were "Socio - Environmental Impacts of Pavement Maintenance, Repair and Rehabilitation Activities", "A Sustainable Asset Management Framework for Transportation System Management and Operation Systems" and "Improving Sustainability of Work-Zones by Implementing Lean Construction and Total Quality Management Techniques" respectively.

D. <u>Texas Southern University</u>:

i. ***A Systematic Evaluation of the Impacts of Traffic Condition Information on the Reduction of On-road Mobile Emissions –*** Nothing to report

ii. ***Education and Outreach Activities –*** Nothing to report.

iii. ***Develop an Integrated Data Management System at the Microscopic, Mesoscopic, and Macroscopic Levels to Assess the Environmental Impacts of the Transportation System***

a. Ziyue Li, Lei Yu, Fengxiang Qiao, Jinghui Wang (2015). Feasibility Study of Using Driving Simulator to Develop Operating Mode Distributions for Emission Analysis. Presented at and Published in the Proceedings of the Transportation Research Board Annual Meeting, Transportation Research Board of the National Academies, Washington, DC, Jan 11-15, 2015.
b. Wu Ying, Mehdi Azimi, Fengxiang Qiao, Po-Hsien Kuo, Pengfei Liu, and Lei Yu, Pilot Test of Vehicular Emissions under Different Pavement Types in Houston Using an Instrumented Vehicle. Presented and published in the proceedings of the 28th International Chinese Transportation Professionals Association (ICTPA), May 14-16, 2015, Los Angeles, CA.

c. Wu Ying, Fengxiang Qiao, and Lei Yu, Modeling of Real Time Emission Related to Vehicle Speed and RPM on Driving Mode. Presented and published in the proceedings of The 108th Air & Waste Management Association (AWMA) Annual Meeting, June 22-25, 2015, Raleigh, North Carolina.

iv. ***Use the Driving Simulator to Synthesize the Related Vehicle Specific Power (VSP) for Emission and Fuel Consumption Estimations***

a. Ziyue Li, Lei Yu, Fengxiang Qiao, Jinghui Wang (2015). Feasibility Study of Using Driving Simulator to Develop Operating Mode Distributions for Emission Analysis. Presented and published in the proceedings of the Transportation Research Board Annual Meeting, Transportation Research Board of the National Academies, Washington, DC, January 11-15, 2015.
b. Johora Munni, Fengxiang Qiao, Qing Li, Lei Yu, and Po-Hsien Kuo. (2015). Driving Behavior and Emission Analysis at Yellow Intervals with Advanced Warning Message under Foggy Weather Condition: A Simulator Test. Presented at the Transportation Research Forum for the 56th Annual Forum, March 12-14, 2015, Atlanta, GA.
c. You, B., F. Qiao, Q., and L. Yu. (2015). Implications of Left Turn Smartphone Warning Messages in Work Zone Termination Areas through Driving Simulator Tests. Presented and published in the proceedings of the 28th Annual Conference of the International Chinese Transportation Professionals Association (ICTPA), May 14-16, 2015, Los Angeles.

v. ***Develop Multi-scale Energy and Emission Models for Arterial Traffic Systems***

a. Wu Ying, Fengxiang Qiao, and Lei Yu. (2015). Modeling of Real Time Emission Related to Vehicle Speed and RPM on Driving Mode. Presented and published in the proceedings of The 108th Air & Waste Management Association (AWMA) Annual Meeting, June 22-25, 2015, Raleigh, North Carolina.
b. Fengxiang Qiao, Ling Liu, Wen Long, and Lei Yu. (2015). Modeling Excess Carbon Dioxide Emissions from Traffic Congestion in Urban Areas. World Soft Computing Conference WSC18 Proceeding in the Springer Book Series "Advances in Intelligent Systems and Computing" 2015. In Print.
c. Fengxiang Qiao, Ling Liu and Lei Yu. (2015). Quantifying Changes of Mobile Source Air Pollution in Metropolitan Areas Using Vehicle Emission Model MOVES. Journal of Environmental Science and Engineering. David Publishing Company.

vi. ***Improve the Environment for a Livable Community: Advance the AERIS Program by Developing and Testing Eco-traffic Signal System Control Applications***

a. Johora Munni, Fengxiang Qiao, Qing Li, Lei Yu, and Po-Hsien Kuo. (2015). Driving Behavior and Emission Analysis at Yellow Intervals with Advanced Warning Message under Foggy Weather Condition: A Simulator Test. Presented at and published in the proceedings of the Transportation Research Forum for the 56th Annual Forum, March 12-14, 2015 in Atlanta, GA.
b. Chelse Hoover, Lei Yu, Fengxiang Qiao, and Mehdi Azimi. (2015). Emission Implications of Alternative Origin-Destination Routes: Case Study in Houston, Texas. TRB 15-2511. Presented at Transportation Research Board Annual Meeting, Washington, DC, January 11-15, 2015.

vii. ***Developing Short Range Vehicle-to-Infrastructure Communication Systems***

a. Qi Zhao, Sicong Zhu, Lei Yu, Fengxiang Qiao (2015). Experimental Development and Testing of Smartphone Eco-driving App. TRB 15-3211. Presented at Transportation Research Board Annual Meeting, Washington, DC, January 11-15, 2015.
b. Rahman, R., F. Qiao, Q. Li, L. Yu, and P.-H. Kuo (2015). Smart Phone Based Forward Collision Warning Message in Work Zones to Enhance Safety and Reduce Emissions. Presented at and Published in the Proceedings of the Transportation Research Board

Annual Meeting, Transportation Research Board of the National Academies, Washington, DC, Jan 11-15, 2015.

c. You, B., F. Qiao, Q., and L. Yu. (2015). Implications of Left Turn Smartphone Warning Messages in Work Zone Termination Areas through Driving Simulator Tests. Accepted for publication in the proceedings of the 28th Annual Conference of the International Chinese Transportation Professionals Association (ICTPA), May 14-16, 2015, Los Angeles, CA.
d. Li, Q., F. Qiao, and L. Yu. (2015). Update Flow Dispersion Model to Incorporate Impacts of V2I Advanced Warning Message. Accepted for publication in the proceedings of the 28th Annual Conference of the International Chinese Transportation Professionals Association (ICTPA), May 14-16, 2015, Los Angeles, CA.
e. Li, Q., F. Qiao, X. Wang, and L. Yu. (2015). Measures of Performance when Drivers Approaching STOP Sign Intersections with the Presence of Drivers Smart Advisory System. Accepted for publication in the proceedings of the 28th Annual Conference of the International Chinese Transportation Professionals Association (ICTPA), May 14-16, 2015, Los Angeles, CA.
f. Johora Munni, Fengxiang Qiao, Qing Li, Lei Yu, and Po-Hsien Kuo. (2015). Driving Behavior and Emission Analysis at Yellow Intervals with Advanced Warning Message under Foggy Weather Condition: A Simulator Test. Accepted by the Transportation Research Forum for the 56th Annual Forum March 12-14, 2015 in Atlanta, GA.

E. <u>Virginia Tech</u>:

i. *Develop Mesoscopic Fuel Consumption and CO_2 Emission Models*

Rakha H. (2015), "Transportation Sustainability: What Can Intelligent Transportation Systems Offer?" in Engineering and Technology Reference.

ii. *Develop Macroscopic Fuel Consumption and CO2 Emission Models*

Wang J., Rakha H. and Yu L. (2015), "Operating Mode Distribution Characteristics of Different Freeway Weaving Configurations and their Effects on Vehicular Emissions," Presented at the 94th Transportation Research Board Annual Meeting, Washington DC, January 11-15, CD-ROM [Paper # 15-1429].

iii. *Develop Multi-scale Energy and Emission Models*

a. Edwardes W. and Rakha H. (2015), "Modeling Diesel and Hybrid Bus Fuel Consumption using VT-CPFM: Model Enhancements and Calibration," Transportation Research Record: Journal of the Transportation Research Board.
b. Park S., Ahn K., Rakha H., and Lee C. (2015), "Real-Time Emission Modeling with EPA MOVES: Framework Development and Preliminary Investigation," Transportation Research Record: Journal of the Transportation Research Board.

F. <u>Multi-institution</u>:

i. *Developing and Field Implementing a Dynamic Eco-routing System* –Virginia Tech, lead; University of Idaho and Old Dominion University, partners

a. Wang J. and Rakha H. (2015), "Impact of Dynamic Route Information on Day-to-Day Driver Route Choice Behavior," Presented at the 94th Transportation Research Board Annual Meeting, Washington DC, January 11-15, CD-ROM [Paper # 15-4918].
b. Tawfik A. and Rakha H. (2015), "Modeling Heterogeneity of Driver Route Choice Behavior using Hierarchical Learning-Based Models: A Longitudinal, In-Situ Experiment in Real World Conditions," Presented at the 94th Transportation Research Board Annual Meeting, Washington DC, January 11-15, CD-ROM [Paper # 15-3135].

c. Elbery A., Rakha H.A., ElNainay M., and Hoque M.A., (2015) "VNetIntSim: An Integrated Simulation Platform to Model Transportation and Communication Networks," International Conference on Vehicle Technology and Intelligent Transport Systems, Lisbon, Portugal, May 20-22.

ii. ***Smartphone-based Solutions to Monitor and Reduce Fuel Consumption and Co2 Footprint – Old Dominion University, lead; Virginia Tech and Texas Southern University, partners***

a. The following papers were presented or will be presented:
   1) Jahangiri A. and Rakha H. (2015), "Distributed Learning: An Application to Transportation Mode Identification," Presented at the 94th Transportation Research Board Annual Meeting, Washington DC, January 11-15, CD-ROM [Paper # 15-0826].
   2) I. Makohon, Z. Li, M. Sosonkina, Y. Shen, M.Cetin, M. Ng, D.T. Nguyen, "JAVA Based Visualization and Animation for Teaching Dijkstra Shortest Path Algorithm in Transportation Networks", Presented at the MODSIM '2015 conference, Virginia Beach Convention & Visitor Bureau, VA Beach, VA, March 31-April 2, 2015.
   3) Z. Li, I. Makohon, M. Sosonkina, Y. Shen, D.T. Nguyen, "Visualization and Animation for Teaching Frank-Wolfe Transportation Network Equilibrium", to be presented at the MODSIM '2015 conference, Virginia Beach Convention & Visitor Bureau, VA Beach, VA, March 31-April 2, 2015.
   4) A. Salem, T. Nadeem, M. Cetin, S. EL-Tawab, "DriveBlue: Traffic Incident Prediction through Single Site Bluetooth", To be presented at the 18th International IEEE Conference on Intelligent Transportation Systems, 15 – 18 September 2015.
   5) Ruksana Rahman, Fengxiang Qiao, Qing Li, and Lei Yu. (2015). Identifying suitable warning message from smartphone app to enhance safety in work zone. Presenter: Fengxiang Qiao. Accepted for presentation in the 2015 Intelligent Transportation System World Conference, October 3 - 11, 2015, Bordeaux, France.

b. Journal paper:
   Jahangiri A. and Rakha H. (2015) Applying Machine Learning Techniques to Transportation Mode Recognition Using Mobile Phone Sensor Data, IEEE ITS Transactions, 2015.

c. The following presentation was done:
   D.T. Nguyen, M. Ng "Domain Decomposition, Parallel Computing and Traffic Assignment", invited presentation (P15-6590; January 11-2015) at the TRB'2015 Annual Meeting (Workshop on Parallel Computing in Traffic Simulation and Assignment: Moving from Innovations to Practice), Washington, D.C., January 11- 15, 2015.

iii. ***Eco-traffic Signal System – University of Idaho, lead; Virginia Tech and Syracuse University, partners***

a. A connected vehicle traffic signal system lab in which data are exchanged between the vehicle, the road side unit, and the traffic controller that will facilitate field deployment.
b. A laboratory prototype for connected vehicle traffic signal system applications.

iv. ***Studying the impact of accelerated construction methods in work zones using micro-simulation, on vehicle emissions and the environment*** **– Syracuse University, lead; Virginia Tech and University of Idaho, partners**

Abstract submitted: Ghorai, S., Salem, O., and Salman, B. "Assessment of Traffic Emission Impacts Due To Rigid Pavement Repair And Rehabilitation Activities", Eighth International Conference on Maintenance and Rehabilitation of Pavements.

3. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS:

A. University of Idaho:

UI has been working with the Idaho Transportation Department, Decagon Devices, Inc., Harbrick, AutonomouStuff, LLC., and Econolite Controls holding various meetings to collaborate on projects and holding training meetings.

B. Old Dominion University:

Dr. Khattak worked collaboratively with foreign collaborators at University of Aveiro, Portugal (J. Bandeira, T. Almeida, & M. Coelho) on research papers that are related to the TranLIVE theme and were submitted for review in refereed journals.

C. Syracuse University:

Nothing to report

D. Texas Southern University:

i. Dr. Xumei Chen from Beijing Jiaotong University in China and Dr. Yi Qi, TSU, were awarded a project "Dynamic Model on Emission Control and Estimation at Multimodal Signalized Intersections with Traveler Information System" by the National Science Foundation of China (grant #71373018) based on some results from "A Systematic Evaluation of the Impacts of Traffic Condition Information on the Reduction of On-road Mobile Emissions" project.
ii. One exchange graduate student from Beijing Jiaotong University visited TSU in summer 2015, exchanging research ideas and activities with TSU graduate students.
iii. Exchanged ideas and potential collaborative work with researchers at the University of Texas, El Paso.
ii. Professor Haibo Zou from Chang-an University, and Professor Liqing Wei from Chongqing Jiaotong University (both from China) worked as visiting scholars at TSU.
iii. Conducted collaborative research with National Science Foundation (NSF) CREST center on complex network, especially its subcenter on wireless communications at TSU.
iv. Texas Department of Transportation (TxDOT) project vehicle emissions have been tested in junction with the records of pavement roughness information.

E. Virginia Tech:

i. ***Develop Multi-scale Energy and Emission Models***
The research team collaborated with researchers from the International Islamic University of Malaysia (IIUM).

F. Multi-institution:

i. ***Developing and Field Implementing a Dynamic Eco-routing System* –Virginia Tech, lead; University of Idaho and Old Dominion University, partners –** Nothing to report
ii. ***Smartphone-based Solutions to Monitor and Reduce Fuel Consumption and Co2 Footprint – Old Dominion University, lead; Virginia Tech and Texas Southern University, partners –*** Nothing to report
iii. ***Eco-traffic Signal System – University of Idaho, lead; Virginia Tech and Syracuse University, partners –*** Harbrick, AutonomouStuff, LLC – Moscow, Idaho
iv. ***Studying the impact of accelerated construction methods in work zones using micro-simulation, on vehicle emissions and the environment* – Syracuse University, lead; Virginia Tech and University of Idaho, partners** – Nothing to report.

4. IMPACT:

A. University of Idaho:

i. ***Developing and Testing Eco-Traffic Signal System Applications***

a. Education:
   1) One Bachelor of Science in Civil Engineering student graduated and joined the transportation engineering graduate program at the University of Idaho.
   2) Two undergraduate Civil Engineering students joined as undergraduate research interns.
   1) One Ph.D. student graduated in May 2015 and joined the transportation engineering workforce in a lead consultant firm in the area of traffic signal system operations.

b. Research:
   1) Guidelines for actuated control parameters to minimize fuel consumption and vehicle emissions for fully actuated signaled intersections operating on isolated or free mode of operation.
   2) Guidelines for optimizing coordinated corridors to minimize fuel consumptions and emissions.
   3) Guidelines on using advanced controller parameters to minimize fuel consumption and vehicle emissions for fully actuated signaled intersections operating on isolated or free mode of operation.
   4) Architecture for a hardware-in-the-loop simulation environment for connected-vehicle applications for corridor operations integrating.

c. Tech Transfer: Publication of results at various meetings and conferences.

ii. ***Calibration of Multi-Scale Energy and Emissions Models***

a. Education:
   1) One undergraduate electrical engineering student continued working as research intern.

b. Research:
   1) Calibrated fuel consumption and emission models for three traffic engineering software tools: VISSIM and Integration, and Transyt 7-F.
   2) Developed a rule-based energy management strategy for fuel economy improvements in Hybrid Electric Vehicles.

iii. ***Direct Drive AC Rim Motor for Responsive Energy Control of Alternative Electric Vehicle***

Nothing to report

iv. ***Daily Travel Feedback to Encourage Eco-Routing***

Tech transfer will continue through conference presentations and journal publications.

v. ***Eco-driving Modeling Environment***

a. Education: One computer science undergraduate student, one mechanical engineering undergraduate student, and one psychology graduate student.

b. Research: An Eco-Driving modeling environment that integrates the NADS MiniSim driver simulator model and the GT-Suite advanced engine modeling tool.

B. Old Dominion University:

i. ***Real-time Prediction of Queues at Signalized Intersections to Support Eco-driving Applications***

a. In terms of education, this project is contributing by training a post-docs (Dr. J. Liu, and X. Wang) and several graduate students (J. Liu, M. Zhang, G. Amoli, S. Son) who worked on

modeling and smart growth land use strategies, microscopic driving decisions, energy use and emissions issues.

b. In terms of research, the project has generated nine international conference presentations and six refereed papers in high-impact journals. These represent important contributions to the state of the art in energy and emissions modeling.
c. Various products and applications were developed in order to support more eco-friendly driving decisions.
d. The study contributed toward greater consciousness about the energy and environmental issues.

C. Syracuse University:

i. ***Enhancing TSM&O Strategies through User Cost Analysis and Life Cycle Assessment***

The hypothetical case studies demonstrate that the B/C ratio for ATCS applications may range between 6.5 and 13.0 and the B/C ratio for ramp meters may be approximately 6.4.

D. Texas Southern University:

i. ***A Systematic Evaluation of the Impacts of Traffic Condition Information on the Reduction of On-road Mobile Emissions***

This project will provide transportation planners or environmental analysts with qualitative assessments of the impacts on air quality of different types of traffic condition information. It will also help the traffic engineer to appropriately deploy the most effective traveler information systems to achieve more environmental benefits. In addition, since very few studies have been performed to directly investigate the impacts of the traveler information on on-road mobile emissions, the proposed research will fill this gap and will help the researchers and practitioners to better understand the related issues in the future. Furthermore, the operating mode ID distributions developed by this study can be used as input to run MOVES and obtain the emission level of any pollutants. The results of this study will facilitate the evaluation of transportation operation and demand management strategies with respect to their impacts on air quality. Finally, the results of project can be incorporated into some teaching curriculums, such as the class TMGT 885 “Quantitative Assessment of Transportation Environmental Impact” at TSU.

ii. ***Education and Outreach Activities***

a. The education program helps to promote interests of K-12 and college students in STEM programs, especially in transportation and environment related areas. The developed curricula and experiences can be easily further expanded and applied to other schools.
b. The education program has brought awareness to students, teachers, community organizers, organizations and families about the impact of transportation on the environment. In addition, these groups have come to understand that their personal decisions regarding transportation impact the quality of their environment.
c. The students learned new transportation and environmental concepts and terms; the students made a connection to how goods, services and people are transported efficiently through various modes and networks of transportation infrastructure.

iii. ***Develop an Integrated Data Management System at the Microscopic, Mesoscopic, and Macroscopic Levels to Assess the Environmental Impacts of Transportation System***

Once the emission and activity database is fully developed, researchers, students at different levels (graduate students, undergraduate students, K-12 students) from different geographic areas (within or outside the consortium, within or outside the country) can utilize this database easily for various transportation and environment related research and education purposes through web access.

iv. ***Use the Driving Simulator to Synthesize the Related Vehicle Specific Power (VSP) for Emission and Fuel Consumption Estimations***
The developed algorithm will help to calibrate the simulation results from the driving simulator, which will make better use of the driving simulator for vehicle emission and fuel consumption analyses.

v. **Develop Multi-scale Energy and Emission Models for Arterial Traffic Systems**
The developed models are important to further research in developing suitable urban transportation management systems and vehicle emission reduction strategies. They also provide very good examples for undergraduate and graduate level courses. The developed techniques can be expanded for direct use by industry and government.

vi. ***Improve the Environment for a Livable Community: Advance the AERIS Program by Developing and Testing Eco-traffic Signal System Control Applications***
   a. Results from the emission analysis demonstrate that the DSSS helps to reduce emission rates at yellow intervals when approaching an intersection. While the DSSS message in foggy weather conditions cannot fully recover drivers' behaviors to normal weather conditions, it can somehow reduce the risk of safety such as running red lights and sharp decelerations, and may also reduce emissions.
   b. The findings can be a good reference in developing optimal strategies for eco-traffic signal system control at intersections and in dynamic traffic assignment.

vii. ***Developing Short Range Vehicle-to-Infrastructure Communication Systems***
The developed system can help to not only enhance safety, but also reduce vehicle emissions. With more tests, it can be widely used in research, industry and for education purposes.

E. <u>Virginia Tech:</u>

i. ***Develop Mesoscopic Fuel Consumption and CO_2 Emission Models***
   a. Education: The funding of a graduate student assistantship.
   b. Research: Development of mesoscopic fuel consumption models for light duty cars and buses.

ii. ***Develop Macroscopic Fuel Consumption and CO_2 Emission Models***
   a. Education: The funding of a graduate student assistantship.
   b. Research: Development of macroscopic fuel consumption models for light duty cars and buses.

iii. ***Develop Multi-scale Energy and Emission Models***
   a. Education: The funding of a graduate student assistantship.
   b. Research: Development of fuel consumption models for light duty cars and buses.
   c. Technology Transfer: Publication of results at various conferences.

F. <u>Multi-institution</u>:

i. ***Developing and Field Implementing a Dynamic Eco-routing System* –Virginia Tech, lead; University of Idaho and Old Dominion University, partners**
   a. Education: The funding of a graduate student assistantship.
   b. Research: Development of eco-routing prototype.

ii. ***Smartphone-based Solutions to Monitor and Reduce Fuel Consumption and Co2 Footprint – Old Dominion University, lead; Virginia Tech and Texas Southern University, partners***
The results of the research are being disseminated though journal publications and presentations at international conferences and workshops.

iii. ***Eco-traffic Signal System – University of Idaho, lead; Virginia Tech and Syracuse University, partners***

a. Education: One computer science graduate student and one civil engineering Ph.D. student.
b. Research:
    1. A connected vehicle traffic signal system lab in which data are exchanged between the vehicle, the road side unit, and the traffic controller that will facilitate field deployment.
    2. A laboratory prototype for connected vehicle traffic signal system application

iv. ***Studying the impact of accelerated construction methods in work zones using micro-simulation, on vehicle emissions and the environment*** **– Syracuse University, lead; Virginia Tech and University of Idaho, partners**
Nothing to report

5. <u>CHANGES/PROBLEMS</u>

A. <u>University of Idaho</u>:
Field deployment implementation delay issues due to the time needed to integrate different test components.

B. <u>Old Dominion University</u>:
Nothing to report

C. <u>Syracuse University</u>:

i. ***Enhancing TSM&O Strategies through User Cost Analysis and Life Cycle Assessment***
Some irregularities were noticed and the final report had to be removed and will be sent for peer review after some of the assumptions made in the study are re-visited and the outputs adjusted accordingly. The substantial effort placed on re-evaluating the procedures and assumptions will result in improving the final report considerably.

D. <u>Texas Southern University</u>:

i. ***Develop an Integrated Data Management System at the Microscopic, Mesoscopic, and Macroscopic Levels to Assess the Environmental Impacts of Transportation System***
Need to do new tests with pavement roughness in conjunction with TxDOT.

ii. ***Develop Multi-scale Energy and Emission Models for Arterial Traffic Systems***
Delay in systematically summarizing all developed models and analytical results

vii. ***Improve the Environment for a Livable Community: Advance the AERIS Program by Developing and Testing Eco-traffic Signal System Control Applications***
Data processing tests and summary of findings are still on-going.

iii. ***Developing Short Range Vehicle-to-Infrastructure Communication Systems***
The driver's performance for work zone, intersection, and other locations need to be systematically analyzed.

E. <u>Virginia Tech</u>:

i. ***Develop Mesoscopic Fuel Consumption and CO_2 Emission Models***
This project has been delayed because it requires that the microscopic models be developed first before developing this model.

ii. ***Develop Macroscopic Fuel Consumption and CO_2 Emission Models***
This project has been delayed because it requires that the microscopic models be developed first before developing this model. Furthermore, additional time will be needed to analyze the naturalistic data.

iii. ***Develop Multi-scale Energy and Emission Models***
The scope of the project has been reduced from multi-level modeling to expanding the microscopic modeling framework to consider: (1) buses; (2) trucks; and (3) hybrid vehicles. We are still collecting data on buses and received truck data from the University of California, Riverside.

F. Multi-institution:

i. ***Developing and Field Implementing a Dynamic Eco-routing System* –Virginia Tech, lead; University of Idaho and Old Dominion University, partners**
Additional time is needed to complete this effort and to conduct field tests.

ii. ***Eco-traffic Signal System – University of Idaho, lead; Virginia Tech and Syracuse University, partners***
Field deployment implementation delay issues due to the time needed to integrate different test components.

6. SPECIAL REPORTING REQUIREMENTS

Financials will be sent by the University of Idaho's Office of Sponsored Programs as needed.

Completed by:
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