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

Program Director: Ahmed Abdel-Rahim; Director of NIATT and TranLIVE; ahmed@uidaho.edu; 208-885-2957

Submitting Official: Chuck Jaworski; Assistant to the Director, NIATT; cjaworski@uidaho.edu; 208-885-0576

Submission Date: 7/30/2017

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 April 30, 2017.

Reporting Period End Date: June 30, 2016

Report Frequency: Semi-annual

Signature of Submitting Official:

SEMI-ANNUAL REPORTING CATEGORIES
TranLIVE DTRT12GUTC17
January 1, 2016 to June 30, 2016

1. ACCOMPLISHMENTS:

A. University of Idaho:

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

a. Field demonstrations for connected vehicle traffic signal system applications with Idaho Transportation Department District 2 and the City of Moscow. The field demonstration involved the use of Econolite ASC3 traffic controllers and Arada systems Road Side Unis (RSUs) and onboard units. The field demonstration involved the implementation of Eco-Traffic Signal system strategies including signal priority for heavy vehicles passing through the City of Moscow Network.
b. Educational modules covering eco-routing, eco-traffic signal systems, and eco-driving strategies
c. Connected-vehicle traffic signal system workshop for ITD D2 and The city of Moscow staff.
d. Cyber-security for connected-vehicle operations workshop for ITD D2 and The city of Moscow staff.

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

a. Used the GT-Suite advanced engine modeling software, to generate vehicle-emission and fuel consumption data for passenger vehicles and light-duty trucks under different speed and acceleration operation
b. Used the GT-Suite advanced engine modeling software, to generate vehicle-emission and fuel consumption data for heavy vehicles (diesel engines) under different speed and acceleration operation.
c. Used the data generated through the GT-Suite advanced engine modeling software to calibrate fuel consumption and emission models in two microscopic simulation models: VISSIM and Integration
d. Used vehicle-emission and fuel consumption data to development and optimize of a rule-based energy management strategy for fuel economy improvements in Hybrid Electric Vehicles

iii. *Eco-driving Modeling Environment*

a. A calibrated and validated web-based user interface to display Driver Simulator emissions
b. An EcoDash that display fuel consumption and emission levels that runs along with other system components in real-time with MiniSim
c. A calibrated and validated 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. *Smartphone-based Solutions to Monitor and Reduce Fuel Consumption and CO_2 Footprint*

a. The project has now successfully concluded. A 185-page final project report was submitted to the TranLIVE UTC on this US Department of Transportation sponsored project.

C. Syracuse University:

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

The research team has been working on proof-reading the final report.

ii. ***Assessing Environmental Impacts of Traffic Congestion and Vehicular Emissions on Urban Fresh Water***

Alex Johnson is working on developing an improved method for sampling trace metal depositions from vehicle emissions.

iii. ***Studying the Impact of Accelerated Construction Methods in Work Zones Using Microsimulation on Vehicle Emissions and the Environment***

The research team is preparing a manuscript to be submitted to the Transportation Research Board's 2017 Annual Meeting.

Note on Project 3: This research project is currently underway. Outcomes are expected to be achieved by the end of Spring Term in 2016.

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

The research team continued working on preparation of the final report.

Note on Project 4: This research project is currently underway.

D. Texas Southern University:

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

What we have done:

- Further modified the research paper submitted to the Journal of Air and Waste Management Association according to the additional comments from the reviewers and the paper got accepted for publication.
- Further modified the final report draft.

What we have learned:

- Because of some simplifications made during the modeling process, such as discarding the short snippets and reducing the operation at intersections to a single emission rate per stop, some bias will likely be introduced in the estimated emission rates. Thus, the developed method is majorly recommended for conducting emission comparison studies and is not recommended for directly developing actual expected emission inventories.

E. Virginia Tech:

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

a. Developed and validated the VT-CPFM model.
b. Developed a framework for modeling diesel engine vehicle fuel consumption levels.
c. Developed a framework for modeling transit vehicle fuel consumption and emission levels.
d. Investigated the potential for use of electrified vehicles to serve traveler needs using naturalistic driving data.
e. Extended VT-CPFM to model heavy-duty truck fuel consumption and CO, HC, and NOx emissions.
f. Extended VT-CPFM to model electric vehicles (EVs).
g. Extending VT-CPFM to model vehicle emissions of CO, HC, and NOx.
h. Extending VT-CPFM to model plugin hybrid electric vehicles (PHEVs).
i. Extending VT-CPFM to model hybrid electric vehicles (HEVs).

ii. ***Developing and Field Implementing a Dynamic Eco-Routing System***

a. Developed a simulation environment for testing the eco-routing system.

b. Studied the dynamics of driver routing behavior.
c. Developing algorithms to enhance eco-routing algorithms.
d. Conducting simulation tests.

iii. ***Developing and Field Implementing an Eco-Cruise Control System in the Vicinity of Traffic Signalized Intersections***

a. Developed a simulation environment for testing the eco-routing system.
b. Studied the dynamics of driver routing behavior.
c. Developing algorithms to enhance eco-routing algorithms.
d. Conducting simulation tests.

2. <u>PRODUCTS</u>:

A. <u>University of Idaho</u>:

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

- Field test to demonstrate connected vehicle traffic signal system applications
- Field test to demonstrate the security and survivability of connected vehicles communication exchange at signalized intersection approaches.
- 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.
- A laboratory prototype for connected vehicle traffic signal system application
- Educational modules covering eco-routing, eco-traffic signal systems, and eco-driving strategies
- Sherief A. Elbassuoni, Mostafa Asfoor, and Ahmed Abdel-Rahim, "Towards a Better Understanding of the Fuel Consumption and Environmental Costs of Traffic Operations at Signalized Intersection Approaches", CD-ROM, Proceedings of the TRB 95th Annual Meeting, Transportation Research Board, National Research Council, Washington, D.C., January 2016, Paper # 16- 3243.

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

- Vehicle-emission and fuel consumption data for passenger vehicles and light-duty trucks under different speed and acceleration operation.
- Vehicle-emission and fuel consumption data for heavy vehicles (diesel engines) under different speed and acceleration operation.
- Calibrated fuel consumption and emission models in two microscopic simulation models: VISSIM and Integration.

iii. ***Eco-Driving Modeling Environment***

- A calibrated and validated web-based user interface to display Driver Simulator emissions
- An EcoDash that display fuel consumption and emission levels that runs along with other system components in real-time with MiniSim
- A calibrated and validated Java-based application to estimate fuel consumption for a center engine configuration under different driving cycles based on driver simulator output

B. <u>Old Dominion University</u>:

i. ***Smartphone-based Solutions to Monitor and Reduce Fuel Consumption and CO_2 Footprint***

This is a banner project in terms of presentations, papers and techniques contained in the papers. Several individuals have participated in writing relevant papers and completing this

project. Their names appear on the papers listed below. Publications and Presentations supported by this TranLIVE US DOT UTC grant are listed below:

Project Related Refereed Journal Publications

- Wang, X., & A. Khattak. Is smart growth associated with reductions in CO2 emissions? Transportation Research Record, 2375, 2013, pp. 62-70.
- Wang X., A. Khattak, J. Liu, G. Amoli, & S. Son. What is the level of volatility in instantaneous driving decisions? Transportation Research Part C, Volume 58, Part B, September 2015, pp. 413-427.
- 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.
- Bandeira J., T. Almeida, A. Khattak, N. Rouphail, & M. Coelho. Generating emissions information for route selection: Experimental monitoring and routes characterization. Journal of Intelligent Transportation Systems, 17:1 Taylor & Francis Publishers, 2013, pp. 3-17.
- Bandeira, J., D. Carvalho, P. Fernandes, T. Fontes, S. Pereira, N. Rouphail, A. Khattak, M. Coelho. Empirical assessment of route choice impact on emissions over different road types, traffic demands, and driving scenarios. International Journal of Sustainable Transportation, Volume 10, Issue 3, 2016, pp. 271-283.
- Bandeira J., S. Pereira, T. Fontes, P. Fernandes, A. Khattak, M. Coelho. An eco-traffic management tool, computer-based modelling and optimization in transportation. Advances in Intelligent Systems and Computing, Volume 262, 2014, pp 41-56.
- Bandeira, J. M., Fontes, T., Pereira, S. R., Fernandes, P., Khattak, A., & Coelho, M. C. (2014). Assessing the importance of vehicle type for the implementation of eco-routing systems. Transportation Research Procedia, 3, 800-809.

Project Related Presentations

- Wang, X., & A. Khattak, Is smart growth associated with reductions in CO2 emissions? Presented at 2013 Transportation Research Board Annual meeting, Washington, D.C.
- Wang X., A. Khattak, J. Liu, G. Amoli, S. Son. What is the level of volatility in instantaneous driving decisions? Presented at the Transportation Research Board 2014 annual meeting (TRB Paper 14-2780); Presented as plenary Session Invited Talk, 13th COTA International Conference of Transportation Professionals, CICTP, Shenzhen, China, August 2013; presented at Hong Kong University of Science and Technology, and at PacTrans Seminar Series at University of Washington.
- Liu J., X. Wang, A. Khattak. Providing real-time driving volatility information, presented at ITS World Congress 2014 conference (Detroit, Sept 7-11).
- Khattak A. & J. Liu. Supporting calmer instantaneous driving decisions: use of vehicle trajectory data to generate alerts and warnings, TRB paper # 15-1345, presented at 2015 Transportation Research Board Annual meeting, Washington, D.C.
- 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 2015 Transportation Research Board Annual meeting, Washington, D.C.
- Liu J., A. Khattak, & L. Han. What is the magnitude of information loss when sampling driving performance data? TRB paper # 15-0968, presented at 2015 Transportation Research Board Annual meeting, Washington, D.C.

- Liu J., A. Khattak & X. Wang. A comparative study of driving performance in metropolitan regions using large-scale vehicle trajectory, TRB paper # 15-0966, presented at 2015 Transportation Research Board Annual meeting, Washington, D.C.
- Son S., A. Khattak & K. Choi. Comparing travel behavior between transit-oriented developments and automobile-oriented developments: matched pair analysis, TRB Paper 14-2327, presented at the 2014 Transportation Research Board Annual meeting, Washington DC.
- Bandeira J., P. Fernandes, T. Fontes, S. Pereira. A. Khattak, & M. Coelho. Exploring multiple eco-routing guidance strategies in a commuting corridor, presented at 2016 Transportation Research Board Annual meeting, Washington, D.C.

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

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

- Enhancing TSM&O Strategies through User Cost Analysis and Life Cycle Assessment Final Report (needs peer-review)
- Chen, X., Salem, O., and Salman, B. (2016). "Life-Cycle Benefit-Cost Analysis Framework for Ramp Metering Deployments" TRB 95th Annual Meeting. Washington, D.C.: Transportation Research Board. Accepted for publication in the TRR.

ii. *Assessing Environmental Impacts of Traffic Congestion and Vehicular Emissions on Urban Fresh Water*

- Nothing to Report

iii. *Studying the Impact of Accelerated Construction Methods in Work Zones Using Microsimulation on Vehicle Emissions and the Environment*

- Ghorai, S., Salem, O., and Salman, B. (2016). "Assessment Of Traffic Emission Impacts Due To Rigid Pavement Repair And Rehabilitation Activities." Eighth International Conference on Maintenance and Rehabilitation of Pavements (MAIREPAV8), Singapore.

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

- Dr. O. Sam Salem, and Mr. Xifan (Jeff) Chen attended the Transportation Research Board's 95th Annual Meeting (January 10-14, 2016). Mr. Jeff Chen presented a poster titled "Life-Cycle Benefit-Cost Analysis Framework for Ramp Metering Deployments" at the conference.
- Mr. Song He attended the poster session on the Nunan Lecture and Research Day organized by Syracuse University on April 5th, 2016. The title of his poster was "A Sustainable Asset Management Framework for Intelligent Transportation System (ITS) Components".

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

- ***A Systematic Evaluation of the Impacts of Traffic Condition Information on the Reduction of On-road Mobile Emissions***
  - Qi, Y., A. Padiath, and L. Yu. "Development of Operating Mode ID Distributions for Different Types of Roadways under Different Congestion Levels for Vehicle Emission Assessment Using Moves", Journal of the Air & Waste Management Association, 2016. DOI:10.1080/10962247.2016.1194338

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

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

- Park S., Rakha H., Ahn K., and Moran K. (2013), "Virginia Tech Comprehensive Power-based Fuel Consumption Model (VT-CPFM): Model Validation and Calibration Considerations," International Journal of Transportation Science and Technology, Vol. 2, no. 4, pp. 317-336.
- Edwardes W. and Rakha H. (2014), "Virginia Tech Comprehensive Power-Based Fuel Consumption Model: Modeling Diesel and Hybrid Buses," Presented at the 93rd Transportation Research Board Annual Meeting, Washington DC, January 12-16, CD-ROM [Paper # 14-3863].
- Edwardes W. and Rakha H. (2014), "Virginia Tech Comprehensive Power-Based Fuel Consumption Model: Modeling Diesel and Hybrid Buses," Transportation Research Record: Journal of the Transportation Research Board, Issue 2428, pp. 1-9.
- Faris, W.F., Rakha, H.A. and Elmoselhy (2014), "Supercharged Diesel Powertrain Intake Manifold Analytical Model," *International Journal of Vehicle Systems Modelling and Testing*, 9(1), pp. 1-35.
- Faris, W.F., Rakha, H.A. and Elmoselhy (2014), "Impact of Intelligent Transportation Systems on Vehicle Fuel Consumption and Emission Modelling: An Overview," SAE Transactions: International Journal of Materials and Manufacturing, 7 (1), pp. 129-146.
- Faris, W.F., Rakha, H.A. and Elmoselhy (2014), "Analytical Model of Diesel Engines Exhaust NOx Emission Rate," International Journal of Vehicle Systems Modelling and Testing, vol. 9, no. 3/4, pp. 264-280.
- Elmoselhy S., Faris W. and Rakha H. (2014), "Experimentally validated analytical modeling of diesel exhaust HC emission rate," The Journal of Mechanical Science and Technology.
- 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.
- 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.
- Fiori C., Ahn K., and Rakha H. (2016), "Virginia Tech Comprehensive Power-based Electric Vehicle Energy Consumption Model: Model Development and Validation," Accepted for presentation at the 95th Transportation Research Board Annual Meeting, Washington DC, January 10-14. [Paper # 16-0631]
- Wang J. and Rakha H. (2016), "Heavy-Duty Diesel Truck Fuel Consumption Modeling," Accepted for presentation at the 95th Transportation Research Board Annual Meeting, Washington DC, January 10-14. [Paper # 16-2147]
- Wang J. and Rakha H. (2016), "Hybrid-Electric Bus Fuel Consumption Modeling: Model Development and Comparison with Conventional Buses," Accepted for presentation at the 95th Transportation Research Board Annual Meeting, Washington DC, January 10-14. [Paper # 16-0660]
- Abdelmegeed M., Ahn K., and Rakha H. (2016), "Modeling Light Duty Vehicle Emissions Exploiting VT-CPFM Fuel Estimates," Accepted for presentation at the 95th Transportation Research Board Annual Meeting, Washington DC, January 10-14. [Paper # 16-2448]
- Chiara F., Ahn K., and Rakha H.A. (2016), "Power-based Electric Vehicle Energy Consumption Model: Model Development and Validation," Journal of Applied Energy, pp. 257-268 DOI: 10.1016/j.apenergy.2016.01.097.

- Wang J. and Rakha H. (2016), "Hybrid-Electric Bus Fuel Consumption Modeling: Model Development and Comparison with Conventional Buses," Transportation Research Record: Journal of the Transportation Research Board. DOI: 10.3141/2539-11.
- Wang J. and Rakha H. (2016), "Fuel consumption model for conventional diesel buses," Journal of Applied Energy, Volume 170, pp. 394–402. DOI:10.1016/j.apenergy.2016.02.124.
- Elmoselhy S., Faris W. and Rakha H. (2016), "Experimentally validated analytical modeling of diesel engine power and in-cylinder gas speed dynamics," Journal of Mechanical Science and Technology.
- Faris W., Rakha H. and Elmoselhy S. (2016), "Validated Analytical Modeling of Diesel Engine Regulated Exhaust CO Emission Rate," Advances in Mechanical Engineering, 2016, Vol. 8(6), pp. 1–15. DOI: 10.1177/1687814016645981

ii. ***Developing and Field Implementing a Dynamic Eco-Routing System***

- Ahn K. and Rakha H. (2014), "Eco-Lanes Applications: Preliminary Testing and Evaluation," Transportation Research Record: Journal of the Transportation Research Board, Issue 2427, pp. 41-53.
- 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].
- 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].
- 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].
- 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.
- Van Essen, M., Rakha, H., Vreeswijk, J., Wismans, L., & Van Berkum, E. (2015). "Day-to-day route choice modeling incorporating inertial behavior." IATBR Conference, 19-23 July, 2015, Windsor, UK.
- Elbery A., Rakha H., El-Nainay M., Drira W., and Filali F., (2015), "Eco-Routing Using V2I Communication: System Evaluation," IEEE 18th International Conference on Intelligent Transportation Systems, Las Palmas de Gran Canaria, Spain, Sept. 15-18. [Paper # 1436].
- Elbery A., Rakha H., ElNainay M., Drira W. and Felali F. (2016), "Eco-Routing: An Ant Colony Based Approach," 2nd International Conference on Vehicle Technology and Intelligent Transport Systems (VEHITS), Rome, April 23-24.
- Elbery A., El-Nainay M. and Rakha H. (2016), "Proactive and Reactive Carpooling Recommendation System based on Spatiotemporal and Geosocial Data," WiMob, New York, USA, October 17-19.

iii. ***Developing and Field Implementing an Eco-Cruise Control System in the Vicinity of Traffic Signalized Intersections***

- Kishore Kamalanathsharma, R., & Rakha, H. A. (2014). Leveraging Connected Vehicle Technology and Telematics to Enhance Vehicle Fuel Efficiency in the Vicinity of Signalized Intersections. Journal of Intelligent Transportation Systems, (ahead-of-print), 1-12.
- Kamalanathsharma, R. K., and Rakha, H. A. (2014). Agent-Based Simulation of Ecospeed-Controlled Vehicles at Signalized Intersections. Transportation Research Record: Journal of the Transportation Research Board, 2427(1), 1-12.
- Kamalanathsharma R., Rakha H., and Zohdy I. (2015), "Survey on In-vehicle Technology Use: Results and Findings," International Journal of Transportation Science and Technology, vol 4(2), pp. 135-150.
- Kamalanathsharma R., Rakha H. and Yang H. (2015), "Network-wide Impacts of Vehicle Eco-Speed Control in the Vicinity of Traffic Signalized Intersections," Transportation Research Record: Journal of the Transportation Research Board.
- Venkat Ala M., Yang H., and Rakha H. (2016), "Sensitivity Analysis of Eco-Cooperative Adaptive Cruise Control at Signalized Intersections," Accepted for presentation at the 95th Transportation Research Board Annual Meeting, Washington DC, January 10-14. [Paper # 16-2891]
- Yang H., Ala V.M., and Rakha H. (2016), "Eco-Cooperative Adaptive Cruise Control at Signalized Intersections Considering Queue Effects," Accepted for presentation at the 95th Transportation Research Board Annual Meeting, Washington DC, January 10-14. [Paper # 16-1593]
- Chen H., Rakha H., Amara L., El-Shawarby I. and AlMannaa M. (2016), "Development and Preliminary Field Testing of an In-Vehicle Eco-Speed Control System in the Vicinity of Signalized Intersections," 14th IFAC Symposium on Control in Transportation Systems, Istanbul, Turkey, May 18-20.
- Venkat Ala M., Yang H., and Rakha H. (2016), "A Modeling Evaluation of Eco-Cooperative Adaptive Cruise Control in the Vicinity of Signalized Intersections," Transportation Research Record: Journal of the Transportation Research Board. DOI:10.3141/2559-13.

3. <u>PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS</u>:

A. <u>University of Idaho:</u>

Idaho Transportation Department – District 2, Lewiston, Idaho
City of Moscow, Moscow, Idaho
Econolite, Inc.
Arada Systems

B. <u>Old Dominion University:</u>

- Mr. Jun Liu worked with Dr. Khattak during reporting period on the topic of short-term driver behavior and feedback. Dr. Liu defended his dissertation titled “Driving Volatility in Instantaneous Driving Behaviors: Studies Using Large-Scale Trajectory Data” in 2015, with Dr. Khattak as advisor. The dissertation content is directly related to this research project.
- Dr. Khattak, Dr. Wang, Dr. Liu and graduate students Mr. X. Li and Ms. M. Zhang, worked on the project during the reporting period, and successfully completed the project.
- Mr. Xiaobing Li worked on integrating the research papers into the final report. The report also became his Master’s Thesis project.
- Mr. Bandeira worked collaboratively at University of Aveiro with Dr. Khattak on the topic of eco-friendly routes and emissions information generation. Mr. Bandeira defended his dissertation titled “Road traffic information platform for energy and emissions savings” on December 19,

2013, with Dr. Khattak as his co-advisor. The dissertation content is highly related to this project.

- 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. Their collaborative work has appeared in refereed journals.
- Mr. Bandeira from University of Aveiro had joined the research team at Old Dominion University during January and February, 2013, while he worked on the project.
- Relevant work was presented as a technical paper at the Transportation Research Board 2014 annual meeting; plenary session Invited Talk, 13th COTA International Conference of Transportation Professionals, CICTP, Shenzhen, China, August 2013; Hong Kong University of Science and Technology; and at PacTrans Seminar Series at University of Washington. Several relevant papers were presented at the Transportation Research Board 2015 and 2016 annual meetings.

C. Syracuse University:

Nothing to report.

D. Texas Southern University:

- PI is supervising the overall research activities for this project; graduate student assistants provided assistance on field data collection for this study, data analysis, methodology development and conduct case studies; and the research associate provides assistance on advising student assistants.
- PI and Dr. Xumei Chen collaborate on a research paper related to this project and the paper has been submitted to transportation research part D for publication.

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).

ii. ***Developing and Field Implementing a Dynamic Eco-Routing System***
Collaborated with the University of Twente in the Netherlands.

iii. ***Developing and Field Implementing an Eco-Cruise Control System in the Vicinity of Traffic Signalized Intersections***
Lamar University.

4. IMPACT:

A. University of Idaho:

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

Education:

1. Four Ph.D. students (two Civil Engineering and two Computer Science students) and one M.Sc. computer science students working on the project
2. Five undergraduate students working on the field demonstrations.

ii. Research:

1. Field test to demonstrate connected vehicle traffic signal system applications
2. Field test to demonstrate the security and survivability of connected vehicles communication exchange at signalized intersection approaches.
3. 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.
4. A laboratory prototype for connected vehicle traffic signal system application

5. Educational modules covering eco-routing, eco-traffic signal systems, and eco-driving strategies

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

Education:

1. One M. Sc. student in Mechanical Engineering graduated.
2. Two undergraduate electrical engineering student continued working as undergraduate research intern.

Research

1. Vehicle-emission and fuel consumption data for passenger vehicles and light-duty trucks under different speed and acceleration operation.
2. Vehicle-emission and fuel consumption data for heavy vehicles (diesel engines) under different speed and acceleration operation.
3. Calibrated fuel consumption and emission models in two microscopic simulation models: VISSIM and Integration.

iii. ***Eco-driving Modeling Environment***

Research

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

Education

1. One computer science undergraduate student and one psychology graduate student
2. Two undergraduate students (psychology and mechanical engineering)

B. <u>Old Dominion University</u>:

i. ***Smartphone-based Solutions to Monitor and Reduce Fuel Consumption and CO_2 Footprint***

1. In terms of education, this project contributed by training post-docs (Dr. J. Liu, and X. Wang) and several graduate students (J. Liu, M. Zhang, G. Amoli, and S. Son) who worked on modeling and smart growth land use strategies, microscopic driving decisions, energy use and emissions issues.
2. In terms of research, the project has generated 9 international conference presentations and 7 refereed papers in high-impact journals. These represent important contributions to the state of the art in energy and emissions modeling. The work was disseminated via refereed journals, conference presentations, and invited talks nationally and internationally.
3. Various products and applications were developed in order to support more eco-friendly driving decisions.
4. The study has contributed to greater consciousness about the energy and environmental issues.

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

i. Dr. Baris Salman offered a graduate level course titled: "Sustainable Development and Infrastructure Management (CIE 639 / ECS 636)" in Spring 2016. The class focused on two major components: (i) Infrastructure Asset Management, and (ii) Sustainability of Infrastructure Systems. The course featured lectures, discussions, student presentations and reports, and exams. Management strategies and sustainability concepts for a wide variety of infrastructure systems including transportation infrastructure systems were examined thoroughly. The first part of the class (Asset management part) discussed strategies for determining appropriate maintenance, repair and rehabilitation activities for existing infrastructures in consideration of economic impacts. Topics such as Life Cycle Cost Analysis

(LCCA), inventory databases, condition assessment, performance and deterioration modeling, failure analysis, economic analysis, and decision making procedures were covered. The second part of the course (sustainability part) addressed sustainable infrastructure development considering the triple-bottom-line of sustainability (i.e., environmental, social/cultural and economic sustainability.) Various types of sustainable infrastructure frameworks that can be used to evaluate the impacts of infrastructure projects were discussed. Students were introduced with the steps involved in conducting a Life Cycle Assessment (LCA) and various sustainability rating tools such as LEED and ENVISION. Number of graduate students enrolled = 30.

ii. Dr. Davidson and Ms. Joan Dannenhoffer offered the course "Sustainability in Civil and Environmental Systems" in Spring 2016. The primary objectives of this course were to: 1) introduce principles of sustainability and systems as applied to the natural and built environments; 2) provide skills necessary for quantitative assessments of civil and environmental engineering problems; 3) use principles developed in class to evaluate and solve complex open-ended environmental problems and communicate the results of the analysis. Number of students enrolled = 72.

iii. Dr. Davidson was a co-author of a Final Report on "Teaching of Sustainability in Engineering Schools", which was submitted to National Science Foundation.

iv. Dr. Davidson participated in ASCE's Global Sustainability Workshop in January 2016.

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

a. 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.

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

i. ***Develop Multi-scale Energy and Emission Models***
   a. **Education**: The funding of several graduate student assistantships.
   b. **Research**: Development of fuel consumption models for light duty cars, buses, heavy duty trucks, EVs, PHEVs and HEVs.
   c. **Technology Transfer**: Publication of results at various conferences.

ii. ***Developing and Field Implementing a Dynamic Eco-Routing System***
   a. **Education**: The funding of several graduate student assistantships.
   b. **Research**: Development of an eco-routing prototype.

iii. ***Developing and Field Implementing an Eco-Cruise Control System in the Vicinity of Traffic Signalized Intersections***
   a. **Education**: The funding of several graduate student assistantships.
   b. **Research**: Development of an eco-CACC prototype and testing it in the field.

5. CHANGES/PROBLEMS

A. University of Idaho:

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

Nothing to Report.

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

Nothing to Report.

iii. ***Eco-driving Modeling Environment***

Nothing to Report.

B. Old Dominion University:

Nothing to report.

C. Syracuse University:

Nothing to report.

D. Texas Southern University:

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

A no-cost extension to August 31 2016 is requested.

E. Virginia Tech:

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

Nothing to report.

ii. ***Developing and Field Implementing a Dynamic Eco-Routing System***

Nothing to report.

iii. ***Developing and Field Implementing an Eco-Cruise Control System in the Vicinity of Traffic Signalized Intersections***

Nothing to report.

6. SPECIAL REPORTING REQUIREMENTS

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

Completed by:
University of Idaho: Ahmed Abdel-Rahim
Old Dominion University: Mecit Cetin
Syracuse University: O. Sam Salem
Texas Southern University: Fengxiang Qiao, Yi Qi
Virginia Tech: Hesham Rakha