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: April 30, 2017

Report Frequency: Semi-annual

Signature of Submitting Official:

SEMI-ANNUAL REPORTING CATEGORIES
TranLIVE DTRT12GUTC17
January 1, 2017 to April 30, 2017

1. ACCOMPLISHMENTS:

A. University of Idaho:

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

a. Two field demonstrations for connected vehicle traffic signal system applications one at Ada County Highway District in Boise, Idaho and the second in Idaho National Lab and the Center for Advanced Energy Studies (CAES) in Idaho Falls, Idaho
b. Two field tests to demonstrate the security and survivability of connected vehicles communication exchange at signalized intersection approaches at Ada County Highway District in Boise, Idaho and the second in Idaho National Lab and the Center for Advanced Energy Studies (CAES) in Idaho Falls, Idaho
c. Two connected-vehicle traffic signal system workshops for the staff at Ada County Highway District in Boise, Idaho and the second in Idaho National Lab and the Center for Advanced Energy Studies (CAES) in Idaho Falls, Idaho
d. Web-Based Eco-Traffic Signal System educational modules (total 11 modules)
e. Project final report

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 GT-Suite advanced engine modeling software, to generate vehicle-emission and fuel consumption data for hybrid passenger vehicles under different speed and acceleration operation
d. 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
e. Project final report

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

a. A calibrated and validated An Eco-Driving modeling environment that integrates the NADS MiniSim driver simulator model and the GT-Suite advanced engine modeling tool
b. Web-based Eco-Driving educational modules
c. Project Final Report

B. Old Dominion University:

Nothing to Report

C. Syracuse University:

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

The research team worked on finalizing the final report.

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

The research team worked on writing the final report.

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

The research team worked on finalizing the final report.

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

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

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.
- Completed 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).
j. Extending VT-CPFM to model electric trains.

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.
e. Study the impact of communication network on the eco-routing application performance.
f. Developing a system equilibrium eco-routing system.
g. Developing new fuel consumption model for heavy duty diesel trucks

h. Developing a scalable realistic model for simulation of the eco-routing in connected vehicles networks.

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.
e. Conducted simulation tests of eco-CACC algorithms.
f. Conducted field tests of eco-CACC system with participants in four scenarios.
g. Analyzed the field test results of eco-CACC system.
h. Conducted the data analysis of simulation tests.
i. Completed the final report.

2. <u>PRODUCTS</u>:

- **<u>University of Idaho</u>:**

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

- Two field tests to demonstrate connected vehicle traffic signal system applications
- Two field tests 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.
- Web-based connected-vehicle traffic signal system educational modules
- A laboratory prototype for connected vehicle traffic signal system application
- Mohamed S. Mohamed, Sherif Hussein, and Axel Krings, "An Enhanced Voting Algorithm for Hybrid Jamming Attacks in VANET", in Proc. IEEE 7th Annual Computing and Communication Workshop and Conference (CCWC), Las Vegas, January 9-11, 2017.
- Sherif Hussein, Mohamed S. Mohamed, and Axel Krings, "A New Hybrid Jammer and its Impact on DSRC Safety Application Reliability", in Proc. 7th IEEE Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON), Vancouver, Canada, 13- 15 October, 2016.
- Yassine Maalej, Ahmed Abdel-Rahim, Mohsen Guizani, Bechir Hamdaoui, Elyes Balti, “Advanced Activity-Aware Multi-Channel Operations in IEEE 1609.4 in VANETs for Vehicular Clouds”, Proceedings of the IEEE GLOBECOM 2016 Conference, Washington, D.C., USA, December 2016.
- Bingxing Wu; Ahmed Abdel-Rahim, and Suat Ay, “A Trapezoid Multiresolution CMOS Image Sensor for Traffic Monitoring”, 2016 IEEE 59th International Midwest Symposium on Circuits and Systems, Abu Dhabi, United Arab Emirates, October 2016
- Web-Based Eco-Traffic Signal System educational modules (total 11 modules)
- Project final report

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

- Used the GT-Suite advanced engine modeling software, to generate vehicle-emission and fuel consumption data for hybrid passenger vehicles under different speed and acceleration operation
- Calibrated fuel consumption and emission models in two microscopic simulation models: VISSIM and Integration
- Project final report

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

- A calibrated and validated An Eco-Driving modeling environment that integrates the NADS MiniSim driver simulator model and the GT-Suite advanced engine modeling tool
- Web-based Eco-Driving educational modules
- Project Final Report

- **<u>Old Dominion University</u>:**

Nothing to Report

- **<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
- 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.
- Chen, X., Salem, O., and Salman, B. (2016). Life-Cycle Benefit–Cost Analysis Framework for Ramp-Metering Deployments. Transportation Research Record: Journal of the Transportation Research Board, (2554), 69-76.

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

- Johnson, Alex J. and Cliff I. Davidson, Deposition and washoff of atmospheric trace metals and anions from two large building roofs, Platform Presentation, American Association for Aerosol Research, Annual Conference, Portland, OR, October 17-21, 2016 (Abstract only)
- Johnson, Alex J. and Cliff I. Davidson, Washoff of Dry Deposited Atmospheric Aerosol from a Traditional Roof and a Green Roof, Platform Presentation, American Association for Aerosol Research, Annual Conference, Raleigh, NC, October 16-20, 2017 (Abstract only)

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 2018 Annual Meeting.
- 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.
- Ghorai, S., Salem, O., and Salman, B. "Assessment of Traffic Emission Impacts Due to Pavement Rehabilitation Activities" 2017 International Conference on Sustainable Infrastructure, ASCE. (Accepted for Poster Presentation)

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

- Song He, Ossama Salem, Baris Salman (2017). "An Asset Management Framework for Ramp Metering Systems (RMS) and Adaptive Traffic Control Systems (ATCS)" The Ninth International Structural Engineering and Construction Conference (ISEC-9).
- Dr. Baris Salman, and Mr. Song He attended the Transportation Research Board's 96th Annual Meeting (January 8-12, 2017). They presented a poster titled "Innovative Maintenance, Repair, And Reconstruction Techniques for Asphalt Roadways: A Survey of State Departments of Transportation" at the conference.
- Mr. Song He attended the poster session on the ECS Research Day organized by Syracuse University on April 25th, 2017. The title of his poster was "A Survey and Decision Support System for Innovative Maintenance, Repair, and Reconstruction Techniques for Asphalt Roadways".
- Cliff Davidson was the primary organizer of the "Workshop on Sustainability in Engineering Education", Tuesday June 20, at Ann Arbor, Michigan, as part of the Association of Environmental Engineering and Science Professors' Conference. Roughly 50 participants, mainly PhD students who want to become faculty.
- Cliff Davidson is a member of the research project Urban Resilience for Climate Extremes led by Arizona State University. He is a member of the Management Team, the Urban Flooding Task Force, the Transitions and Implementation Work Group, and Education and Diversity Work Group.
- **Texas Southern University:**

Nothing to report.

- **Virginia Tech:**

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
- Wang J. and Rakha H. (2017), “Electric Train Energy Consumption Modeling,” Journal of Applied Energy, Volume 193, pp. 346–355. DOI: 10.1016/j.apenergy.2017.02.058.
- Wang J. and Rakha H. (2017), "Convex Fuel Consumption Model for Diesel and Hybrid Buses," Transportation Research Record: Journal of the Transportation Research Board, No. 2647. DOI: 10.3141/2647-07.
- Wang J. and Rakha H. (2017), “Fuel Consumption Model for Heavy Duty Diesel Trucks: Model Development and Testing,” Transportation Research: Part D, Volume 55, pp.127-141. DOI: 10.1016/j.trd.2017.06.011.

- Abdelmegeed M.and Rakha H. (2017), "Heavy-Duty Diesel Truck Emission Modeling," Transportation Research Record: Journal of the Transportation Research Board, No. 2627. DOI: 10.3141/2627-04.

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.
- Wang, J. and H.A. Rakha, *Fuel consumption model for heavy duty diesel trucks: Model development and testing.* Transportation Research Part D: Transport and Environment, 2017. **55**: p. 127-141.
- Elbery, Ahmed, and Hesham A. Rakha. A Novel Stochastic Linear Programming Feedback Eco-routing Traffic Assignment System. No. 17-00912. 2017.
- Elbery, Ahmed, and Hesham A. Rakha. A Scalable Framework for Modeling Communication in Vehicular Environment and An Application Case Study. Submitted to TRB 2018.

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.
- Hao Chen, Hesham A. Rakha, Mohammed Almannaa, Amara Loulizi and Ihab El-Shawarby (2017), "Field Implementation of an Eco-cooperative Adaptive Cruise System at Signalized Intersections," in 95th Annual Meeting Transportation Research Board, Washington D.C.
- Mohammed Almannaa, Hao Chen, Hesham A. Rakha, Amara Loulizi, Ihab El-Shawarby and (2017), "Controlled-Field Evaluation of Effectiveness of Infrastructure-to-Vehicle Communication in Reducing Vehicle Fuel Consumption and Delay at Signalized Intersections," in 95th Annual Meeting Transportation Research Board, Washington D.C.

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

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

Ada County Highway District (ACHD)
Idaho National Lab
Center for Advanced Energy Studies (CAES)
Econolite, Inc.
Arada Systems

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

Nothing to Report

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

Nothing to report.

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

Nothing to Report.

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:

Nothing to report.

Research:

1. Two field tests to demonstrate connected vehicle traffic signal system applications
2. Two field tests 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. Web-based connected-vehicle traffic signal system educational modules
6. Four peer reviewed publications

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

Education:

Nothing to report.

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. Vehicle-emission and fuel consumption data for hybrid passenger vehicles under different speed and acceleration operation.
4. Calibrated fuel consumption and emission models in two microscopic simulation models: VISSIM and Integration.
5. Project final report

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
2. Web-based Eco-Driving educational modules

Education

Nothing to report.

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

Nothing to Report

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

1. Dr. Baris Salman offered a graduate level course titled: "Sustainable Development and Infrastructure Management (CIE 639 / ECS 636)" in Spring 2017. 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 = 23.
2. Dr. Davidson and Ms. Joan Dannenhoffer offered the course "Sustainability in Civil and Environmental Systems" in Spring 2017. 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 = 68.

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

Nothing to Report**.**

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, HEVs, and electric trains.
   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. Development of a new fuel consumption model for the heavy duty diesel trucks. Studying the impact of communication on the eco-routing application. The study showed that the communication network can significantly affect the system performance. Development of a system equilibrium eco-routing system. Development of a scalable framework to study the eco-routing in connected vehicles environment.

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:

Nothing to Report.

B. Old Dominion University:

Nothing to Report

C. Syracuse University:

Nothing to Report.

D. Texas Southern University:

Nothing to Report.

E. Virginia Tech:

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

The scope of the project has been changed to focus on expanding the microscopic modeling framework to consider: (1) buses; (2) trucks; (3) electric vehicles (4) plug-in hybrid electric vehicles; and (5) hybrid electric vehicles. This extensive framework will be the first to modal all these different vehicle types.

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