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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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.

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Report Frequency: Semi-annual

Signature of Submitting Official:

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
   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
   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

   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*
   A new method of sampling atmospheric deposition of particles emitted from vehicles onto urban surfaces was developed. The method also permits assessment of levels of contamination in precipitation runoff that enters storm sewers and receiving waters in urban areas. The new technique is based on the well-established "throughfall method" for sampling atmospheric deposition of particles over forests. In this method, collection

buckets are placed on towers above the forest canopy and also on the ground beneath the foliated crowns of the trees. Rain washes the deposited particles off the leaves and branches of the trees and into the collection buckets on the ground, thus capturing the throughfall runoff. The chemical concentrations in the runoff will thus be greater than those in the incoming precipitation. The deposition quantity is obtained by subtracting the concentration in the lower buckets from the concentration in the buckets on the towers.

The adaptation of the method to urban areas involves sampling rain runoff from building roofs that flows into the drainpipes. By sampling fresh precipitation on a building roof and simultaneously sampling the drainpipe runoff, one can estimate the increase in concentration of a chemical species in particles deposited from the atmosphere that are washed by rain into the drainpipes. In Project 2, large horizontal Teflon-coated disks that reliably measure dry deposition without excess turbulence were set up to estimate deposition of atmospheric particles emitted from vehicles. This step enabled a check against contamination of the runoff samples by roofing and pipe materials. In addition, runoff from a large green roof was sampled to identify which chemical species were leached out of the growth medium, and which chemical species from the atmosphere were being filtered out by the growth medium.

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.
- 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.
        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
  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.

2. PRODUCTS:

- **University of Idaho:**
   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

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.

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

- **Old Dominion University:**

Nothing to Report
- **Syracuse University:**

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)

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*

- The research team is preparing a manuscript to be submitted to an international conference.
- **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

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.

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. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS:
   A. University of Idaho:
   Ada County Highway District (ACHD)
   Idaho National Lab
   Center for Advanced Energy Studies (CAES)
   Econolite, Inc.
   Arada Systems
   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 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. Two Ph.D., and one M.Sc. computer science student and two Civil Engineering M. Sc. student working on the project
            2. Four undergraduate students working on the field demonstrations.
        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:
            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. 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.
        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
1. Two undergraduate students (Psychology and Mechanical Engineering)

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

C. <u>Syracuse University</u>:
1. Dr. Baris Salman offered "Transportation Engineering" course in Fall 2016. Number of students enrolled = 83. The topics covered included geometric design of highways, fundamentals of traffic engineering, level of service, and signalized intersections.
2. Dr. Cliff Davidson offered "Introduction to Sustainable Engineering" course in Fall 2016. Number of students enrolled = 21. The topics covered included principles of sustainable engineering, environmental history, the rise of sustainability arguments in the twentieth century, modeling population, food production, and water management, industrial ecology, and energy and materials.
3. Cliff Davidson presented invited keynote talks at two conferences: (1) The Second International Conference on Sustainable Infrastructure in Shenzhen, China, October 18, 2016, and (2) The Fifth International Conference on Sustainability Science and Engineering in Suzhou, China, October 26, 2017.
4. Also during this trip, Davidson met with senior personnel at four Chinese institutions to plan a collaborative research proposal for the Partnerships in International Research and Education (PIRE) program at NSF. These institutions included (1) the Institute for Building Research in Shenzhen, (2) Southeastern University in Nanjing, (3) Nanjing University, and (4) the Chinese Research Academy in Environmental Sciences in Beijing. Informal talks were given at the first three of these institutions, and an advertised research seminar was given at the last one. Detailed research plans were discussed at each institution.

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

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

        Nothing to Report**.**

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

      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*

        The simulation time for the V2I model is too long. So, the developed model lacks for scalability. We are working to develop another model scalable model.

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

        Nothing to report.

6. <u>SPECIAL REPORTING REQUIREMENTS</u>

    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