

**Program Progress Performance Report
University Transportation Centers
Cover Page TranLIVE**

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

Program Director: Karen Den Braven; Director of NIATT and TranLIVE; kdenb@uidaho.edu; 208-885-7655

Submitting Official: Tami Noble; Assistant to the Director, NIATT; tnoble@uidaho.edu; 208-885-0576

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Tami Noble

SEMI-ANNUAL REPORTING CATEGORIES
University of Idaho
July 1, 2012 to December 31, 2012

1. ACCOMPLISHMENTS:

A. University of Idaho:

Karen Den Braven & Ahmed Abdel-Rahim attended the 2012 UTC Spotlight Conference on Sustainable Energy and Transportation: Strategies, Research, and Data” on November 8-9, 2012 held at The Keck Center of the National Academies in Washington, DC.

Karen Den Braven did site visits to all TranLIVE partner’s universities.

Joint graduate seminar series/class among all five partner universities for fall semester was a success.

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

The capabilities and the source of environmental data used in different emission and fuel consumption modeling tools as well as in traffic analysis and optimization tools were investigated and documented. An extensive literature review focusing on eco-traffic signal control applications including strategies developed and tested as part of the FHWA’s AERIS program was also conducted. Hardware-in-the-loop and software-in-the-loop test environments were developed and validated. These models will be used to test eco-traffic signal system control strategies in the next phase of the project.

ii. *In situ Transesterification of Microalgal Oil to Produce Algal Biodiesel*

The research objective in this stage is to pre-screen the operating variables for in situ processing of microalgal biomass directly in supercritical methanol (i.e., 239.5 °C; 8.14 MPa). The rationale is to utilize the beneficial effect of supercritical methanol as a strong solvent (to extract the lipids from algal biomass) and as the reactant (to transesterify the lipids to biodiesel).

Preliminary experiments have been carried out first to explore the operability of a batch reactor system. In doing so, experiments were conducted using different feedstocks, i.e., soybean and rapeseed oils.

Results show that the methanol-to-oil molar ratio affects the conversion in the range explored. It is also revealed that the conversions of microalgae samples are considerably lower than those of vegetable oils. Such result still reveals that in situ transesterification work feasibly on complex biomass.

iii. *Security and Survivability of Real-Time Communication Architecture for Connected-Vehicle Eco-Traffic Signal System Applications*

A thorough investigation has been conducted to assess the survivability of Dedicated Short-Range Communications (DSRC) in intelligent transportation systems (ITS). In addition to a literature overview the DSRC Message Set Standard, SAE J2735 has been examined in order to map out the communication protocol and the dependencies of the messages. Furthermore we have started deriving a model allowing the analysis of timing dependencies of messages, in addition to identifying basic functionalities associated with DSRC packet sequences in order to detect deviations from normal behavior.

iv. *Developing Active Learning Materials for the Introductory Transportation Engineering Course*

Began process of new curriculum for intersection operations

v. *Pyrolysis Bio-Oil Upgrading to Renewable Fuels*

The nanosprings (NS) were first grown on glass frits via a vapor-liquid-solid mechanism and subsequently decorated with cobalt (Co) nanoparticles using a thermal assisted reduction process. Morphologies of the catalysts were characterized by scanning and transmission electron microscopes (SEM and TEM). X-ray diffraction (XRD) and TEM were used to identify the crystal structure and estimate the cobalt crystallite size.

X-ray photoelectron spectroscopy (XPS) was used to monitor the oxidation states and chemical bondings of cobalt in the fresh and used catalysts.

For Co-NS catalysts preparation, the attempt to use cobalt nitrate used as precursor for the sol-gel catalyst was unsuccessful. Larger size cobalt oxide nanoparticles with the tendency to aggregate were produced.

vi. *Progress in Catalytic Ignition Fabrication, Modeling and Infrastructure*

a. In the Small Engine Research Facility, a flowbench that was made in-house a few years back has been revived to take detailed flow measurements of engine exhaust systems that are used by both our Formula Hybrid and Clean Snowmobile Challenge teams. A dynamometer-equipped engine was created that will be used to train student researchers on how to safely and properly use the dynamometer and emissions equipment before they do those types of tests on their research engines.

Much effort has gone in to preparing to move the Small Engine Research Facility into the new Vehicle Research Building that was recently renovated on campus. The final move occurred in December, 2012.

b. Understanding the catalytic ignition of alternative transportation fuels requires measurement of the light-off temperature of fuel-oxidizer mixtures on different catalyst surfaces. A key component of the measurement is the variable temperature coefficient of resistance, $\alpha(T)$, for combustion catalysts including platinum. Literature data gives $\alpha(T)$ for 273-373 K and 1200-1900 K, but no values in between where most of the fuel-oxidizer mixtures react on the catalyst surface.

Experiments in a muffle furnace were conducted to obtain the missing data. Using a 4-lead technique, the electrical resistance of a platinum wire was determined as a function of temperature.

vii. *Design Improvements and Performance Validation of a Competitive Hybrid FSAE Vehicle*

This semester began with the majority of the vehicle's systems and components needing to be redesigned in order to ensure the lightest and most reliable design possible. Many of the systems are nearing full completion; the frame, suspension, steering, and braking systems have been designed, manufactured, and assembled. The high voltage powertrain, pedal assembly, and exhaust system designs are completed and they are in the manufacturing stage.



Completed chassis with completed front suspension, steering, and engine installed. Through the design and manufacturing process our team discovered which team members possessed certain gifts and skills. Moving forward utilizing each team member's specialties will help propel our project forward.

B. Old Dominion University:

i. *New strategies for the emergency vehicle routing to reduce response time using vehicle-to-vehicle communications*

A microscopic simulation model was created in VISSIM to evaluate different strategies for expediting the travel times for Emergency Vehicles (EVs) through signalized intersections. These strategies involve both signal preemption and controlling movement of some vehicles within the queues to open gaps for the emergency vehicles. Based on the initial results, the proposed platoon split strategy was found to be very effective in reducing the EV travel times where there is significant congestion at the intersections.

ii. *Real-time prediction of queues at signalized intersections to support eco-driving applications*

Modeling work is underway to predict queue lengths from the known locations of probe vehicles. Based on the shockwaves generated when signals change phases and the real-time data provided by probe vehicles, a model is being developed to predict the queue size that will be encountered by a particular vehicle approaching the signal. This information will be useful to control the trajectory of the approaching vehicle in eco-signal and eco-driving applications.

iii. *Exploring image-based classification to detect vehicle make and model*

Two software products were developed to solve tasks related to the project. These products are described in the next section. In the development of these products, the adaptive mixture of Gaussians algorithm was learned. Additionally, techniques for handling vehicle occlusion, optical flow, and energy-based learning are being studied.

iv. *A Study on the Impact of Parameter Uncertainty on the Emission-based Ranking of Transportation Projects*

The impact of *not* accounting for capacity uncertainty in the ranking of capacity expansion projects based on traffic assignment has been examined. We found that capacity expansion decisions can be different in up to 15% of the cases when using mean capacity values. Whereas, it might be necessary and critical to evaluate mean system performance (as opposed to the system performance at mean capacity), the computational time will generally increase due to sampling requirements. We explored the use of Common Random Numbers (CRN) to reduce the sample size needed. For our case study using the Sioux Falls network, it

has been found that the reduction in sample size can be dramatic: Instead of 1200 samples (based on non-CRN), only 35 samples were needed in case of CRN.

v. *Reducing energy use and emissions through innovative community designs: methodology and application*

A framework was developed to model whether CO₂ emissions are associated with land use, socio-demographics, and preferences for information technology adoption. Using 2009 travel behavioral dataset (15,213 households from Virginia), sample selection models were estimated to answer whether smart growth developments are associated with lower CO₂ emissions. Conditionality of emissions on the decision to drive or not by household members on an assigned day was captured in the analysis. CO₂ emissions were calculated based on vehicle miles traveled and the fuel efficiency of the vehicle used for specific trips undertaken by household members. Tailpipe CO₂ emissions were found to be lower for households that reside in more mixed land use neighborhoods with denser roadway networks and better network connections in the neighborhood (on the order of 12%). Therefore, CO₂ emission reductions from smart growth developments can be substantial as a long-term strategy.

vi. *Optimize freight routes and modes to minimize environmental impacts*

Work was started on to use microscopic simulation of vehicle performance to produce better estimates of the fuel consumption and emission impacts of various transportation strategies and technologies for freight movement.

C. Syracuse University:

- i. The research projects focusing on the following topics started from July, 2012 –
 - a. Enhancing TSM&O strategies through user cost analysis and life cycle assessment;
 - b. Assessing social and environmental impacts of work-zones in arterial improvement projects;
 - c. Assessing environmental impacts of traffic congestion and vehicular emissions on groundwater and fresh water supplies.
- ii. Search for graduate students and a research associate, who will be participating in the research projects, was successful.
 - a. Ms. Shiuli Mahmud, a PhD Candidate in Environmental and Resource Engineering has been appointed as the Research Associate for her extensive research, project management and lean six-sigma background. She has an M.Sc and a B.Sc degree in Forestry and has a Diploma in Bioprocessing from SUNY ESF College. She is assisting Dr. Salem in directing Syracuse University's efforts in the TranLIVE Project, guiding the graduate students in their project work and monitoring their progress.
 - b. Xifan (Jeff) Chen, a graduate student, has completed the detailed literature search on enhancing TSM&O strategies through user cost analysis as well as life cycle assessment and reported it to Dr. Salem. The goal of his literature search is to understand the mechanism behind different existing LCA models, studying their feasibility with the TSM&O project and also to find out the different cost estimation processes involved at each stage of TSM&O. The critical analysis of the information gathered from the literature search helped him to understand the subject matter well, choose the right model to conduct the life cycle assessment, and formulate the data collection strategy. He started the data collection process and has recently got access to a nation-wide database on TSM&O strategies from INFOSYNC, the largest company to work on TSM&O strategies. He is currently working on processing the collected data.
 - c. Ms. Sharareh Pirzadeh, a graduate student, has conducted a detailed literature search. The objective of the literature search was to collect existing information in the following focus areas:

- The environmental impacts of arterial maintenance, repair and renewal procedures.
- The social impacts (user costs) of arterial maintenance, repair, and renewal procedures.
- How accelerated construction techniques can be utilized to reduce environmental and social impacts

The detailed literature search helped her to critically analyze the gathered information to develop her knowledge in this research area, understand the feasibility of the existing practices and she also developed methodology to address the research needs. She identified and listed the different existing tools available on LCA and LCCA that could be applied in her research area. Based on the information collected, she has formulated her data collection strategy and has started the data collection process from different agencies.

- d. Sudipta Ghorai, a graduate student, has just joined the TranLIVE project and has almost finished conducting a preliminary literature search on accelerated construction techniques, work zone management practices, life cycle assessment (LCA) and existing user cost and environmental impact assessment tools for maintenance, repair, and renewal activities. He is also developing the data collection strategy to address the research issues.
 - e. Jeremy Tamargo, a graduate student, is working on the issues of contamination of urban surface water by vehicle emissions. He has successfully completed an extensive literature search and is now working on the data collection strategy.
 - f. Mallory Squier, a graduate student, is working on the performance of the green infrastructures to reduce storm water runoffs. She is utilizing the largest green-grey roof available in New York State to reduce the edge effects for her study to compare the measurements with the roads, which will enable accurate measurements. She has completed her extensive literature search and now collecting data from the green roof using an above ground piping system she developed just for the study.
- iii. Dr. Sam Salem (PI) and Dr. Cliff Davidson (Co-PI) presented a seminar each for the TranLIVE seminar series. Dr. Salem presented on “Evaluating the Environmental, Social and Economic Impacts of arterial improvement projects,” whereas Dr. Davidson’s presentation was titled “User Cost Analysis and Life Cycle Assessment – An Overview.” Both of the topics addressed issues very related to the TranLIVE projects and are highly informative on the current issues.
 - iv. Dr. Sam Salem participated in the TRB conference titled “2012 UTC Spotlight Conference on Sustainable Energy and Transportation: Strategies, Research, and Data” on November 8-9, 2012 held at The Keck Center of the National Academies in Washington, DC.
 - v. Dr. Karen DenBraven, the Director of the National Institute for Advanced Transportation Technology of the University of Idaho visited Syracuse University on the 30th November, 2012 to increase the partnership among the participant universities of the TranLIVE project. She visited the Center of Excellence in Syracuse, where Edward A. Bogucz, the Executive Director of the Center of Excellence gave her a guided tour. Later on, four of the TranLIVE project participants presented their work to her. The following lively discussion and inputs from Karen had been a good opportunity for the participant students to understand the importance of their projects further and understand its value from a different perspective. It helped them to understand the importance of their contributions in the overall TranLIVE project.
 - vi. Two higher officials from USDOT, Dr. Nadarajah Sivanewaran and Mr. Eric Ross, conducted a daylong training session on LCCA and LCA techniques at the end of October 2012. They also delivered lectures on many current issues in the roads and highways construction fields, which helped our students to become aware of the emerging issues in this field.

- vii. A day long discussion session with another higher official from the USDOT, Mr. Timothy Cupples, was arranged by the Research Associate, Ms. Shiuli Mahmud, to help one of the participant graduate students, Mr. Sudipta Ghorai, to verify his developed decision – making a model on the accelerated construction techniques applied on bridges. Mr. Cupples has agreed to bring his team of experts in different fields of roads and highway construction field to Syracuse University next year in February, 2013 for a daylong seminar series, focusing mostly on the accelerated construction techniques and sustainable engineering in the transportation sector.
- viii. Dr. Cliff Davidson, Co PI of the TranLIVE projects at Syracuse University has taught a modified graduate level course on “Sustainable Development and Infrastructure Management” in Fall 2012, and all the graduate students selected for the TranLIVE project enrolled in this class. The class is divided into two major portions: (1) Infrastructure Asset Management and (2) Sustainability Aspects of Infrastructure Systems. In the first portion of the class, conventional management strategies for infrastructure systems are covered. These strategies include: inventorying, inspection, risk assessment and performance modeling, and decision making procedures. Software programs that are newly developed or commonly used in the infrastructure management sector have been introduced. In the second portion of the course, a special emphasis is placed on the environmental, social, and cultural impacts and benefits of infrastructure systems. The theory of life-cycle assessment (LCA) has been introduced and various applications of LCA have been covered. Throughout the semester, transportation systems have been one of the major points of focus of the course. Transportation asset management strategies and sustainability of transportation systems have been discussed thoroughly in the classroom.
- ix. Purchase of computers, equipped with the necessary software programs to conduct various types of analysis such as life-cycle assessment analysis, life-cycle cost analysis, user cost analysis, and etc. completed the establishment of a high-end computer laboratory that will be used for the research projects under the TranLIVE program.

D. Texas Southern University:

i. *A Systematic Evaluation of the Impacts of traffic Condition Information on the reduction of on-road mobile emissions*

- a. Reviewed literatures in following areas:
 - Studies on the impacts of traveler information on travelers
 - Studies on the impacts of traveler information on traffic flow
 - Studies on the impacts of traffic flow improvements on emission reduction
 - Methods of evaluating/quantifying the impacts of the traveler information systems on traffic flow/emissions
- b. Collected the GPS data and accident data in some selected roadway sections.

ii. *Education and Outreach Activities*

- a. Successfully organized the summer transportation academy at TSU June 2012 for two sessions of high school students (primarily minority).
- b. Contacted Mac Gregory Primary School (majority minority) in Houston to initiate a transportation club for grade 3-5 pupils.
- c. Prepared curriculum, list of reference books, assigned college students from TSU to advise the club in detail.
- d. Presented research papers, had papers accepted or receive student awards in academic conferences:

- The 15th IEEE Intelligent Transportation Systems Conference, Alaska, AK, September 16-19, 2012.
 - The Annual Meeting of Intelligent Transportation Society, Texas Chapter in Dallas, Texas, October 24-26, 2012.
 - The 92nd Transportation Research Board Annual Meeting, Transportation Research Board of the National Academies, Washington, DC, Jan 2013.
- iii. Develop an integrated data management system at the microscopic, mesoscopic, and macroscopic levels to assess the environmental impacts of transportation system**
- a. Developed framework of data management system
 - b. Identified data structure and vehicle emission and travel activity data sources
 - c. Coded necessary computer programs and web language
 - d. Used part of emission and activity data collected at Texas Southern University (TSU) to test the computer program and web language
- iv. Use the driving simulator to synthesize the related vehicle specific power (VSP) for emission and fuel consumption estimations**
- A scenario was designed for the driving simulator based on the real-world traffic situations including road type, traffic flow, signal time, etc. The test subjects drove on both the real-world roadways and the driving simulator with similar driving behaviors. By analyzing real-world and simulated vehicle activity data, it is found that the operating mode bins distributions from real-world roadway and from the simulator tests are different from each other. In order to make full use of the driving simulator data for emission estimation, a fuzzy logic based Table Look-Up Scheme was identified to calibrate the Operating Mode distributions from the simulator. The modeling results show that the validation error of overall emissions can therefore be reduced to less than 2%. These results imply that the operation data (e.g. speed, acceleration, VSP) from driving simulator can be used for vehicle emission estimation in the case that these data are correctly calibrated.
- v. Develop multi-scale energy and emission models for arterial traffic systems**
- a. Developed several scenarios on various designs of network topologies including one-way vs. two-way streets, different weaving path along freeway on- and off-ramps, and different densities of traffic signal designs. These scenarios have been used in modeling the impacts of different design and control strategies on vehicle emissions.
 - b. Used computer simulation software including VISSIM to simulate the traffic operations along one way vs. two way streets and along arterial traffic systems with different signal densities. Through simulation, we have learned that vehicles that run on one-way or two-way streets often generate totally different emissions.
 - c. Developed test and simulation plan to simulate the traffic operations at different weaving areas on freeways.
- vi. Improve the environment for a livable community: advance the AERIS program by developing and testing eco-traffic signal system control applications**
- a. Developed vehicle to infrastructure (V2I) communication system to improve the environment for a livable community. This is a RFID based short-range communication system with GPS as a supplemental device to provide position information.
 - b. Tested the RFID based V2I system in stop sign controlled unsignalized intersections and evaluated its impacts on environment. A Radio Frequency Identification (RFID) based Driver's Smart Assistance System (DSAS) was developed. The system hardware is inexpensive, while the current version of the system software is compiled in the computer program Visual Basic (VB). The RFID tags are placed on roadside, while the readers (receivers) and other devices such as GPS are equipped into the vehicles. Once a tag

coded as a stop sign is detected by the in-vehicle reader, the warning signal(s) will be broadcasted to drivers in the form of verbal and/or image message. Twenty subjects were recruited and tested while driving in a residential area in Houston. The statistical results from the tests show that the warning message from the DSAS can help vehicles to start to decelerate at an earlier distance from an unsignalized intersection, and so could enhance the safety at such intersections. The impacts of DSAS on vehicle emissions were also tested. Results show that the possible effects of DSAS on vehicle emissions are not clear, so more testing may be required.

- c. Tested the RFID based V2I system in work zone areas. The RFID devices provide the opportunity to communicate between vehicles and roadside work zone(s) in real-time and compensate with GPS and other sensors in traffic management. Suitable verbal and image warning message are provided to drivers when approaching work zone areas. Real road tests in the Houston area by twenty drivers were conducted and the impacts to vehicle speed, safety and vehicle emissions are examined. Statistical results from the test show that the DSAS helps drivers take earlier actions to decelerate and reduce vehicle speeds, improving workplace safety. Besides, this system can also be used to reduce most types of vehicle emissions, and receives good evaluations from all test subjects. It is recommended further testing and improving this promising system.
- d. Tested the RFID based V2I system in a signalized intersection. This research develops a smart warning system so that the drivers can be informed about the change of traffic signals through an RFID based in-vehicle smart warning system, which will reduce the crashes caused by possible sun glare on traffic lights. This research can have a great impact on both safety and air quality at intersections. The RFID based smart earlier warning system can be embedded into the current GPS system, and can be incorporated into future advanced in-vehicle co-pilot systems. With the implementation of this early warning system, it is envisioned that crash rates at signalized intersections will be greatly reduced and the surrounding environment be improved.

E. **Virginia Tech:**

i. Develop Eco-adaptive Cruise Control Systems

- a. Developed an eco-cruise control system.
- b. Compared eco-cruise control to manual and conventional cruise control driving.
- c. Integrated the eco-cruise control system with car-following models to develop an eco-drive system.

ii. Develop Green Cooperative Adaptive Control Systems in the Vicinity of Signalized Intersections

- a. Developed the cooperative adaptive control system logic in the vicinity of signalized intersections.
- b. Extended the logic to use dynamic programming to optimize the driver throttle input on a continuous basis. A publication on this is being prepared and submitted to the Journal of ITS.

iii. Develop Dynamic Eco-routing Systems

- a. Developed an eco-routing logic and incorporated the logic in the INTEGRATION software.
- b. Tested the logic on two large networks, namely: downtown Cleveland and downtown Columbus.

iv. Develop Multi-scale Energy and Emission Models

- a. Developed and validated the VT-CPFM model.

- b. Started developing a framework for modeling diesel engine vehicle fuel consumption levels.
- c. Assembled data on buses from China.
- d. Investigated the potential for use of electrified vehicles to serve traveler needs using naturalistic driving data.

2. **PRODUCTS:**

A. **University of Idaho:**

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

A white paper documenting the state-of-the-practice in fuel consumption and vehicle emission modeling covering emission modeling tools such as MOVES, CMEM, VT-Micro and traffic modeling and optimization tools such as CORSIM, VISSIM, TRNASY-7F, SYNCHRO was developed.

Abdel-Rahim, A., "Modeling Fuel Consumption and Emissions at Signalized Intersection Approaches: A Synthesis of Data Sources and Analysis Tools," Transportation Research Forum, March 21-23, 2013, Annapolis, MD.

ii. ***In situ Transesterification of Microalgal Oil to Produce Algal Biodiesel***

Nothing to report at this time

iii. ***Security and Survivability of Real-Time Communication Architecture for Connected-Vehicle Eco-Traffic Signal System Applications***

Nothing to report at this time

iv. ***Developing Active Learning Materials for the Introductory Transportation Engineering Course***

Nothing to report at this time

v. ***Pyrolysis Bio-Oil Upgrading to Renewable Fuels***

A poster was presented at the College of Science 8th Annual Research Exposition.

vi. ***Progress in Catalytic Ignition Fabrication, Modeling and Infrastructure***

Nothing to report at this time

vii. ***Design Improvements and Performance Validation of a Competitive Hybrid FSAE Vehicle***

D. Cordon, S. Wos, S. Beyerlein, E. Odom, "Highly Integrated Parallel Hybrid Powertrain" Presented at Society of Automotive Engineers 2012 Small Engine Technology Conference & Exhibition, October 16, 2012, Madison, WI, SAE Technical Paper doi:10.4271/2012-32-0026.

B. **Old Dominion University:**

i. ***New strategies for the emergency vehicle routing to reduce response time using vehicle-to-vehicle communications***

a. C.A. Jordan, M. Cetin, and R.M. Robinson, "Clearing Paths For Emergency Vehicles Using Vehicle-to-Vehicle Communication" To be presented at *the 92nd Annual meeting of the Transportation Research Board*, Washington, D.C., January 13-17, 2013.

b. M. Cetin and C. A. Jordan, "Making Way for Emergency Vehicles at Oversaturated Signals under Vehicle-to-Vehicle Communications" *2012 IEEE International Conference on Vehicular Electronics and Safety (ICVES'12)*, Istanbul, Turkey, July 24-27, 2012.

c. A webinar was given to the TranLive UTC partners:

<http://www.uidaho.edu/~media/Files/orgs/ENGR/Research/NIATT/TranLIVE/Seminars/Making%20Way%20for%20Emergency%20Vehicles.ashx>

- ii. ***Real-time prediction of queues at signalized intersections to support eco-driving applications***
A webinar was given to the TranLive UTC partners: “Understanding queue dynamics at signalized intersections based on Connected Vehicle data,” Sept 19, 2012.
- iii. ***Exploring image-based classification to detect vehicle make and model***
The program produced two methods. The first module is a UNIX script tool is used to automate the capture and categorization of sample traffic video to form a standard input database. The second module is a MATLAB implementation of an adaptive mixture of Gaussians algorithm to perform segmentation of vehicles from a background scene and to identify and label detected vehicles from this segmented data.
- iv. ***A Study on the Impact of Parameter Uncertainty on the Emission-based Ranking of Transportation Projects***
We are currently preparing a manuscript for submission to a journal.
- v. ***Reducing energy use and emissions through innovative community designs: methodology and application***
 - a. X. Wang, A. Khattak, Y., Zhang, “Is Smart Growth Associated with Reductions in CO₂ Emissions?” To be presented at the 92nd Annual meeting of the Transportation Research Board, Washington, D.C., January 13-17, 2013. Also accepted for publication in Transportation Research Record.
 - b. A. Khattak, “Is Smart Growth Associated with Reductions in CO₂ Emissions?” Invited talk at China-United States Bilateral Forum on Strategic Development of Transportation August 7, 2012, Shanghai, China.
 - c. A. Khattak, “Transportation for Livability by Integrating Vehicles and the Environment”, Invited talk at 12th COTA International Conference of Transportation Professionals (CICTP 2012), August 3-6, 2012, Beihang University (BUAA), Beijing, China.
- vi. ***Optimize freight routes and modes to minimize environmental impacts***
Nothing to report at this time

C. Syracuse University:

Nothing to report at this time

D. Texas Southern University:

- i. ***A Systematic Evaluation of the Impacts of traffic Condition Information on the reduction of on-road mobile emissions***
Nothing to report at this time
- ii. ***Education and Outreach Activities***
 - a. A series of education programs are in production, covering all ages of students (K-12 through college).
 - b. Two academic papers were presented or accepted for presentation at conferences on education efforts to minority high school students to promote their interests in transportation
 - Qiao, F., Godazi, K., and Yu, L. (2012). Increasing Interests of High School Students in Engineering through Summer Education. Presented and published in proceedings of the ASCE Earth & Space 2012 Conference, Pasadena, CA, April 15-18, 2012. Paper ID: 272.
 - Godazi, K., R. Goodwin, F. Qiao, A. Miller (2013). Exposing Minority Students to Transportation and STEM-related Careers Through Summer Education Programs. Accepted for presentation and publication in the 92nd Annual Meeting of

Transportation Research Board (TRB) Annual Meeting, Washington, DC. January 13-17, 2013.

iii. ***Develop an integrated data management system at the microscopic, mesoscopic, and macroscopic levels to assess the environmental impacts of transportation system***

Nothing to report at this time

iv. ***Use the driving simulator to synthesize the related vehicle specific power (VSP) for emission and fuel consumption estimations***

Ziyue Li, Fengxiang Qiao, and Lei Yu. Using Driving Simulator for Vehicle Specific Power (VSP) Simulation in Vehicle Emission Analyses - A Feasibility Study. Accepted for presentation at the 2013 Emerging Researchers National (ERN) Conference in STEM, February 28 – March 1, 2013. Washington, DC.

v. ***Develop multi-scale energy and emission models for arterial traffic systems***

Wang, J., L. Yu, and F. Qiao (2013). Micro Traffic Simulation Approach to the Evaluation of Vehicle Emission on One-way vs. Two-way Streets: A Case Study in Houston Downtown. Accepted for 92nd Transportation Research Board Annual Meeting, Transportation Research Board of the National Academies, Washington, DC, Jan 2013.

vi. ***Improve the environment for a livable community: advance the AERIS program by developing and testing eco-traffic signal system control applications***

- a. Qiao, F., Yu, L., Fatholahzadeh, R., and Yuan, X. (2012). Smart Guide Signing System Using RFID as an Intelligent Sensor. Presented and published in proceedings of the ASCE Earth & Space 2012 Conference, Pasadena, CA, April 15-18, 2012. Paper ID: 285.
- b. Qiao, F., J. Wang, X. Wang, J. Jia, and L. Yu (2012). A RFID Based E-STOP Sign and Its Impacts to Vehicle Emissions. Presented at and Published in the Proceedings of the 15th IEEE Intelligent Transportation Systems Conference, Alaska, AK, September 16-19, 2012.
- c. Qiao, Y., and F. Qiao (2012), Person-to-Infrastructure (P2I) Wireless Communications for Work Zone Safety Enhancement. Presented at and Published in the Proceedings of the 15th IEEE Intelligent Transportation Systems Conference, Alaska, AK, September 16-19, 2012.
- d. Qiao, F., X. Wang, L. Yu, and J. Jia (2013). Using RFID to Improve Drivers Awareness of STOP Sign at Unsignalized Intersections. Accepted for 92nd Transportation Research Board Annual Meeting, Transportation Research Board of the National Academies, Washington, DC, Jan 2013.
- e. Jing Jia, Fengxiang Qiao, and Lei Yu (2013). An prototype of an advanced traffic warning system in safety improvement and emission reduction, Accepted for presentation of Emerging Researchers National Conference by National Science Foundation, February 28– March 2, 2013, in Washington, D.C.
- f. Fengxiang Qiao, Jing Jia, and Lei Yu (2013). Development of a RFID Based Driver Smart Assistance System for Safety Improvement in Work Zones, Stop Sign Area and Signalized Intersections, working paper submitted to ITS America 23rd Annual Meeting, April 22-24, 2013, Nashville, TN.

E. **Virginia Tech:**

i. ***Develop Eco-adaptive Cruise Control Systems***

- a. Saerens B., Rakha H., Diehl M., Van den Bulck E. (In press), "Eco-Cruise Control for Passenger Vehicles: Methodology," *Transportation Research Part D: Transport and Environment*.
- b. Park S., Rakha H., and Ahn K. (2013), "Fuel Economy Impacts of Manual, Conventional Cruise Control, and Predictive Eco-Cruise Control Driving," Submitted to the 92nd Transportation Research Board Annual Meeting.

- c. Ahn K., Rakha H., and Park S. (2013), "ECO-Drive Application: Algorithmic Development and Preliminary Testing," Submitted to the 92nd Transportation Research Board Annual Meeting.
- ii. **Develop Green Cooperative Adaptive Control Systems in the Vicinity of Signalized Intersections**
Kamalanathsharma R., and Rakha H., (2012), "Agent-based Modeling of Eco-Cooperative Adaptive Cruise Control Systems in the Vicinity of Intersections," 15th IEEE Intelligent Transportation Systems Conference, Alaska, USA; September 16-19, 2012.
- iii. **Develop Dynamic Eco-routing Systems**
 - a. Rakha H., Ahn K., and Moran K., (2012), INTEGRATION Framework for Modeling Eco-routing Strategies: Logic and Preliminary Results, *International Journal of Transportation Science and Technology*, Vol. 1, no. 3, pp. 259-274.
 - b. Ahn K., Rakha H., and Moran K. (2012), "System-wide Impacts of Eco-routing Strategies on Large-scale Networks", Transportation Research Board 91st Annual Meeting, Washington DC, January 22-26, CD-ROM [Paper # 12-1638].
 - c. Tawfik A. and Rakha H. (2013), "A Latent Class Choice Model of Heterogeneous Drivers Route Choice Behavior Based on a Real-World Experiment," Transportation Research Board 92nd Annual Meeting, Washington DC, January 13-16.
- iv. **Develop Multi-scale Energy and Emission Models**
 - a. Saerens, B., Rakha, H., Ahn, K., and Van den Bulck, E. (In press), "Assessment of Alternative Polynomial Fuel Consumption Models for use in ITS Applications," *Journal of Intelligent Transportation Systems: Technology, Planning, and Operations*.
 - b. Park S., Rakha H., and Ahn K. (2013), "Virginia Tech Comprehensive Power-based Fuel Consumption Model (VT-CPFM): Model Validation and Calibration Considerations," Submitted to the 92nd Transportation Research Board Annual Meeting.
 - c. Faris W., Rakha H., Kafafy R., Idres M., Elmoselhy S., (2012), "Diesel Engine Analytical Model," *International Journal of Scientific & Engineering Research*, Volume 3, Issue 8, ISSN 2229-5518.
 - d. Faris W., Rakha H., Kafafy R., Idres M., and Elmoselhy S. (2012), "Analytical Modelling of Supercharging Diesel Radial Centrifugal Compressors with Vanes-Based Diffuser," *International Journal of Advances in Engineering and Technology (IJAET)*, Vol. 5, Issue 1, pp. 84-106, ISSN: 2231-1963.
 - e. Du J., Rakha H., and Sangster J. (In press), "Can Electricity Powered Vehicles Serve Traveler Needs?" *International Journal of Transportation Science and Technology*.

3. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS:

A. University of Idaho:

- i. **Developing and Testing Eco-Traffic Signal System Applications**
Tasks of these projects are coordinated with other projects conducted in two other universities in the TranLive consortium: Virginia Tech and Texas Southern University. No outside participants or collaborating organizations at this time.
- ii. **In situ Transesterification of Microalgal Oil to Produce Algal Biodiesel**
Nothing to report at this time
- iii. **Security and Survivability of Real-Time Communication Architecture for Connected-Vehicle Eco-Traffic Signal System Applications**
Nothing to report at this time

iv. ***Developing Active Learning Materials for the Introductory Transportation Engineering Course***

Nothing to report at this time

v. ***Pyrolysis Bio-Oil Upgrading to Renewable Fuels***

Nothing to report at this time

vi. ***Progress in Catalytic Ignition Fabrication, Modeling and Infrastructure***

Funding for the renovated Vehicle Research Building was obtained from a Federal Transit Administration 5309 grant approximately \$200,000.

Funding for research-quality emissions analysis, flow metering, and precision infrared temperature measurement was obtained from a Murdock Trust equipment grant for \$292,000.

vii. ***Design Improvements and Performance Validation of a Competitive Hybrid FSAE Vehicle***

Nelson Metal Technology from Payette, Idaho has been contributing in-kind donations. They have used their facilities to laser cut and water-jet metal flat patterns, and donated the stock material, all for free. The pieces they have cut for us include brake rotors, suspension tabs, shear panels, seat, firewall, and suspension uprights.

B. Old Dominion University:

i. ***New strategies for the emergency vehicle routing to reduce response time using vehicle-to-vehicle communications***

Nothing to report at this time

ii. ***Real-time prediction of queues at signalized intersections to support eco-driving applications***

Nothing to report at this time

iii. ***Exploring image-based classification to detect vehicle make and model***

Nothing to report at this time

iv. ***A Study on the Impact of Parameter Uncertainty on the Emission-based Ranking of Transportation Projects***

Nothing to report at this time

v. ***Reducing energy use and emissions through innovative community designs: methodology and application***

Foreign collaboration with University of Aveiro in Portugal resulted in the following publication:

Bandeira J., T. Almeida, A. Khattak, N. Roupail, and M. Coelho, Generating Emissions Information for Route Selection: Experimental Monitoring and Routes Characterization, Forthcoming in *Journal of Intelligent Transportation Systems*, Taylor & Francis Publishers, 2013.

Specifically, Dr. Khattak worked collaboratively with University of Aveiro, Portugal (J. Bandeira, T. Almeida, & M. Coelho) on this research paper that is related to the TranLIVE theme.

vi. ***Optimize freight routes and modes to minimize environmental impacts***

Nothing to report at this time

C. Syracuse University:

Nothing to report at this time

D. Texas Southern University:

i. ***A Systematic Evaluation of the Impacts of traffic Condition Information on the reduction of on-road mobile emissions***

a. A visiting scholar from Shandong Jiatong University in China, Dr. Liyan Qin

b. Shandong province office of education provided funding support for the exchange visitor, Dr. Liyan Qin from Shandong Jiatong University in China.

ii. **Education and Outreach Activities**

The Mac Gregory Primary School in Houston is very cooperative, and is willing to provide space and science teacher(s) to create a transportation club.

iii. **Develop an integrated data management system at the microscopic, mesoscopic, and macroscopic levels to assess the environmental impacts of transportation system**

Nothing to report at this time

iv. **Use the driving simulator to synthesize the related vehicle specific power (VSP) for emission and fuel consumption estimations**

Nothing to report at this time

v. **Develop multi-scale energy and emission models for arterial traffic systems**

Conducted collaborative research with National Science Foundation (NSF) CREST center on complex network at TSU.

vi. **Improve the environment for a livable community: advance the AERIS program by developing and testing eco-traffic signal system control applications**

Conducted collaborative research with National Science Foundation (NSF) CREST center on complex network, especially its subcenter on wireless communications at TSU.

E. **Virginia Tech:**

i. **Develop Eco-adaptive Cruise Control Systems**

The research team collaborated with researchers from KULeuven.

ii. **Develop Green Cooperative Adaptive Control Systems in the Vicinity of Signalized Intersections**

Nothing to report at this time

iii. **Develop Dynamic Eco-routing Systems**

Nothing to report at this time

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

The research team collaborated with researchers from KULeuven and the International Islamic University of Malaysia (IIUM).

4. **IMPACT:**

A. **University of Idaho:**

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

This work focuses on modeling the fuel consumption and vehicle emissions of arterial system operations. Two of the undergraduate students who worked in the project graduated. One joined the transportation engineering graduate program at the University of Washington and the second entered the transportation engineering workforce in the industry.

ii. **In situ Transesterification of Microalgal Oil to Produce Algal Biodiesel**

Lipid-bearing microalgae have been proven to be a promising feedstock for biofuel production and tremendous effort has been put into microalgal biology, strain screening, and cultivation. The post-harvest processing of microalgae, i.e., lipids extraction and conversion to biofuels, is now the logical next step in microalgae-to-biofuel research. This project is proposed to respond to the demand for advanced processing technologies for microalgae conversion for biofuels.

Conduction and accomplishment of this project will greatly contribute to the knowledge base of understanding microalgae processing from engineering aspect, and to the technological advancement on microalgal conversion for biofuel production. Additionally, the outcomes

from this project would also contribute to the establishment of advanced biofuels industry, as defined by the Renewable Fuels Standards, to promote environment protection and to enhance energy security in the nation.

iii. ***Security and Survivability of Real-Time Communication Architecture for Connected-Vehicle Eco-Traffic Signal System Applications***

Nothing to report at this time

iv. ***Developing Active Learning Materials for the Introductory Transportation Engineering Course***

This work will serve as basis for a new way of teaching introductory transportation courses.

v. ***Pyrolysis Bio-Oil Upgrading to Renewable Fuels***

The improvement of bio-fuels production will contribute to reducing the dependency from fossil fuels largely used in the transportation sector.

vi. ***Progress in Catalytic Ignition Fabrication, Modeling and Infrastructure***

Nothing to report at this time

vii. ***Design Improvements and Performance Validation of a Competitive Hybrid FSAE Vehicle***

The basis for this hybrid vehicle project is that of sustainability, fuel economy, and system optimization. Research in these areas has resulted in student learning and product realization, but in the process of building a vehicle, publicity for the program has given these technologies, USDoT, and NIATT exposure. Working towards ever more efficient and higher performing vehicles creates a wake of interest and public notice.

B. Old Dominion University:

i. ***New strategies for the emergency vehicle routing to reduce response time using vehicle-to-vehicle communications***

Nothing to report at this time

ii. ***Real-time prediction of queues at signalized intersections to support eco-driving applications***

Nothing to report at this time

iii. ***Exploring image-based classification to detect vehicle make and model***

The impact of this of the research being conducted is to develop an automated technique that is efficient, fast and accurate to extract a set of attributes that will be used in the EPA's MOVES software to estimate the vehicle emission on the street and highways.

The program also educates one graduate student in Intelligent Transportation System research. It is also expected that one MS thesis will be generated from this research.

iv. ***A Study on the Impact of Parameter Uncertainty on the Emission-based Ranking of Transportation Projects***

Thus far, this research has complemented the existing literature by providing valuable insights into the impact of capacity uncertainty on the ranking of capacity expansion projects.

v. ***Reducing energy use and emissions through innovative community designs: methodology and application***

This project is contributing by training a post-doc and graduate students who are working on energy and emissions issues. The research has generated research papers that are being presented at the Transportation Research Board Annual meeting and disseminated via refereed journals.

vi. ***Optimize freight routes and modes to minimize environmental impacts***

Nothing to report at this time

C. Syracuse University:

- i. The literature search conducted by all the projects participants helped to develop a comprehensive database on all the projects and increased the understandings of the students in-depth. It was useful to the graduate students to acquire knowledge on their respective TranLIVE project components and develop their problem solving capability. It taught them to critically analyze the existing information in a scientific manner and to develop the most feasible methodology to address the research needs, define the scope of their projects, decide on the right model to conduct the analysis, develop a comprehensive database, filter out the less important factors, and provide them with a basis to compare their results against.
- ii. The data collection strategy helped the graduate students to acquire detailed data on their respective TranLIVE project components and is increasing their understanding of the problems in the field from different sources. It is building their understandings on the issues and helping them to work on and develop possible solution measures in a scientific manner. It is directly supporting them to develop the most feasible methodology to address the research needs, develop the appropriate model to conduct the analysis, develop a comprehensive database, and filter out the less important factors to find out the possible solutions.
- iii. The modifications brought to the existing graduate level course on “Sustainable Development and Infrastructure Management” raised graduate students’ awareness on sustainability of infrastructure systems, especially transportation systems and increased the knowledge base of the enrolled graduate students.
- iv. The LCA and LCCA trainings from USDOT are helping the students to evaluate the collected data and develop the model using appropriate software.
- v. The purchase of new computers helped to establish the computer lab as a part of the TranLIVE program. The newly established research lab is aiding students in analyzing the collected data of the TranLIVE research projects using different software to develop models for their respective projects.
- vi. The frequent interactions with USDOT are increasingly benefitting students in developing their project work in a manner that is more acceptable and applicable in the real world. On the other hand, USDOT is also appreciating the initiatives taken in the TranLIVE projects, which is increasing the understanding and acceptance of our works among the practitioners.
- vii. The seminar series is educating a larger community on the different issues and possible solutions in the sustainable transportation sector.

D. Texas Southern University:

i. ***A Systematic Evaluation of the Impacts of traffic Condition Information on the reduction of on-road mobile emissions***

This project will provide transportation planners or environmental analysts with qualitative assessments of the impacts on air quality of different types of traffic condition information. It will also help the traffic engineer to appropriately deploy the most effective traveler information systems to achieve more environmental benefits. In addition, since very few studies have been performed to directly investigate the impacts of the traveler information on on-road mobile emissions, the proposed research will fill this gap and will help the researchers and practitioners to better understand the related issues in the future. Furthermore, the results of project can be incorporated into some teaching curricula, such as the class TMGT 885 “Quantitative Assessment of Transportation Environmental Impact” at TSU.

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

The education program will help to promote interests of K-12 and college students in STEM programs, especially in transportation and environment related areas. The developed

curriculum and experiences can be easily further expanded and applied to other areas of the country.

iii. ***Develop an integrated data management system at the microscopic, mesoscopic, and macroscopic levels to assess the environmental impacts of transportation system***

- a. Wang, J., L. Yu, and F. Qiao (2013). Micro Traffic Simulation Approach to the Evaluation of Vehicle Emission on One-way vs. Two-way Streets: A Case Study in Houston Downtown. Accepted for 92nd Transportation Research Board Annual Meeting, Transportation Research Board of the National Academies, Washington, DC, Jan 2013.
- b. Qiao, F., X. Wang, L. Yu, and J. Jia (2013). Using RFID to Improve Drivers Awareness of Stop Signs at Unsignalized Intersections. Accepted for 92nd Transportation Research Board Annual Meeting, Transportation Research Board of the National Academies, Washington, DC, Jan 2013.
- c. Qiao, F., J. Wang, X. Wang, J. Jia, and L. Yu (2012). A RFID Based E-STOP Sign and Its Impacts to Vehicle Emissions. Presented at and Published in the Proceedings of the 15th IEEE Intelligent Transportation Systems Conference, Alaska, September 16-19, 2012.
- d. Once the emission and activity database is fully developed, researchers, students at different levels (graduate students, undergraduate students, K-12 students) from different geographic areas (within or outside the consortium, within or outside the country) can utilize this database for various transportation and environment related research and education purposes through simply web access.

iv. ***Use the driving simulator to synthesize the related vehicle specific power (VSP) for emission and fuel consumption estimations***

The developed algorithm will help to calibrate the simulation results from driving simulator, which will thus make better use of the driving simulator for vehicle emission and fuel consumption prediction.

v. ***Develop multi-scale energy and emission models for arterial traffic systems***

The developed simulation based models can be of great use for researchers, planners, and engineers in developing or retrofitting better arterial and freeway traffic system for reduced vehicle emissions and improved air quality.

vi. ***Improve the environment for a livable community: advance the AERIS program by developing and testing eco-traffic signal system control applications***

The developed V2I communication system can help to provide more and timely information to drivers, and thus will enhance the safety and air quality of the eco-driving traffic operations.

E. **Virginia Tech:**

i. ***Develop Eco-adaptive Cruise Control Systems***

- a. Education: The funding of a graduate student assistantship.
- b. Research: Development of an eco-cruise control and eco-drive system.
- c. Technology Transfer: Publication of results at various conferences.

ii. ***Develop Green Cooperative Adaptive Control Systems in the Vicinity of Signalized Intersections***

- a. Education: The funding of a graduate student assistantship.
- b. Research: Development of an eco-cruise control in the vicinity of traffic signalized intersections.
- c. Technology Transfer: Publication of results at various conferences.

iii. ***Develop Dynamic Eco-routing Systems***

- a. Research: Development of an eco-routing system.
- b. Technology Transfer: Publication of results at various conferences.

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

- a. Education: The funding of a graduate student assistantship.
- b. Research: Development of an eco-cruise control and eco-drive system.
- c. Technology Transfer: Publication of results at various conferences.

5. CHANGES/PROBLEMS

A. University of Idaho:

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

Nothing to report at this time

ii. *In situ Transesterification of Microalgal Oil to Produce Algal Biodiesel*

We experienced a bit of difficulty in acquiring specialty microalgae that are high in lipids content and more suitable for processing in the proposed system. Very recently, we have a good international contact who has agreed to sell us a type of microalga that meets our research requirement.

iii. *Security and Survivability of Real-Time Communication Architecture for Connected-Vehicle Eco-Traffic Signal System Applications*

Nothing to report at this time

iv. *Developing Active Learning Materials for the Introductory Transportation Engineering Course*

Nothing to report at this time

v. *Pyrolysis Bio-Oil Upgrading to Renewable Fuels*

An issue with the quartz frit support is problematic in getting uniform NS deposition and metal coating to NS within the frit. We plan to overcome this issue by growing NS onto stainless-steel wire mesh and then decorating the NS with Ni and Ru.

vi. *Progress in Catalytic Ignition Fabrication, Modeling and Infrastructure*

Moving the facility to a new location has been the biggest obstacle. The CFR engine has been disconnected for a few months, and it will probably be mid-Spring at the earliest when it is set up and ready to be used again. The primary eddy current dynamometer has been moved, and the remaining lab connections and needed accessories have been ordered. The system should be operational soon after the beginning of the spring semester.

vii. *Design Improvements and Performance Validation of a Competitive Hybrid FSAE Vehicle*

Funding will soon become an issue making it difficult to travel to our competition. However, our team has been working to gather sponsorship from other sources.

B. Old Dominion University:

i. *New strategies for the emergency vehicle routing to reduce response time using vehicle-to-vehicle communications*

Nothing to report at this time

ii. *Real-time prediction of queues at signalized intersections to support eco-driving applications*

Nothing to report at this time

iii. *Exploring image-based classification to detect vehicle make and model*

One important consideration for the future requirement is the classification of vehicles by their make and model which requires the availability of a high resolution camera that streams directly from the provider (i.e. VDOT). It appears the high resolution camera streams require fees to obtain from VDOT. Unavailability of this high resolution camera streams may impede the ability to classify vehicles by their make and model.

iv. ***A Study on the Impact of Parameter Uncertainty on the Emission-based Ranking of Transportation Projects***

We have found that the MOVES software is more computationally expensive than expected. This is particularly an issue since various replications are typically needed to investigate the impact of uncertainty. To address this issue, we will limit the case studies to medium size test networks found in the literature.

v. ***Reducing energy use and emissions through innovative community designs: methodology and application***

Nothing to report at this time

vi. ***Optimize freight routes and modes to minimize environmental impacts***

Nothing to report at this time

C. **Syracuse University:**

Nothing to report at this time

D. **Texas Southern University:**

i. ***A Systematic Evaluation of the Impacts of traffic Condition Information on the reduction of on-road mobile emissions***

Nothing to report at this time

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

Nothing to report at this time

iii. ***Develop an integrated data management system at the microscopic, mesoscopic, and macroscopic levels to assess the environmental impacts of transportation system***

Nothing to report at this time

iv. ***Use the driving simulator to synthesize the related vehicle specific power (VSP) for emission and fuel consumption estimations***

Nothing to report at this time

v. ***Develop multi-scale energy and emission models for arterial traffic systems***

Nothing to report at this time

vi. ***Improve the environment for a livable community: advance the AERIS program by developing and testing eco-traffic signal system control applications***

Nothing to report at this time

E. **Virginia Tech:**

i. ***Develop Eco-adaptive Cruise Control Systems***

Nothing to report at this time

ii. ***Develop Green Cooperative Adaptive Control Systems in the Vicinity of Signalized Intersections***

Nothing to report at this time

iii. ***Develop Dynamic Eco-routing Systems***

Nothing to report at this time

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

The scope of the project has been reduced from multi-level modeling to expanding the microscopic modeling framework to consider: (1) buses; (2) trucks; and (3) hybrid vehicles.

6. SPECIAL REPORTING REQUIREMENTS

Financials will be sent by the University of Idaho's Office of Sponsored Programs as needed. Performance Indicators and the Annual Recipient Share Report will be submitted by January 30, 2013.

Completed by:

University of Idaho: Karen R. Den Braven

Old Dominion University: Asad Khattak

Syracuse University: O. Sam Salem

Texas Southern University: Fengxiang Qiao

Virginia Tech: Hesham Rakha