Program Progress Performance Report for University Transportation Research Centers (PPPR #2)

Prepared for the Research and Innovative Technology Administration (RITA);
U.S. Department of Transportation (US DOT)

Grant Project Title:

Advanced Operations Focused on Connected Vehicles/Infrastructure (CVI-UTC)

Consortium Members:

Virginia Tech Transportation Institute (VTTI), University of Virginia (UVA) Center for Transportation Studies, and Morgan State University (MSU).

Submitted by:
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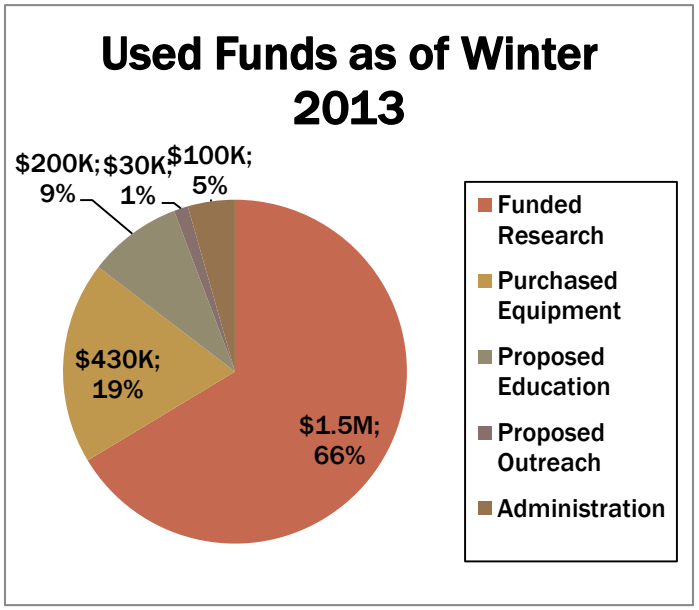
Grant Period: January 2012 – January 2014
Reporting Period End Date: April 2014
Semi-annual reporting periods

Fall: December 15, 2012



Accomplishments

What are the major goals and objectives of the program?

- Safety
- State of Good Repair
- Economic Competitiveness
- Livable Communities
- Environmental Sustainability
- All goals though connected vehicles/infrastructure

What was accomplished under these goals?

- Major activities:
  - The finalization and funding of 10 new inner-consortium UTC research projects
  - Equipment inventory, development, building and testing
  - Test bed installation and construction in SWVA and NOVA
  - Instrumenting vehicles for research and testing
  - CVI-UTC Research Presentations at SURF and ITS World Congress
  - 10 Short courses selection and funding
  - Major equipment manufacturer resource meetings with stakeholders
  - UGA and GRA direct tuition and work study funding
  - Applicant for winter banquet 2013 and summer meeting host 2014
  - Continued website development and content
  - 2nd research call planning and issuing to consortium and outside universities

- Specific objectives:

Major Activities:	Safety	State of Good Repair	Economic Competitiveness	Livable Communities	Environmental Sustainability
Funding/Starting 10 Research Projects	X	X	X	X	X
Equipment development and testing	X	X	X		
Test bed installation in SWVA and NOVA	X	X	X	X	X
Instrumenting vehicles for research	X	X	X		
Research Presentations at conferences	X	X	X	X	X
10 Short course selections and funding	X	X	X	X	X
OEM resource meetings	X	X	X		
Student tuition and work funding	X	X	X	X	X
Applied for CUTC opportunities			X	X	
Website content development/editing	X	X	X	X	X
2nd Research Call planning and issuing	X	X	X	X	X

- Significant results, including major findings, developments, conclusions (+ and -):
  - Nothing to report – research has begun, but no research is fully completed yet.

- Key outcomes or other achievements:
    - Starting research programs, starting short courses, and completing equipment testing for test bed installation have been our three major outcomes/achievements during this first reporting period.
- Discussion of stated goals not met:
    - After reviewing spending this first year of the grant, we would like to be able to arrest our equipment spending and focus efforts more toward education and outreach. We already have a plan to additionally fund 5-6 research projects in the next year, but it is a goal to implement more student and workforce programs through education and outreach based on the research done this past year.

What opportunities for training and professional development has the program provided?
There was a fall "Call for Short Courses" within the consortium that resulted in 10 proposals; with one certificate program suggested:

- *The Cost-Benefit Analysis of Connected Vehicles (Schaudt/Medina; VTTI)*
- *Development, Testing, and Verification of Algorithms that Trigger Warnings/Countermeasures in Vehicles (Perez; VTTI)*
- *Connected Vehicles and the Environment (Rakha; VTTI)*
- *Modeling of Connected Vehicle Applications (Rakha; VTTI)*
- *Cooperative Adaptive Cruise Control Systems (Rakha; VTTI)*
- *An Introduction to CVI Technology to Improve Safety (Medina; VTTI)*
- *An Introduction to CVI as a Workshop and Distance Learning Practicum (Park; UVA)*
- *CVI Technology for Roadway Health Assessment and Road Monitoring (Flintsch; VTTI)*
- *Various Optimization Techniques and Optimal Control Theory for CVI Applications (Kishore; VTTI)*
- *Artificial Intelligence, Game Theory, and Various Soft Computing Techniques for CVI Applications (Zohdy; VTTI)*
- *Traffic Safety and Human Factors Certification Program (Antin; VTTI)* [proposed, NOT funded]

It was decided via input from the UTC consortium leaders and advisory board members to direct education and training efforts towards short courses and not certification programs at this time, because it would allow for more education programs to be funded, whereas the certification program would be a singular effort at great expense that required a better future project than the UTC could current offer. Currently, the 10 suggested courses are being funded and developed through the UTC and the Virginia Tech Center for Professional Education to be presented in the spring, summer, and fall 2013 to all consortium universities and VDOT. We will look into considering funding the certification program when the CVI-UTC is more established with a proven track record of successful projects in education and research.

How have the results been disseminated? If so, in what ways?

- Our main source of dissemination has been through virtual sources, such as our UTC website, the TRB database, and social media like a CVI-UTC Twitter account. We have also utilized invitations to speak at conferences, conference presentations, and general attendance in professional conferences and networking events hosted by consortium universities or large scale industry events to disseminate research results to a professional audience.

What do you plan to do during the next reporting period to accomplish the goal's end objectives?

- Currently we are still in the process of holding an additional research call for 2013 research and evaluating and selecting the research through the Advisory Board, we are looking at funding 5-6 projects with an emphasis on additional outside collaboration from universities outside of the consortium. Also, we are fulfilling our education goals by funding the new short courses and using the resources at each of the consortium universities to attract students and transportation professionals. These short courses are something that will continue throughout 2013 and then we hope to be able to make them into "courses in a box" where we can further use these courses in the future and expand the audience either through travel with the course, or through a virtual classroom, like ITunes U, podcasting, or online courses offered through the consortium universities. By offering the short courses and then evolving them to "courses in a box", we feel that this is the best value for the investment for the funding and allows a great education and outreach opportunity. Another outreach goal will be accomplished within the CVI-UTC in 2013 is our participation at the TRB conference in January, and the ITS America conference in the spring. We will be hosting a professional booth at both events, and a reception at TRB that showcases the CVI-UTC research. We will also continue looking for similar opportunities where we can gain a large influence of our research for a low investment of funding. We also will continue to look for expanding our CVI-UTC for the next funding period, that way we can also consider additional academic and professional research and direct student support for research, education, and workforce development.

Products

What has the program produced?

- Publications, conference papers, presentations:
    - Rakha H. (2012), "Transportation Sustainability: What can ITS Offer?" ITS World Congress, Vienna, Austria, Oct. 22-26. (Session SIS06 Emerging ITS Strategies and Sustainability - Tuesday 11:00 - 12:30).
    - Rakha H. (2012), "Case Study Evaluation of the Environmental Impacts of Adaptive Traffic Signal Control and Transit Signal Priority," ITS World Congress, Vienna, Austria, Oct. 22-26. (Session SIS35 - Demonstrating the environmental contributions from demand responsive traffic control - Wednesday 16:00 - 17:30).
    - Tawfik A. and Rakha H. (2012), "Modeling Driver Heterogeneity in Route Choice Behavior based on a Real-life Naturalistic Driving Experiment," ITS World Congress, Vienna, Austria, Oct. 22-26. (Session TS064 - Navigation system and digital maps (1) - Thursday 11:00 - 12:30).
    - Zohdy I. and Rakha H. (2012), "Optimizing Driverless Vehicles at Intersections," ITS World Congress, Vienna, Austria, Oct. 22-26. (Session TS108 - Autonomous vehicle concepts - Friday 11:00 - 12:30)
    - Rakha H. (2012), "Energy Impacts of Cooperative Vehicle Systems," ITS World Congress, Vienna, Austria, Oct. 22-26. (Session TSIS78 - Global perspectives - Cooperative energy efficiency applications - Friday 9:00 - 10:30)
    - Flintsch, G. Pavement Surface Characteristics Symposium: http://www.cpe.vt.edu/surf2012/index.html

- Websites; other Internet (http://www.connectedvehicleinfrastructure-utc.org)
- Technologies, techniques: Nothing to report
- Inventions, patent applications, licenses: Nothing to report
- Other: the Northern Virginia and Southwest Virginia Highly Instrumented Test Beds.

Have other collaborators or contacts been involved? (Can be "nothing to report", if so.)

- Nothing to report.
  - Collaborations with others within the lead or partner universities, especially interdepartmental or interdisciplinary collaborations: Brian Smith (UVA) and Gerardo Flintsch (VTTI) Research: "Infrastructure Pavement Assessment and Management Applications Enabled by the Connected Vehicles Environment Research Program - Phase I: Proof-of-Concept" (CONTINUING); Manoj Jha (Morgan State) and Shinya Kikuchi (VT) Research: "Connected Vehicle-Infrastructure Application Development for Addressing Safety and Congestion Issues Related to Public Transportation, Pedestrians, and Bicyclists" (CONTINUING).
  - Collaborations or contact with others outside the UTC: Nothing to report.
  - Collaborations or contacts with others outside of the United States or with an international organization: countries of collaborations or contacts: Nothing to report.

Impact

What is the impact of the program?

- The biggest impact of this first report is the funding of the research projects and the short courses through the grant. The secondary impacts have been the continuing construction of the highly-instrumented vehicles and the Northern Virginia and Southwest Virginia highly-instrumented test beds. Other important impacts the program has had during this reporting period has been the outreach efforts at the ITS World Congress and SURF conference, as well as, being able to support undergraduate and graduate students in the field of transportation, engineering, and psychology who assist in the UTC research.

How has it contributed to transportation education, research and technology transfer?

- The test beds will influence the way connected vehicle/infrastructure research is conducted for our UTC, and in the future, incorporated into the national connected vehicle test bed. The test beds will also be able to be used not only by our specific UTC, but to any institution or university that desires to do simulation and real-world connected vehicle/infrastructure research.
- The research, outreach and student education and workforce funding that is accomplished through our UTC is designed to educate future engineers, STEM educators, and current engineers (civil, mechanical, electrical, etc.)/human factors (psychology, social sciences, etc.) practitioners.
- The ultimate goal is to expand our current CVI-UTC efforts more online/virtually to affect a broader national audience, and to complete more research using the developed test beds to enable professional conference attendance, publication, and presentations.

How has the program provided opportunities for research and teaching in transportation and related disciplines?

- This reporting period we are still working with the ten research projects that were established on Sept. 1st. These ten projects are on a one year timeline to be completed in August 2013. For the next reporting period, we are looking for expanding the research opportunities both to universities inside and outside of the UTC consortium and we are looking to do broader outreach and education. At the end of this reporting period, we issued a call for more research that will be funded from February 2013-January 2014. It is likely that 5-6 research projects will be selected for funding, with an additional opportunity for two outside consortium projects where outside universities will work with the consortium to create relevant and innovative transportation research.

How has the program improved the performance, skills, or attitudes of members of underrepresented groups that will improve their access to or retention in transportation research, teaching, or other related professions?

- Morgan State's participation in our UTC has been able to majorly affect underrepresented groups through their research projects and outreach and education opportunities. By inner-consortium research work with Morgan State, this has allowed UVA and VTTI to participate in influencing underrepresented groups. Morgan State also directly offers programs for Baltimore-area high school students and teachers, which include underrepresented populations, and has allowed UTC research to directly affect future generations of potential engineers and human factors professionals.
- We are also looking for active participating at programming at Virginia Tech like VT Advance and VT Engage, two programs which focus on mentorship programs for women and minority students, faculty, and staff. Dr. Alejandra Medina has led this effort through her participation in CVI-UTC research and education efforts.

How has the program developed and disseminated new educational materials or provided scholarships?

- Yes, these students are currently working and being educated under the grant:
- **Andy Anton** (GRA, VT NCR) Working on "Connected Vehicle-Infrastructure Application Development for Addressing Safety and Congestion Issues Related to Public Transportation, Pedestrians, and Bicyclists" under the direction of Dr. Shinya Kikuchi.
- **Michael Baird** (GRA, VTTI) Working on "Safety and Human Factors of Adaptive Stop/Yield Signs Using Connected-Vehicle Infrastructure" as a PI with Dr. Tom Dingus.
- **Karim Fadhloun** (GRA, VTTI) tuition and work study funded through the CVI-UTC grant, works at VTTI, studies Civil Engineering at Virginia Tech and advised by Dr. Hesham Rakha.
- **Tanveer Hayat** (GRA, UVA) Working on "Connected Vehicle Enabled Freeway Merge Management - Field Test" under the direction of Dr. Brian L. Smith.
- **Naser Hdieb** (GRA, VT NCR) Working on "Emergency Vehicle-to-Vehicle Communication" under the direction of Dr. Pamela Murray-Tuite.
- **Arash Jahangiri** (GRA, VTTI) tuition and work study funded through the CVI-UTC grant, works at VTTI, studies Civil Engineering at Virginia Tech and advised by Dr. Tom Dingus.
- **Raj Kishore** (GRA, VTTI) Working on "Field Testing of Eco-Speed Control Using V2I Communication" as a PI with Dr. Hesham Rakha.

- **Robert Kluger** (GRA, UVA) Working on "Infrastructure Safety Assessment Using Connected Vehicle Data" under the direction of Dr. Brian L. Smith.
- **Ismail Zohdy** (GRA, VTTI) Working on "Intersection Management Using In-Vehicle Speed Advisory/Adaptation" as a PI with Dr. Hesham Rakha.
- Also it is estimated that 12 additional GRAs and 6 additional URAs currently unidentified, but funding has been set aside for tuition and work study employment, and these students will be funded on the CVI-UTC research projects – there is just no names attached to these positions at this time.

How has the program provided exposure to transportation, science and technology for practitioners, teachers, young people, or other members of the project?

- By selecting, funding, and beginning the new short course programs, the UTC has been able to access more students in transportation, engineering, and psychology, as well as, reaching transportation professionals for workforce development through the Virginia DOT. The UTC also hosts monthly meetings with our advisory board and consortium leaders to aid in directing education and outreach opportunities, and to help evaluate and review research that drives the direction of the UTC.

Has the grant money or research done impacted physical resources at the university, institutional resources or information resources?

- The grant money has absolutely been instrumental in developing and installing the highly instrumented test beds in Northern Virginia and Southwest Virginia. Without the UTC funding, it would be unlikely that these projects could have been completed with the velocity that they have been propelled. It has offered the consortium universities opportunities for research that would not have been possible this year without the grant. The grant money has also indirectly created several short-term job opportunities at consortium universities via the opportunities for reach and the equipment construction and installation. As the UTC progresses, it is anticipated that many of these job opportunities may become longer term as research progresses and value of CVI is heightened within the field of transportation.

Describe ways in which the program made an impact, or is likely to make an impact, on commercial technology or public use.

- Because our UTC has been fortunate enough to work closely with automotive, technology, and wireless communication professionals through assembling our advisory board with these types of professionals, how closely our consortium university leaders works with these professionals, and through our test bed installations – we believe that this allows our UTC a unique opportunity not only to have this commercial technology and public use influence on the direction of our research goals, but also an opportunity to do work that is directly practically applicable and has a great deal of potential for commercial marketing and public use, probably a lot faster than the majority of university research may have an impact on the commercially viable aspects of transportation.

Describe how results from the program made an impact, or are likely to make an impact, beyond the bounds of science, engineering, and the academic world.

- The CVI-UTC is likely to make an impact beyond STEM or academia because it is a field and a UTC that encourages safety, affordability, and practicality for every transportation consumer in America. This may sound grandiose, but through the research this UTC is completing, the outreach and education opportunities, and the technical development of aftermarket safety devices that use CVI technology for naïve drivers, these are practical applications that are occurring right now in Maryland and Virginia because of the UTC funding. We know that we can expand these current activities to a broader audience in future reporting periods.

Changes/Problems

- Changes in approach and reasons for change. – Nothing to report.
- Actual or anticipated problems or delays and actions or plans to resolve them. – Nothing to report.
- Changes that have a significant impact on expenditures. – Nothing to report.
- Significant changes in use or care of animals, human subjects, and biohazards. – Nothing to report.

Outputs

- Research projects awarded:

Research Projects:	Safety	State of Good Repair	Economic Competitiveness	Livable Communities	Environmental Sustainability
Safety and Human Factors of Adaptive Stop/Yield Signs Using Connected-Vehicle Infrastructure	X	X		X	
Connected Vehicle Applications for Adaptive Overhead Lighting	X	X		X	X
Intersection Management Using In-Vehicle Speed Advisory/Adaptation	X	X	X	X	X
Field Testing of Eco-Speed Control Using V2I Communication		X	X	X	X
Innovative "Intelligent" Awareness System for Roadway Workers Using Dedicated Short-Range Communications	X	X		X	
Emergency Vehicle-to-Vehicle Communication	X	X	X	X	X
Connected Vehicle Enabled Freeway Merge Management - Field Test	X	X	X	X	X
Infrastructure Safety Assessment Using Connected Vehicle Data	X	X	X	X	X
Infrastructure Pavement Assessment and Management Applications Enabled by the Connected Vehicles Environment Research Program - Phase I: Proof-of-Concept	X	X	X	X	X
Connected Vehicle-Infrastructure Application Development for Addressing Safety and Congestion Issues Related to Public Transportation, Pedestrians, and Bicyclists	X	X	X	X	X

- Publications, conference papers, presentations:
    - Rakha H. (2012), "Transportation Sustainability: What can ITS Offer?" ITS World Congress, Vienna, Austria, Oct. 22-26. (Session SIS06 Emerging ITS Strategies and Sustainability - Tuesday 11:00 - 12:30).
    - Rakha H. (2012), "Case Study Evaluation of the Environmental Impacts of Adaptive Traffic Signal Control and Transit Signal Priority," ITS World Congress, Vienna,

Austria, Oct. 22-26. (Session SIS35 - Demonstrating the environmental contributions from demand responsive traffic control - Wednesday 16:00 - 17:30).
    - Tawfik A. and Rakha H. (2012), "Modeling Driver Heterogeneity in Route Choice Behavior based on a Real-life Naturalistic Driving Experiment," ITS World Congress, Vienna, Austria, Oct. 22-26. (Session TS064 - Navigation system and digital maps (1) - Thursday 11:00 - 12:30).
    - Zohdy I. and Rakha H. (2012), "Optimizing Driverless Vehicles at Intersections," ITS World Congress, Vienna, Austria, Oct. 22-26. (Session TS108 - Autonomous vehicle concepts - Friday 11:00 - 12:30)
    - Rakha H. (2012), "Energy Impacts of Cooperative Vehicle Systems," ITS World Congress, Vienna, Austria, Oct. 22-26. (Session TSIS78 - Global perspectives - Cooperative energy efficiency applications - Friday 9:00 - 10:30)
    - Flintsch, G. Pavement Surface Characteristics Symposium: http://www.cpe.vt.edu/surf2012/index.html
- Websites: (http://www.connectedvehicleinfrastructure-utc.org)
- Technologies or technology assessments; databases, software or models: Nothing to report yet – still developing things for the highly connected vehicles and the two test beds.
- Outreach activities:
    - ITS World Congress Participation
    - Pavement Surface Characteristics Symposium Participation
- Courses and workshops; patents filed or issues, licenses:
    - *The Cost-Benefit Analysis of Connected Vehicles (Schaudt/Medina; VTTI)*
    - *Development, Testing, and Verification of Algorithms that Trigger Warnings/Countermeasures in Vehicles (Perez; VTTI)*
    - *Connected Vehicles and the Environment (Rakha; VTTI)*
    - *Modeling of Connected Vehicle Applications (Rakha; VTTI)*
    - *Cooperative Adaptive Cruise Control Systems (Rakha; VTTI)*
    - *An Introduction to CVI Technology to Improve Safety (Medina; VTTI)*
    - *An Introduction to CVI as a Workshop and Distance Learning Practicum (Park; UVA)*
    - *CVI Technology for Roadway Health Assessment and Road Monitoring (Flintsch; VTTI)*
    - *Various Optimization Techniques and Optimal Control Theory for CVI Applications (Kishore; VTTI)*
    - *Artificial Intelligence, Game Theory, and Various Soft Computing Techniques for CVI Applications (Zohdy; VTTI)*

Outcomes

	Increased understanding and awareness of transportation issues:	Improved body of knowledge:	Improved processes, techniques and skills in addressing transportation issues:	Enlarged pool of trained transportation professionals:	Greater adoption of new technology:
Funding/Starting 10 Research Projects	X	X	X	X	X
Equipment development and testing			X	X	X
Test bed installation in SWVA and NOVA			X	X	X
Instrumenting vehicles for research			X	X	X
Research Presentations at conferences	X	X		X	
10 Short course selections and funding	X	X	X	X	X

OEM resource meetings	X			X	X
Student tuition and work funding		X	X	X	
Applied for CUTC opportunities			X	X	
Website content development/editing	X		X		X
2nd Research Call planning and issuing	X	X	X	X	X
Safety and Human Factors of Adaptive Stop/Yield Signs Using Connected-Vehicle Infrastructure	X	X	X		X
Connected Vehicle Applications for Adaptive Overhead Lighting	X	X	X		X
Intersection Management Using In-Vehicle Speed Advisory/Adaptation	X	X	X		X
Field Testing of Eco-Speed Control Using V2I Communication	X	X	X		X
Innovative "Intelligent" Awareness System for Roadway Workers Using Dedicated Short-Range Communications	X	X	X		X
Emergency Vehicle-to-Vehicle Communication	X	X	X		X
Connected Vehicle Enabled Freeway Merge Management - Field Test	X	X	X		X
Infrastructure Safety Assessment Using Connected Vehicle Data	X	X	X		X
Infrastructure Pavement Assessment and Management Applications Enabled by the Connected Vehicles Environment Research Program - Phase I: Proof-of-Concept	X	X	X		X
Connected Vehicle-Infrastructure Application Development for Addressing Safety and Congestion Issues Related to Public Transportation, Pedestrians, and Bicyclists	X	X	X		X

Impacts

	Safer driver behavior:	Increased travel time reliability:	Increased intermodal transportation operations:	Reduction in carbon and other harmful emissions from transportation sources:
Funding/Starting 10 Research Projects	X	X	X	X
Equipment development and testing			X	
Test bed installation in SWVA and NOVA			X	
Instrumenting vehicles for research	X	X	X	X
Research Presentations at conferences	X	X	X	X
10 Short course selections and funding	X	X	X	X
OEM resource meetings			X	
Student tuition and work funding			X	
Applied for CUTC opportunities			X	
Website content development/editing	X		X	
2nd Research Call planning and issuing	X	X	X	X
Safety and Human Factors of Adaptive Stop/Yield Signs Using Connected-Vehicle Infrastructure	X	X	X	X
Connected Vehicle Applications for Adaptive Overhead Lighting	X		X	X
Intersection Management Using In-Vehicle Speed Advisory/Adaptation	X	X	X	X
Field Testing of Eco-Speed Control Using V2I Communication	X	X	X	X
Innovative "Intelligent" Awareness System for Roadway Workers Using Dedicated Short-Range Communications	X		X	

Emergency Vehicle-to-Vehicle Communication	X	X	X	X
Connected Vehicle Enabled Freeway Merge Management - Field Test	X	X	X	X
Infrastructure Safety Assessment Using Connected Vehicle Data	X		X	
Infrastructure Pavement Assessment and Management Applications Enabled by the Connected Vehicles Environment Research Program - Phase I: Proof-of-Concept	X		X	
Connected Vehicle-Infrastructure Application Development for Addressing Safety and Congestion Issues Related to Public Transportation, Pedestrians, and Bicyclists	X	X	X	X

Special Reporting Requirements

If there are any special reporting requirements specified in the award terms and conditions (do not think this is the case for CVI-UTC).