UTC Project Information	
Project Title	Infrastructure Pavement Assessment and Management Applications Enabled by the Connected Vehicles Environment Research Program - Phase I: Proof-of-Concept
University	Virginia Tech
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Agency ID or Contract Number	451192
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Project Duration	1 year
Brief Description of Research Project	A fundamental role of transportation agencies is to effectively manage the enormous public investment in pavement. This ranges from developing strategies and systems to periodically assess pavement condition and develop maintenance plans to maximize pavement life within limited budgets, to making tactical decisions regarding treatment during adverse weather conditions to keep roadways functional. A fundamental requirement in this management activity is to collect data to assess the condition of the pavement. The current state-of-the-practice in pavement condition data collection is to use specialized sensors and equipment to support this activity. This represents a significant cost burden on agencies, and also this technical approach to data collection scales poorly. In other words, given the need for specialized equipment and sensors, it is very difficult to collect data at more locations in a timely, cost effective manner. A potential advantage offered by connected vehicles is that this program promises to closely tie the infrastructure to the vast vehicle fleet using the infrastructure. Given the large set of sophisticated sensors integrated in modern vehicles, it is possible that these vehicular sensors may be used as a means to assess pavement conditions. In other words, the entire vehicle fleet can be transformed into probes measuring pavement conditions at all locations in frequent time intervals. The purpose of this collaborative research program between Virginia Tech and the University of Virginia is to conduct the applied research necessary to investigate the feasibility of this concept through component and system prototyping and testing on the Virginia Connected Vehicle UTC testbed. To provide a specific focus to the research program, the work will address 2 specific pavement

	applications: roughness measurement and friction assessment during snow and rain.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	As the lead state in the Cooperative Transportation System Pooled Fund Study (CTS PFS), VDOT has led a number of projects designed to accelerate infrastructure-focused applications of connected vehicles. One of the CTS PFS projects investigated the use of connected vehicles to "pull" vehicle accelerometer and GPS data from equipped vehicles to estimate pavement roughness measures. Currently, ride quality is obtained from the roadway profile by simulating the effect of this profile on the vertical acceleration of a standard (quarter-) car traveling along the roadway. Within the connected vehicle environment, the car acceleration response can now be directly measured rather than simulated. In fact, some cars are already collecting this information for other purposes such as improving the driver experience. This data can be used directly to estimate user perception of ride quality and identification of areas that need maintenance. A considerable amount of work has been completed to prepare for a field test of this concept. The CTS PFS project, conducted at Auburn University, demonstrated the technical feasibility of this operational concept *(1)*. Subsequent work at VTTI has shown a high-level of repeatability and reasonable precision under controlled conditions *(2)*. Finally, UVA CTS has extended this work under their participation in the Mid-Atlantic Universities Transportation Center (MAUTC) to investigate system-level designs to extend the technical feasibility to a "system" that could support transportation agency pavement management. Multiple concept of operations were developed that may support such a capability. Currently, pavement assessment data is collected by VDOT once per year for the interstate highway system and primary roadways, and once every five years for secondary roadways *(3)*. The data is collected by a VDOT contractor using a specialized vehicle platform and a suite of sensors. This condition data is analyzed to produce indices which serve as the basis for pavement maintenance decision making, and thus allocation and disbursement of the portion of the annual budget dedicated to pavement maintenance. If a connected vehicle approach were utilized, VDOT could experience significant cost savings in terms of data collection, and have access to data on a much more frequent basis. The core hypothesis of this component of the program is that V2I technology can be used to collect and integrate information from connected vehicles to (1) provide uniform, continuous, and immediate and cost-effective data about transportation infrastructure health and level of service, which can be used to support pavement management decisions; and (2) define performance measures and health indices that better relate with users' safety, perception, and expectations. Highway maintenance operations are also important for maintaining road safety during inclement weather. Such operations integrate snow- and ice-control strategies, travel information, traffic operations,

	weather effects, environmental impacts, incident management, and customer satisfaction *(4)*. For example, under winter conditions, the main objective of a snow- and ice-control strategy is to bring the road surface to a safe state for the driving public within a reasonable period of time. An important factor during such operations is the ability to determine the optimum treatment and timing for the treatment, and the amount of chemicals/ abrasives that must be applied to achieve a safe surface condition. Surface friction measurements provide useful information for improved winter maintenance operations and mobility. Recent studies suggest surface friction levels could be obtained from the traction control system (TCS) and antilock breaking system (ABS) already installed on production vehicles. The objective of this collaborative research program is to develop prototypes and conduct a field test of system level applications of a connected vehicle pavement condition measurement system. This will allow the research team to investigate (1) different approaches to a connected vehicle pavement measurement system; and (2) determine the optimum procedures for collecting, processing, aggregating, and storing the data to support engineering and management decisions. The UTC Virginia test bed will be used to support this work, and it will build upon previous work funded by the Cooperative Transportation Systems Pooled Fund Study (CTS PFS) and the Mid-Atlantic University Transportation Center (MAUTC). Specific objectives of this program can be summarized as follows: 1. To gain experience in a system-level pavement condition measurement applications to determine feasibility. 2. To compare a DSRC versus a smart phone based approach to this application. To investigate the utility of the data produced for supporting pavement/asset management decisions (connected vehicle experts at UVA CTS will work collaboratively with pavement experts at VTTI). The research program has been developed as a two-phase effort. This proposal covers Phase I, which will include the refinement and deployment at the Smart Road of the roughness approach, and a proof-of-concept validation of the friction measurement application. The second phase (not included in this proposal) is planned to include the deployment of the ride quality applications at the more complex NOVA CV Testbed, the validation of the friction measurement application and a comprehensive evaluation of the novel pavement assessment approach.
Impacts/Benefits of Implementation (actual, not anticipated)	This study is still in progress, actual impacts and benefits of implementation will be determined in Summer 2013 when the study is completed. This page will be resubmitted in the next round of reporting to state these actual impacts and benefits.

Web Links • Reports • Project Website	http://www.connectedvehicleinfrastructure-utc.org/?q=node/62 http://rip.trb.org/browse/dproject.asp?n=32357