UTC Project Information	
Project Title	Connected Motorcycle System Performance
University	Virginia Tech Transportation Institute
Principal Investigator	Reginald Viray
PI Contact Information	RViray@vtti.vt.edu
Funding Agencies	CVI-UTC (Tier 1 UTC)
Agency ID or Contract Number	TBD
Project Cost	$149,604.00
Start and End Dates	February 1, 2013 – January 31, 2015
Project Duration	2 years
Brief Description of Research Project	Motorcycle riders have much to gain with widespread adoption of Connected Vehicle Systems (CVSs). One in every seven fatalities on our nation's roads is a motorcycle rider; even with substantially lower reported annual vehicle miles traveled. Crash rates have been increasing in recent years; rising from seven percent to thirteen percent of all traffic fatalities over a ten year period (NHTSA, 2010). Consider two additional crash statistics (Hurt, Ouellet, Thom; 1981): 1) 75 percent of motorcycle crashes involve a passenger vehicle; and, 2) in 66 percent of these crashes the passenger vehicle violated the motorcycles right of way. With supporting statistics such as these, it is generally accepted that the failure of motorists to detect motorcycles is the predominate cause of motorcycle accidents. The Crash Avoidance Metrics Partnership (CAMP) and the United States Department of Transportation (USDOT) have demonstrated that safety systems based Dedicated Short Range Communications (DSRC) are feasible and may address as much as 82 percent of the crash types (Rita; 2012). The installation of an inexpensive Vehicle Awareness Device on a motorcycle would allow the benefit of DSRC safety systems to apply to the rider as well as the driver. By transmitting the Basic Safety Message (BSM), connected vehicles in the area will become aware of the motorcycle and can deliver relevant crash warnings to their driver. Applications such as Blind Spot Warning, Left Turn Assist, Intersection Movement Assist, and Emergence Electronic Brake Lights could profoundly impact motorcycle conspicuity. Furthermore, although largely untested, there is also potential for riders to directly receive crash warnings on their motorcycles (see corresponding proposal "Connected Motorcycle Crash Warning Interfaces"). Such systems will improve the riders' situational

	awareness with applications such as Curve Speed Warning and Slippery Surface Condition; which could impact the prevalent run off road crash type. Although only very limited testing has been performed, it is generally expected that CVSs should easily be ported to motorcycles; research is required to verify this assumption. For example, the Society of Automotive Engineers (SAE) standard J2735 has provisions such as vehicle width and length such that algorithms can compensate for the smaller size of the motorcycle. Whether adjusting such parameters is sufficient to allow for target classification equivalent to four-wheel vehicles has not been proven. The unique requirements for CVSs on motorcycles may further impact the target classification process. Preparatory research for the Safety Pilot Model Deployment project clearly demonstrated the critical importance of where key CVS components are located on the vehicle. Differences in DSRC communication range and packet error rate were found as a function of antenna location. Of considerably greater consequence, selection, location, and orientation of the Global Position System (GPS) antenna also was found to greatly impact performance. Motorcycles have a limited number of mounting locations for the DSRC and GPS antennas. There are small to non-existent ground planes for the antennas which will likely impact the range of the DSRC in particular. Antennas will always be partially occluded by the rider's body. The impact on DSRC performance due to this occlusion (which can be rather large due to the close proximity between the rider and antenna) is unknown. The rider occlusion is of greater concern with the GPS positioning system. Depending on the location of the antenna and rider, it is possible the mask angle will be substantial; thus, greatly reducing the number of visible satellites. The precision of threat assessment in V2V systems depends on a consistent position fix between the two involved vehicles. When the solutions for nearby vehicles are based on a different set of satellites, error in the target classification often results. This proposed research project focuses on characterizing the target classification, positioning, and communications performance of CVSs on motorcycles. The research will investigate a number of different configurations to identify the optimal selection of location(s) and orientations for mounting the DSRC and GPS antennas; based on communications and positioning performance. For the optimal location(s), target classification performance will be characterized across a set of topographically diverse test drives. The experiment will be designed for compatibility with the System Performance Tests performed by VTTI in cooperation with the CAMP Vehicle Safety Consortium 3 (VSC3) during the Safety Pilot Driver Clinics project. This will allow a direct comparison of results between the four- and two-wheeled connected vehicles. The outcomes of this research will feed directly into currently

	ongoing CVS research. The work will provide both motorcycle and automotive industries with system performance data specific to motorcycles. These results will indicate if additional research and development will be required to before deployment in a mixed vehicle environment or if performance is sufficient and the automotive findings are generally applicable to motorcycles.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	This project will focus on the following primary objectives: • Characterize the impact of antenna configurations on communications and positioning performance. • Characterize the target classification performance of vehicles when communicating with a motorcycle across varied terrain and roadway geometries. • Compare motorcycle mounted system performance to performance found in automotive testing. • Compare differences between two automobiles communicating vs. mixed vehicle communications. Report observations and provide recommendations.
Impacts/Benefits of Implementation (actual, not anticipated)	This study is still in progress, actual impacts and benefits of implementation will be determined in Winter 2014 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/21 https://rip.trb.org/browse/dproject.asp?n=33460