UTC Project Information	
Project Title	MPC-547 – Infrastructure Safety Support System for Smart Cities with Autonomous Vehicles
University	North Dakota State University
Principal Investigator	Ying Huang Pan Lu Raj Bridgelall
PI Contact Information	Ying Huang Assistant Professor North Dakota State University Phone: (701) 231-7651 Email: ying.huang@ndsu.edu ORCID: 0000-0003-4119-9522 Pan Lu Assistant Professor North Dakota State University Phone: (701) 231-5185 Email: pan.lu@ndsu.edu ORCID: 0000-0002-1640-3598 Raj Bridgelall Assistant Professor North Dakota State University Phone: (408) 607-3214 Email: raj.bridgelall@ndsu.edu ORCID: 0000-0003-3743-6652
Funding Source(s) and Amounts Provided (by each agency or organization)	USDOT, Research and Innovative Technology Administration $282,450 Graduate Student Tuition Wavier from CEE department $282,450
Total Project Cost	$564,900
Agency ID or Contract Number	69A3551747108
Start and End Dates	November 20, 2017 to July 31, 2022
Brief Description of Research Project	A smart city integrates diverse sets of information and communication technologies to monitor asset condition, security, safety, service quality, and operational efficiencies, often in real time [1-3]. Smart cities are continually hosting a growing number of autonomous vehicles that can sense their environment and navigate without human input [4]. Studies anticipate that autonomous vehicles will significantly improve transport efficiencies, reduce crashes, provide smoother rides, decrease congestion, and simultaneously increase traffic flow through speed harmonization and reduced demand for roadway capacity [5-9]. The USDOT expects that autonomous

vehicles could eliminate more than 90% of crashes, depending on their level of adoption [10].

Many nations such United Kingdom, France, Australia, and United States have welcomed the deployment of autonomous vehicles [11-12]. As of 2016, seven states in the United States (Nevada, California, Florida, Michigan, Hawaii, Washington, Tennessee), along with the District of Columbia have enacted laws to support autonomous vehicle testing and deployment [13-14]. Despite this momentum and the anticipated benefits, studies show that residents hesitate to embrace autonomous vehicles primarily because of safety concerns [15]. Many expect that the full adoption of autonomous vehicles will take 50 years or longer [16]. Therefore, driverless vehicles will share the roads with human-operated vehicles for a long time. Subsequently, autonomous vehicles of various levels of automation will continue to rely on human inputs. Thus, one of the biggest challenges facing smart cities is achieving fully harmonized vehicle operation in mixed driver scenarios.

Research Objectives:

1. Develop an infrastructure embedded sensor network to provide real-time traffic and road condition information such as traffic volume (e.g. ADT, peak-hour traffic), traffic composition (vehicle classification), vehicle speed, dynamic weight via weigh-in-motion (WIM), traffic density, traffic flow rate, road roughness, and other data;
2. Develop algorithms that the infrastructure safety support system will use to process the sensor-based real-time traffic data and pavement conditions to support the decision making processes of autonomous vehicles such as driving speed and safe vehicle following distances when sharing the road with human-driven vehicles;
3. Develop real-time warnings based on the data derived from the infrastructure support system;
4. Optimize the infrastructure support system such as the sensor and V2I facility layout;
5. Validate the developed infrastructure support system through simulations and field tests.

Driverless vehicles must be self-aware to make learned and ethical decisions to avoid crashes in multimodal and diverse settings. This proposed effort will develop an Infrastructure Safety Support System by embedding V2I enabled sensor networks into the transportation infrastructure to provide autonomous vehicles and human drivers with inputs to improve their decision making when obvious decisions may not possible. In addition to the four research objectives of this project, the team will use the results from this development to enhance curricula that would engage and mentor students in the practice of developing safe smart cities. This project will involve three

	graduate students and several undergraduate students. The trainings through this project will prepare students for potential careers in smart city developments.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	
Impacts/Benefits of Implementation (actual, not anticipated)	
Web Links • Reports • Project Website	