**Title.** Smart Barrier Control System for Imposing Boundary Coordinate System on Vehicular Systems

**Background.** Control Systems are utilized to provide stability of technological systems. These systems cover a great variety of domains including mechanical, electrical, magnetic, and hydraulic systems. These systems often need to be mathematically formulated and then integrated with control stability to converge in the desired results. Transportation systems utilize many of these stability controllers to provide logic-based decisions to the Electronic Center Unit (ECU) in vehicles to determine proper action. The fields of study and improvement in autonomous vehicles are vast, but the focus is on vehicle to infrastructure (V2I) communication combined with Control System Stability. V2I systems focus on transmitting in situ parameters. In example, V2I systems are limited to only transmitting velocity values, or approximate positions of objects based on cameras located at the infrastructure. Limitations arise from this system being passive and have no access to vehicle ECU, so it just provide information to drivers where dangers can be imminent unless an automatic system takes action for the driver. For this reason, a system that contains both mathematical formulations in control stability and infrastructure communications is needed. This way, it will be possible for vehicles to obtain infrastructure input, and based from it, determine vehicle output actions.

**Objective.** To formulate a mathematical model of infrastructure coordinates in vehicle space that uses V2I communications. Implement model with control system stability convergence criteria, and experimentally determine the efficiency and limitations of the aforementioned system.

**Research Plan.** Relevant coursework will be taken such as Control System Design and Continuous System Modeling. Literature review will be finalized within the early stages of the current year. As a mechanical engineering student, to consult knowledge of V2I communication and programming skills, a team will be assembled with the computer engineering department for collaboration. Mathematical models will be created on the software MATLAB and for stability control Simulink will be used. To implement convergence criteria, simulations will be performed on CarSim software. Simulation results will be used to determine the efficiency of the system and make any improvements before testing.

The convergence criteria is based on the current vehicle parameters during driving performance. These include: Braking Distance, Steering Angle, Yaw Rate, Wheel Torque/Speed, Wheel Slip, Acceleration, and Velocity Reduction Rate. Since results from simulations will be heavily affected by sensors data, investigation will be performed on the accuracy, sensitivity and resolution of sensors. Furthermore, filtering techniques will be explored and implemented to reduce noise from environmental factors. Some of the filters include but are not limited to: Kalman Filters, Particle Filters, Bandwidth Filters, and SAE Filters.

Midwest Roadside Safety Facility (MwRSF) will provide testing equipment and requirements such as infrastructure construction, road pre-determined conditions, and approved vehicles for high-limit testing. Also, MwRSF has a full-scale crash testing area certified for research use. Thus, exploring the capacity of current systems compared to the proposed system will be performed during experimentation phase. Testing will be based on different speed levels and infrastructure configurations.

**Impact/Understanding of the Field.** Autonomous Vehicles and V2I as research field have been experiencing a substantial growth in recent years. However, both fields have been developing in their own, by having vehicle technology focusing on control systems and having infrastructure technology focusing on passive information streams. This research poses a new bridge in between infrastructure technology and vehicle technology. The final product will culminate in a thesis writing offering a detailed description of how the mathematical model serves as a tool that can connect both infrastructure coordinates and vehicle space during autonomous vehicle operations. Understanding of this fields merging will offer new approaches to reach the desired fully autonomous system in the near future.

**Provide Societal Benefits.** Car accidents had been decreasing with the increment of technology being implemented on vehicles. However, this stopped being true when the introduction of smartphones commercialized worldwide. Since then, there has been another increase on vehicle accidents due to the population use of cellphone technology. To asses this problems, new intelligent systems are needed, and this project is one of them. Having infrastructure as stability control input on ECUs can provide a new line of prevention for the society. With the creation of this system, the possibility arises to obtain an agreement in between state municipalities, and private companies to cooperate in the implementation of these systems with a general guideline. This will offer a new state of art for the advancement of the autonomous vehicle industry.