**Title.** On Road Coordinates Decomposition for Autonomous Guidance

**Background.** Vehicle autonomy has been touted as the future of transportation, but there are significant challenges which remain to be addressed. Tremendous growth has been achieved in driving assistance devices, collectively termed Advanced Driver Assistance Systems (ADAS). Safety organizations such as the Institute for Highway Safety, Highway Loss Data Institute, and the National Highway Traffic Safety Administration reviewed recent U.S. traffic data and confirmed that ADAS systems directly contributed to an overall reduction in annual crashes, and likely prevented deaths and serious injuries.

However, road navigation remains the biggest hurdle for fully-autonomous vehicle implementation. Current vehicle guidance techniques have relied on either high-precision tracking (at low-speeds on urban environments) or lane edge identification (with machine vision technologies). Both techniques suffer a high decline in performance when poor road visibility conditions appear. These conditions vary from snow on roads, or poor lane markings. Thus, a new method has been developed to supplement road profiles to the vehicles, for them to navigate independently of road visibility.

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

**Research Plan.** At this point of research, all relevant coursework has been taken such as Control Systems, Numerical Methods, and Analytical Methods. Literature review of current technology of vehicles has been completed and finalized with testing on vehicle performance during emergency braking. A method has been devised in which geospatial data can be obtained from multiple sources such as LIDAR scans or satellite scans. Data is selected from these sources and a trajectory heading angle is calculated for the vehicle. The trajectory takes into consideration the geometry of the road as per A Policy on Geometric Design of Highways and Streets by AASHTO. The convergence criteria for road selection 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.

Path evaluation is subdivided in two categories: Data Filtering/Smoothing, and Data Optimization. Since data to create road profiles needs to satisfy continuity and lack outliers, it is needed to have filtering/smoothing techniques. Similarly, the data can come from multiple sources, thus a general evaluation guideline is being develop to obtain an ideal path from any data source possible.

Data Optimization takes part after obtaining a “clean” road profile that does not contain noisy elements or outliers. Optimization relies on creating an “optimum path” that is dependent on the vehicle parameters itself. Some include, vehicle wheelbase or length. To do this, an objective function is selected that takes general vehicle parameters, and is optimized for the road profile parameters mentioned before (i.e. velocity, acceleration). The objective function in place is the Ackerman Steering which can be extended for any car type or some specific truck types.

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, road configurations, and vehicle types.

**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 collaborating with vehicle’s ECU 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.