

Title:	Evaluate Alternative Methods to Examine Visibility of Pavement Markings
The Problem:	Safety of the roadway users is the top priority for TxDOT. Current practices to specify and qualify pavement markings do not take a comprehensive account of the variability and efficacy of pavement markings due to differences in pavement surface type, environmental conditions, aging, and visibility of these markings. Retroreflectivity is currently used as a measure of how well drivers can see markings at night. Retroreflectivity is the measure used in specifications by DOTs and it is the amount of light from the vehicle that is incident on the marking and retroreflected from the markings back to the driver. Although retroreflectivity measures the amount of light reflected by the marking to the driver, human perception of visibility relies on factors other than retroreflectivity and environmental conditions. In some conditions, a pavement marking with acceptable levels of retroreflectivity may have poor visibility due to factors such as the pavement type; e.g., NGCS pavement, pavement or exposed aggregate color with similar color as the stripe, and environmental conditions; e.g., wet weather conditions, glare. Further, pavement markings degrade from wear by vehicle tracking and the environment. In extreme cases, the marking is slowly eroded from the surface, resulting in less of the original marking present. Markings also lose the glass beads embedded in the surface that produce retroreflectivity. Environmental aging can change the color of some markings over time. Many DOT specifications require a measure of color stability for this reason. Looking ahead, such visibility measures not only impact human drivers, but also several different types of technologies in vehicles currently being sold in the market and being developed for future autonomous vehicles. Given that contrast, not retroreflectivity, is the most important metric for machine-vision/AI automated driving as well as visibility for human drivers, there is a need to better understand the relationship between perceived visibility, safety, and retroreflectivity for pavement markings under a variety of conditions. There is also a need to use this knowledge to improve the current guidelines for specification, maintenance, and rating of pavement markings on different types of surfaces and geographical conditions. This information can also include and be used to examine feasibility of alternative pavement marking technologies; e.g., solar LEDs.
Technical Objectives:	This project will make improvements to the practices followed for placement of pavement markings as well as a tool to assess the current visibility of pavement markings. To achieve these objectives, the work to be performed shall include: 1. Identify the diversity of pavement surfaces in the state of Texas across different geographic regions along with the type of pavement marking. 2. For a diverse set of pavement types and markings, catalog the types of surface markings, age of these markings, their present condition, measured retroreflectivity, and measured contrast ratio using a gloss meter or other devices. 3. Investigate and estimate the visibility of these markings for both human drivers and automated vehicles and develop a model to predict this visibility as a function of the pavement type, marking type, age of the pavement, and environmental conditions. 4. Examine feasibility of using other technologies to improve pavement markings and safety as well as technologies to improve the quality of the existing pavement marking. 5. Use the findings from this study to develop recommendations for improving specifications and practices for placement of new pavement markings. 6. Provide a tool to effectively assess the visibility of existing pavement markings and make suggestions for maintenance or replacement as necessary. The expectation of the project end product(s) shall attain a Technology Readiness Level of 7.

Anticipated Deliverables:	1. Technical memorandum for each task completed. 2. Monthly progress reports. 3. Value of Research (VoR) that includes both qualitative and economic benefits, to be included in the final research report; <u>not a stand-alone deliverable</u>. 4. Research report documenting the findings of the research, including recommended guidelines to improve placement and maintenance of pavement markings. 5. Project Summary Report
Proposal Requirements:	1. Utilize the "Proj/Agre" and "PA_Form" templates located at the TxDOT RTI website. 2. Proposals will be considered non-responsive and will not be accepted for technical evaluation if they are not received by the deadline or do not meet the requirements stated in RTI's University Handbook, which is also located at the RTI website. 3. Proposals should be submitted in PDF format, 1 PDF file per proposal. File name should include project name and university abbreviation. 4. This project will be tracked during the life of the project using a Technology Readiness Level (TRL) scale. For more information about the use of a TRL, click.