Exhibit D – Research Project Requirement

Decoding Road-User Intent: Advancing Surrogate Safety Measures through Behavior-Aware Generative World Models

Recipient/Grant (Contract) Number: The University of Texas at Austin/Grant # 69A3552344815 and 69A3552348320

Center Name: National Center for Understanding Future Travel Behavior and Demand (TBD)

Research Priority: Improving Mobility of People and Goods

Principal Investigator(s): Yiqiao Li

Project Partners: New York State Department of Transportation (NYSDOT)

Research Project Funding: $200,000 (Federal and non-Federal funding amounts.)

Project Start and End Date: 6/1/2026 – 5/31/2027

Project Description: This project investigates how roadside LiDAR sensing and generative scene prediction models can support more informative and uncertainty-aware traffic safety assessment at urban intersections. Conventional surrogate safety measures, such as time-to-collision and post-encroachment time, are widely used to identify potential traffic conflicts. However, these measures are primarily based on observed kinematic relationships and may not fully capture road-user behavior, interaction context, or uncertainty caused by sensing noise, occlusion, and tracking errors. The project will develop and evaluate a pilot infrastructure-centric modeling framework that uses roadside LiDAR data to forecast short-term movements of vehicles, pedestrians, cyclists, and other road users from a fixed roadside perspective. Rather than treating observed trajectories as deterministic, the framework will explore probabilistic scene prediction methods that represent multiple plausible future interactions and provide uncertainty estimates. Building on these forecasts, the project will develop prototype intention-aware and uncertainty-aware surrogate safety measures. These measures may include probabilistic conflict indicators, uncertainty-calibrated risk scores, and other metrics that supplement conventional kinematic safety measures. The proposed metrics will be evaluated using roadside LiDAR data and manually reviewed conflict events, with attention to prediction accuracy, uncertainty calibration, interpretability, and practical relevance for proactive safety analysis. The project will also produce implementation-oriented resources, including a prototype Roadside Safety Forecasting Toolkit, example workflows, evaluation scripts, documentation, and a practitioner-facing brief. These products are intended to support future research, agency evaluation, and potential application of infrastructure-based safety monitoring and connected vehicle support systems.

US DOT Priorities: This project supports US DOT priorities by advancing data-driven methods for improving roadway safety, strengthening the use of emerging transportation technologies, and supporting more efficient infrastructure-based monitoring. The project is directly aligned with the safety goal by focusing on proactive identification and interpretation of traffic conflicts before crashes occur. By using roadside LiDAR and probabilistic scene prediction, the research explores how transportation agencies may better understand interactions among vehicles, pedestrians, cyclists, and other road users at complex urban intersections. The project also supports US DOT research, development, and technology goals by examining how AI, advanced sensing, and infrastructure-based analytics can be translated into practical tools for transportation safety assessment. The work is advanced and potentially transformative because it moves beyond deterministic, proximity-based safety metrics toward probabilistic and behavior-aware safety measures that explicitly account for uncertainty. Rather than proposing immediate operational deployment, this project will develop and test a research prototype, evaluation workflow, and practitioner-oriented resources that can help bridge academic research and future implementation. The project further supports technology transfer by producing tangible products beyond traditional publications, including a prototype toolkit, data-processing workflow, evaluation scripts, and a practitioner brief. These outputs are intended to make the research more accessible to agencies, researchers, and students interested in infrastructure-based safety monitoring and connected transportation systems.

Outputs: The project is expected to produce several research and implementation-oriented outputs. First, the project will develop a pilot infrastructure-centric scene prediction framework using roadside LiDAR-derived trajectories and/or spatial representations. The framework will be designed to generate short-term probabilistic forecasts of road-user movements from a fixed roadside perspective. Second, the project will produce a prototype suite of uncertainty-aware surrogate safety measures. These may include probabilistic time-to-collision indicators, conflict probability scores, uncertainty-calibrated risk measures, and related metrics that can be compared with conventional kinematic surrogate safety measures. Third, the project will produce a reproducible evaluation workflow, including data-processing scripts, model evaluation procedures, uncertainty calibration metrics, and example analyses. This workflow will support comparison between conventional and probabilistic safety measures. Fourth, the project will produce a tangible implementation-oriented product: a prototype Roadside Safety Forecasting Toolkit. The toolkit is expected to include example code, documentation, data format guidance, evaluation scripts, and sample outputs for generating and interpreting safety metrics from roadside LiDAR trajectory data. A companion practitioner brief will summarize the proposed methods, potential use cases, interpretation guidance, and limitations. Fifth, the project may produce an anonymized roadside LiDAR trajectory dataset or sample benchmark dataset, subject to data-sharing and privacy requirements. The project is also expected to support student training and may strengthen collaboration with transportation agency partners such as NYSDOT through data collection, technical feedback, and discussion of potential future applications.

Outcomes/Impacts: The expected outcome of this project is a pilot framework and practical resource base for exploring uncertainty-aware, infrastructure-based traffic safety monitoring. The project does not claim immediate operational deployment or direct changes to transportation policy within the project period. Instead, it aims to provide preliminary evidence, methods, and tools that can support future agency evaluation and potential implementation. If further validated, the proposed framework could help transportation agencies supplement conventional conflict analysis with metrics that better reflect uncertainty, behavioral context, and multiple possible future interactions. This may improve how safety-critical interactions are interpreted, particularly at complex urban intersections involving pedestrians, cyclists, micromobility users, passenger vehicles, and commercial vehicles. The prototype toolkit and practitioner brief are intended to support broader application of the research by making the methods more accessible to agencies, researchers, and students. These products may help practitioners understand when conventional surrogate safety measures are reliable, when uncertainty is high, and how probabilistic forecasts can be used cautiously in safety screening or before-and-after evaluation. In the longer term, the research may contribute to safer and more reliable transportation systems by improving the evidence base for proactive intersection safety assessment, infrastructure-based sensing, and future vehicle-to-infrastructure applications. The project may also support workforce development by training students in roadside sensing, AI-based transportation analytics, uncertainty quantification, and safety-focused technology transfer.

Final Research Report: A URL link to the final report will be provided upon completion of the project.