AI-Enabled Intelligent Vibration Sensor for Active Highway-Rail Grade Crossings

Exhibit D

Research Project Requirement Template

Recipient/Grant (Contract) Number: University of Texas Rio Grande Valley (UTRGV)/Grant No. 69A3552348340

Center Name: University Transportation Center for Railway Safety (UTCRS)

Research Priority: Promoting Safety

Principal Investigator(s): Dr. Mohsen Amjadian (PI, UTRGV) and Dr. Constantine Tarawneh (Co-PI, UTRGV)

Project Partners: Rio Valley Switching Company

Research Project Funding: $51,836 (Federal), $34,866 (Non-Federal Cost Share)

Project Start and End Date: 09/01/2023 to 08/31/2024

Project Description: Highway-Rail Grade Crossings (HRGCs) have many safety challenges due to the potential collisions between oncoming trains and road users, including vehicles, bicycles, and pedestrians. The implementation of Positive Train Control (PTC) technology is regarded as a promising solution to reduce rail accidents. However, its effectiveness is hindered at HRGCs, especially in rural regions, where radio and GPS communication can be unreliable or lost (dark territory). To mitigate the risk of catastrophe, it is imperative for road users to detect trains early and maintain a safe distance allowing sufficient reaction time. This can be challenging especially in rural regions where it is difficult to supply enough power for advanced and heavy train detection sensors. This research seeks to develop an AI-enabled vibration sensing system capable of identifying and tracking approaching trains from a considerable distance upstream. This advancement enables road users to preemptively initiate responsive actions within a secure timeframe. The system's design is especially tailored for deployment in remote areas where there is limited access to electric power sources required for conventional vibration sensors.

US DOT Priorities: The proposed work in this project is aligned with three of the six USDOT strategic goals, which are listed hereafter: **(a) Safety:** By developing theoretical (analytical) and numerical models to assess the performance of vibration-based sensors for detection of trains from a considerable distance upstream and leveraging advanced signal processing and data analytic techniques to analyze the time series data. **(b) Equity:** By providing training opportunities to graduate and undergraduate students coming from underrepresented populations and diverse communities and equipping them with the necessary skills and knowledge for pursuing successful careers in the field of transportation. **(c) Transformation:** By developing translating developments from other engineering fields (e.g., computer and electrical) into vibration monitoring of railroad track system, conducting research to understand the needs and implications of smart sensing technologies in railroad engineering, and eventually transferring technology to stakeholders and industry partners.

Outputs: The expected products include:

a. Finite element model(s) of a rail-track system in OpenSEESPy package which is an interpreter for Open System for Earthquake Engineering Simulation in Python including the dynamic effects of ties, rail pads, and the ballast. [File Format: PY]

b. Field measurement data on the vibration response of a rail-track system next to a rail grade crossing in a rural zone in Texas [File Format: TXT and CSV]. This task will be accomplished by partnering with the Rio Valley Switching Company that oversees the rail track system in the Lower Rio Grande Valley.
c. Final report on the results of finite element modeling and numerical simulation of the rail-track system under the moving load and time-history data collected during field measurement.
d. One or more conference or journal publications prepared by the PIs and students involved in this project.

Outcomes/Impacts: The research results of this project will be used to develop a cost-effective AI-enabled vibration sensing system to identify and track approaching trains in highway-rail-grade-crossings (HRGCs) in rural areas from a considerable distance (>1 mile) upstream. This will eventually help to improve the safety of railway travel and reduce the risk of accidents. Additionally, this project aims to foster diversity and inclusion in STEM education by supporting students from underrepresented racial and ethnic groups at UTRGV. This will be accomplished by creating hands-on educational activities and materials for K-12 students during summer camps in UTCRS and taking advantage of senior design courses in the Civil Engineering and Mechanical Engineering departments to involve undergraduate students in different research tasks of the project. The objective is to train a diverse and skilled STEM workforce to contribute to the safety and sustainability of the U.S. rail network. Furthermore, this project promotes partnerships between academia and industry, and engagement with stakeholders and policy makers by organizing workshops, webinars, and publicly available publications to share the potential applications of the developed technology once a proof of concept has been demonstrated.

Final Research Report: Upon completion of the project, a URL link to the final report will be provided.