Rapid Detection of Track Changes from Onboard Data Acquisition Records: Year 2

Exhibit D

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): Dimitris Rizos (PI, University of South Carolina (USC)) and Yu Qian (Co-PI, USC)

Project Partners: N/A

Research Project Funding: $64,628 (Federal), $31,282 (Non-Federal Cost Share)

Project Start and End Date: 06/01/2024 to 08/31/2025

Project Description: Spurred by the findings of the current effort, the objective of this research project is to continue with the development of the simple yet efficient track stiffness assessment system, proposed in Year 1. The proposed system can quickly estimate both the lateral and the vertical track stiffness and detect stiffness changes in space and time. The proposed system uses track geometry data and vehicle response data collected from instrumentation already onboard railroad inspection cars or locomotives (e.g. DOTX220, DOTX216). The acquired measurements are processed through the innovative Rapid Vehicle-Track Interaction (R-VTI) calculator developed by the PI to calculate the track stiffness while the vehicle is moving at its normal operation speed along the track. Furthermore, it integrates the novel technique developed in Year 1 that is based on the frequency shift curve (FSC) framework to identify stiffness changes in the track, including loose or missing fasteners, damaged ballast, broken sleepers, etc. This method leverages the complementary strengths of wavelet packet analysis and the Hilbert-Huang transform for signal processing.

The proposed approach facilitates continuous track stiffness assessment along the network in space and time. In addition, it provides the real track stiffness values as vehicles move on top of the loaded track. The proposed technology applies to: (1) real-time monitoring and detection, (2) on-demand real-time monitoring of high-risk areas, and (3) accident investigation to identify possible contributing track conditions. It is noted that the proposed system simply makes better use of existing data already being collected and does not require any additional instrumentation in the track.

US DOT Priorities: This project revolutionizes the current practice in vehicle-track interaction by solving the inverse problem to calculate the track dynamic stiffness and to detect changes over space and time addressing, thus, track infrastructure inspection for safer operations. It aligns directly with five USDOT strategic goals: **(a) Safety:** This project directly impacts safety of operations since it automates the quantification of the track stiffness and detects stiffness changes in real-time or near real-time for continuous track monitoring simultaneously with standard track geometry inspections, enabling performance-based maintenance that accounts for vulnerability, risk and consequence. **(b) Economic Strength:** Service disruptions due to compromised track cause serious economic impact and loss of confidence in service reliability. Preventing track caused derailments minimizes the financial and societal impact, especially when hazmat is involved. **(c) Sustainability:** The detection of factors that lead to track settlement and failures along the right of way enables predictive action for hazard mitigation, extending the life of track and structures. The proposed technology makes better use of the existing recourses and provides more useful information without the need for additional sensors and instrumentation on track, enabling performance-based maintenance. As a result, targeted maintenance operations that account for risk, vulnerability, and consequence lead to maximizing track life and minimizing the environmental impact. **(d) Transformation:** This project revolutionizes the current practice in vehicle-track interaction by solving the inverse problem to calculate the track dynamic stiffness and to detect changes over space and time. The proposed system can be integrated with existing automated track geometry inspection technologies without additional resources and becomes the backbone for developing performance-based maintenance practices.

Outputs: Specific outcomes stemming from this project's mission are centered around the need to improve the safety of track infrastructure and performance of track risk management, and will be captured in the following deliverables:

1. IP (Intellectual Property) disclosure of the technology.
2. A minimum of one journal paper and one conference paper on the development and implementation of proposed technology.

Outcomes/Impacts: The broader impacts of this project include:

1. Revolutionizing the current practice in vehicle-track interaction by solving the inverse problem to calculate the track dynamic stiffness and to detect changes over space and time.
2. Quantifying the track stiffness directly based on the existing track geometry data, vehicle configurations, and vehicle dynamic responses data. The proposed technology makes better use of the existing recourses and provides more useful information without the need of additional sensors and instrumentation on track.
3. Automatically quantifying the track stiffness and detecting stiffness changes in real-time or near real-time for continuous track monitoring simultaneously with standard track geometry inspections.
4. Integrating the proposed system with existing automated track geometry inspection technologies without additional resources.

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