Phase 1: Wearable IMU-Based Fall, Near-Fall, and Incapacitation Detection for a Biometric and Environmental Awareness for Connected Operator Networks (BEACON) Sensor for High-Risk Environments

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: Networked Sensors and Sensing; Artificial Intelligence and Machine Learning

Principal Investigator(s): Jazmin Ley (PI, UTRGV). Weiguang Yang (Co-PI, UTRGV), Lei Cheng (Co-PI, UTRGV), and Constantine Tarawneh (Co-PI, UTRGV)

Project Partners: Rio Valley Switching Company (RVSC); MxV Rail; Brotherhood of Railroad Signalmen (BRS)

Research Project Funding: $107,309 (Federal), $71,151 (Non-Federal Cost Share)

Project Start and End Date: 09/01/2026 to 12/31/2027

Project Description: Railroad workers routinely operate in dynamic, hazardous environments, exposed to moving trains, maintenance equipment, adverse weather, and complex worksite activities. This project is **Phase 1** of the development of **BEACON (Biometric and Environmental Awareness for Connected Operator Networks)**, an intelligent wearable safety platform designed to improve situational awareness and reduce worker risk in high-risk environments. Although the project is proposed for a railway environment, the final product could be applied to other high-risk transportation settings, potentially supporting the Digital Corridors Initiative (DCI) of the US DOT.

This Phase 1 proposal focuses on developing an intelligent, railroad-specific wearable safety platform to detect falls and incapacitation. The system will utilize a hip-mounted device incorporating an Inertial Measurement Unit (IMU), temperature, and acoustic sensing to monitor the worker and their environment. The BEACON prototype will integrate biometric monitoring and machine learning to distinguish normal railroad work activities from slips, trips, near-falls, falls, impacts, and prolonged inactivity indicative of worker incapacitation. Initial model development will leverage publicly available activity recognition and fall detection datasets (e.g., ICUHAR, WISDM, SisFall, MobiFall, MobiAct), followed by the creation of a railroad-specific dataset that includes representative worker activities and controlled fall scenarios. The final product, comprising Phases 1-4, will provide haptic, visual, and audio alerts and transmit emergency notifications and worker status information to a centralized monitoring station to support rapid response.

Expected outcomes for Phase 1 include a wearable prototype, a railroad-specific movement dataset, initial development of ML models for fall and incapacitation detection, and implementation guidelines for future development. BEACON has the potential to significantly improve worker safety for railroad personnel and establish a scalable framework for intelligent worker technologies across all transportation industries. This project directly supports FRA and UTCRS priorities related to railroad safety, workforce protection, human factors, and emerging technologies to reduce transportation-related injuries and fatalities.

US DOT Priorities: SAFETY: 1.2 Reduce surface transportation-related fatalities and serious injuries. SAFETY: 1.3 Improve transportation worker safety. SAFETY: 1.4 Develop improved safety management systems across transportation modes. INNOVATION: 3.2 Enable transportation technology development and adoption. INNOVATION: 3.3 Invest in transformative technologies

Outputs: The research will result in the following outputs:

1. BEACON prototype wearable device (Transferable End Product).
2. Railroad Worker Movement Database (RWMD) (Transferable End Product).
3. Machine Learning Risk Assessment Framework: Machine learning algorithms
4. Final Technical Report
5. Peer-Reviewed Journal and Conference Publications and Professional Presentations

Outcomes/Impacts: The proposed research will improve railroad worker safety by developing intelligent technologies that detect hazards and high-risk conditions before incidents occur. The project will contribute to fewer worker injuries, improved situational awareness, enhanced emergency response, and increased operational efficiency. **Industry Impact:** The technology developed in this project may be adapted to other transportation sectors, including highway construction, transit operations, ports, and aviation, thereby potentially augmenting the initiatives undertaken by the Digital Corridors Initiative (DCI) of the US DOT. **Educational Impact:** The project will engage students in hands-on experience in wearable sensing technologies, machine learning, transportation safety, and human factors engineering.

Final Research Report: Upon completion of the project, provide URL link to final report.