

FAST® Loop Comparison of Onboard Condition Monitoring Versus Wayside Detection Systems

Deliverables and Reporting Requirements for UTC Grants Awarded in 2023 (June 2023)

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): Heinrich Foltz (PI, UTRGV) and Constantine Tarawneh (co-PI, UTRGV)

Project Partners: Hum Industrial Technology, Inc. and MxV Rail

Research Project Funding: \$126,416 (Federal), \$127,785 (Non-Federal Cost Share)

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

Project Description: Prior research at UTCRS has demonstrated that onboard sensor technology can make early and accurate detections of defect initiation in railcar bearings and wheels. Hum Industrial Technology, Inc., has further developed this technology to the point of field deployment in commercial applications with multiple railcar operators. Although these field deployments have already shown the ability to detect defective wheelsets, there is a lack of head-to-head comparison data in which the same bearings and wheels are monitored using both conventional wayside sensors (Hot Bearing Detectors (HBD) and Wheel Impact Load Detectors (WILD)) and onboard monitoring (commercial units from Hum and next generation prototypes from UTCRS), at the same time on the same track. This is a crucial step in validating the current onboard technology, as well as an initial field test of newer experimental techniques.

We propose a large scale (40+ sensor units) test to be conducted at the MxV Rail FAST® (Facility for Accelerated Service Testing) track loop. The test will acquire data from (a) commercial Hum Boomerang wireless sensors, (b) UTCRS prototype sensors developed during the 2023-2024 funding cycle, (c) an existing HBD installed at FAST®, and (d) an existing WILD installed at FAST®. The test will include several randomly selected cars, and one car intentionally installed with a combination of healthy wheels/bearings and wheels/bearings with known early-stage defects. At the end of the test run, selected bearings and wheels will be pulled and inspected for a "ground truth" evaluation of defect severity.

The outcomes of this project would include quantitative, calibrated comparisons of (a) temperature only (HBD) versus temperature and vibration (onboard) measures of bearing health and (b) wheel flat measurements from onboard accelerometers versus WILD. It will allow direct evaluation of the relative performance of onboard and wayside in early detection. The UTCRS prototype portion of the project would also demonstrate the viability of new techniques such as synchronized sampling and adaptive filter cutoffs and provide a large-scale public database for training AI/ML systems.

US DOT Priorities: The proposed work in this project is aligned with five of the six USDOT strategic goals: **(a) Safety:** The project directly investigates a potential safety concern that has been identified by the National Transportation Safety Board (NTSB). **(b) Economic Strength:** Unscheduled stoppages and field repairs cause serious economic losses for rail companies and their customers, and other users of the track. **(c) Equity:** UTRGV is a minority serving institution with an established record of training students from underrepresented groups and placing them in professional positions in the transportation industry. This project will directly employ three students, and indirectly support the employment of several others. **(d) Sustainability:** By enabling proactive preventive maintenance, this project will extend the useful lifetime of rolling stock and reduce the number of environmentally significant derailments. **(e) Transformation:** The high-resolution data streams generated by the sensors will be a resource that can be mined for new insights beyond the currently envisioned application. In

particular, it will provide extensive training and validation data sets for machine learning (ML) and artificial intelligence (AI).

Outputs: The expected products include:

1. A database that includes:
 - a. Timestamps
 - b. Train location at each timestamp
 - c. BHI readings for all bearings
 - d. Full vibration waveforms for eight bearings
 - e. Direct (contact) temperature readings for eight bearings
 - f. HBD readings
 - g. WILD readings
 - h. Annotations giving load condition for each car and identifying events of interest.
2. Post-inspection data including mechanical measurements, weight, photographs of disassembly, and measurement of spalls.
3. Complete test description for the UTCRS portion of the experiment including schematic diagrams, firmware, setup, and test procedure. The level of detail will be sufficient to allow independent replication of the experiment.
4. For the eight bearings with advanced instrumentation, analysis of cross-correlation between vibration waveforms acquired simultaneously will be carried out.
5. Recommended algorithms for identifying and suppressing external sources of vibration to improve the accuracy of bearing and wheel monitoring.
6. Publications and reports

Outcomes/Impacts: Industry Impact: The results could lead to recommendations for industry best practices, in particular deployment of onboard sensing. Even if onboard sensing is not deployed, industry will have increased knowledge of what level and types of bearing and wheel damage fall below the current thresholds of wayside instruments, which could lead to modified thresholds or trend analysis. **Educational Impact:** The UTCRS portions of the project will be carried out by students working under the supervision of the PIs. As a minority serving institution in a rapidly growing metropolitan area, we anticipate that most of the students will be from underrepresented groups. The students will work directly on rail equipment and learn industry operating procedures as part of their MxV FAST[®] experience. We anticipate that at least eight students will participate, whether supported by the project directly or from other sources.

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