Next Generation On-Board Sensor Technologies for Rolling Stock

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

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): Heinrich Foltz (PI, UTRGV), Ping Xu (Co-PI, UTRGV), Constantine Tarawneh (Co-PI, UTRGV)

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

Research Project Funding: $117,971 (Federal), $72,073 (Non-Federal Cost Share)

Project Start and End Date: 06/01/2023 to 08/31/2024

Project Description: In prior work, UTCRS has developed on-board, wireless sensor technology that makes early and accurate detections of defect initiation in railcar bearings and wheels. This technology has been transferred to industrial partners for field trials, and in the first deployment detected a condemnable wheelset. For the current project, we will develop next generation sensors to enable (a) detection of a wider range of safety hazards, including damaged couplers, track defects, and load shifts, (b) even earlier predictions of failures, and (c) further reduction of false positives. The key to these advances will be coordinated sensors with precision synchronization at the level of tens of microseconds and relative position self-awareness at the centimeter level across an entire train, combined with an order of magnitude improvement in sensitivity. This will provide richer datasets that allow comparison of signatures from different bearings on the same bogie, different bogies on the same railcar, and different railcars on the same train.

The challenge is implementing these improvements within limitations on power consumption and communication bandwidth. In this 15-month project we will design, fabricate, and demonstrate new modules that add temporal and spatial awareness to existing vibration, load, and temperature sensing. Due to power consumption and spatial accuracy requirements, this cannot be readily accomplished with GPS or other commercial off-the-shelf (COTS) systems at the wheel level; instead, a dedicated on-board system must be developed. The data acquisition will also be improved based on lessons from past projects, with the goal of obtaining a ten-fold improvement in resolution and sensitivity.

US DOT Priorities: The proposed work in this project is aligned with four USDOT strategic goals: **(a) Safety:** The project directly addresses safety through earlier and more accurate detection of impending failures in bearings, wheels, and other railcar components. The improved system also has potential to detect track damage and railcar coupling impacts that exceed recommendations. **(b) Economic Strength:** Unscheduled stoppages and field repairs cause serious economic losses for rail companies and their customers, and other users of the track. Early prediction allows repairs to be deferred to scheduled maintenance periods that will not disrupt the rail transportation system. **(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 two 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 thus amortize the carbon footprint of manufacturing a railcar over a longer period. It will reduce the number of environmentally significant derailments. **(e) Transformation:** The extensive high resolution data streams generated by the next generation sensors will be a rich resource that can be mined for new insights beyond the currently envisioned application, using recent and future advances in machine learning.

Outputs: The expected products and deliverables will include:

a. A set of working hardware prototypes for next generation wireless sensors.
b. Design files for the prototypes including schematics, layout, assembly instructions, and bill of materials, in format compatible with open-source EDA tools.
c. A working integrated prototype for a data collection hub suitable for both laboratory and test railcar use. The laboratory/testbed version will be based on commercial modules.
d. Embedded software for the sensor prototypes, documented and archived, using only bare metal code and open-source libraries, in format compatible with free IDE tools.
e. Software for the data collection hub, documented and archived.
f. Sample raw and processed datasets from test runs on laboratory bearing testers, annotated with information on test conditions and bearing conditions. These datasets will be archived and available for potential collaborators upon request.
g. Preliminary machine learning methods with experiment results that demonstrate the success of automated data analysis.
h. Final report including any DoT or UTCRS required information.
i. One or more conference or journal publications. At a minimum we will submit to the Spring 2024 Joint Rail Conference (JRC) with intermediate results.

Outcomes/Impacts: The research itself, as well as the training of engineering students, will have impacts beyond the immediate usage of the sensors to avert accidents and enable proactive maintenance. **Research Activities:** As stated earlier, the next generation of sensors, when deployed in the field, will produce data about railcars and track of type and quality that have not been previously available. Both industry and academic professionals will be able to conduct their own investigations and use the data in ways the current PIs have not yet contemplated. Our previous generations of wired and wireless sensors each generated multiple independent projects and publications using the data produced. **Educational Activities:** As a minority serving institution in rapidly growing metropolitan area, we anticipate that most of the students will be from underrepresented groups and that a good fraction of them will contribute to industrial development in the region. The project budget itself supports two students who will gain experience in developing rail-specific electronics and software, as well as bearing test equipment. The sensor platform will also enable several other students to be trained in the use of the system and its data for independent research projects on mechanical, thermal, and operational aspects of railcar and track performance. We anticipate that at least eight students will participate directly and indirectly in the various aspects of the project.

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