UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

Exhibit F - UTCRS

UTC Project Information	
Project Title	Vehicle-Bourne Autonomous Railroad Bridge Impairment Detection Systems
University	Texas A&M University (TAMU)
Principal Investigator	Gary Fry, Ph.D., P.E., Civil Engineering (PI)
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Funding Source(s) and Amounts Provided (by each agency or organization)	Federal Funds (USDOT UTC Program): $102,176 Cost Share Funds (TAMU): $33,040
Total Project Cost	$135,216
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	January 2014 – December 2016
Brief Description of Research Project	Timber bridges constitute approximately 30% of current railroad bridge inventories in North America. Inspections of these structures usually comprise visual assessments of the condition of individual, observable components of the bridge. Special inspections may call for the field personnel to observe a bridge under load: that is, while a train is crossing. When creating a prioritized list of critical bridges to be replaced or repaired, there is advantage to having complementary *measurements* of bridge structural behavior under load. The objective of the proposed research program is to develop technology that will facilitate detecting structural impairments in timber railroad bridges using data gathered from rail vehicles that cross the bridges. Such a capability would represent a significant

	improvement over the current approaches used to maintain timber railroad bridges. The underlying logic behind using rail vehicle measurements to determine bridge fitness can be summarized as follows: • Serious structural impairments in timber railroad bridges cause increased bridge motions under loading. • Bridge motions comprise one aspect of the overall motions rail vehicles experience when crossing a bridge. • The motions of a rail vehicle can be measured by sensors attached to the vehicle. • Once appropriate signal processing algorithms are developed, this being a key objective of the proposed research program, it might be possible to infer bridge motions from the measured behavior of a rail vehicle crossing the bridge. • Measured motions of a bridge can be compared against threshold values of motions that are considered safe. In order to meet these objectives, this research project incorporated (1) modeling of railcar-bridge system, (2) instrumentation of timber railroad bridges and railcars, (3) large scale experimentation of railcar-bridge systems, and (4) development of an Autonomous Data Reduction and Interpretation System using artificial neural networks to correlate vehicle dynamic response to bridge response and subsequently determine possible structural impairment.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	An open deck timber trestle railway bridge in service, was chosen for field testing. Two 15-foot spans were instrumented and monitored to observe the bridge's behavior under live loading. String potentiometers were used to measure the total and net mid-span stringer deflections of the test spans. The locations of the string potentiometers on the two spans are shown in Figure 1. The devices located in the center of the stringers record the total mid-span stringer deflection. The net stringer deflection is found by subtracting the average of the two end string potentiometer values of a stringer from the total deflection. The net deflection is an additional measurement that takes the settlement of the supports into account.

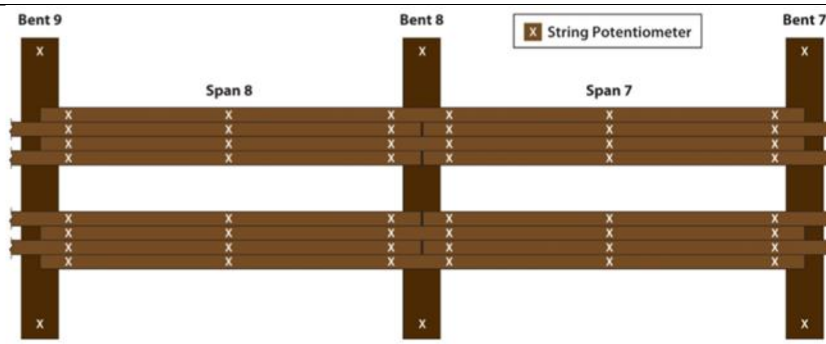

Figure 1: String Potentiometer Locations

Figure shows two rows of string potentiometers attached to the underside of the bridge during a test.

Figure 2: String Potentiometer Setup under Span 7

In addition to the instrumentation attached to the bridge, the ends of four axles of a train were instrumented with accelerometers to capture the vertical accelerations of the associated wheels. The locations of the wheel paths with respect to the rest of the work train are shown in Figure 3. Wheel path 1 was the first axle to enter a test span, and wheel path 4 was the last to exit.

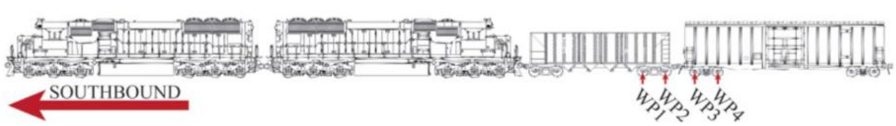

Figure 3: Work Train

Data was collected at speeds ranging from 10 mph to 50 mph with increasing increments of 10 mph. The objective of the project was to train a neural network-based data processing system to estimate the mid-span deflection of bridge spans given only the axle-end accelerations from a train crossing the bridge.

Figure 4 shows a comparison of the experimentally measured span deflections to those predicted blindly from the trained neural network processing system.

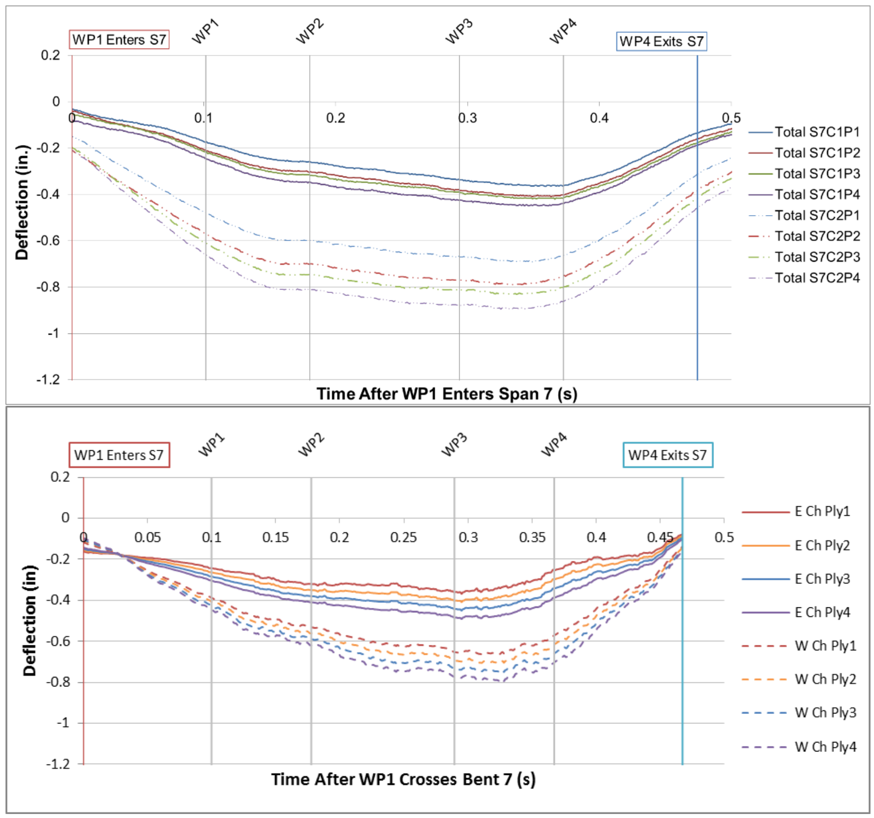

Figure 4: Span 7 Test 9 Stringer Time History Comparison: Experimental (Top), Predicted (Bottom)

Impacts/Benefits of Implementation (actual, not anticipated)	Using as input data, the vertical accelerations of the axle ends of a moving railcar, the proposed system for timber railroad bridge deflection detection is confirmed experimentally to predict the maximum mid-span deflection to within a 10% error.

	So far, this project has resulted in two journal manuscripts under revision for submission. In addition, a Ph.D. dissertation is under final revision and will be defended in May 2017. • Allard, A. J., “Vehicle Bourne Autonomous Railroad Bridge Impairment Detection Systems,” Doctoral Dissertation, Zachry Department of Civil Engineering, Texas A&M University, May 2017.
Web Links • Reports • Project website	http://www.utrgv.edu/railwaysafety/research/infrastructure/railroad-bridge-impairment-detection-systems/index.htm