UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

Exhibit F - UTCRS

UTC Project Information	
Project Title	Demonstration of Magnetostrictive Materials for Self-Powered Monitoring of Rail Vehicle Suspension Components
University	The University of Texas Rio Grande Valley (UTRGV)
Principal Investigator	Heinrich Foltz, Ph.D., P.E., Electrical Engineering (PI) Constantine Tarawneh, Ph.D., Mechanical Engineering (Co-PI) Jazmin Ley, M.S., Mechanical Engineering (Co-PI)
PI Contact Information	Electrical Engineering ENGR 3.214 Dept. (956) 665-2609 Office (956) 665-5016 heinrich.foltz@utrgv.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	Federal Funds (US DOT UTC Program): $63,417 Cost Share Funds (UTPA): $33,423
Total Project Cost	$96,840
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	January 2015 – December 2016
Brief Description of Research Project	The purpose of the proposed project is to demonstrate the use of magneto-strictive materials for self-powered sensors in railroad suspension components. Results obtained in a previously funded University Transportation Center for Railway Safety (UTCRS) project have shown that Terfenol-D has the capability to harvest significant amounts of energy (on the order of 100 mW/cm3) under conditions typical of those found in railcar bearing adapters, and is also capable of acting as a real time load sensor. Both applications use the same mounting fixture and static magnetic field bias, indicating that a single Terfenol-D core could simultaneously provide load sensing as well as sufficient power generation to supply its own support

	electronics, multiple additional sensors, and a low-power RF transceiver for wireless monitoring. The primary deliverable for this project will be an integrated, self-powered prototype comprising (a) a magnetostrictive core biased and packaged appropriately for mounting in or on a railroad bearing adapter, (b) support electronics simultaneously extracting power and providing calibrated load measurement, and (c) a basic wireless transceiver. The prototype will be tested in the UTCRS laboratory on a railroad bearing tester that closely simulates field service operating conditions.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Competition.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Competition.
Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/mechanical/2015/energy-harvesting-applications/index.htm

UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

Exhibit F - UTCRS

UTC Project Information	
Project Title	The Effect of Heat Generation in the Railroad Bearing Thermoplastic Elastomer Suspension Element on the Thermal Behavior of Railroad Bearing Assembly
University	The University of Texas Rio Grande Valley (UTRGV)
Principal Investigator	Arturo Fuentes, Ph.D., Mechanical Engineering (PI) Robert Jones, Ph.D., Mechanical Engineering (Co-PI) Constantine Tarawneh, Ph.D., Mechanical Engineering (Co-PI)
PI Contact Information	Mechanical Engineering ENGR 3.234 Dept. (956) 665-2394 Office (956) 665-5015 arturo.fuentes@utrgv.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	Federal Funds (US DOT UTC Program): $59,324 Cost Share Funds (UTPA): $12,352
Total Project Cost	$71,676
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	January 2015 – December 2016
Brief Description of Research Project	The main purpose of the proposed study is to investigate the effect of heat generation in the railroad thermoplastic elastomer suspension element to develop an experimentally informed and validated finite element thermal model which can be used to attain temperature distribution maps of railroad bearing assemblies under a variety of normal and abnormal service conditions. Among other things, these maps will be useful for sensor data interpretation and identifying ideal locations for sensor placement for continuous temperature tracking of railroad bearings (e.g. IONX motes). Specifically, the main objectives of this project are: 1) to explore and quantify the heat generation in the railroad bearing elastomer suspension element with different material systems and under different loads, frequencies, and temperature

	scenarios; and 2) to determine the effect of this heat generation on the thermal behavior of railroad bearing assembly under different operating conditions. To that end, the contribution of the elastomer pad to the system energy balance will be modeled using data from dynamic mechanical analysis (DMA) of common materials in use for that part. DMA will provide a full characterization of the elastic deformation (energy storage) and viscous dissipation (energy dissipation) behavior of the material as a function of load, frequency, and temperature. In parallel, CAD models of the railroad bearing assembly will be developed using Solidworks commercial software to be used in constructing finite element models utilizing the ALGOR commercial software. The finite element (FE) model will be used to conduct thermal finite element analyses using some of the expected operational boundary conditions and loads including the heat generation in the elastomer suspension system. The FE models will then be validated with some physical laboratory experiments. Finally, based on the simulations and experimental results, bearing assembly recommendations will be suggested to further ensure the safe operation of railroad bearings.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/mechanical/2015/heat-generation-in-the-railroad-bearing-suspension-element/index.htm

UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

Exhibit F - UTCRS

UTC Project Information	
Project Title	Development of Predictive Models for Spall Growth in Railroad Bearing Rolling Elements
University	The University of Texas Rio Grande Valley (UTRGV)
Principal Investigator	Robert Jones, Ph.D., Mechanical Engineering (PI) Arturo Fuentes, Ph.D., Mechanical Engineering (Co-PI) Constantine Tarawneh, Ph.D., Mechanical Engineering (Co-PI)
PI Contact Information	Mechanical Engineering ENGR 3.246 Dept. (956) 665-2394 Office (956) 665-5019 robert.jones@utrgv.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	Federal Funds (US DOT UTC Program): $52,424 Cost Share Funds (UTPA): $26,756
Total Project Cost	$79,180
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	January 2015 – December 2016
Brief Description of Research Project	The mechanics of spall growth in a railroad rolling element bearing will be studied using a number of bearings with spalls of various sizes. Bearings undergoing simulated service life testing will be monitored and the developing spalls will be periodically measured. From this data, a model for spall growth as a function of bearing loading, speed, and mileage will be developed. The thermal signature and vibration response of bearings with the spalls will also be obtained during testing. This signal information will permit the eventual coupling of a model of spall growth to spall detection technology to permit economical scheduling of bearing replacement after spall detection without a reduction of safety margin. Given advancements in monitoring technologies which are likely to emerge in the near future, operators will be able to identify the initiation of a spall on a bearing in

	service. However, a bearing with a spall is not necessarily in danger of imminent failure. To minimize disruption to operations while providing the same level of accident prevention that early detection provides, it will be necessary to understand the growth process and the associated signals generated by various size spalls to permit timely and economical replacement of failing components.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/mechanical/2015/predictive-models-for-spall-growth-in-railroad-bearings/index.htm

UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

Exhibit F - UTCRS

UTC Project Information	
Project Title	Radiative Heat Transfer Analysis of Railroad Bearings Using a Single Bearing Test Rig for Wayside Thermal Detector Optimization
University	The University of Texas Rio Grande Valley (UTRGV)
Principal Investigator	Stephen Crown, Ph.D., Mechanical Engineering (PI) Constantine Tarawneh, Ph.D., Mechanical Engineering (Co-PI)
PI Contact Information	Mechanical Engineering ENGR 3.234 Dept. (956) 665-2394 Office (956) 665-5015 stephen.crown@utrgv.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	Federal Funds (US DOT UTC Program): $62,904 Cost Share Funds (UTPA): $26,230
Total Project Cost	$89,134
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	January 2015 – December 2016
Brief Description of Research Project	Testing of tapered-roller bearings for freight railcars is an area of active research at The University of Texas-Pan American (UTPA). Current efforts are aimed at bearing health monitoring utilizing emerging temperature and vibration sensor technologies. UTPA currently possesses two four-bearing test rigs that are used to perform laboratory experiments required to support the ongoing development of rolling stock condition monitoring research projects. Recently two bearing testers were built that allow for vertical, lateral, and impact loading capabilities in a dynamic single railroad bearing configuration. The newest single bearing test rig, built through a UTCRS funded project, provides a testing environment that more closely simulates the conditions experienced by railroad bearings in field service. The test rig will enable detailed laboratory testing that correlates realistic field service loading with railroad bearing temperature profiles. A

	better understanding of the correlation between loading conditions, including loads caused by defects, and temperature profiles at the bearing surface allow for greater predictive capabilities using wayside thermal detector data (e.g. data collected by Hot Box Detectors – HBDs). The data and correlations derived from the proposed in-depth thermal analysis will help identify key target areas for hot box detectors and greater understanding about the causes of particular thermal signatures detected. The impact on railway safety will be fewer temperature related failures that could potentially cause catastrophic derailments and fewer bearings pulled that do not pose a significant safety concern.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/mechanical/2015/radiative-heat-transfer-analysis-of-railroad-bearings/index.htm

UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

Exhibit F - UTCRS

UTC Project Information	
Project Title	Estimating Bridge Span Deflections using Data Streams from Rolling Stock
University	Texas A&M University (TAMU)
Principal Investigator	Gary Fry, Ph.D., P.E., Civil Engineering (PI)
PI Contact Information	3135 TAMU College Station, TX 77843-3135 Office (979) 862-1339 garyfry@tamu.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	Federal Funds (USDOT UTC Program): $75,000
Total Project Cost	$75,000
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	May 2016 – December 2017
Brief Description of Research Project	The research being conducted is Phase II of a process that is envisioned as a complementary enhancement to visual evaluation methods by providing system-wide trending data for human decision makers. The objective is to measure the motions of the bridge and the railcar as it passes over the span. Neural networks, a type of pattern recognition technology, will be used to determine a relationship between the bridge and vehicle behaviors. Once a relationship is established, a new railcar motion can be presented to the network and the corresponding bridge behavior can be predicted using this technology.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.

Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/infrastructure/bridge-span-deflection-estimation/index.htm

UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

Exhibit F - UTCRS

UTC Project Information	
Project Title	Bumps in High Speed Rails: What is Tolerable?
University	Texas A&M University (TAMU)
Principal Investigator	Jean-Louis Briaud, Ph.D., Civil Engineering (PI)
PI Contact Information	808Q CEOB College Station, TX 77843-3135 (979) 845-3795 briaud@tamu.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	Federal Funds (USDOT UTC Program): $40,000
Total Project Cost	$40,000
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	May 2016 – December 2017
Brief Description of Research Project	California is planning a high speed train (HST) to link Los Angeles, San Francisco, and Sacramento. Texas is planning a high speed train to link Houston to Dallas. In both cases, the embankments and bridges over which the train will travel are likely to develop bumps arising from subgrade soil movements. What is a tolerable bump for a train travelling at 400 km/hr.? That is the question. This project advances knowledge in this area and provides guidance as to what bump is tolerable at what speed. This project is building upon previous studies of bumps at the end of railway bridges, but extends the work to much higher speeds associated with high speed trains.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	There are different sources resulting in various types of track irregularities such as the non-homogenous properties of the ballast and subgrade soil, rail defects, joints, welds and transition zones near bridges and tunnels. In this research, the train/track interaction problem particularly at the bridge/embankment transition zone is of primary concern. Indeed a major source of track bumps is the transition zone between compacted soil embankments and bridge abutments resting on deep foundations. This irregularity is due to the

difference in stiffness between the two rolling surfaces (Davis and Plotkin, 2009) that leads to a dynamic oscillation of the train wheels, and to a cyclic variation of the contact force between the wheels and the rail. This dynamic effect can result in accelerating deterioration of the track near bridges. The problem of irregularities along railway tracks is a concern for both freight and public transportation. The main problem associated with freight tracks is the maintenance cost to repair the irregularities generated along the railway lines due to high impact load especially at the transition zones. On the other hand, for the passengers, the main concern is the train body acceleration which can affect the quality of the ride.

In this study, both the train/track interaction forces and the train body acceleration criteria were considered to define the allowable irregularity size at a wide range of train speeds [18 ≤ VT ≤720 (km/h)]. In the present research study, the influence of different parameters is studied such as train speeds, different irregularities types (Table 1), a wide range of irregularity sizes (Table 2), and the subgrade modulus.

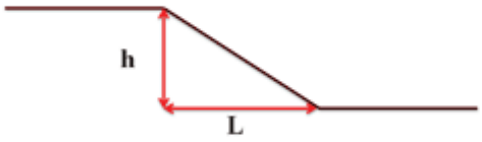
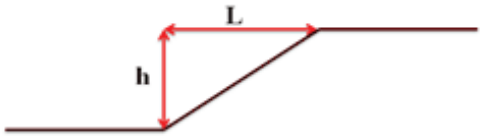
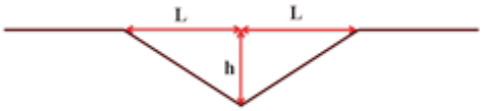
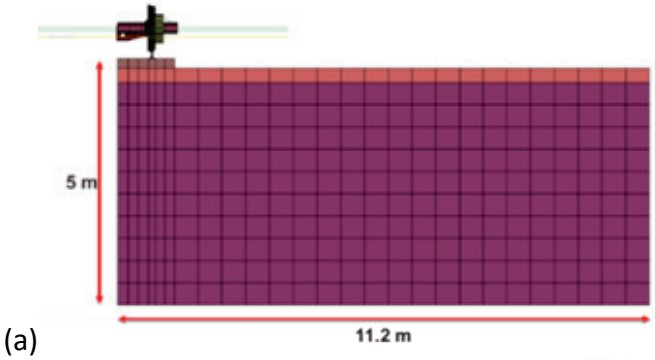
Irregularity type	Variables
Drop	
Rise	
Bump	
Dip	

Table 1: Irregularity Profile

L,m	h,mm	S=L/h
6	60	100
	30	200
	15	400
	7.5	800
	3.75	1600
12	120	100
	60	200
	30	400
	15	800
	7.5	1600

Table 2: Irregularity Size

All these parameters play important roles in defining the size of the tolerable irregularity; they were investigated through an extensive parametric study. A well-developed 4-D FEM in LS-DYNA including coupled train/track/soil model was first verified and then used to investigate the impact of different types of irregularity along HSRs (Figure 1). The problem of stiffness transition between a track on top of the embankment and a track on top of the bridge abutment (non-faulted track) was first addressed in the case of a non-faulted track. Then, the case of various types of irregularities in a faulted track along HSRs was then studied. To assess the allowable irregularity size, two criteria were considered: the allowable wheel/rail force, and the allowable train body acceleration (Table 3). The allowable values for these criteria are defined as those which keep the passenger safe and comfortable and decrease the maintenance cost and the required frequency of repair. The final results are presented in the form of applicable guideline charts which consider different influence factors including the subsoil modulus, the train speed, irregularity types, and irregularity sizes.



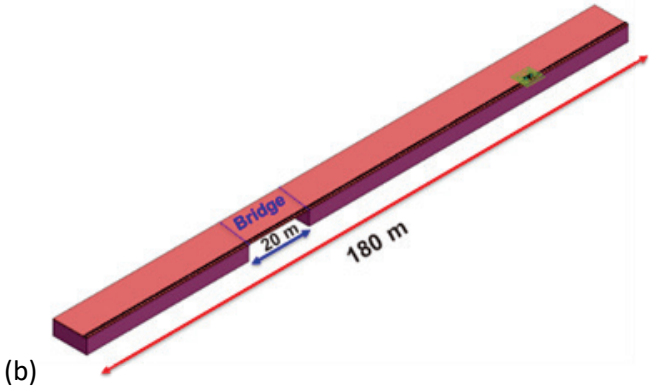


Figure 1: FEM mesh (a) Cross section, (b) 3D view

Parameter	Value	Reference
DAF*	1.50	Plotkin and Davis, 2008
DAF	2.00	Banimahd, 2008
DAF	2.50	Majka, 2009 (based on EN1991-2 Recommendation)
DAF	1.50	AS 1085.14
a_{max}** (g***)	0.10	Eurocode (European Committee for Standardization, 1995)
a_{max} (g)	0.12	Zhai et al., 2001
a_{max} (g)	0.20	Mao, 2004 (based on Chinese railway practice)
a_{max} (g)	0.05	SNCF, 1990 (the national railway of France)

* DAF: Dynamic Amplification Factor
** a_{max}: Maximum Permissible Vertical Train Body Acceleration
*** g = 9.81 m/s^2

Table 3: Threshold limit values

The final report including all these applicable guideline charts are presented in the form of one chapter of the PhD dissertation. Figure 2 shows one example of these guideline charts. In that figure, the Dynamic Amplification Factor (DAF) is defined as the ratio of the maximum dynamic rail/wheel reaction force to the static load on the wheel. Figure 2 indicates that for a constant irregularity type and size, the maximum train body acceleration and the DAF increase as the train speed increases. When train enters the range of high-speed, both the force and the DAF increase and become much worse than in the lower range of train speed. Indeed, the higher the train speed is, the larger the vibration experienced.

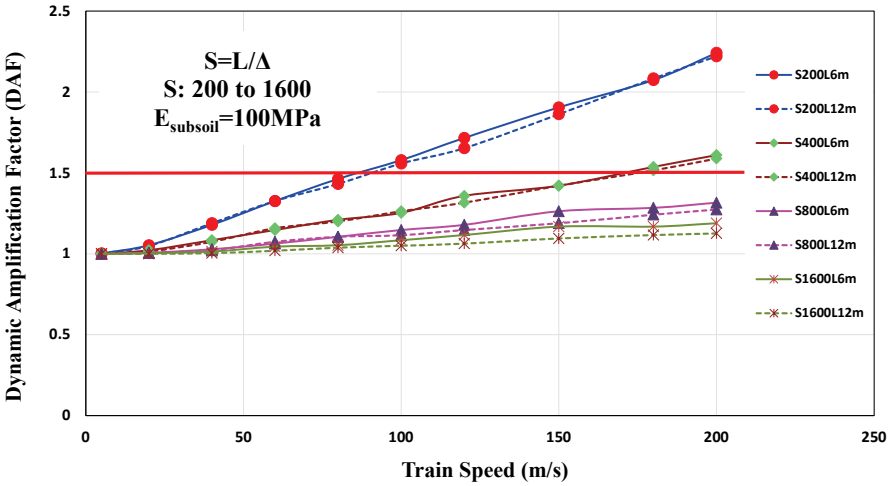


Figure 2: Effect of train speed, bump size and bump length on DAF

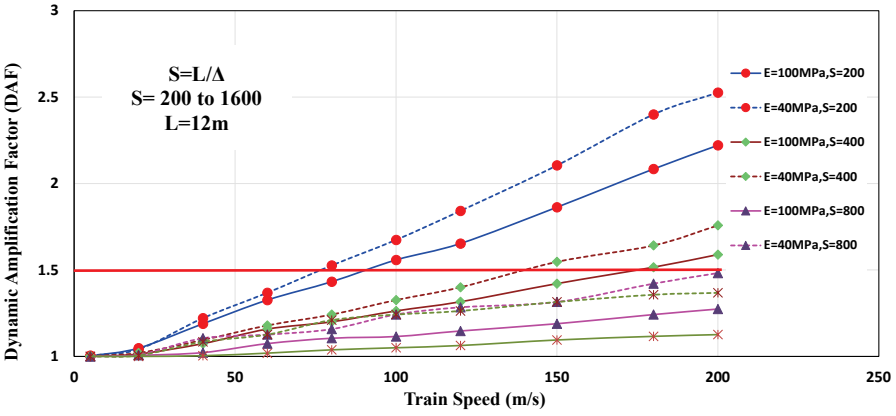


Figure 3: Effect of Soil Young Modulus on DAF

As an additional parameter, the modulus of the soil under the compacted embankment was varied within a reasonable range

	during the parametric study. The results show that the DAF decreases as the modulus increases (Figure 3). The reason is postulated as follows. If the soil is more compressible, the settlement of the track in the embankment zone is larger and thus a bigger "bump" is created when the train transitions onto the bridge.
Impacts/Benefits of Implementation (actual, not anticipated)	The work performed for this project contributed significantly to a doctoral dissertation titled: ▪ Tafti, S. R., "High Speed Train Geotechnics: Numerical and Experimental Simulation of Some Embankment Problems," Doctoral Dissertation, Zachry Department of Civil Engineering, Texas A&M University, December 2017.
Web Links • Reports • Project Website	http://www.utrgv.edu/railwaysafety/research/infrastructure/bumps-in-high-speed-rails/index.htm

Exhibit F - UTCRS

UTC Project Information	
Project Title	Dynamic Live Load Effects of Railroads on Retaining Walls and Temporary Shoring
University	Texas A&M University (TAMU)
Principal Investigator	Charles Aubeny, Ph.D., Civil Engineering (PI) Gary Fry, Ph.D., P.E., Civil Engineering (Co-PI)
PI Contact Information	808P CEOB College Station, TX 77843-3135 (979) 845-4478 caubeny@civil.tamu.edu 3135 TAMU College Station, TX 77843-3135 Office (979) 862-1339 garyfry@tamu.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	Federal Funds (USDOT UTC Program): $75,000
Total Project Cost	$75,000
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	May 2016 – December 2017
Brief Description of Research Project	Analysis of causes of major train derailment and their effect on accident rates shows that the second major reason of train derailment is change of track geometry. Shored excavations near railway alignments can introduce significant potential for changes in the track geometry; thus, a thorough understanding of the mechanisms of wall and soil mass movements is essential to limiting changes of track geometry to acceptable levels, thereby making a significant contribution to railroad safety. Recently, an instrumented test wall site comprising a sheet pile wall segment and a soldier pile/timber lagging wall segment was installed adjacent to a UPRR

	site in south College Station, Texas. This project is designed to measure both instantaneous and long-term permanent displacements and strains in the wall. Additionally, periodic surveys will be performed to measure changes in track geometry, and correlate these measurements to wall movements. High quality measurements from this test site can be used to validate numerical models of wall response. Such numerical models provide a means for extrapolating the findings from the test site to other soil types, wall types and wall geometries. An instrumented test wall adjacent to an active railway is a very unique asset, so this test site presents a rare opportunity to improve the current level of understanding of wall systems subjected to repeated live railroad loads.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/infrastructure/dynamic-live-load-effects-of-railroads-on-retaining-walls/index.htm

Exhibit F - UTCRS

UTC Project Information	
Project Title	Strength and Fracture Toughness of Railroad Eyebar Members
University	Texas A&M University (TAMU)
Principal Investigator	Peter Keating, Ph.D., Civil Engineering (PI)
PI Contact Information	709C CEOB College Station, TX 77843-3135 (979) 845-9969 keating@civil.tamu.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	Federal Funds (USDOT UTC Program): $25,000
Total Project Cost	$25,000
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	May 2016 – December 2017
Brief Description of Research Project	The decommissioning of two truss railroad bridges has presented an opportunity to better understand and document the strength and fracture toughness of eyebar members. The eyebar members from these bridges have been in service for over one hundred years. A companion research project will fatigue test approximately half the available eyebars, the remaining eyebars are available for further study. The strength of the eyebars (both yield and tensile) will be determined through small-scale tensile tests. Fracture toughness will be evaluated using CVN specimens. Both the main body of the eyebar as well as the eyebar heads will be investigated. Additionally, the effects of heat-shortening on the mechanical properties of eyebars will be investigated.

Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/infrastructure/fracture-of-eyebar-members/index.htm

UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

Exhibit F - UTCRS

UTC Project Information	
Project Title	A Mechanistic Investigation of Concrete Tie Degradation in the Rail Seat
University	Texas A&M University (TAMU)
Principal Investigator	Zachary Grasley, Ph.D., Civil Engineering (PI)
PI Contact Information	503B CEOB College Station, TX 77843-3135 (979) 353-1324 zgrasley@civil.tamu.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	Federal Funds (USDOT UTC Program): $75,000
Total Project Cost	$75,000
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	May 2016 – December 2017
Brief Description of Research Project	Concrete rail ties often degrade prematurely at the rail seat. Such deterioration has been investigated by other researchers, but such studies have generally associated deterioration with a single environmental or mechanical source. In contrast, it is hypothesized here that rail seat degradation is due to a complex coupling of environmental and mechanical sources. Based on this unique perspective, the proposed research is aimed at developing an advanced poroelastic model and a novel, lab-scale model rail seat experiment in order to elucidate the role of enviro-mechanical coupling. Furthermore, based on the model predictions – validated by the experiments – new concrete mixture design and curing protocols that reduce the risk of damage to the rail seat will be crafted.

Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/infrastructure/investigation-concrete-tie-degradation/index.htm

UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

Exhibit F - UTCRS

UTC Project Information	
Project Title	Fatigue and Service Analysis of Railroad Eyebar Members
University	Texas A&M University (TAMU)
Principal Investigator	Peter Keating, Ph.D., Civil Engineering (PI)
PI Contact Information	709C CEOB College Station, TX 77843-3135 (979) 845-9969 keating@civil.tamu.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	Federal Funds (USDOT UTC Program): $70,000
Total Project Cost	$70,000
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	May 2016 – December 2017
Brief Description of Research Project	Insufficient knowledge of the fatigue behavior of railroad eyebars exists. As rail traffic increases with respect to both number of cars and their weights, the probability of fatigue damage and significant fatigue crack propagation increases. The proposed research will investigate the fatigue behavior of railroad eyebars through full-scale laboratory fatigue testing. The results of the research will provide a more accurate estimation of the fatigue strength of railroad eyebars and a better prediction of their remaining fatigue lives.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.

Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/infrastructure/service-analysis-of-eyebar-members/index.htm

UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

Exhibit F - UTCRS

UTC Project Information	
Project Title	Method for Predicting Thermal Buckling in Rails
University	Texas A&M University (TAMU)
Principal Investigator	David Allen, Ph.D., Civil Engineering (PI) Gary Fry, Ph.D., P.E., Civil Engineering (Co-PI)
PI Contact Information	3135 TAMU College Station, TX 77843-3135 Office (979)862-2531 d-allen@tti.tamu.edu Office (979) 862-1339 garyfry@tamu.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	Federal Funds (USDOT UTC Program): $150,000
Total Project Cost	$150,000
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	May 2016 – December 2017
Brief Description of Research Project	A method is proposed herein for predicting the onset of thermal buckling in rails in such a way as to provide a means of avoiding this type of potentially devastating failure. The method consists of the development of a thermomechanical model of rail buckling, together with the construction of an on-the-fly experimental apparatus that is capable of concomitantly foretelling the onset of thermally induced rail buckling. As such, the combination of these two components is intended to provide a tool that can be employed as a means of determining when intervention is necessary in order to ensure that rails will not fail due to thermal buckling.

Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/infrastructure/thermal-buckling-in-rails/index.htm

Exhibit F - UTCRS

UTC Project Information	
Project Title	Multi-Scale Fatigue Damage Life Assessment of Railroad Wheels
University	Texas A&M University (TAMU)
Principal Investigator	Gary Fry, Ph.D., P.E., Civil Engineering (PI)
PI Contact Information	3135 TAMU College Station, TX 77843-3135 Office (979) 862-1339 garyfry@tamu.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	Federal Funds (USDOT UTC Program): $75,000
Total Project Cost	$75,000
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	May 2016 – December 2017
Brief Description of Research Project	This study will focus on the presence of a crack in the railway wheel's subsurface and how it affects the wheel's fatigue life. A 3-D FE-models will be constructed to simulate the stress/strain fields that take place under the rolling contact of railway wheels on rails. To achieve computational efficiency and accuracy a sub-modeling technique will be employed. Different locations of the crack from the wheel surface will be considered to detect the influence of a crack/defect on stress distribution of wheel/rail contact, as well as to possibly investigate the crack propagation rate and direction as a function of the crack's distance to the wheel thread. Moreover, by changing the crack plane angle in each specific increment of loading, it may be possible to observe mixed mode crack growth behavior based on the crack's orientation with respect to the wheel's surface. The outcome of this work gives valuable insights into fatigue induced cracking in railroad wheels in order to have a better understanding of the root causes of failures such as both shattered rims and vertical

	split rims (VSR) as a means of reducing the probability of derailment.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/infrastructure/wheel-fatigue-damage-life-assessment/index.htm

UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

Exhibit F - UTCRS

UTC Project Information	
Project Title	Railyard Worker Safety through Innovative Mobile Active Train Detection and Risk Localization
University	University of Nebraska-Lincoln
Principal Investigator	Dr. Hamid Sharif, Ph.D., Telecommunication and Computer Engineering (PI) Dr. Michael Hempel, Ph.D., Research Assistant Professor (Co-PI)
PI Contact Information	PKI 200C Omaha/PKI Lincoln, NE 68583-0851 Office (402) 554-3628 hsharif@unl.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	UTCRS (US DOT UTC Program): $109, 952 Union Pacific Railroad: $100,000 Advanced TEL Lab: $77,465
Total Project Cost	$287,417
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	July 2016 – June 2018
Brief Description of Research Project	Our team proposes to research a lightweight, energy efficient, Wireless Body Area Network-based solution for automated threat detection, localization, and alerting. This solution will not require yard equipment installation and integrates with any existing infrastructure. For this solution we propose to research a variety of different detection approaches, such as passive acoustic localization using microphone arrays for precise distance and direction determination, 360degree point-of-view (POV) camera systems and active image processing to visually detect trains, active echo

	localization for moving obstacle detection, and RF & EM detection to detect interference from the locomotive itself. Processing of sensor information will be performed collaboratively amongst the WBAN sensors worn by each worker, and results reported wirelessly to yard infrastructure and operators. We will research detection and threat classification algorithms using approaches such as Decision Trees, Bayesian Networks, Gaussian Mixture Models, Hidden Markov Models, and Hierarchical Clustering. We will research localization methods using signal strength information, GPS, or other approaches. The system will also be able to detect and report worker accidents that may prevent a worker from vacating a danger zone and alert surrounding workers to the situation.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Competition.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Competition.
Web Links • Reports • Project website	http://www.utrgv.edu/railwaysafety/research/operations/railyard-worker-safety-mobile-active-train-detection/index.htm

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Exhibit F - UTCRS

UTC Project Information	
Project Title	Highway-Rail Crossing Safety Improvement by Diverting Motorists to Alternate Routes
University	University of Nebraska-Lincoln
Principal Investigator	Dr. Aemal Khattak
PI Contact Information	262D Whittier Research Center Lincoln, NE 68583-0851 Office (402) 472-8126 akhattak2@unl.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	UTCRS (US DOT): $99,996 NE Department of Roads: $49,998
Total Project Cost	$149,994
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	July 2016 – June 2018
Brief Description of Research Project	The research will develop a system that detects the presence of a train in proximity of a crossing, estimate its length and speed and then calculate the expected crossing occupancy time of the train. This information is then shared with motorists upstream of the crossing via variable message signs. Some drivers may divert to alternate routes to avoid delay at the crossing, thereby resulting in fewer motor vehicles when a train the crossing. The system will be field-tested at an appropriate location in Lincoln, Nebraska. Motorists will be recorded via video for diversion before and after implementation of the system. Based on the field test results guidelines will be developed for improving safety at highway-rail crossings by diverting motor vehicle traffic away from the crossing when trains are on their way toward or occupying a crossing.

Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Competition.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Competition.
Web Links • Reports • Project website	http://www.utrgv.edu/railwaysafety/research/operations/highway-rail-crossing-safety-diverting-motorists/index.htm

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Exhibit F - UTCRS

UTC Project Information	
Project Title	Anti-Icing LED Light Covers for Railroad Safety
University	University of Nebraska-Lincoln (UNL)
Principal Investigator	Dennis Alexander, Ph.D., Kingery Engineering (PI) Craig Zuhlke, Ph.D., Electrical & Computer Engineering (Co-PI)
PI Contact Information	202N SEC Lincoln: City Campus (402) 472-3091 dalexander1@unl.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	UTCRS (USDOT UTC Program): $72,250 NE Department of Roads: $36,125
Total Project Cost	$108,375
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	October 2016 – June 2018
Brief Description of Research Project	There is a growing trend to use highly efficient light emitting diode (LED) lights on railroad signals. Although LEDs would save energy, there is the issue of snow and ice build-up on the signals which prevents them from being seen from the streets or railroad tracks. This makes the traffic control signal unreadable and represents a tremendous safety issue for train operators and the public. The build-up of ice results from the LED's low thermal output which prevents ice and snow on the lens cover from melting. The objective of this proposal is to functionalize the plastic lenses that cover railroad transportation signals to make them anti-icing. The PI proposes to perform research on using femtosecond laser surface processing (FLSP) to produce antiwetting surfaces on hard materials, such as tungsten carbide (WC), which will be used as a very hard and durable stamp to then imprint a superhydrophobic (anti-icing) surface on the

	lens of a traffic signal. Task 1 will be to functionalize very hard materials, such as WC, to produce a durable and long-lasting surface. The FLSP process will only alter the top 50-100 microns (a human hair is 100 microns) of the WC surface. Therefore, a large amount of time will be spent investigating the best FLSP surface to act as the stamp. Task 2 will be to use FLSP-functionalized hard materials as a stamp and transfer micron/nanoscale features to the plastic traffic signal material. The first year of research will be conducted on flat plastic samples. Plastic samples containing the imprinted structures will be analyzed for anti-icing properties using procedures and equipment currently used to study anti-icing of 7075 aircraft aluminum for Boeing. In Task 3, drop wettability and anti-icing studies will be conducted on surfaces that have the best superhydrophobic properties.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Reports • Project webs	http://www.utrgv.edu/railwaysafety/research/operations/anti-icing-led-light-covers-for-railroad-safety/index.htm

UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

Exhibit F - UTCRS

UTC Project Information	
Project Title	Heavy Truck and Bus Traversability at Highway-Rail Grade Crossings
University	University of Nebraska-Lincoln (UNL)
Principal Investigator	Jennifer Schmidt, Ph.D., P.E., Civil Engineering (PI) Cody Stolle, Ph.D., Mechanical and Materials Engineering (Co-PI) Ronald Faller, Ph.D., Civil Engineering (Co-PI) Mojdeh Asadollahipajouh, PhD., MwRSF (Co-PI)
PI Contact Information	WHIT 130J Lincoln: City Campus Office (402) 472-0870 jennifer.schmidt@unl.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	UTCRS (US DOT UTC Program): $100,000 NE Department of Roads: $50,000
Total Project Cost	$150,000
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	October 2016 – June 2018
Brief Description of Research Project	A research study is proposed to provide recommendations for traversable railway crossing cross-sections for heavy trucks and buses. Heavy trucks and buses have long wheel bases and low ground clearance that make it difficult to traverse at-grade rail crossings with sloped sides. An investigation of existing railway crossing cross-sections and heavy vehicle dimensions and suspension properties will be conducted. TruckSim will be utilized to study heavy vehicles traversing various cross-sections and to provide acceptable cross-sections at railway crossings. Improving the traversability of heavy trucks over at-grade rail crossings will reduce the time vehicles are on the railway and reduce the potential for trains to collide with heavy

	trucks.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Reports • Project webs	http://www.utrgv.edu/railwaysafety/research/operations/heavy-truck-traversability-at-hrgc/index.htm

UNIVERSITY TRANSPORTATION CENTER FOR RAILWAY SAFETY

Exhibit F - UTCRS

UTC Project Information	
Project Title	Improving Crash Prediction – A More Relevant Exposure Measure than AADT for Highway-Rail Crossing Safety and Safety Models
University	University of Nebraska-Lincoln (UNL)
Principal Investigator	Aemal Khattak, Ph.D., Civil Engineering (PI)
PI Contact Information	262D Whittier Research Center Lincoln, NE 68583-0851 Office (402) 472-8126 akhattak2@unl.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	UTCRS (US DOT UTC Program): $93,028 NE Department of Roads: $93,028
Total Project Cost	$186,056
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	January 2017 – June 2018
Brief Description of Research Project	The objective of this research is to improve Highway-Rail Grade Crossing (HRGC) crash prediction by developing a more relevant crash exposure term in place of AADT for use in HRGC safety models. HRGC safety models have been around in the United States since at least 1940s (e.g., Peabody-Dimmick Formula). Safety models are used for HRGC crash predictions and the results often used for allocation of safety resources ($) amongst HRGCs. A staple of these models is the annual average daily traffic (AADT), which is a measure of yearly motor vehicle roadway usage and serves as a crash exposure term in safety models. Crash exposure accounts for the state of being subjected to the likelihood of a crash; higher exposure implies higher likelihood of crashes. A more relevant measure of exposure at HRGCs is to consider only

	the portion of AADT that encounters train traffic, called (AADT)Encounter_Train in this research. This is theoretically more suitable because the exposure of motorists to train-involved crashes in the absence of trains is zero and consideration of the non-relevant portion of AADT (i.e., vehicular traffic at the HRGC when no trains are present) in safety models masks the true picture. This research will undertake the following: • Develop a taxonomy of different Nebraska HRGCs based on criteria such as presence of gates, flashing lights, number of crossing tracks, etc. • For each group of HRGCs, estimate (AADT)Encounter_Train as well as estimate the roadway AADT. • Establish a relationship between (AADT)Encounter_Train and AADT for each group of HRGCs. • Test the validity of using (AADT)Encounter_Train in place of AADT in HRGC safety models and assess differences in crash predictions using (AADT)Encounter_Train and AADT. This research is expected to improve the quality of crash predictions at HRGCs thereby improving public safety and aiding more informed resource allocation for HRGC safety improvements.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/operations/improving-crash-predictions-at-hrgc/index.htm

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Exhibit F - UTCRS

UTC Project Information	
Project Title	Best Practices for Modeling Light Rail at Intersections
University	University of Nebraska-Lincoln (UNL)
Principal Investigator	John Sangster, Ph.D., P.E., PTOE, Civil Engineering (PI)
PI Contact Information	330F WHIT Lincoln: City Campus Office (402) 472-0314 john.sangster@unl.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	UTCRS (US DOT UTC Program): $72,250 NE Department of Roads: $36,125
Total Project Cost	$108,375
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	October 2016 – June 2018
Brief Description of Research Project	The peak demand on urban light rail facilities coincides with the peak for motorized vehicles and pedestrian traffic, maximizing the potential for conflict between the various modes. If signal timing plans are not properly coordinated between light rail and the motorized vehicles, excessive queuing and delays may occur. High levels of congestion have been linked to aggressive driving behaviors, increasing the likelihood of signal violations by drivers and negative safety outcomes for the light rail facility. This research proposes to provide guidelines for best practices in modeling urban light rail facilities within transportation simulation software packages, improving the understanding of engineers and planners considering light rail facilities, and increasing the safety of those facilities with best-possible signal operations. Two case study locations are proposed, including the square city block defined by Stout St, California St, 18th St, and 19th St in

	Denver, Colorado, and the corridor along Main St between South Temple and 100 South in Salt Lake City, Utah. On-site video data will be collected and used for validation of simulated facilities within three simulation environments, including VISSIM, Aimsun, and Paramics traffic simulation software. Of particular concern are: modeling the scheduled behavior of the light-rail facility; interactions between the light-rail, motor vehicles, and pedestrians; signal preemption by the rail; and optimization of the actuated signal systems to minimize motor vehicle delay while prioritizing light-rail movements. In addition to the project report outlining best practices for modeling this type of facility, extension components of the research are proposed to present these findings at national conferences, and develop tutorial walkthroughs for inclusion on a file sharing site such as YouTube.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/operations/modeling-light-rail-intersections/index.htm

Exhibit F - UTCRS

UTC Project Information	
Project Title	Unifying Railcar Monitoring Sensor Data, Maintenance Records, and Railcar Usage Information through Big Data Processing for Optimizing Railcar Maintenance and Safety
University	University of Nebraska-Lincoln (UNL)
Principal Investigator	Hamid Sharif, Ph.D., Electrical and Computer Engineering (PI) Michael Hempel, Ph.D., Electrical and Computer Engineering (Co-PI)
PI Contact Information	PKI 200C Omaha/PKI Office (402) 554-3628 hsharif@unl.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	UTCRS (US DOT UTC Program): $139,931 NE Department of Roads: $122,000
Total Project Cost	$261,931
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	October 2016 – March 2018
Brief Description of Research Project	This proposed research effort addresses a timely and urgent need in transportation safety: preventing costly and devastating derailments through optimized equipment maintenance using Big Data Analytics. Safety continues to be of primary concern within the North American railroad industry, highlighted by efforts in freight train Wireless Sensor Network monitoring and Positive Train Control (PTC). Despite these efforts, statistics by the Federal Railroad Administration (FRA) Office of Safety Analysis [1] show that from 2010 through 2015 over 1000 derailments occurred directly linked to rolling stock equipment failure, causing over $240 million in losses.

	Current methods for equipment maintenance rely on fixed schedules, which either are too frequent and result in unnecessary operational expenses, or are not frequent enough and result in high equipment failure rates. Despite producing detailed records for all maintenance efforts, incidents, etc., this data remains largely unutilized in the optimization of operational processes such as maintenance scheduling, supplier quality ranking, parts optimization based on past component failures, etc. Optimization such as this is made possible through Big Data Analytics. However, the particular nature of the railroad application, combined with the myriad different report formats poses significant challenges to current data analytics approaches. Our team proposes to address the various research challenges that currently prevent Big Data Analytics, including data acquisition from handwritten records or incomplete reports, data normalization for proper significance assignment, forecasting of component failures and for optimized maintenance scheduling, multi-variate hyperdimensional clustering for trend and causality analyses to analyze supplier reliability, the impact of cargo types and routes travelled on failure probabilities, and so much more. We will research all required methodologies and demonstrate Big Data Analytics' capabilities using synthetic or real-world data provided by Union Pacific. We believe that this approach is vital in further enhancing railroad operational safety and prevent derailments and the resulting significant monetary and environmental damages.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Link • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/operations/unifying-railcar-monitoring-system/index.htm

Exhibit F - UTCRS

UTC Project Information	
Project Title	Shipments of Oil By Rail: Economic Implications for Safety and Safety-Related Investments
University	University of Nebraska-Lincoln (UNL)
Principal Investigator	Eric Thompson, Associate Professor of Economics (PI) Aemal Khattal, Ph.D., Civil Engineering (Co-PI)
PI Contact Information	CBA 347 Lincoln NE 68588-0406 Office (402) 472-3318 ethompson2@unl.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	UTCRS (US DOT UTC Program): $71,645 NE Department of Roads: $76,009
Total Project Cost	$147,654
Agency ID or Contract Number	DTRT13-G-UTC59
Start and End Dates	January 2017 – December 2017
Brief Description of Research Project	Fracking technology has allowed for a significant expansion of oil production in regions with limited past production and oil pipeline capacity, such as the Bakken formation centered in North Dakota. The result has been significant growth in shipments of oil, a flammable substance, by rail. The growth in shipments has implications for both the number and severity of rail accidents and for the economic feasibility of safety investments both at and away from at-grade rail crossings. The proposed research would conduct four tasks, using the example of the Bakken formation. Task 1 would be a forecast for the projected increase in oil by rail shipments in the impacted region through 2040, based on oil production projections from the Energy Information Administration. A baseline scenario will be developed assuming no expansion of oil pipeline capacity in the

	region and an alternative scenario(s) would be developed based on the development of proposed or probable regional pipeline projects. Task 2 would be an evaluation changes in the number and severity of rail accidents as a result of increased shipping of oil by rail. Based on existing data on rail capacity, usage and the number of accidents, the research team would develop an estimate of the marginal increase in the number of accidents resulting from existing and projected increases in oil by rail shipment. Task 3 would estimate the increase in accident costs due to the marginal expansion in the number and severity of accidents. Task 4 would examine the resulting increase in the benefits from potential rail safety investments projects, with implications for relative project benefits and costs.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Pending Project Completion.
Impacts/Benefits of Implementation (actual, not anticipated)	Pending Project Completion.
Web Links • Report • Project Website	http://www.utrgv.edu/railwaysafety/research/operations/shipments-of-oil-by-rail/index.htm