



# The Innovative Engineer

“Innovative Engineering Against Hazards”

Vol. 5, No. 1

Spring 2011

## University Transportation Centers— Preparing for Tomorrow with Research Today

by Utah Transportation Center Director, Dr. Kevin C. Womack, Ph.D., P.E., F.ASCE

The past few months have seen UTC colleagues begin performing research under a \$1 million dollar grant to the UTC, part of a larger \$10 million Department of Energy grant to Utah State University, to investigate the algorithms and controls that would be necessary to advance toward a National Highway System that would be populated by automated vehicles. This is part of the Automated Electric Transportation system effort at Utah State University.

It is my view that we, as university transportation centers, must begin to be more forward-looking in our research. If the RITA-administered university transportation centers don't do the long-term, advanced research necessary to transform our existing transportation systems, then I do not believe it will be done.

In the past 100 years our roadway system has progressed from mud roads to what was once the pre-eminent system of freeways in the world. The vehicles that traveled the roads early in the last century produced only a few horsepower and were capable of traveling at very modest velocities. Today our vehicles are pinnacles of technology, running very efficiently and yet capable of producing significant power.

The research that is needed to produce the same magnitude of change in our surface transportation system over the next 100 years that occurred in the past 100 years, must begin now, and it must begin with the uni-

versity transportation centers, in cooperation with national laboratories and industry.

It is my hope that a new surface transportation authorization bill will have a research title that maintains a strong university transportation centers program; and that allows these cen-

ters to perform the high risk research that is necessary to transform our transportation system into one that will improve safety, and reduce the use of fossil fuels and the production of green house gases.



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# Live-Load Testing of the Lambert Road Bridge

by Dr. Paul J. Barr, Associate Professor, Civil & Environmental Engineering,  
Utah State University



The Long-Term Bridge Performance (LTBP) Program was initiated by the Federal Highway Administration (FHWA) to quantify, with high quality data, the long-term behavior of bridges. This program includes periodic testing and long-term monitoring of a representative sample of bridges across the United States. The Lambert Road Bridge near Sacramento, California was selected as one of seven pilot bridges for this program.

The Lambert Road Bridge is located near Elk Grove, California, which is 10 miles south of Sacramento. The bridge was designed as a two span, cast-in-place, prestressed, continuous box girder bridge. It was built in 1975 using an HS20-44 truck as the design live-load. The Lambert Road Bridge has an overall span length of 78.7 m (258 ft) comprised of two equal spans of 39.4 m (129 ft) at a 8° skew (see above). The width of the deck (including barrier railings) is 12.8 m (42 ft). The vehicle live-load is supported on a four cell configuration with girder spacing of 2.7 m (9 ft). The webs of the girders are 0.3 m (1 ft) thick and the exterior girders were constructed at a slope of 2 to 1.

Prior to performing the live-load test on the Lambert Road Bridge, 53 instruments were installed on the bridge. The instrumentation package included 42 uniaxial strain transducers, 10 vertical displacement sensors, and 1 uniaxial rotation sensor. These wireless sensors were part of a Bridge Diagnostic, Inc. data acquisition system. For the live-load test, two trucks were slowly driven along five different load paths. The load paths were selected to maximize the moment in different girders as well as calibrate typical lane traffic. In all, sixteen semi-static live-load tests were conducted by driving the trucks along the various load paths.

A finite-element model of the Lambert Road Bridge was developed using primarily eight nodal solid elements. To validate the finite-element model, the measured strains, displacements, and rotations from the live-load test were compared with those predicted by the finite-element model. Various load paths and truck combinations were considered. The recorded bridge response from the live-load test indicated that the end supports exhibited some partial fixity, which significantly differed from the assumed pin and roller supports. To model this apparent fixity, longitudinal and vertical springs were applied to the model at the abutment and pier nodes. Figure 2 (below) shows a comparison of the finite-element strain and the measured strain when the truck was driven along three load paths. A linear trendline was obtained that had a slope of 0.96 with a coefficient of correlation of 0.96. These values indicate that an excellent correlation existed between the strains calculated from the model and the measured values from the live-load test.

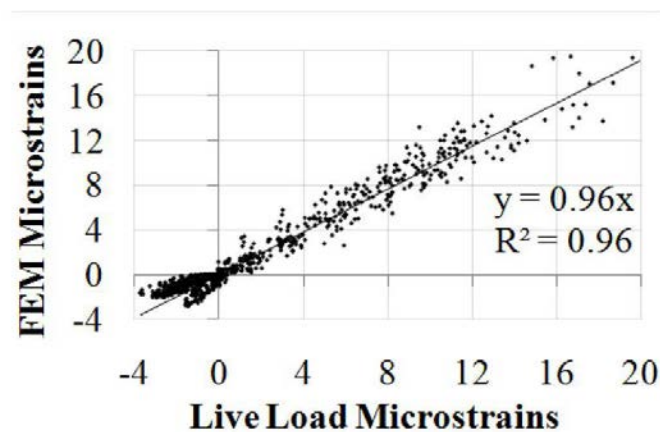


Figure 2 FEM vs live load strain relationship

The load rating of the Lambert Road Bridge was found based on distribution factors calculated using the

validated finite-element model. Both the inventory and operating ratings were determined. These rating factors were multiplied by the bending moment induced by an HS20-44 truck to obtain the maximum vehicle load that the bridge can safely carry. The calculation of both ratings was obtained using the following equation:  $RF = (R_n - \gamma_D D) / (\gamma_L L(1+I))$ . Where RF= bridge load rating (operating or inventory);  $R_n$ = nominal flexure capacity;  $\gamma_D$ = dead load factor (1.3);  $\gamma_L$ = live-load factor (1.3 for operating, 2.17 for inventory);  $D$ = nominal dead load effect (composite and non-composite dead load);  $L$ = nominal live-load effect (caused by a HS20-44 truck);  $I$ = live-load impact factor (33%).

The inventory and operating ratings for the Lambert Road Bridge are listed in Table 1 (right). The inventory and operating ratings were 1.53 and 2.55 when

the FEM distribution factor was used and 1.18 and 1.97 when the AASHTO LRFD distribution factor was used. The live-load distribution factors obtained from the finite-element model substantially increased both load ratings by 29% compared to those obtained using the AASHTO LRFD Specifications. This finding is a result of the AASHTO LRFD Specifications distribution factor being overly conservative.

Table 1. Inventory & Operating Ratings  
Load Ratings

	Inventory	Operating
FEM	1.53	2.55
AASHTO	1.18	1.97

Find more at <http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/structures/ltbp/>

## Dr. Patricia Cramer Recognized for Work on Wildlife Roadway Interactions

Recently, one of our own Center colleagues, USU Research Assistant Professor Dr. Patty Cramer was honored by the Denver Zoo with its 2010 Conservation Award. She formally received the award and its accompanying \$5,000 prize in an October 14, 2010 ceremony.

According to the announcement on the Denver Zoo website [<http://www.denverzoo.org/conservation/award.asp>], "Dr. Cramer...has advanced the scientific study of wildlife crossing structures and advocates for landscape connectivity in North America. Wildlife crossings are essential for establishing wildlife corridors between areas of fragmented habitat. For years, Denver Zoo has led and supported conservation projects focused on landscape connectivity; much of this work has been possible through the efforts of scientists like Dr. Cramer."



Dr. Cramer's work was also honored when she received an award for her work as part of a multi-agency committee that worked to plan the upgrades to Utah's US 6 along with wildlife mitigation. The committee won a Federal Highways Exemplary Ecosystem Initiative Award for 2010. Ed Woolford of FHWA gave the representatives of the groups plaques at a February US 6 Wildlife Coordination Committee meeting.

The award was given for "outstanding commitment to environmental stewardship for developing an early partnership to ensure wildlife and wildlife habitat mitigation during a long-term improvement project along US 6 in Utah."

There were 77 applicants for the seven awards given. You can learn more about the award at [<http://www.environment.fhwa.dot.gov/strmlng/newsletters/dec10nl.asp>]. Project details can be found at [<http://www.environment.fhwa.dot.gov/ecosystems/eei/ut10.asp>].

# Faces of the Utah Transportation Center

There are many faces that make up the Utah Transportation Center at Utah State University. These include faculty colleagues, members of our on-campus staff, advisory board members, and graduate and undergraduate students. In this issue we are pleased to introduce a few of them.

## Jim McMinimee, P.E., Center Advisory Board Member, AASHTO Implementation Manager for SHRP

Jim McMinimee has been a member of the Center advisory board for nearly five years. He began that role while working for the Utah Department of Transportation Center (UDOT) and has continued to serve after his retirement from UDOT and now with his work as AASHTO's implementation manager for the second Strategic Highway Research Program (SHRP).



As a member of the board, Mr. McMinimee lends his years of experience in the transportation arena to guiding the work the Center undertakes. That experience includes 25 years working for UDOT, most recently as chief engineer and director of project development. Throughout his career with UDOT, he served in progressive leadership roles in maintenance, operations, and project development. This gives him insight into the problems and concerns state DOTs face. Jim led the successful implementation of many initiatives for UDOT in such diverse subject areas as performance management, innovative contracting, partnering, maintenance management, traffic operations, design, software development, Olympic operations, and project management. He also helped UDOT pioneer the use of construction manager general contracting on highway projects, and oversaw the technical expertise and process for several methods of accelerating program delivery.

After leaving UDOT, Mr. McMinimee worked for

a year with Applied Research Associates (ARA), a national transportation research firm. He worked with ARA on FHWA's Highways for Life Program, and most recently on FHWA's "Every Day Counts" initiative.

Throughout his career he has been active within AASHTO as a member of the Technology Implementation Group and the Subcommittee on Design, participating in the development of the Standing Committee on Highways strategic plan, and co-chairing AASHTO's first domestic scan.

Mr. McMinimee holds a Bachelor of Science degree in civil engineering from the University of Utah, conducted master's work at Utah State University, and is a registered professional structural engineer in Utah.

When asked about his service on the board, Mr. McMinimee said, "I've enjoyed my time with the board helping translate what is done in the transportation industry into research that fulfills degree needs, and that also fulfills transportation industry needs. I've noticed that the staff at Utah State University are very dedicated and energetic in helping students. I've seen the time that they put in and the nature of their interactions, and have come to believe that Utah State University offers a great engineering education."

Further, he said, "One of the things that I enjoy most about being a member of the board is it allows me to visit the campus. I enjoy the energy and the atmosphere of the campus and it takes me back to exciting days, and a great learning experience at USU! I have enjoyed my time on the board and relish the opportunity to give back to the transportation community." We appreciate Mr. McMinimee's willingness to share his expertise and serve on the Center's advisory board.

## Ben Fore, Systems Administrator

The Utah Transportation Center is pleased to introduce our Systems Administrator, Mr. Ben Fore. Ben serves a dual role for both the Utah Transportation Center and the Utah LTAP Center.

Ben brings a wealth of expertise to his role including more than 14 years of experience in this field, along with his formal training. He graduated from USU in

2002 with a Bachelor of Science degree in Computer Science, after receiving his Associate degree from Snow College in 1998 (graduating Suma Cum Laude). For the last 7 years he has worked as a Systems Administrator for a variety of departments and organizations at Utah State University.



His work for both Centers includes system administration, IT support, web development, and software development. When asked about his work he said, "I work with a great group of people. [While] this position also has plenty of challenges, [it also has] chances for learning and lets me apply technology toward [Center] goals." We're glad to have Ben as part of the team!

## Tomás E. Lindheimer, Student of the Year

Tomás Lindheimer was born and raised in Buenos Aires, Argentina until he immigrated to Sandy, Utah when he was 13 years old. Tomás attended a private English school, St. Peter's, with the goal of attending an American university.

While still in high school, he decided to pursue an engineering career, and chose to attend Utah State Uni-

versity because of its reputation. Tomás attended USU for one year, and then lived in Bulgaria for two years. After his time in Bulgaria, Tomás was tempted to pursue a career in linguistics. However, he still pursued a degree in engineering because it was a challenging and interesting field.

After his a year in the Mechanical Engineering program, Tomás matriculated into the Civil Engineering program. In the summer following his entrance to the civil engineering program he took an internship with the Utah Department of Transportation (UDOT). The internship with UDOT and Dr. Heaslip's Introduction to Engineering course piqued his interest in the field of transportation. Upon completion of his bachelors' degree, he pursued a Master's in Transportation studying design and safety considerations in highway work zones. His thesis is titled, "Evaluation of Work Zone Practices in Utah."



Tomás was chosen to represent the Utah Transportation Center as our Student of the Year for 2011. Congratulations Tomás!

# USU Students Participate in TRB

Many current and former USU students were able to take part in TRB meetings this winter in Washington DC. Some of these included the following:

- Mr. Matthew Manley (PhD student from Department of Management Information Systems, USU)—He presented a paper entitled "Modeling emergency evacuation of individuals with disabilities in a densely populated airport" co-written with Y.S. Kim, K. Christensen and Dr. Anthony Chen. This work was supported by a grant from the Airport Cooperative Research Program #A11-04 through the Transportation Research Board of the National Academies.
- Mr. Xiangdong Xu (visiting PhD student from Southeast University, Nanjing, China)—He presented two papers with Dr. Anthony Chen includ-

- ing: "Assessing the effects of stochastic perception error in the stochastic mean-excess traffic equilibrium model," and "Solving stochastic multi-objective network design problem: A goal programming approach."
- Dr. Zhong Zhou (former USU student, currently senior software developer at Citilabs, Florida, USA)—He presented a paper entitled, "Finding alpha reliable mean-excess path in stochastic networks," with Dr. Anthony Chen.
- Dr. Chao Yang (former USU postdoc, currently associate professor at Tongji University, Shanghai, China)—Dr. Yang presented a paper entitled, "Sensitivity-based uncertainty analysis of a combined travel demand model," co-authored with Dr. Anthony Chen.

# Center Director Travels to APTA Meeting

On February 17, 2011 Dr. Womack, UTC Director, attended the American Public Transit Association (APTA) Research and Technology Committee meeting, held in Dallas at the Dallas Area Rapid Transit headquarters.

Dr. Womack was invited to attend this meeting by committee chair Jonathan McDonald of HNTB Corporation to present to the committee the transit research activities being conducted by the Utah Transportation Center. Research projects covered by Dr. Womack were the placement of Wi-Fi on the FrontRunner commuter rail, the combined I-15 corridor pricing project which is examining the potential for real time fare shifts between the I-15 HOT lane and the FrontRunner, and the lidar-based automated passenger counting which included a film clip of a test of the technology.

The project that generated the most discussion was the automated passenger counting technology. This lidar camera technology is capable of identifying and counting, in a pixel format, individual passengers as they enter a bus and then again as they disembark from the bus. This type of rider information that goes beyond just the number of passengers but also notes the places where a passenger enters and leaves a bus will be of major value to transit agencies as they more efficiently plan their routes.

A prototype of the automated passenger counting camera has been made, and further trials are planned for this fall, with the anticipation of a national demonstration in the spring of 2012.

## Center Projects in Progress

- UTC0803 “ABC Deck Connections, Laboratory Testing and Evaluation,” Dr. Marvin Halling, PI. Co-funded by UDOT and UTC.
- UTC1001 “Work Zone Design Evaluation,” Dr. Kevin Heaslip, PI. Co-funded by UDOT and UTC.
- UTC1002 “Forecasting Network Traffic for Small Communities in Utah,” Dr. Anthony Chen, PI. Funded by UTC.
- UTC1003 “Highway Wildlife Crossing Design Study,” Dr. Patricia Cramer, PI. Funded by UTC.
- UTC1004 “Investigation of the Use of Texel Cameras for Counting Passengers on Public Transportation, Phase II,” Dr. Scott Budge, PI. Funded by UTC.
- UTC1101 “Parametric Study of the Effects of Seismic Strength Degradation of Fine Grained Soils Beneath Highway Embankments and Bridge Abutments,” Dr. James Bay, PI. Funded by UTC.
- UTC 1102 “Integrated Corridor Pricing Structure Modeling and Evaluation,” Dr. Kevin Heaslip, PI. Funded by UTC.
- UTC 1103 “Surveying the Transportation Needs of Low Mobility Individuals in Cache Valley,” Dr. Anthony Chen, PI. Funded by UTC.
- UTC 1104 “Transportation Network Resiliency Framework Development,” Dr. Kevin Heaslip, PI. Funded by UTC.

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