

UTAH TRANSPORTATION CENTER 2008-09 ANNUAL REPORT



“INNOVATIVE ENGINEERING AGAINST HAZARDS”



UtahState
University



ABOUT THE UTAH TRANSPORTATION CENTER

The theme for the Utah Transportation Center (UTC) is “Innovative Engineering Against Hazards” and comes from the core expertise of the initial group of colleagues associated with the Center. For the past decade the transportation research expertise within the Department of Civil and Environmental Engineering (CEE) at Utah State University has been in areas addressing natural hazards: earthquakes, landslides, and flooding. It was decided to mold the Center around this expertise and then reach out to other colleagues to provide expertise that can be applied to both hazards and other areas of transportation--congestion and transit being two prime examples.

This approach has been very successful during the first three years of the Center. In particular, the association of colleagues in Utah State University’s Department of Electrical and Computer Engineering (ECE) and the College of Natural Resources has expanded the Center’s ability to look at transportation issues from a wide variety of perspectives. We anticipate continued expansion of those cross-discipline partnering efforts in the future.

The *educational activities* of the Center continue to be centered primarily around instruction by CEE faculty associated with the Center. These faculty teach an array of transportation-related courses in many disciplines of civil engineering: surveying, structures, hydraulics, operations, transportation design, planning, and engineering economics. Center *research activities* continue to focus on “engineering against hazards,” and have also expanded to include transit and even wildlife transportation corridor users. The Center’s principal research partner continues to be the Utah Department of Transportation (UDOT) and has grown to include the Utah Transit Authority (UTA). Our partnership with the Federal Highway Administration (FHWA) has continued as work on the Long Term Bridge Performance (LTBP) Program moves forward into the pilot phase. Work with local agencies has also expanded with our consolidation of the Utah Local Technical Assistance Program (LTAP) under the auspices of the Center. Throughout all of our activities the underlying emphasis on undergraduate and graduate student development continues to be a focus beyond the classroom. Students learn hands-on as they participate with Center faculty in their real-world research projects, serve local agency needs by providing technical assistance through the Utah LTAP Center, and learn from classroom instruction based on the latest in the ever-changing transportation curriculum.

The *technology transfer activities* of the Center this past year have been three-pronged: (1) the presentation of papers at professional conferences—the annual Transportation Research Board meeting being the principal medium for these presentations; (2) peer reviewed journal publications (see page 9-10 for the list of presentations and publications); and (3) utilizing the Utah LTAP Center for dissemination of Center research results to local agencies (still in the beginning stages).



The Utah Transportation Center is located on the campus of Utah State University, in Logan, Utah. Since its founding in 1888, Utah State University has evolved from a small, agricultural college to one that is nationally and internationally recognized for its intellectual and technological leadership in land, water, space, and life enhancement.

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ANNUAL REPORT 2008-09

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FROM THE DIRECTOR KEVIN C. WOMACK, PH.D, P.E.



Fiscal year 2009 was another very good year for the Utah Transportation Center (UTC). We ended the first year of effort on the Federal Highway Administration Long Term Bridge Performance (LTBP) Program, with our research partners, the Center for Advanced Infrastructure and Transportation at Rutgers University, and the Virginia Transportation Research Council along with Virginia Tech University. We also constructed and began using a new large scale structures testing laboratory which will be immensely useful as we move forward in doing research on the LTBP program and for the Utah Department of Transportation (see related articles on pages 4 and 5). These major milestones are in addition to the numerous other research projects being conducted by UTC colleagues; four of these projects are new for fiscal year 2009.

The funding situation for the UTC continues to be very positive. The base UTC funding from the US Department of Transportation (USDOT) was leveraged by a 2.71:1 ratio, the best we have done yet at the UTC! Center funding comes from a variety of sources, with FHWA, UDOT, and Utah State University being the major contributors.

As good a year as 2009 was for the UTC, I would like to look forward rather than review the past, as the next few years will be critical not only for transportation research and education but for the whole surface transportation system in the United States. The current surface transportation authorization bill, SAFETEA-LU, is set to expire on September 30, 2009. It is apparent that a new bill will not be passed through Congress and signed into law by the President before that day. A long term continuing resolution bill is being discussed even as the House Transportation and Infrastructure Committee is trying to prepare a bill to be passed by the deadline. I do not see any way that a well crafted bill, that aggressively and thoughtfully addresses the critical issues, can be prepared by September 30. Rather than rush an inadequate bill, it is my opinion that a long term continuing resolution on the order of two years would be a better response at this time. For the most part, this bill could be a roll over of the existing bill, with the one important exception being the Highway Trust Fund revenue issue. This must be addressed in any continuing resolution to properly fund the Trust Fund and avoid the very real possibility of not being able to fund all that is authorized by SAFETEA-LU, which we would all agree is a minimum funding schedule.

By eliminating the pressure of producing a bill before the expiration of SAFETEA-LU, the Congress can take their time, hold hearings, dis-

Discuss the infrastructure needs, examine potential alternative revenue schemes aside from the fuel user fee, and most of all, develop a visionary bill that begins to address the triumvirate of issues critical to the United States: (1) the use of fossil fuels in automobiles; (2) the production of CO₂ by automobiles; and, (3) the need for infrastructure renewal (including safety). The need to begin addressing these issues is at a critical point in time, any

delay may have dire consequences in terms of the economy and global climate change.

Now is the time for Congress to act with a vision for the next 50 years, to redefine a surface transportation system that will be clean, safe, efficient and a positive economic tool (as the Interstate was for our generation) for the future generations that will occupy this great land. It is my hope that, in a new

surface transportation authorization bill, the university transportation centers will be recognized by the Congress for the key role they play and that sufficient funding will be provided to the centers that they might perform research necessary to the redefining and reconstruction of the surface transportation system and provide the transportation engineers that will be needed to design, construct and operate such a new system.

UTAH TRANSPORTATION CENTER HOLDS ANNUAL ADVISORY BOARD MEETING

On June 22, 2009 the Utah Transportation Center (UTC) held its annual advisory board meeting in the Long Term Bridge Performance (LTBP) Lab on the Utah State University campus in Logan, Utah. Attending the meeting were board members Dr. Bill Rahmeyer (Utah State University), Russell Robertson (Federal Highway Administration), Clair Fiet (Utah Transit Authority), Jim McMinimee (Utah Department of Transportation), Benjamin Tang (Oregon Department of Transportation), Dr. Kevin Womack (Director, UTC) and Dr. Marvin Halling (Associate Director, UTC).

The initial part of the meeting was a review by Dr. Womack of FY2009 activities, including funding levels and research projects being conducted. The board was particularly pleased with the ability that the Center has to leverage the base federal funding at a 2.71:1 ratio.

Subsequent to the look at the past fiscal year, four UTC colleagues presented their research work to the board. Dr. Marvin Halling began by providing a review of the prog-



Utah Transportation Center Advisory Board, during their June meeting (left to right): Benjamin Tang, Jim McMinimee, Russell Robertson, Kevin Womack, Clair Fiet, Marvin Halling, Bill Rahmeyer.

ress made this past year by the Long Term Bridge Performance research team. Dr. Scott Budge (Electrical and Computer Engineering) then presented the results of his "Investigation of the Use of Texel Cameras for Counting Passengers on Public Transportation" project which was funded by the Utah Transit Authority. Next Dr. Patricia Cramer (Wildland Resources) discussed her

current work on highway wildlife crossings, which is being funded by the Utah Department of Transportation (UDOT).

Last to present was Dr. Anthony Chen (Civil and Environmental Engineering). He showed the board his progress on the "Development of a Decision Support Tool for Assessing Vulnerability of Transportation

Networks,” a project being funded by both the Utah Department of Transportation and the Utah Transportation Center.

The response of the Advisory Board to these presentations was very positive, with much discussion on the variety of the projects and the fact that the Center is looking to be very diverse to broaden its potential for research and funding.

Just before lunch, Dr. Womack presented to the Advisory Board the proposed budget for fiscal year 2010. This included a second year of supplemental funding provided by the UTC for the Long Term Bridge Performance Program research, funding for two new projects, and funding for two ongoing projects.

The two new projects were ranked highly in the UDOT research project review process and are a work zone safety control project and a forecasting network traffic for small communities in Utah project. The other two projects that are underway and will be receiving



The annual advisory board meeting included a visit to the new Structures Lab (left to right): Bill Rahmeyer, Russell Robertson, Clair Fiet, Kevin Womack, Benjamin Tang, Jim McMinimee, Marvin Halling

UTC funding are the highway wildlife crossing project (Dr. Patricia Cramer) and continued work on the passenger counting project of Dr. Scott Budge. The UTC funding for these last two projects and the Forecasting Network Traffic project will be for graduate students only.

After lunch the Advisory Board was taken for a tour of the newly

constructed large scale structural testing laboratory associated with the UTC. Currently, in this lab, full scale pre-stressed concrete girders salvaged from a demolished UDOT bridge are being prepared for testing of the residual shear capacity at the girder ends (see photos on page 5). This was a great way to end the meeting and the Board was rightly impressed with this new facility.

SCOTT D. PORTER NAMED AS STUDENT OF THE YEAR



Sal Lake County native, Scott Porter, was recently named the Utah Transportation Center Student of the Year. He received his BS degree in Civil and Environ-

mental Engineering from Utah State University in 2007 and just recently completed his MS in Civil and Environmental Engineering (Structures) also from Utah State. His dedication to his studies shows in the honor he earned in graduating Summa Cum Laude with both degrees.

But it hasn't all been study for Scott. His research focus was on connections between precast bridge deck panels for use in accelerated

bridge construction. Working with the transportation faculty at USU, he did shear and flexural testing of the connections.

In addition to his studies and research at USU, Scott also worked as an intern for the Utah Department of Transportation during the summer of 2007.

Congratulations to Scott on this well-deserved honor!

CENTER COLLEAGUES CONTINUE WORK AS THE NATIONAL LONG TERM BRIDGE PERFORMANCE (LTBP) PROGRAM ENTERS PILOT PHASE

In the United States, the stewardship and management of more than 590,000 bridges are ongoing planning, operational, maintenance, and economic challenges faced by Federal, State, and local transportation agencies.

To help overcome these challenges and foster the next generation of bridge and bridge management systems, in April 2008, the Federal Highway Administration's (FHWA's) Office of Infrastructure Research and Development launched the Long Term Bridge Performance (LTBP) Program, a major new strategic initiative designated as a flagship research project.

The LTBP Program is intended to be a 20-year undertaking, with the global objective of collecting quality scientific data from the Nation's highway bridges, as critical node-points of the highway transportation network. The data and information collected in this program will provide a more detailed and timely picture of bridge health, improve knowledge of bridge performance, and ultimately promote the safety, mobility, longevity, and reliability of the Nation's highway transportation assets.

Funding for the program was included in legislation for surface transportation enacted by the U.S. Congress in 2005—the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU).

Utah State University's Utah Transportation Center is part of this effort under the direction of Center colleagues, Dr. Paul Barr and Dr. Marv Halling.

The LTBP Program is now moving into year two, the pilot phase (phase II). With the completion of the development phase (phase I), the infrastructure is now in place to collect, maintain and retrieve the data that will be collected at test sites during phase II.

During this pilot phase, Utah Transportation Center faculty members, Dr. Paul Barr and Dr. Marv Halling, will be overseeing the installation of the instrumentation that will study bridge dynamics at three test sites (one in Utah, one in California and one in Minnesota) while their counterparts will oversee the installation of instrumentation at other test sites around the U.S. Under the direction of the Federal Highway Administration,



photo courtesy of <http://www.tfhrc.gov/ltp/about.htm>

and project PIs at Rutgers University, this pilot phase will be carried out to validate protocols for data collection and management, to ensure all necessary arrangements are made with bridge owners for accessing bridges, and to make certain that all of the components needed to achieve the long-term objectives of the LTBP Program are specified before initiating the study on the large population of bridges nationwide.

NEW STRUCTURES LAB EXTENDS CENTER RESEARCH CAPABILITIES



The new Utah State University (USU) College of Engineering Structures Lab officially opened in Spring 2009. The 5000 square foot structure greatly expanded the ability of Utah Transportation Center faculty to conduct large-scale structural testing, and provide timely data in response to the pressing research questions of the day.

The research lab includes two 20-ton cranes, a 60 foot by 24 foot strong floor, and a 12 foot biaxial strong wall. The cranes allow for a full range of movement of structural components within the lab. The lab is set up to allow trucks to drive directly into the lab, and then have materials lifted off effortlessly by the cranes and moved where needed for further testing. (Shown in the pictures—top right and bottom left—are girders salvaged from UDOT bridges which are being tested to determine remaining capacity.)



Up to this point, USU structural researchers have had to make do with an outdoor facility. This facility was only available during favorable weather conditions and with less equipment and capacity to test full-scale structures. With this new facility, not only can full-scale research projects be conducted, but they can be conducted in a much more efficient and timely manner.

Also in the lab is the ability to build upon the outstanding pipe research begun with Dr. Reynold Watkins and Dr. Al Moser. Dr. Steve

Folkman and his colleagues are now able to utilize the cranes in the lab to more efficiently conduct their pipe research.

The facility cost \$600,000 and was made possible through a special State appropriation and the USU College of Engineering.

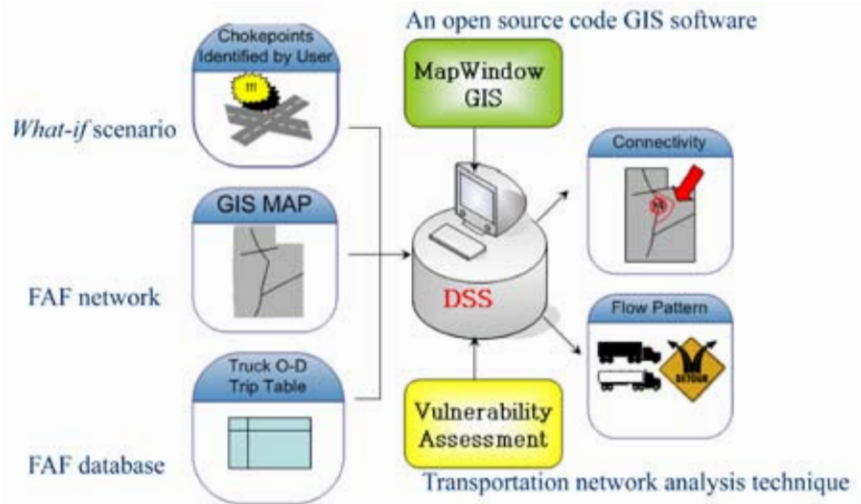


Clockwise from top left: outside the USU Structures Lab; two 20 ton cranes inside the lab; a view from under the 60 x 24 foot strong floor; 12 foot biaxial strong wall; close-up view of the strong floor

CENTER COLLEAGUE DEVELOPS A MULTI-FACETED DECISION SUPPORT TOOL FOR ASSESSING THE VULNERABILITY OF TRANSPORTATION NETWORKS IN UTAH

Utah Transportation Center colleague, Dr. Anthony Chen, along with Ph.D. student, Sarawut Jansuwan, are in the process of completing their two-year project for the Utah Department of Transportation (UDOT), entitled “Development of a Decision Support Tool for Assessing Vulnerability of Transportation Networks.” This project, begun in 2007, was initially tasked with developing a tool to provide UDOT with a model to address freight chokepoints along State roadways in Utah.

Thanks to the input from their technical advisory committee, they have developed a decision support tool that addresses the initial scope of work, with the added potential for even greater applications!



By using the latest in GIS-linked mapping technology, and tapping into the federal Freight Analysis Framework (FAF), Dr. Chen and Mr. Jansuwan will soon be providing UDOT with a completed decision support tool that looks not only where bottlenecks (chokepoints)

This tool allows planners and other involved parties to plan for detours and other responses to single and multiple chokepoint issues in order to address the need for the free movement of freight within the State.

can and do occur, but plan for potential scenarios (i.e. seismic disruptions, road closures, bridge collapses, etc.) that will affect the movement of freight within the State of Utah. This includes issues found in both rural and heavily traveled urban areas.

This tool also has the potential to help homeland security personnel plan for and address national security issues affecting the free-flow of traffic along the transportation system.

Dr. Chen is Associate Professor and Transportation Division Head in the Department of Civil & Environmental Engineering at Utah State University. He can be reached by e-mail at [achen@engineering.usu.edu]. Mr. Jansuwan is a Ph.D. student from Thailand. He received his bachelors and masters degrees from Chiang Mai University, and Chulalongkorn University, respectively.



from left to right, Ph.D student Sarawut Jansuwan, and Dr. Anthony Chen, review their work on the UDOT Decision Support Tool in Dr. Chen's office

NATURAL RESOURCE FACULTY PARTNER PEEKS “INSIDE” AT WILDLIFE “ROAD USERS”

Dr. Patricia Cramer, Research Assistant Professor in the Department of Wildland Resources at Utah State University, is taking a peek “inside” at an often overlooked transportation corridor user...wildlife. With the focus on conservation of the natural world from global, national, regional and local organizations, her research is both timely, and practical in addressing ways to safeguard wildlife along busy transportation corridors in the Western United States. Her research also has application beyond that geographic area, and may help address this issue wherever it is found.

Her prior work and professional network has uniquely qualified Dr. Cramer to conduct this research. Input in such work as the Western Governor’s Association (WSA) “Wildlife Corridors Initiative” and working relationships with non-profit and sportsman’s groups alike



Motion detection cameras are a key component of Dr. Cramer’s research. Seen here, one of the motion detection cameras used to document wildlife usage of under road passageways (left) and a picture taken of a moose as it exited an under road passage (right).

have broadened her perspective and given her the chance to look at unique ways to accommodate the human need for transportation with the need for wildlife to move freely within their already bisected habitat.

The Center has joined with Dr. Cramer in support of her work with the Utah Department of Transportation (UDOT) and Utah Division of

Wildlife Resources in order to determine if deer, elk and other animals are willing to use wildlife crossings such as culverts, bridged underpasses, and overpasses, and how different crossing elements (i.e. passage size, length, visibility, etc.) impact wildlife use. Using movement triggered cameras placed at strategic

locations, pellet counts, GPS collars on animals, etc. Dr. Cramer hopes to determine the minimum and range of best dimensions for these structure in order to encourage the highest deer, elk, and moose use in an area so these animals do not attempt to go around the concurrent fences or attempt to push through them. The results of this study will help UDOT prevent additional wildlife-vehicle collisions and their associated cost (in lives and money), better allocate limited funds on the most effective new structures, and help wildlife move safely across their habitat.

Dr. Cramer’s prior work includes: TRB-NCHRP Report 615, ‘Evaluation of the Use and Effectiveness of Wildlife Crossings,’ and a to-be published NCHRP research report on Ecological Surveys. She is also conducting the project ‘Monitoring Wildlife Crossings in Montana on US 93 South.’

For more information, you can visit [www.wildlifeandroads.org].



Dr. Cramer inside one of the wildlife tunnels used during her research (photo courtesy of USU photographer, Donna Barry)

2008-09 UTAH TRANSPORTATION CENTER PROJECTS

NEW PROJECTS

- UTC0901 “Long Term Bridge Performance Program, Supplemental Funding, Year 1,” Dr. Marvin Halling, PI. *Funded by UTC and FHWA.*
- UTC0902 “Cache Valley Transit District (CVTD) Rider Surveys and Analyses,” Dr. Kevin Heaslip, PI. *Funded by the CVTD.*
- UTC0903 “Cache Metropolitan Planning Organization (CMPO) Traveler Preference Study,” Dr. Kevin Heaslip, PI. *Funded by the CMPO.*
- UTC0904 “Quality of Life in Cache Valley Study,” Dr. Kevin Heaslip, PI. *Funded by UTC.*

ONGOING PROJECTS

- UTC0703 “Strong Motion Instrumentation Plan for UDOT Bridges: Array Design, Typical Details, and Specifications,” Dr. Marvin Halling, PI. *Co-funded by UDOT and UTC.*
- UTC0704 “Failure Modes Analysis of UDOT’s MSE Wall Inventory,” Dr. James Bay, PI. *Co-funded by UDOT and UTC.*
- UTC0801 “Development of a Decision Support Tool for Assessing Vulnerability of Transportation Networks,” Dr. Anthony Chen, PI. *Co-funded by UDOT and UTC.*
- UTC0802 “Synthesis Study and Field Evaluation of In-Situ Culvert Rehabilitation in Utah,” Dr. Blake Tullis, PI. *Co-funded by UDOT and UTC.*
- UTC0803 “ABC Deck Connections, Laboratory Testing and Evaluation,” Dr. Marvin Halling, PI. *Co-funded by UDOT and UTC.*
- UTC0805 “Shear Capacity of Pre-stressed Girders,” Dr. Paul Barr, PI. *Co-funded by UDOT and UTC.*

COMPLETED PROJECTS

- UTC0701 “Evaluation of Bridges for Seismic Retrofit,” Dr. Keri Ryan, PI. *Co-funded by UDOT and UTC.*
- UTC0702 “UDOT’s Calibration of AASHTO’s New Prestress Loss Design Equations,” Dr. Paul Barr, PI. *Co-funded by UDOT and UTC.*
- UTC0705 “Logan Bluff Landslide Risk Analysis,” Dr. Robert Pack, PI. *Funded by UDOT.*
- UTC0706 “Wireless Broadband for Commuter Rail: ‘River of RF’,” Dr. Chris Winstead, PI. *Funded by UTC.*
- UTC0804 “Investigation of the Use of Texel Cameras for Counting Passengers on Public Transportation,” Dr. Scott Budge, PI. *Funded by UTA.*

2008-09 PRESENTATIONS & PUBLICATIONS

PRESENTATIONS

listed alphabetically by lead author; Utah Transportation Center colleagues in bold

- Barr, P.J., Halling, M.W.,** Cousins, T.E., Roberts-Wollmann, C.L. and Sotelino, E.D. LTBP Bridge Monitoring, Testing, and Instrumentation. Proceedings of the ASCE Structures Congress, Austin, Texas, April 30-May 2, 2009.
- Barr, P.J., Halling, M.W., and Womack, K.C.** Influence of Changes in Boundary Condition on Bridge Response. 24th US-Japan Bridge Engineering Workshop, Minneapolis, Minnesota, September 2008.
- Chen, A.** and Chootinan, P. Visual PFE: A convex program with side constraints for estimating path flows. Proceedings of the 13th Hong Kong Society of Transportation Studies Conference: Transportation and Management Science, Hong Kong, P.R. China, edited by H.P. Lo, S.CH. Leung, and S.M.L. Tam, 249-258.
- Chen, A.,** Ryu, S., and Chootinan, P. An ∞ -norm model for handling traffic count inconsistencies in path flow estimator. The 88th annual meeting of the Transportation Research Board, January 11-15, 2009, Washington, D.C., USA.
- Halling, M.W.,** Xing, S., **Barr, P.J.** and Hansen, Z.C. Changes in Modal Frequencies of a Highway Bridge. Proceedings of the Sixth National Conference on Bridges and Highways, Charleston, South Carolina, July 2008.
- Halling, M.W.** A Sample of Technology Challenges in Bridge Monitoring. NSF Bridge Workshop, University of Minnesota, Minneapolis MN, November 2008.
- Heaslip, K.,** Louisell, W. and Collura, J. Concepts to Aid in Modeling the Impact of Driver Behavior on Traffic Flow and Capacity in Work Zones. The Proceedings of the 2009 TRB Annual Meeting, January 2009.
- Heaslip, K.,** Collura, J. and Knodler, M. Evaluation of Work Zone Design Features to Aid Older Drivers. The Proceedings of the 2009 TRB Annual Meeting, January 2009.
- Heaslip, K.,** Louisell, W. and Collura, J. Quantitative Evaluation of Transportation Resiliency for Regional Networks. The Proceedings of the 2009 TRB Annual Meeting, January 2009.
- Heaslip, K.,** Louisell, W. and Collura, J. An Algorithm to Quantify the Effects of Driver Behavior on Work Zone Capacity. Proceedings of the 2008 ITS World Congress, New York City, November 2008.
- Heaslip, K.,** Collura, J. and Louisell, W. A Methodology to Determine Priorities after Major Disasters. Proceedings of the Intelligent Transportation Society of America's Annual Meeting, Washington, DC, June 2009.
- Mertlich, T., **Barr, P.J., Halling, M.W.** and **Womack, K.C.** Structural Health Monitoring of a Curved Girder Bridge Subjected to Different Boundary Conditions. The 14th World Conference on Earthquake Engineering, Beijing, China, October 12-17, 2008.

Ryan, K.L. and Hu, W. Effectiveness of Partial Isolation of Bridges for Improving Column Performance. Proceedings of the ASCE Structures Congress, Austin, Texas, April 30-May 2, 2009.

Xing, S., **Halling, M.W.**, **Barr, P.J.** and Meng, Q. Ambient Vibration Analysis of a Highway Bridge with Subspace Method and Frequency Domain Decomposition. Proceedings of the 14th World Conference on Earthquake Engineering, Beijing, China, Oct 12-17, 2008.

Zhu, J.S., Lam, W.H.K., **Chen, A.** and Lo, H.K. Modeling the Impacts of Turn-Delay Uncertainties on Route Choice Behavior in Signalized Road Networks. The 88th annual meeting of the Transportation Research Board, January 11-15, 2009, Washington, D.C., USA.

PUBLICATIONS

listed alphabetically by lead author; Utah Transportation Center colleagues in bold

Barr, P.J., **Kukay, B.M.**, **Halling, M.W.** (2008). Comparison of Prestress Losses in a High Performance Concrete Bridge. ASCE Journal of Bridge Engineering, September/October 2008, Vol. 13, No. 5, 468-475.

Chaovalitwongse, W.A., He, X., and **Chen, A.** (2009). Multi-quadratic integer programming: Models and applications. In Encyclopedia of Optimization, 2nd Edition, Edited by C.A. Floudas and P.M. Pardalos, Springer, Part 13, 2513-2520.

Chen, A., Kim, J., Lee, S., and Choi, J. (2009). Models and algorithm for stochastic network designs. Tsinghua Science and Technology, 14(3), 341-351.

Hsieh, K.H., **Halling, M.W.**, **Barr, P.J.**, and Robinson, M. (2008). Damage Detection Using Dynamic Properties Determined from Laboratory and Field Testing. ASCE Journal of Performance of Constructed Facilities, July/August 2008, Vol. 22, No. 4, 238-244.

Womack, K.C. (2008). Infrastructure Renewal: The Need for Political Leadership. ASCE Journal of Leadership and Management in Engineering, October, 2008, Vol. 8, No. 4, 297-300.

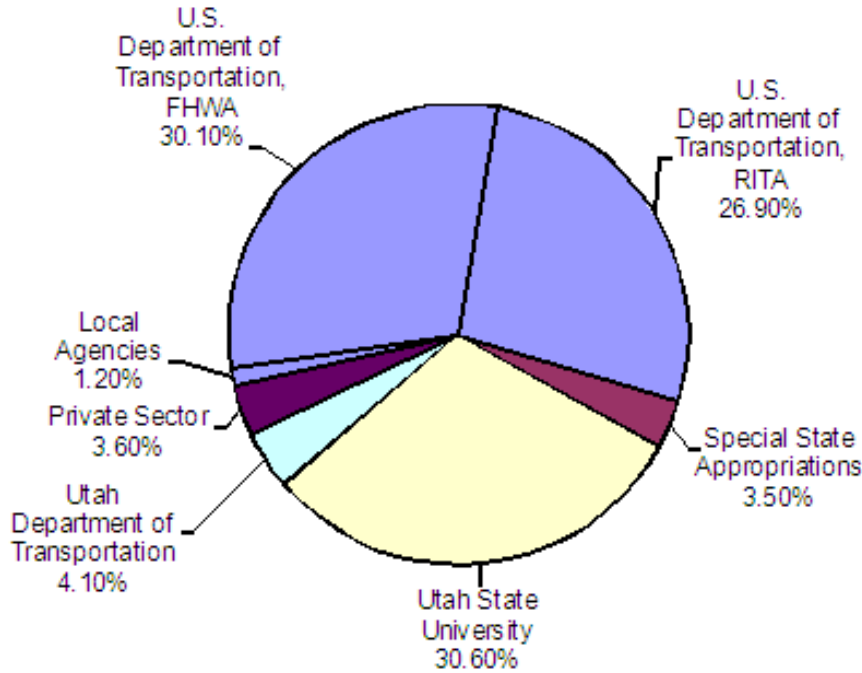
Xu, M., **Chen, A.**, and Gao, Z. (2008). An improved origin-based algorithm for solving the combined distribution and assignment problem. European Journal of Operational Research, 188(2), 354-369.

Yang, C. and **Chen, A.** (2009). Sensitivity analysis of the combined travel demand model with applications. European Journal of Operational Research, 198(3), 909-921.

Zhou, Z., **Chen, A.** and Wong, S.C. (2009). Alternative formulations of a combined trip generation, trip distribution, modal split, and trip assignment model. European Journal of Operational Research, 198(1), 129-138.

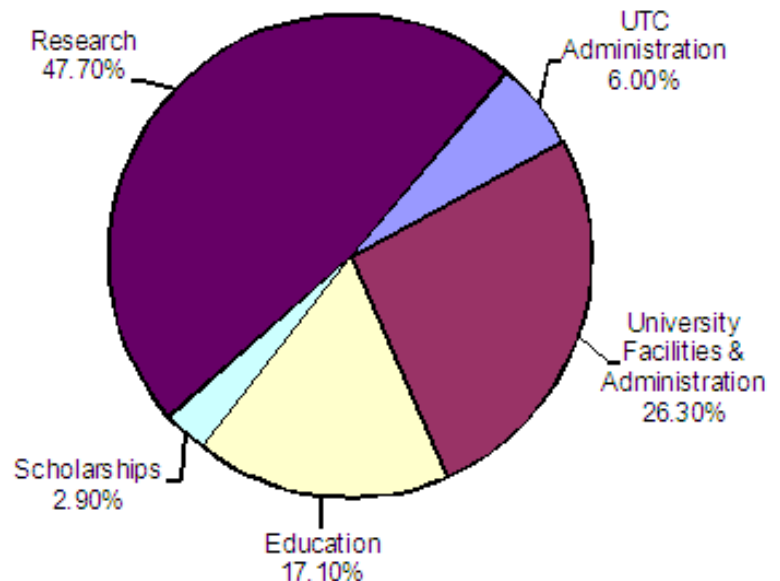
Zhou, Z. and **Chen, A.** (2008). Comparative analysis of three user equilibrium models under stochastic demand. Journal of Advanced Transportation, 42(3), 239-263.

Funding by Source



FUNDING BY SOURCE
Total budget for FY2009: \$1,564,999 (includes funds from all sources)

Funding by Use



FUNDING BY USE
includes all funds expended and encumbered during FY2009

ADVISORY BOARD

Dr. William Rahmeyer, P.E.

Advisory Board Chair and Head, Department of Civil & Environmental Engineering, Utah State University

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Chief Technology Officer, Utah Transit Authority

Ian M. Friedland, P.E.

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Director, Project Development Division, Utah Department of Transportation

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Benjamin Tang, P.E.

Bridge Preservation Managing Engineer, Oregon Department of Transportation



The Utah Transportation Center is housed in the Civil & Environmental Engineering Department in the College of Engineering, on the campus of Utah State University in Logan, Utah,



*photo courtesy of Jennifer Carroll,
College of Engineering*

