

# UTAH TRANSPORTATION CENTER 2006-07 ANNUAL REPORT

“INNOVATIVE ENGINEERING AGAINST HAZARDS”



**Utah State**  
UNIVERSITY



## FROM THE DIRECTOR

KEVIN C. WOMACK, PH.D, P.E.



The first year as a Tier II University Transportation Center for the Utah Transportation Center has been a successful one; full of growth, strengthening old relationships and building new ones.

We have been able to strengthen our long-standing partnership with the Utah Department of Transportation (UDOT), both financially and technically. During this first year, with funding available through the UTC program, we have been able to partner with UDOT to fund four research projects with budgets totally more than \$324,000. We look forward to continuing this partnership with UDOT. We anticipate long-term benefit for the advancement of transportation research generally and providing specific research that will enhance UDOT's ability to manage Utah's complex transportation infrastructure.

We have also developed two very strong, yet different, relationships with other transportation entities during this first year. One of these is a partnership developed between our center, the Utah Transportation Center, and the university transportation center at Rutgers, the Center for Advanced Infrastructure and Transportation (CAIT). We have collaborated on a very significant proposal for the FHWA Long Term Bridge Performance Program, and look forward to further collaborative endeavors with the CAIT group. The second of these new relationships is the one that has grown between the Utah Transportation Center and the Utah Transit Authority (UTA). The UTC wholly funded one research project for UTA, looking at passenger counting technology, and a second project, to be funded 100% by UTA, is currently under contract negotiations. This partnership between the UTC and UTA will focus on the application of existing technologies to optimize the operations of major transit agencies. This is a very exciting relationship and will bring colleagues from other engineering disciplines into the Utah Transportation Center which has up to this point consisted mainly of civil engineering colleagues.

From a purely financial point of view, the Utah Transportation Center managed to leverage its Tier II Federal funding at a 1.65:1 ratio, with a total center budget of nearly \$1,139,000 (see figures on page 10). This type of leverage means more research projects and technology transfer, graduate student scholarships, and in the not too distant future an additional faculty member specializing in transportation.

So after a great first year, the future looks bright for the Utah Transportation Center and we look forward to sharing that bright future with you.

## CENTER STAFF

### **Kevin C. Womack, Ph.D, P.E.**

Director  
Civil & Environmental Engineering

### **Marvin W. Halling, Ph.D, P.E.**

Associate Director  
Civil & Environmental Engineering

### **Julie H. Duersch**

Newsletter Editor

## FACULTY COLLEAGUES

### **Paul J. Barr, Ph.D**

Assistant Professor  
Civil & Environmental Engineering

### **James A. Bay, Ph.D**

Associate Professor  
Civil & Environmental Engineering

### **Joseph A. Caliendo, Ph.D**

Associate Professor  
Civil & Environmental Engineering

### **Anthony Chen, Ph.D**

Associate Professor  
Civil & Environmental Engineering

### **Robert T. Pack, Ph.D**

Associate Professor & Director, Center  
for Advanced Imaging Ladar  
Civil & Environmental Engineering

### **Keri L. Ryan, Ph.D**

Assistant Professor  
Civil & Environmental Engineering

### **Blake P. Tullis, Ph.D**

Assistant Professor  
Civil & Environmental Engineering

### **Chris Winstead, Ph.D**

Assistant Professor  
Electrical & Computer Engineering

## WEBSITE

<http://transportation.usu.edu>

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# ANNUAL REPORT 2006-07

# 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. Congestion relating to evacuation issues in the case of a natural hazard, and transit being simply the mass movement of people for whatever reason, be it commuting or evacuation.

This approach has been very successful in the first year of the Center, particularly in the association of colleagues in the Department of Electrical and Computer Engineering (ECE) to perform transit research. As the Center moves forward, it is anticipated that more faculty from the ECE department will become involved in Center activities, as well as the USU College of Natural Resources.

The educational activities of the Center primarily involve instruction by CEE faculty associated with the Center. These faculty teach transportation-related courses in many disciplines of civil engineering: surveying, structures, hydraulics, operations, transportation design, planning, and engineering economics. The research activities, as discussed above, focus on “engineering against hazards,” and the principal research partner for the Center in its first year has been the Utah Department of Transportation (UDOT). In the future, it is expected that this field of partners will expand significantly to include the Federal Highway Administration (FHWA), the Utah Transit Authority (UTA), and other local governmental entities.

The technology transfer activities of the Center this past year have been in the presentation of papers at professional conferences--the annual Transportation Research Board meeting being the principal medium for these presentations. Peer reviewed journal publications are also a key element to the Center’s technology transfer activities (see page 8-9 for the list of presentations and publications). The Utah LTAP Center is located in the CEE department at Utah State University, but as of yet the ability to utilize the Utah LTAP Center for dissemination of Center research results has been limited. This is a relationship that both the Utah LTAP Center and the Center look to improve over the near future.



*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.*



# MARVIN HALLING...STUDYING SEISMIC IMPACTS ON STRUCTURES

Dr. Marvin W. “Marv” Halling serves as associate director of the Utah Transportation Center and as a structural engineer in Utah, is very aware of the impact of earthquakes on structures.

But in the past few years, he has migrated from a purely earthquake emphasis to a more broad look at structural health. This is no more evident than in his current research project with the Utah Transportation Center, “Real Time Health Monitoring of the 21st South Overpass.”

This project has converted a seismic instrumentation package into use as a real-time web-based vibration monitoring system. The data gathered through this instrumentation is a key part in monitoring the structural health of this bridge as well as aiding in overall damage detection.

It is expected that the data gathered through this monitoring will prove critical in helping determine the health of this bridge before and after a damaging event. This is a critical step toward a future of “smart structures” that will help monitor themselves and provide data on their own health, allowing for more efficient use of resources in safeguarding our nation’s infrastructure. This project meshes well with work Dr. Halling is doing with

Center colleague, Dr. Paul Barr, on other areas of structural health.

In addition to this project, Dr. Halling is principal investigator on the following projects:

- Strong Motion Instrumentation Plan for UDOT Bridges: Array Design, Typical Details, and Specifications
- Structural Health Monitoring Using Vibrational Techniques of a Multispan Flyover Bridge

Dr. Halling has been a part of the Civil & Environmental Engineering faculty at Utah State University since 1994 (currently serving as Associate Professor and Head of the Structural Division), but he is not

a newcomer to Utah State. In fact, he received his BS degree in Civil Engineering from USU. This was followed by his MS degree from Stanford and his PhD from CalTech in Applied Mechanics (with a minor in geophysics).

His expertise goes beyond the walls of Utah State and he serves as a member of the ASCE Seismic Effects Committee, ASCE Structural Health Monitoring Committee and the TRB ASF40 Dynamics and Field Testing of Bridges Committee as well as serving as an Associate Editor of the ASCE Journal of Structural Engineering. He is a licensed professional engineer in both Utah and California.



# IT'S ALL ABOUT BRIDGE RESEARCH FOR PAUL BARR

Dr. Paul Barr first became interested in civil engineering because he said, "I just liked being around construction projects."

That fascination took Dr. Barr to Utah State University for his bachelor's degree in Civil Engineering, and from there to the University of Washington for his Masters and PhD.

After receiving his PhD, he took his first full-time position as Assistant Professor at New Mexico State University. When the job opening came up at Utah State University in 2003, he thought he would enjoy working at Utah State and he hasn't been disappointed. Since then, his research interests have focused on nondestructive evaluation of bridges due to earthquake loads, live loads, changes in temperature, and prestress losses.

Dr. Barr truly enjoys bridge research; this includes sharing that enthusiasm with students on bridge-related projects.

In all that work, Dr. Barr never loses sight of providing a useful end product for project funders. And in the case of his projects with the Utah Transportation Center, that means UDOT and the FHWA. Each of Dr. Barr's projects with the UTC has the focus of a better understanding of bridge behavior and design.

Even in a field as old as civil engineering, new and cutting edge technology has emerged to help in

conducting research. Dr. Barr noted that they are working on some non-destructive methods that hopefully will be useful in the future for determining residual prestress losses. This kind of technological breakthrough will save money for state DOTs in the long run.

Dr. Barr is the principal investigator for the following projects:

- UDOTs Calibration of AASHTO's New Prestress Loss Design Equations
- Development and Testing of a Non-Destructive Method for Determining Residual Pre-stress
- A Comparison of Time Dependent Prestress Losses in a Two-span, Prestressed Concrete Bridge
- Dynamic and Static Behavior of a Curved-girder Bridge with Varying Boundary Conditions
- Long-term Structural Health Monitoring of the San Ysidro Bridge

Dr. Barr is a member of the American Society of Civil Engineers (ASCE) and Prestressed Concrete Institute (PCI).



Dr. Barr also serves on a variety of committees:

- ASCE Seismic Effects Committee (Secretary), 2005-present
- ASCE Field Testing Committee, 2006-present
- PCI Committee on Bridges, 2004-present
- SEI Committee on Structural Identification of Constructed Systems, 2006-present
- PCI Prestress Loss Committee, 2004-present

During his career, Dr. Barr has also received several honors and awards:

- Outstanding Advisor, Utah State University, Logan, 2004
- Outstanding Teacher, Utah State University, Logan, 2004
- Professor of the Year, New Mexico State University, Las Cruces, 2003

# KERI RYAN...ANALYTICAL MODELING & SEISMIC ANALYSIS

Dr. Keri Ryan, an Idaho native, joined the USU faculty in 2004 and currently serves as an Assistant Professor in the Structures Division of the Civil & Environmental Engineering Department. Dr. Ryan received her BS in Engineering and Applied Science from the California Institute of Technology, followed by her MS and PhD in Civil and Environmental Engineering from the University of California, Berkeley.

Dr. Ryan's expertise lies in analytical modeling and seismic analysis of structural components and systems, with emphasis in the area of seismic isolation and protective systems. Dr. Ryan is applying this expertise as the principal investigator on a UDOT/UTC project entitled, "Evaluation of Bridges for Seismic Retrofit."

Dr. Ryan uses computer modeling and analysis extensively for this project and other research work she is involved in. Her work is truly "math in action" with practical application as the end result of her work.

In particular, she anticipates that her analysis of the performance and practicality of seismic isolation measures will allow decision-makers to gain a greater understanding of these measures. It is anticipated that this will lead to greater demand and thus supply of isolation measures that will eventually bring down the cost and allow greater use of seismic isolators on such structures as bridges and buildings.

In Utah, and other seismically active states, a major seismic event has the potential to completely dis-



rupt transportation systems. This would prove catastrophic across the economic and social spectrum for the affected areas.

Seismic isolators are a critical part of the solution in the aftermath of a seismic event. They allow the public to, for example, continue driving on bridges after a seismic event or utilize a building until repairs can be made. A decrease in the cost of this technology, through greater implementation, would bring great benefit for the public. At present, seismic isolation systems have to be built from scratch by suppliers because of the limited demand, and that makes it a cost prohibitive technology for many local agencies and even state and federal agencies.

To that end, Dr. Ryan is looking at three specific plan sets for bridges built in the 1960s (since many of bridges built in the 1950s and 60s are still in use today). These specific examples will provide feedback for modeling in the LARSA computer software system. That model will then lead to new bridge analysis measures, and feedback on how best to build new bridges. The project will provide the Utah Department of Transportation with the ability to use more advanced analysis techniques for analyzing bridges on the State transportation system.





# CHRIS WINSTEAD... BRINGING ELECTRICAL ENGINEERING EXPERTISE TO “RIVER OF RF” PROJECT



When asked what first interested Dr. Chris Winstead in engineering, he replied, “I believe it was probably my first experience with lego building blocks that led me into engineering. It might also have started earlier with alphabet blocks...I’ve just always been building things.”

That interest sent him to the University of Utah for his undergraduate work and later to the University of Alberta where he received his PhD.

His partnership with the Utah Transportation Center has provided a variety of opportunities for Dr. Winstead. He commented, “My background is in the general theory of telecommunication technology, where it is all too easy to lose track of real-world needs and limitations. My work with the UTC created an opportunity to study the varieties of technical solutions that are being deployed in commuter rail installations. These installations offer a very practical way to measure the cost-effectiveness and reliability of

some of the latest wireless technologies. This information will influence future directions for theoretical research.”

Dr. Winstead is “fascinated by failures.” He likes to understand what happened when a great idea failed to work out in practice. With the “River of RF” project, he is looking at “a few ‘good’ examples of lackluster wireless deployments.” By understanding these, they can create an effective wireless system for the Utah Transit Authority commuter rail systems including advising UTA on technology options, and assessing the best network design choices for long-term reliability and value. Dr. Winstead tells us that, “It was most interesting to see the wide variety of low-to-medium bandwidth solutions that were successfully deployed in rail installations around the world. Some of these used satellite links or cell network connections, and some used older WiFi approaches that are not originally intended for highly-mobile applications. Although these networks employed some ingenious designs and were “good enough” to satisfy customer needs, the newer WiMAX approach has fast become dominant in new installations. It will be interesting to see, in the long term, whether it proved more advantageous to offer low-bandwidth access early (and consequently be saddled with outdated technology

after a few years), or was it ultimately more cost-effective to wait for the higher-quality WiMAX systems to mature? This question will soon be recapitulated by the emerging 802.24 standard, which is intended to replace WiMAX for high-speed rail systems.”

He anticipates that the greatest benefit from this research will lead to “[discovery] of some practical difficulties for high-speed wireless access that have been overlooked in theoretical analysis. This will help us refocus our work on wireless systems onto problems that have the highest impact for real-world deployments.”

In the field of electrical engineering, there is always some new or cutting edge technology emerging to help in conducting research. For the “River of RF” project this has been WiMAX. In Dr. Winstead’s words, “the real benefit is that it organizes many independent vendors and developers around a well-defined game plan...Now that the standard is relatively stable, companies are able to work together to economically deliver all the parts of a complex wireless network system that will work in a fast-moving train. When the industry crystallizes around a new standard, doors open everywhere for exciting new applications.”





# JAMES BAY TAKES A LOOK AT SOIL DYNAMICS & MSE WALL INSTRUMENTATION

Dr. James A. Bay received his B.S. and M.S. degrees in Civil and Environmental Engineering from Utah State University and continued his education at The University of Texas, Austin where he received his PhD.

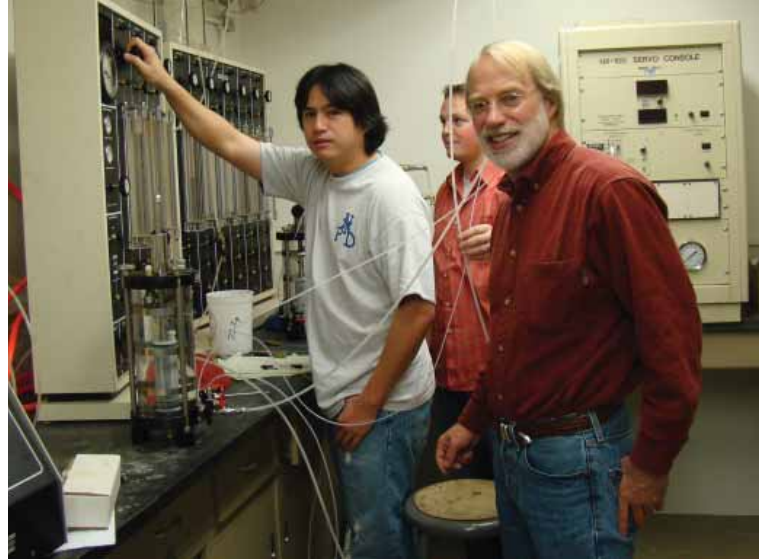
Dr. Bay is an Associate Professor in the Department of Civil and Environmental Engineering Department at Utah State University. He has been on the faculty since 1998.

His work focuses on geotechnical engineering, specializing in soil dynamics, geophysical site characterization, nondestructive material evaluation, and instrumentation. These areas of expertise lend themselves well to the projects Dr. Bay

is working on for the Utah Transportation Center. That includes research work improving geophysical measurements in noise environments, design of wave sources, site characterization for predicting earthquake response, MSE wall instrumentation, and evaluation of soft clay.

Dr. Bay is the principal investigator for the following Center projects:

- Failure Modes Analysis of UDOT's MSE Wall Inventory
- Logan Bluff Landslide Risk Analysis



## “STUDENT OF THE YEAR” HONORS FOR BRIAN M. KUKAY

The Utah Transportation Center recognized Brian M. Kukay as the “Student of the Year” for 2007. Brian is from Butte, Montana and is currently pursuing a Ph.D in Civil Engineering at Utah State University. Under the direction of Dr. Paul Barr, Dr. Marv Halling and Dr. Kevin Womack, his research efforts focus on the development (and testing) of a non-destructive method to determine residual tendon stress in pre-stressed girders.

The ability to determine the remaining force in the tendons of in service pre-stressed girders is important in both bridge load ratings and repairing damaged pre-stressed members. Should this method prove accurate and doable in the field, this will be a significant advancement in the area of bridge inspection, rating and repair; which could ultimately save significant amounts of money (because actual bridge capacities may be determined and not have to be conservatively estimated).



Ultimately, Brian’s goal is to seek out an academic appointment at a school of higher education. Accordingly, he would be able to fulfill his passion for teaching and conducting research related to reinforced concrete at a four-year college or university.

# 2006-07 UTAH TRANSPORTATION CENTER PROJECTS

## PROJECTS RECEIVING UTC FUNDING

### New Projects

- UTC0701 “Evaluation of Bridges for Seismic Retrofit,” Dr. Keri Ryan, PI. *Co-funded by the Utah Department of Transportation (UDOT).*
- UTC0702 “UDOT’s Calibration of AASHTO’s New Prestress Loss Design Equations,” Dr. Paul Barr, PI. *Co-funded by UDOT.*
- UTC0703 “Strong Motion Instrumentation Plan for UDOT Bridges: Array Design, Typical Details, and Specifications,” Dr. Marvin Halling, PI. *Co-funded by UDOT.*
- UTC0704 “Failure Modes Analysis of UDOT’s MSE Wall Inventory,” Dr. James Bay, PI. *Co-funded by UDOT.*

### Completed Projects

- UTC0706 “Wireless Broadband for Commuter Rail: ‘River of RF’,” Dr. Chris Winstead, PI.

## OTHER UTAH TRANSPORTATION CENTER PROJECTS (not receiving UTC funding)

- UTC0705 “Logan Bluff Landslide Risk Analysis,” Dr. James Bay, PI. *Funded by UDOT.*

## OTHER PROJECTS EXECUTED BY UTAH TRANSPORTATION CENTER COLLEAGUES

- “Structural Health Monitoring Using Vibrational Techniques of a Multi-span Flyover Bridge,” Dr. Marvin Halling, PI.
- “A Comparison of Time Dependent Prestress Losses in a Two-span, Prestressed Concrete Bridge,” Dr. Paul Barr, PI.
- “Dynamic and Static Behavior of a Curved Girder Bridge With Varying Boundary Conditions,” Dr. Paul Barr, PI.
- “Long Term Health Monitoring of the San Ysidro Bridge,” Dr. Paul Barr, PI.

# 2006-07 PRESENTATIONS & PUBLICATIONS

## PRESENTATIONS

*listed alphabetically by lead author*

- Chen, A., Chootinan, P., and Wong, S.C. (2006) Link overload minimization versus reserve capacity maximization in the network design problem. Proceedings of the 11th Hong Kong Society of Transportation Studies Conference: Sustainable Transportation, Hong Kong, P.R. China, edited by S.C. Wong, T.D. Hau, J.J. Wang, K.W. Chau, and H.W. Ho, pp. 205-214.
- Chen, A. and Chootinan, P. (2007) Handling inconsistency of traffic counts in path flow estimator. Paper presented at the 6th Triennial Symposium on Transportation Analysis (TRISTAN), June 10-15, 2007, Phuket, Thailand.
- Chen, A., Kongsomsaksakul, S., and Zhou, Z. (2007) Assessing network vulnerability using a combined travel demand model. Paper presented at the 86th annual meeting of the Transportation Research Board, Washington, D.C., USA.
- Chen, A., Kim, J., Zhou, Z., and Chootinan, P. (2007) An alpha reliable network design problem. Paper presented at the 86th annual meeting of the Transportation Research Board, Washington, D.C., USA.
- Hsieh, K.H., Halling, M.W., and Barr, P.J. "Comparisons of Excitation Sources for Use in Structural Health Monitoring," Proceedings of the Fourth World Conference on Structural Control and Monitoring, San Diego, CA July 2006. (Contributed)
- Jansuwan, S., Chootinan, P., and Chen, A. (2006) A constrained generalized least squares technique for origin-destination trip table estimation: An application in Paramics. Proceedings of the 11th Hong Kong Society of Transportation Studies Conference: Sustainable Transportation, Hong Kong, P.R. China, edited by S.C. Wong, T.D. Hau, J.J. Wang, K.W. Chau, and H.W. Ho, pp. 249-258.
- Jansuwan, S., Chootinan, P., and Chen, A. (2007) Visual PFE: A convex programming approach for estimating O-D trip tables from traffic counts. Proceedings of the 12th National Convention on Civil Engineering, 2-4 May 2007, Phitsanulok, Thailand.
- Kukay, B., Barr, P.J. and Halling, M.W. (2007) "A Comparison of Time Dependent Prestress Losses in a Two-Span, Prestressed Concrete Bridge." Proceedings ASCE Structures Congress, Long Beach, CA. May, 2007.
- Recker, W., Zhang, H.M., Chu, L., Chen, A., and McNally, M. (2006) Development of methods and tools for managing traffic congestion in freeway corridors. Paper presented at the 9th Annual International IEEE Intelligent Transportation Systems Conference, Toronto, Canada.
- Yim, K., Wong, S.C., Chen, A., and Wong, C.K. (2007) A reliability-based land use and transportation optimization model. Paper presented at the International Symposium on Land Use and Transportation, 16 March 2007, Seoul, Korea.



## PUBLICATIONS

*listed alphabetically by lead author*

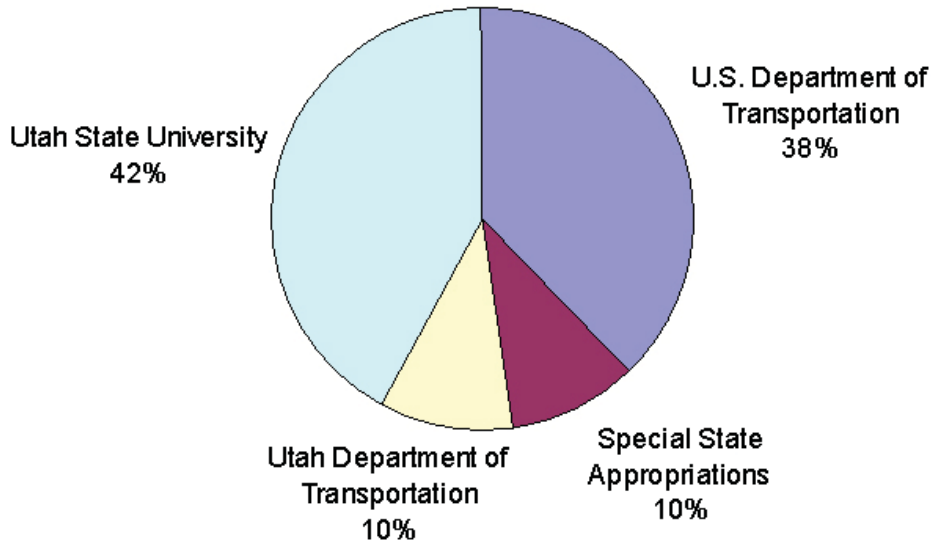
- Chen, A., Subprasom, K., and Ji, Z. (2006) A simulation-based multi-objective genetic algorithm (SMOGA) for build-operate-transfer network design problem. *Optimization and Engineering Journal*, 7(3), 225-247.
- Chen, A. and Subprasom, K. (2007) Analysis of regulation and policy of private toll roads in a build-operate-transfer scheme under demand uncertainty. *Transportation Research, Part A: Policy and Practice* 41(6), 537-558.
- Chen, A., Chootinan, P., and Wong, S.C. (2006) New reserve capacity model of a signal-controlled road network. *Transportation Research Record*, 1964, 35-4.
- Chootinan, P., Chen, A., Horrocks, M., and Bolling, D. (2006) Multi-year pavement maintenance programming using a stochastic simulation based genetic algorithm approach, *Transportation Research Part A: Policy and Practice*, 40A, 725-743.
- Hsieh, K.H., Halling, M.W., and Barr, P.J. (2006) "Overview of Vibrational Structural Health Monitoring with Representative Case Studies," *ASCE Journal of Bridge Engineering* Vol 11 No 6 Nov/Dec 2006.
- Lee, M., Chen, A., Chootinan, P., Laabs, W., and Recker, W. (2006) Modeling network traffic for planning applications in a small community. *ASCE Journal of Urban Planning and Development*, 132(3), 156-159.
- Mertlich, T.B., Halling, M.W., and Barr, P.J. (2007) "Dynamic and Static Behavior of a Curved-Girder Bridge with Varying Boundary Conditions," *ASCE Journal of Performance of Constructed Facilities*, Vol 21, No 3, May/June 2007.
- Subprasom, K. and Chen, A. (2007) Effects of regulation on highway pricing and capacity choice of a build-operate-transfer scheme. *ASCE Journal of Construction Engineering and Management*, 133(1), 64-7.
- Zhou, Z., Chen, A., and Han, D. (2007) An extended alternating direction method for variational inequalities with linear equality and inequality constraints. *Applied Mathematics and Computation*, 184(2), 769-782.

## UTAH TRANSPORTATION CENTER PUBLICATIONS

*available at the Utah Transportation Center Website: <http://transportation.usu.edu>*

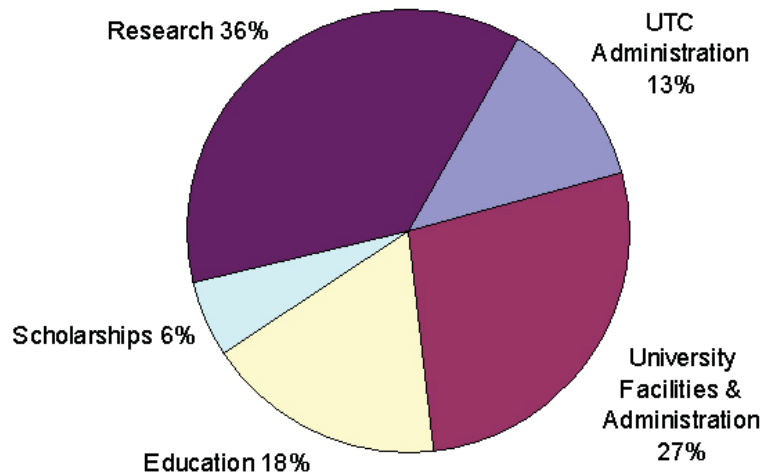
- UTC Project UTC0706      Winstead, C., "Wireless Broadband for Commuter Rail: 'River of RF'," 2007.

## UTAH TRANSPORTATION CENTER FUNDING



**FUNDING  
BY SOURCE**  
*Total budget  
for FY2007 is  
\$1,138,890.00 and  
includes funds from all  
sources*

**FUNDING  
BY USE**  
*includes all funds  
expended and  
encumbered during  
FY2007*



# ADVISORY BOARD

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**Clair Fiet**

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**Ian M. Friedland, P.E.**

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**Ron Hynes**

Deputy Associate Administrator, Federal Transit Administration

**Jim McMinimee, P.E.**

Director, Project Development Division, Utah Department of Transportation

**Benjamin Tang, P.E.**

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*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,*





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