Midwest Transportation Consortium
2005–2006 Annual Report

Prepared by

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Introduction

The Midwest Transportation Consortium (MTC) recently completed its seventh year of operation. At this point, the MTC has become an established portion of the research and educational programs at Iowa State University (ISU) and the MTC's other partner universities. Additionally, the MTC continues to emphasize its primary focus of developing human capital. The academic year completed in spring 2006 saw the largest number of transportation scholars ever enrolled, roughly 30 students enrolled at ISU. We also recognize that the federal grant is an opportunity to build programs at our respective universities that will continue after the U.S. DOT University Transportation Center Program may end (UTC) Program. In last year's report, we proudly announced that the University of Missouri, St. Louis was developing a transportation Ph.D. program within its business college. This year, University of Missouri, St. Louis has started a Ph.D. program in Logistics and Supply Change Management, predominately through the UTC program. Because this is the only Ph.D. program in the St. Louis metropolitan area, it has the opportunity to provide a long-lasting impact on an important national transportation hub.

The MTC has also been the driving force in establishing a MS program in Geography with an emphasis in Transportation at the University of Northern Iowa. This year, two more students graduated through this program and will be looking to begin their transportation careers in the Midwest. At the University of Missouri, Columbia, the Transportation Infrastructure Center has continued to build its program on the project started by the MTC. The University of Missouri, Columbia has been working to build important ITS-related research facilities, including the Translab and the Translab North, which will be discussed further in this report. In addition, as we announced in last year's report, ISU has generated two related initiatives, the Road and Infrastructure Management and Operations Systems (RIMOS), and the Center for Weather Impacts on Mobility and Safety (C-WIMS).

The MTC research program has always played two key roles. The first key role was to serve as the primary funding source for a competitive research program. When adequate funding was available, a competitive research program was conducted through proposal solicitation to all universities in the region with a transportation research program. The second key role was to leverage federal funds to influence the scope of projects, or even to help make certain projects possible. For example, the Iowa DOT Office of Safety has a small state-funded research program, and the office wanted to have clear zone guidance for research on urban streets (streets with curbs and gutters). Roadway construction projects were sometimes not funded or left incomplete because meeting clear zone requirements was too expensive. Moreover, failing to complete projects often had greater negative safety impacts than occasionally violating clear zone guidelines. However, the Office of Safety only had $25,000 to examine this problem. The Iowa Highway Research Board has far greater resources and had this same research problem in its backlog of topics, but needed sufficient reasons to advance project funding. The MTC management agreed to provide the equivalent of a half-time graduate student for one year to the project (a value of about $25,000), and the Iowa Highway Research Board agreed to advance the project and provided about $53,000 in funding. Each of the three participants

is pleased with the outcome of the project's funding, and all three parties will share in the acknowledgement of the project.

During its seventh year, the MTC's ability to influence other research funding organizations continued. Each of the projects from these organizations will acknowledge the MTC funding, and the findings will be published as the findings of the University Transportation Center in Region 7. However, during year seven, the MTC's educational program became so large that little funding remained for an MTC competitive research program. Recognizing that the education program was consuming much of our federal grant and wishing to have even a modest research program, we announced a mini-grant program, predominately targeted to universities and investigators who had not been actively involved in the MTC program in the past. We distributed a call for proposals for mini-grants, which had the impact we wished it to achieve. We allocated $60,000 to this program and then distributed requests for proposals from institutions around the region that had not traditionally participated in the MTC program. Ultimately, we funded two small projects (each for $20,000, $10,000 in MTC funding at Missouri State University (formerly Southwest Missouri State University in Springfield, Missouri), one project at Wichita State University, and one in the Department of Mechanical Engineering at Iowa State University (a group that had not participated in the MTC). In most cases, the PI conducting research is not able to attract the necessary level of non-federal matching funds for a normal-sized project ($40,000 to $100,000), and most matched dollars are provided through the PI's institution by providing faculty time to match federal dollars. It was hoped that, by using small-funded projects, new researchers would be attracted to become engaged in the MTC.

As part of the ongoing MTC program, we have established an effective network that promotes the education of future transportation professionals and the development of new knowledge about managing transportation infrastructure and services in a sustainable manner. The MTC has a record of developing outstanding students; these students are now becoming leaders in the private sector, government, and academia. The MTC has also supported the development of an extensive research portfolio related to sustainable transportation asset management, and more research projects are in the pipeline. Finally, the MTC has dedicated itself to the dissemination of asset management research results through an ongoing technology transfer program. This document describes the progress for the latest fiscal year of operation of the MTC, which ran from October 2005 through September 2006.

MTC Organization and Theme

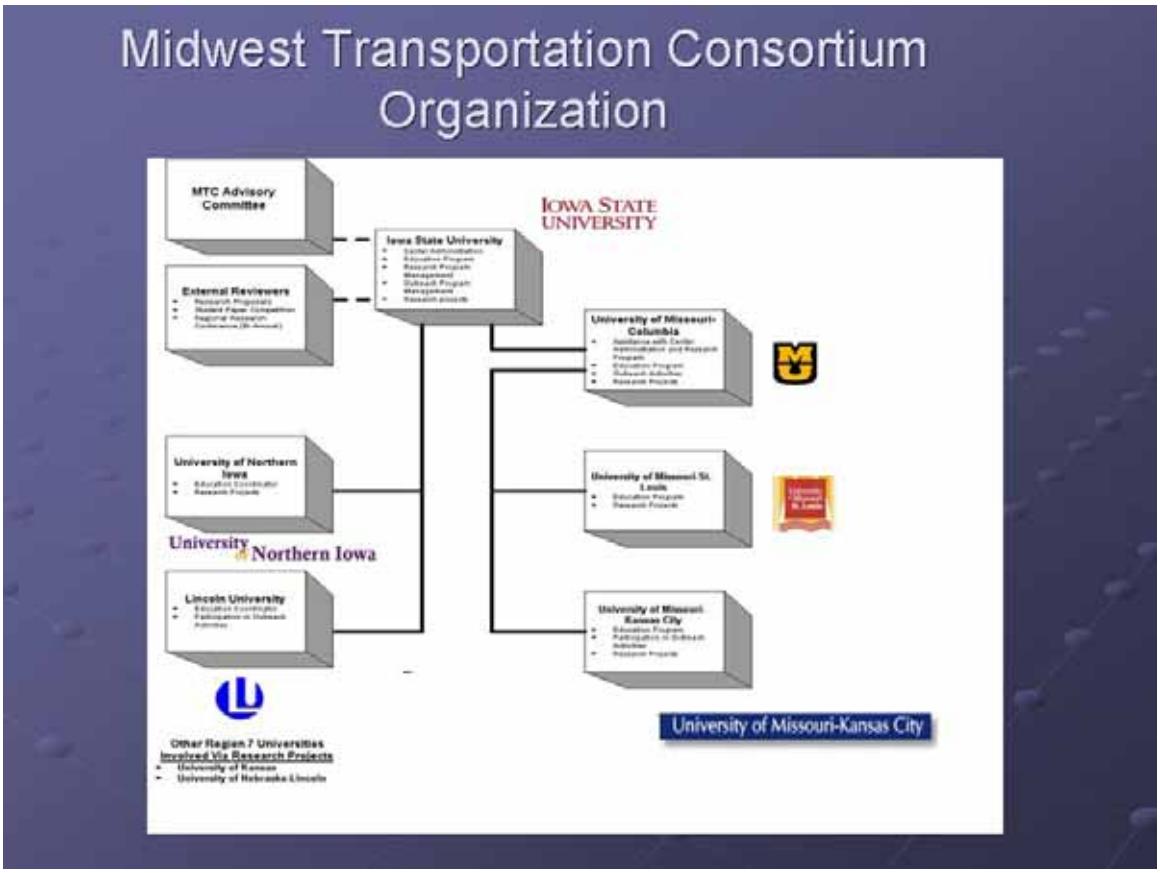
The MTC is one of ten regional UTCs located in the ten federal regions of the United States. These ten centers were established through a regional competition. The MTC is now entering its eighth and final year of existence. The MTC is the University Transportation Center for Region 7, which includes the states of Iowa, Kansas, Missouri, and Nebraska.

The MTC is organized as a constellation of six cooperating educational institutions. Two universities make up the administrative core of the consortium and employ the center director, Dr. Tom Maze at Iowa State University, and associate director, Mr. Charles Nemmers at the University of Missouri, Columbia. The other four universities are involved in the education and research functions of the consortium. The University of Northern Iowa and the historically Black institution, Lincoln University, had essentially no involvement in transportation education and research before the MTC was established.

Administrative Core: Two universities
- Iowa State University
- University of Missouri, Columbia

Junior Partners: Four universities, primarily serving educational functions
- University of Missouri, Kansas City
- University of Missouri, St. Louis
- University of Northern Iowa
- Lincoln University (Jefferson City, Missouri)

A diagram of the consortium organization is shown below. Most of the administrative functions of the consortium take place at Iowa State University. These functions include reviewing and contracting MTC-funded competitive research projects and educational competitions. The University of Missouri, Columbia provides a single point of administration for the participation of the three University of Missouri system campuses. This includes administering all budgets and contracts. The University of Missouri, Columbia also coordinates some of its activities with Lincoln University, which is located nearby in central Missouri. The University of Missouri, Kansas City appears on the diagram below because it was one of the MTC's original partners, though this university's transportation program is essentially dormant.



The theme of the MTC is "Transportation Management Systems and Operations Focusing on Sustainable Asset Management." As such, the MTC participating institutions are working to prepare students to be leaders in an industry that is quickly evolving from a paradigm of building transportation systems and infrastructure to managing transportation systems and infrastructure for best results. The MTC aims to integrate operations, management, and renewal disciplines, as well as traditional construction.

The MTC concentrates on education and human capital development, believing that a new generation of leaders is needed to help make the transition from the building era to the managing era. The need for leadership is pressing, given the large number of retirements that are occurring among today's leaders in the transportation industry. The MTC's emphasis on creating new transportation professionals is illustrated in the distribution of funding. Typically, more than half of the resources managed through the MTC go to support the MTC's educational program, and the majority of these funds support graduate assistantships and undergraduate students completing degrees that will support a career in transportation. In the last year, our education program grew so large that it consumed most resources managed by the MTC, resulting in a very small research program in 2005–2006. The MTC management saw the predominant focus of resources on educational programs as a success, indicating the attractiveness of our transportation education program and the need to provide new human capital to transportation interest in the Midwest and throughout the United States.

The MTC has a number of central focus areas for its expenditures:

- To fund graduate assistantships for the next generation of industry leaders
- To develop new courses and new course materials for transportation asset management
- To attract new faculty members and researchers involved in transportation and transportation asset management activities
- To provide regional leadership for advancing transportation asset management through competitively funded research projects and technology transfer activities
- To make a national contribution through participation and leadership in asset management via involvement in organizations such as the Transportation Research Board, and the American Association of State Highway and Transportation Officials

Key Consortium Personnel

The MTC's key personnel consist of a Director, an Associate Director, and Educational Coordinators at each MTC member school. As of the end of the 2005–2006 fiscal year, the key personnel were as follows:

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MTC Educational Activities

One of the primary missions of the MTC is to develop the future leaders—the human capital—for the transportation industry in our four-state region. Today's students will become tomorrow's transportation experts, managers, and teachers. The MTC accomplishes this mission in a variety of ways, including supporting a portion of almost fifty graduate research assistantships at our member institutions, organizing student competitions, supporting student travel, and sponsoring a unique multi-university, interdisciplinary transportation seminar each spring.

2005 MTC Scholar of the Year

Hillary Isebrands

Iowa State University Ph.D. student, Hillary Isebrands, was named MTC student of the year for 2005. After earning her bachelor's degree in civil engineering from ISU in 1997, Isebrands worked for six years as a transportation engineer in highway design for an engineering consulting firm in Wisconsin. She returned to ISU to attend graduate school in 2003, and completed her master's degree in 2004.

Isebrands is currently working on several research projects at ISU's Center for Transportation Research and Education, as well as her dissertation research on modern

roundabouts in rural settings. She published her first journal paper last year, and presented two papers at TRB in January 2006. Isebrands will embark this fall on a scanning tour of several countries in Europe, including the United Kingdom, France, and Italy, to learn more about rural roundabouts.

MTC Students at TRB 2006

The MTC helps students fund their travel and attendance at the TRB's Annual Meeting. The TRB Annual Meeting attracts almost 10,000 transportation researchers and practitioners from around the globe and is an extremely rich learning experience for students. Following are a few ISU students' reactions to the TRB experience.

Eric Fitzsimmons

This trip has been the highlight of my graduate school experience at Iowa State. I now have a better understanding of what the transportation side of civil engineering deals with and what possibilities are out there for my future.

One of my favorite sessions was about airport terminals of the future. The topic was whether we should design airports to be great gathering places or design an airport around low cost carriers. The panelists literally disagreed with each other.

Neil Burke

I attended a session on the application of public-private partnerships in highway financing. Having written a course paper on this topic, I thought I was fairly well versed on it. I found out that there are many additional variables to consider and from different viewpoints than those I included in my course paper.

Victor Lund

Viewing TRB presentations on well thought out research projects further deepened my interest in transportation research. However, it was also educational to view some presentations on research projects that were not well thought out. The presentations that I thoroughly enjoyed include the "Airport Terminal of the Future" and a presentation by ISU's Dr. Charles Jahren, "Deciding When to Pave an Aggregate Road." Not only did the presentations deepen my interest in research, but they also strengthened my desire to produce professional work in everything I do.

Jon Wiegand

The most interesting part of the conference was discovering what makes a quality technical paper and presentation. After listening to various question and answer sessions, along with discussion outside of the room, I learned about the key factors that are required to improve the research's credibility. The conversation of participants outside of

the presentations was also interesting, discussing research that is not published yet and hearing what is currently being done at other locations.

Dan Ormand

One of the topics I learned more about at TRB was perceptual countermeasures to reduce speeds. Decreasing the lane width, pavement width, or lateral clearance are perceptual countermeasures I have been aware of. The use of pavement markings such as transverse bars and peripheral transverse lines to reduce speeds is an idea I found to be very interesting.

Eric R. Petersen

It was a good opportunity to network with professionals and, with the help of the employment opportunities room, I was able to set up interviews with potential employers.

Transportation Scholars Conference 2005

In mid-November of each year, the MTC coordinates and hosts a student paper competition for its four-state region. This Transportation Scholars Conference seems to have become more competitive every year.

Two students were named co-winners in the student paper competition. Devi Prasad Tulasi (University of Missouri, Columbia) and Tom Stout (ISU) were each awarded $1,000. Tulasi won for “Asset Management System for Communication Towers Operated by the Missouri Department of Transportation.” Stout won for “Matched Pair Safety Analysis of Four-Lane to Three-Lane Roadway Conversions in Iowa.”

In 2005, other students presented about

- Dedicated truck lanes on interstates
- Nighttime road construction
- Managing data for long-term health monitoring
- Offsetting opposing left-turn lanes at signalized intersections
- Taxicab industry’s regulatory structure
- Modernizing a proven automated transit system to enhance cost effectiveness

All presented student papers for the years 2000 through 2005 are available on the MTC website at www.ctre.iastate.edu/mtc/papers/.

UNI Steers Students toward Transportation Careers

When Jess Elder, James Gerjevic, and Matthew Kajewski started their master’s programs in the Department of Geography at the University of Northern Iowa, they weren’t

particularly interested in transportation. Elder was interested in GIS and planning, Gerjevic in GIS and remote sensing, and Kajewski in GIS and computer science. With MTC support and faculty encouragement, all three students were able to develop their interests in transportation, combine them with their backgrounds in geospatial technologies, and enter careers as transportation professionals.

Jess Elder, who studied the application of travel demand models to university campuses, landed a job with the Federal Aviation Administration in Washington, D.C., as a GIS analyst/cartographer on flight path and terrain analysis. (He's since taken a job with the National Geographic Society.)

James Gerjevic, after completing his thesis on the extraction of transportation infrastructure data from hyperspectral remote sensing imagery, found work as a GIS specialist at the Union Pacific Railroad. His focus is on the management of railroad infrastructure assets.

Matthew Kajewski conducted research on the automated query and analysis of crash statistics in a GIS environment using MapObjects, Visual Basic, and CrimeStat (a point pattern analysis package). He now works as a GIS architect/programmer at IMAPS, LLC, a firm in the St. Louis area involved in GIS, navigation, and aviation flight planning. Kajewski's work deals with aeronautical and nautical navigation applications and charts for the National Geospatial-Intelligence Agency, the U.S. Navy, and the U.S. Coast Guard.

UNI Grad Makes Good at Union Pacific Railroad

James Gerjevic was involved in a project to make the process of locating railroad maps more efficient. It included scanning and georeferencing 15,000 or so paper maps. It also involved developing some ArcIMS and stand-alone applications to deliver the maps to the people who wanted to see them. Union Pacific was pleased with the results, so much so that its real estate department's GIS group has grown from one person to five. The project was featured in the spring 2005 edition of ArcNews.

Former ISU Transportation Scholars on the World Stage

Two recent ISU transportation scholars have been active in world affairs. Reggie Sinha, who is now an instructor in International Business at the Des Moines Area Community College, was recently involved in a high-level trade mission involving the State of Iowa and the nation of India. It is expected that the visit will open new opportunities for Iowa and India companies to work together in areas of agriculture, biotechnology, manufacturing, transportation, and education.

Another recent student, Turhan Yerdelen, has changed employers. Turhan was a traffic safety expert with the Turkish National Police. As of October 2006, he has worked for the United Nations at its headquarters in New York City. He works for the Department of Peacekeeping Operations (DPKO) Transport Section as "Transport Safety Officer."

Turhan will be acting as the DPKO focal point for all safety matters related to ground transportation, including road safety and vehicle workshop safety.

Former ISU Transportation Scholar Reggie Sinha (right) presents a poster to the President of India, Dr. Avul Pakir Jainulabdeen Abdul Kalam (left)

MTC Spring Transportation Seminar Series

Bascule construction during the Woodrow Wilson Bridge reconstruction project in Washington, D.C.

Each spring, the MTC plans and hosts a seminar series for transportation students at all MTC universities. Each seminar is also broadcasted in real-time to students at the University of Northern Iowa and other sites in Missouri via Internet-based compressed videoconferencing technology. The table below indicates the spring 2005 speakers and topics for the seminar series.

Date	Speaker	Topic
Jan. 13	Steven Chien (New Jersey Institute of Technology)	Microscopic Traffic Simulation
Jan. 20	Brian Chandler (Missouri DOT)	Midwest Highway Safety Scanning Tour
Jan. 27	Alexander Kurgansky (Consultant to U.S. Environmental Protection Agency, SmartWay Transportation Partnership)	Freight Transportation Energy and Environmental Issues
Feb. 3	Mike McGee (Federal Highway Administration)	Woodrow Wilson Bridge Reconstruction Project, Washington, D.C.
Feb. 10	Rich Pirog (Aldo Leopold Center)	Transportation Sustainability Issues
Feb. 17	Chris Fulcher (Community Information Resource Center and Center for Agriculture, Resource and Environmental Systems)	Integrated GIS for Planning and Public Policy Decision Making
Feb. 24	Ron Vititoe (Barrier Systems, Inc.)	Improving Traffic Flow with Movable Barriers
March 3	Gerald Rawling (Chicago Area Transportation Study)	Chicago Freight Hub Issues
March 10	Kevin Dolliole (Lambert-St. Louis International Airport)	St. Louis Airport and Aviation Issues
March 24	Earl Newman (Springfield, Missouri)	Report from the Vice President of ITE
March 31	Wes James (National Ag-Based Lubricant Center, University of Northern Iowa)	The National Ag-Based Lubricant Center (NABL) and Transportation Sustainability
April 7	Ben Allen (Iowa State University Provost) and Neil Burke	Future Freight Capacity Needs
April 14	James Brunke (The Boeing Company)	Boeing Company Supply Chain Issues
April 21	Michael Dreznes (Quixote Corporation)	Utilizing Forgiving Highways to Reduce “Needless Deaths”
April 28	Joe Pestka (Missouri DOT) and Michelle McEnany (Iowa DOT)	Airports and Their Impact on the Economy

Iowa State University Study Abroad in Rome Program, Summer 2006

Traffic in Central Rome

Every other year, Iowa State University students are given a unique opportunity to study transportation in Italy through the College of Design's Rome Program, supported through a combination of student fees and university funds. Located in the heart of the city, the college's Rome studio provides facilities for graduate and undergraduate programs in community and regional planning and a variety of other design disciplines. Knowledgeable ISU and European faculty provide students with the unique opportunity to learn both through classroom studies and through experiential excursions to museums, buildings, ancient monuments, and other sites in and around this historic and cultural center.

The Iowa State Rome Studio hosts scores of students in design disciplines throughout the year, but this is only the second year that the summer program offered transportation and regional planning curriculum. These courses were included in the summer 2006 roster as part of the Urban Sustainability Program. Coursework for this program focused on transportation and development issues; this year, David Plazak taught all transportation offerings. The Rome summer transportation program attracted students from Community

and Regional Planning and Civil Engineering who were able to take several classes, including a course in transportation planning, a studio in urban wayfinding system design, and an independent study of the Rome traffic limitation/road pricing program. In accordance with the interdisciplinary spirit of the Rome Program, faculty intermingled transportation issues with urban design, energy policy and governance issues, providing students with new frameworks for tackling design complexities.

In the first half of the summer, students learned the economics and geography of transportation through seminars, workshops, site visits, and class exercises. In the second half of the program, students explored the spatial and economic structures of Rome through the lenses of urban design and sustainability.

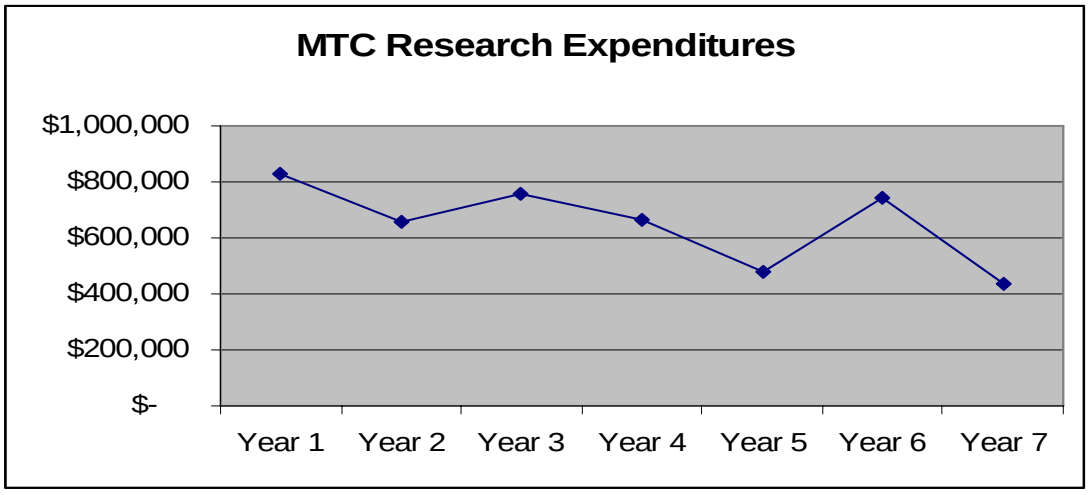
Transportation Graduate Education Certificate Program

During the summer of 2006, and in subsequent conference calls, several of the current regional UTCs have been working together to establish a transportation graduate distance learning certificate program. The driving idea is that several universities would offer graduate courses through a distance learning format, and the groups would certify a series of courses to represent a curriculum in graduate transportation education.

The program is still in the embryonic phase, but the MTC and several other universities have contributed $10,000 in support of this effort. Prior to the MTC's involvement, Tom Humphrey (the group's consultant and former Region 1 UTC director) has been working with several industry groups (e.g., AASHTO, ITE, APTA, etc.) to establish interest in the certificate. Although ISU will not house the Regional UTC in the future, the MTC plans to participate in the distance learning programs and support the University of Nebraska, Lincoln while it asserts itself as the new UTC lead for the region. While it is still unclear as to how the certificate program will materialize, we plan to continue supporting the program.

MTC Research Program

The Midwest Transportation Consortium competitive research program diminished this year due to the MTC's growing educational program and the reduction in federal funding for obligation limits. The amounts over the course of the grant to date, which have been spent on research, both competitively awarded research and research the MTC shared with other sponsors, is shown in the graph below. The roughly $400,000 in expenditures were either expenditures from prior-year research awards or expenditures on research projects for which the MTC's primary role was to provide matching funds to influence project funding and to support students conducting research on projects.



Annual MTC research expenditures

In terms of expenditures, there are two general types of MTC research projects: (1) proposals submitted to the MTC as part of the MTC's competitive research program and (2) projects for which the MTC participates in a research project through the support of graduate students assigned to conduct research on the project. Both types of projects are partially supported by the MTC, and both are counted as MTC projects. The MTC is generally treated as the home for projects selected through the MTC's competitive program and projects for which MTC funding helps leverage projects.

Because only a small amount of funding was available for research during 2005–2006, we announced a small competitive research program offering small grants. These grants were viewed as small seed funds, and we expected to fund mostly graduate research projects. Next year, when federal funds expand from nominally one million dollars to two million dollars per year, the research program will expand again. All past and present research projects can be viewed at http://www.ctre.iastate.edu/mtc/projects/yr1projects.htm.

All MTC-funded projects are expected to provide technology transfer of research results. Many of the results of funded projects have been presented at conferences and workshops, such as regional workshops on asset management, past National Transportation Asset Management workshops, the TRB's Annual Meeting each January, and the Mid-Continent Transportation Symposium, a program shared on alternating years by CTRE and the Midwest University Transportation Center at the University of Wisconsin, Madison. Printed research summaries have been prepared for selected projects, and web documentation has been prepared for all completed projects.

During the 2005–2006 funding year, the MTC produced a brief request for mini-proposals. This award cycle had three primary objectives:

1. To involve researchers and universities that had not previously been involved in MTC research to expand the institutional and geographical coverage of the MTC in Region 7

2. To create opportunities on a small enough scale to allow faculty with meager non-federal resources to become involved in MTC-funded research
3. To provide opportunities principally of a scale that would involve primarily the support of graduate students

This request for mini-proposals only required a two-page response, including a budget, and the request was sent directly to universities and researchers that had not typically received support from the MTC. In cases where the MTC could identify faculty who had not been involved in transportation education or research in Region 7 universities, the request for proposals was sent directly to faculty members. The universities canvassed are too many to report here, but the MTC was successful in gaining the attention of faculty in the Logistics and Supply Chain Management Program at Missouri State University, Industrial and Manufacturing Engineering at Wichita State University, and Mechanical Engineering at ISU (not traditionally involved in the MTC). The two projects funded in Missouri involved trucking fleet energy conservation and conversion to alternative fuels by truck fleets, the project funded in Kansas investigated the use of logistics in the Katrina disaster relief efforts to understand how intermodalism might be more efficiently used in the future, and the ISU project involved the adoption of biodiesel by commercial carriers in Iowa.

In anticipation of a larger allocation of federal funds during year eight, the MTC conducted a research focus group meeting in St. Joseph, Missouri, in late March 2006 to generate research interest and to generate interest by non-federal research funders. The theme of this meeting was traffic operations and traffic safety research. Individuals from all four states were invited and attended. The announcement of this meeting and the meeting final report are posted on the MTC web site, http://www.ctre.iastate.edu/mtc/news/2006/research_forum.htm.

The topics identified at this meeting will be used as a focal point for project selection during year eight. Investigators will be encouraged to select topics from this list and involve regional participation in the project (from local and state agencies in Iowa, Kansas, Missouri, Nebraska, and beyond). This process typically works well for gaining buy-in from non-federal sponsors. As can be seen from meeting report, the Iowa, Missouri, and Kansas DOTs were well represented, as was the Nebraska Governor's Highway Safety Representative. The Federal Highway Administration division offices in Iowa, Kansas, and Missouri were represented, and Mr. Michael Trentacoste, Director of FHWA's Office of Safety Research and Development, attended the meeting.

During year eight, the research selection and competition will return to the normal two-round selection process that has been used in the fall of each year. The year eight research competition will begin when the total allocation of federal funds for year eight is received. During round one, brief (two- to three-page) research prospectuses are submitted by PIs from any academic institution in US DOT Region 7 (Iowa, Kansas, Missouri, and Nebraska). Submitted prospectuses are ranked by academic reviewers from outside the region. About 30% to 50% of prospectuses are selected for further development. During round two, detailed proposals are requested. Matching funds must

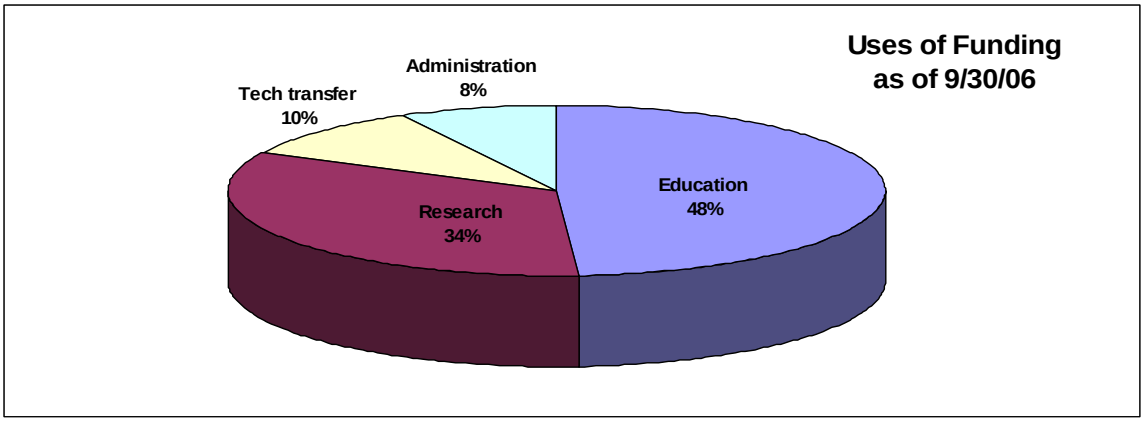
be guaranteed with a letter of commitment for match (50% match must be provided at a minimum, including cash and/or "soft" match).

Associate Director, Charles Nemmers leading research focus group on work zones

Through summer 2006, the MTC had funded 25 research projects at six lead universities in three states through a competitive solicitation. Additionally, the University of Nebraska, Lincoln was a subcontractor for an MTC project. The MTC's competitively selected projects are listed below, but do not include the many projects for which the MTC promoted a project by providing a student to influence project advancement:

- Iowa State University (12)
- Missouri State University (2)
- University of Kansas (1)
- University of Missouri, Columbia (4)
- University of Missouri, Kansas City (1)
- University of Missouri, St. Louis (2)
- University of Northern Iowa (2)
- Wichita State University (1)

The pie chart below clearly shows that, over the course of the MTC program to date, the MTC has emphasized the use of funds to support students working on research assistantships (the education portion of our budget). This is consistent with our plan for the MTC and our objective of focusing on generating future human capital. About one-third of our funds have focused on our competitive research program, although we expect a great deal of growth in the competitive research program in year eight, when our funding will roughly double.



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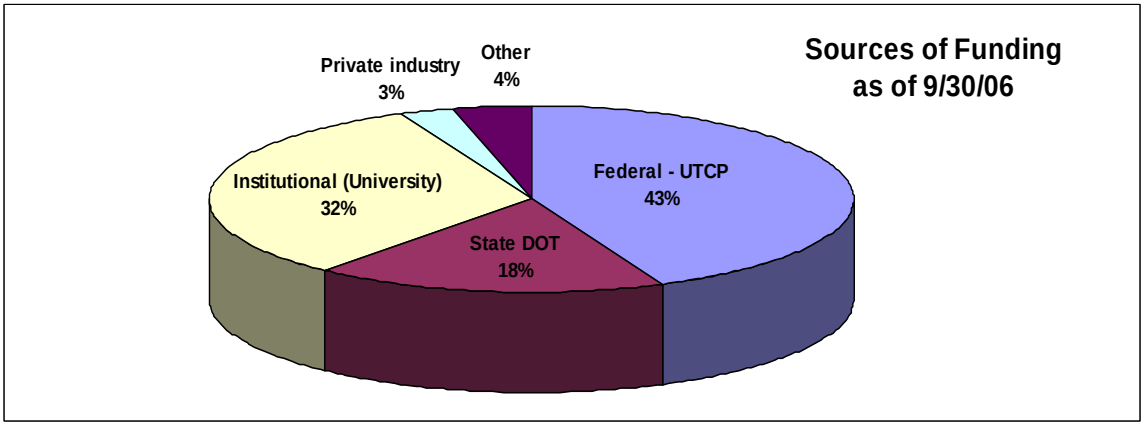
The source of MTC funding is shown in the pie chart below. While federal funding accounts for less than half of the total, institutional funding (from the universities themselves) accounts for about one-third of all expenditures. Institutional sponsorship includes overhead forgiven costs, tuition for students, funding from internal sources, and contributed faculty time.



All of the MTC's competitively selected projects are listed on the MTC website, along with reports and technology transfer briefs. Technology transfer briefs are two- to four-page glossy handouts that are developed using as many graphics as possible and conveying the implications of the research in common terms. One to two hundred copies of the briefs are often printed, but briefs are more commonly distributed electronically.

A sample technology transfer brief is illustrated on the following three pages.

MTC
MIDWEST TRANSPORTATION CONSORTIUM

RESEARCH PROJECT TITLE
Synthesis of Procedures to Forecast and Monitor Work Zone Safety and Mobility Impacts

DATE
October 2005

SPONSOR
Federal Highway Administration Pooled Fund Study

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MORE INFORMATION
www.ctre.iastate.edu/mtc/projects/2005-01.htm

KEY WORDS
lane closure capacity—lane restriction—road closures—work zone capacity

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The mission of the Center for Transportation Research and Education (CTRE) at Iowa State University is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, and reliability while improving the learning environment of students, faculty, and staff in transportation-related fields.

ctre Center for Transportation Research and Education
IOWA STATE UNIVERSITY

Optimizing Work Zone Road Closure Capacity

tech transfer summary

Objectives

Improve understanding of the impact of a variety of traffic characteristics, roadway features, and environmental variables on the capacity of work zone lane closures.

Problem Statement

As urban and even rural multi-lane roadways become more congested, the proper timing of lane closures for construction or maintenance work becomes critical. The key is to leave enough capacity and avoid unacceptable delays and waiting lines upstream from the closure. The balance between traffic volume and the number of vehicles that can pass through a work zone determine the delay. For example, if a lane restriction reduces the maximum throughput to 1,300 vehicles per hour (VPH), but 1,500 vehicles arrive in an hour, then we would expect a 200-vehicle-long queue at the end of an hour (1,500 – 1,300 = 200). Assuming the volume of arriving traffic cannot be controlled, the queue length and, hence, the length of delays are a function of the remaining capacity.

Several states have policies, either written or unwritten, regarding when and under what conditions a lane restriction will be allowed for maintenance and/or construction work. These policies are based on an assumption of the capacity remaining when a lane restriction is implemented. Some states have even created manuals or lookup tables that designate when a lane can be restricted so that unacceptable queues are avoided.

Mechanics of Lane Restriction Queuing

Figure 1 illustrates the mechanics of queuing. It shows volume and speed for a work zone lane closure before a queue is formed, during the queue, and after the queue has subsided. On the upper part of the graph is a plot of the traffic volume (in five-minute intervals) passing the lane closure taper, which restricts traffic to one lane immediately before the work area. On the lower part of the graph is a plot of the speeds averaged over the same five-minute intervals. The left vertical line represents the time when the queue first starts, and the right vertical line represents the time when the queue ends.

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Sample technology transfer brief, page 1

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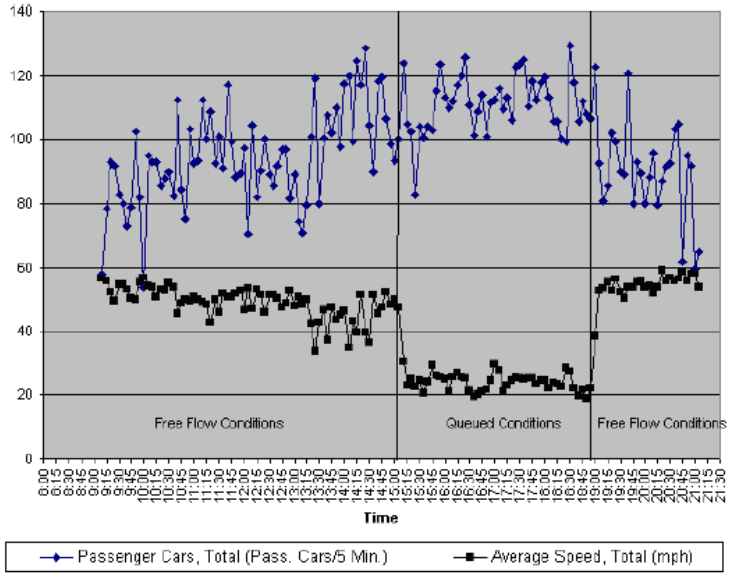

Figure 1. Work zone lane closure flow and speed over time

If the objective of analyzing a restriction is to understand when queuing is likely to begin, free-flow capacity should be used. If the purpose is to calculate queue length and delay after queuing has started, then queue discharge capacity should be used. Methods and computer programs used to estimate the impacts of work zone road closures, such as *Highway Capacity Manual* methods and QUEWZ and its derivative models, including QUEWZ3, QUEWZ-85, QUEWZ-92, and QuickZone, all use queue discharge value for their capacity estimate. If transportation managers are trying to manage traffic volumes so that a queue does not form, then they should focus on the free-flow capacity and seek management strategies that keep traffic volumes below free-flow capacity.

Since the volume of traffic passing the taper before and after queuing occurs varies from one five-minute interval to another, the maximum number of vehicles varies. The average speed drops when queuing begins, and, although it is difficult to tell due to the variation in the volumes, a modest drop occurs in the maximum number of vehicles passing the lane restriction after queuing begins. The maximum flow before the queuing starts is known as the "free-flow capacity," and the maximum flow after queuing starts is called the "queue discharge capacity."

Factors that Impact Lane Closure Capacities

The capacity of a lane closure is dependent on a number of location-specific variables. However, the volumes in Figure 1 illustrate that even when conditions are held constant, maximum throughput (capacity) varies and none of the values specifically represents the capacity of a lane closure. Instead, the maximum throughput is really a distribution of values.

Table 1 lists variables that impact capacity of lane closures. Although many variables are outside of the control of state transportation agencies (e.g., the weather), some variables can be controlled (e.g., the location of merge points relative to grades). The table is intended to provide work zone managers insight into factors that cause the capacity of work zone lane restrictions to vary from location to location.

Benefits of Implementation

- Developers of work zone traffic control plans will understand how a variety of traffic characteristics, roadway features, and environmental variables can impact the capacity at work zone lane restrictions.
- Designers may be able to avoid features that negatively impact the capacity of lane closures.

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Table 1. Variables known to impact work zone capacity

Variable impacting capacity	Attributes associated with variable	Known characteristics
Work zone lane closure configuration	The capacity of a lane closure is dependent on the number of lanes left open and closed and the location of the lane or lanes closed.	When one or more lanes are closed, the remaining open lane(s) have less capacity than normal through lanes. For example, when one lane of a two-lane segment is closed, the open lane has less capacity than one normal lane due to merging. Also, right lane closures result in lower capacity than left lane closures because the right lane generally carries more traffic, resulting in more vehicles merging into the open lane.
Intensity and location of work	The capacity of the open lane will be impacted by visible construction work in proximity to the open lane(s).	Even when there is a concrete barrier between the driver and the construction activity, drivers will slow when the work is in close proximity to the open lane. Intensity and location of work have been found to negatively impact capacity by 1.85%–12.5%.
Percentage of heavy vehicles	Due to their poor speed change performance, high percentages of heavy vehicles will reduce capacity of the through lanes.	Because of poor speed change performance, trucks have a greater impact on capacity after queuing than during free flow. On level terrain and in work zone merge areas, trucks equal 2.4 passenger cars and buses equal 1.5 passenger cars.
Driver characteristics	Drivers that have experience with the work zone are likely to select shorter headway, and capacity will increase.	Commuters making routine trips are familiar with the work zone and are more likely to reduce headways through the work zone. During off-peak hours, capacity reduces by approximately 7% and, during the weekends, by 16%.
Entrance ramp locations and volumes	Ramps in the area of the work zone are likely to create more turbulence in the traffic flow and reduce capacity.	The capacity of the open lanes should be reduced by at least the volume of the ramp within or downstream of the taper.
Grade of lane closure	Positive grades will diminish the capacity of open lanes, particularly where there is a high proportion of heavy vehicles.	At only a 3% grade, passenger car equivalent factors for trucks increased from 2.4 to the range of 2.7–3.2. Positive grades are likely to have the greatest impact if they are located at the lane closure merger point.
Duration of work	As the work zone duration increases, drivers are more likely to be familiar with the work zone and reduce their headways, thus increasing the capacity of the work zone with time.	See comments above for driver characteristics.
Weather conditions	The *Highway Capacity Manual 2000* contains reductions in maximum volumes due to weather.	During trace rainfalls, urban freeway capacity is reduced by 1%–3%; in rainfalls of 0.01–0.25 inches per hour, capacity is reduced by 5%–10%; and for rainfalls above 0.25 inches per hour, capacity is reduced by 10%–17%.
Work time	When work is scheduled at night to avoid peak travel times, traffic control presents significant challenges. Drivers are more frequently impaired by drugs or fatigue and generally behave differently due to lower visibility and glare caused by roadway lighting.	Significant differences in traffic flow exist for nighttime work zones and for daytime work zones.
Location of merge point and enforcement	Merging upstream from the taper point of a lane closure increases capacity more than late merging. However, when using early merge, drivers not following expected merge discipline skip to the head of the queue and force themselves into it, creating a crash risk and turbulence, thus diminishing any efficiency gained through an early merge.	Very little is known about the benefits of enforcement, and most studies of enforcement focus on safety benefits, as opposed to traffic flow efficiency benefits. It is believed that using enforcement personnel to support smooth behavior improves traffic flow.

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Outreach and Technology Transfer Program Highlights

In terms of outreach and technology transfer, the MTC this year has disseminated research results to the community of transportation practitioners through the worldwide web and the new technology transfer summary series of publications. The MTC has also published two newsletter issues, most distributed via the Internet.

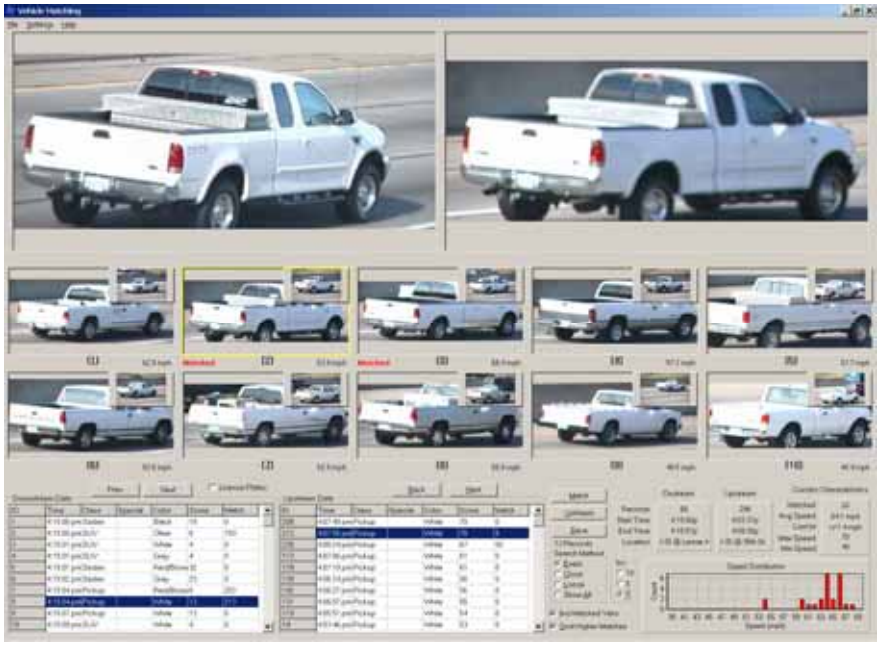
This summer, MTC management spent a large amount of time attempting to reauthorize itself as the Region 7 regional transportation center. The MTC launched an unsuccessful bid to continue as the regional transportation center. This bid was followed by a proposal to become a Tier 1 center, which was successful. Writing two proposals and working with consortium members became the focus of management for several months. The good news from these two competitions is that the MTC will continue, but with new consortium members. After years of competition, Iowa's two major research universities, ISU and the University of Iowa, will be joined together in the same consortium.

During the summer of 2006, the MTC also co-sponsored the Mid-Continent Transportation Symposium at the University of Wisconsin, Madison. Over the last year, the MTC developed an agreement with the University of Wisconsin University Transportation Center (MURTC) to share the conference; on alternating years, it will be held in either Madison or Ames. The summer of 2006 was the first time the University of Wisconsin, Madison hosted the conference, and as a result the conference tended to be smaller than prior conferences in Ames. However, we are certain that the conference will expand in the future. In the summer of 2007, the conference will be hosted in Ames. Prior conferences have been a biennial regional event with roughly 100 paper presentations and about 300 attendees. In the past, several MTC project investigators have presented, and we expect several to present during the 2007 conference.

In November 2007, the seventh National Asset Management meeting was held in New Orleans. The MTC co-sponsored this meeting, and MTC staff helped to plan the meeting. The MTC was also well represented on the agenda.

Related Resources

With the leverage garnered through the students supported by the MTC, the University of Missouri, Columbia was able to develop Translab and Translab North. These laboratories support ITS, traffic operations, and traffic safety research at that university. An important research capability of Translab is determining traffic flow performance. The video screen captures below illustrate the tracking capabilities of Translab for evaluating traffic conditions. The tracking system yields traffic parameters, such as travel time and density, and can be used for measuring travel time reliability.



Example of video image processing and anonymous vehicle tracking

Translab is also central to the development of an instrumented vehicle that can collect driver behavior information. Advanced radar and video detectors have been designed and installed for in-vehicle data collection. Microscopic-level traffic data and lane changing times can then be derived using the laboratory video and computing equipment. The screen capture images below were taken during studies on I-70 in St. Louis, Missouri.

Example of microscopic traffic data collection

Year Seven Performance Indicators

for the

Midwest Transportation Consortium

Lead Institutions:

Iowa State University
Center for Transportation Research and Education

University of Missouri, Columbia
Transportation Infrastructure Center

October 2006

Goal 1 - *Education*: *A multidisciplinary program of course work and experiential learning that reinforces the transportation theme of the Center.*

Performance Indicator 1a. In the Appendix to your Strategic Plan, you provided a baseline list of undergraduate and graduate courses offered by the institution[s] comprising your Center that you considered to be part of a transportation curriculum. Provide a list of courses that have been added or deleted since your submission of the baseline list.

Courses Added:

- **Introduction to Transportation Engineering** (*Iowa State University*)
- **Urban Transportation Planning and Modeling** (*Iowa State University*)
- **Analytical Photogrammetry and Geographic Information Systems** (*Iowa State University*)
- **Physical and Geometric Geodesy** (*Iowa State University*)
- **Transportation Symposium** (*University of Missouri - Columbia and St. Louis*)
- **Software Applications in Supply Chain Management** (*University of Missouri - St. Louis*)
- **GIS Applications** (*University of Northern Iowa*)
- **Transportation Geography** (*University of Northern Iowa*)
- **Public Sector Accounting** (*Lincoln University*)
- **Infrastructure Management** (*University of Missouri - Columbia*)
- **Contemporary Issues in Transportation** (*University of Northern Iowa*)
- **Transportation Policy Planning** (Iowa State *University*)
- **Domestic Transportation** (*University of Missouri - St. Louis*)
- **Transportation Geography** (*University of Northern Iowa*)
- **Regional Economic Theory and Methods** (*University of Missouri - Columbia*)
- **GIS I** (*University of Northern Iowa*)
- **GIS II** (*University of Northern Iowa*)
- **Regional Analysis and Planning** (*University of Northern Iowa*)
- **Transportation Seminar** (*University of Northern Iowa*)
- **Railroads in American Life** (*University of Missouri - Columbia*)
- **Advanced Traffic Operations** (*Iowa State University*)
- **Transportation Systems Development and Management Laboratory** (*Iowa State University*) *
- **Advanced Highway Design** (*Iowa State University*) *
- **Traffic Engineering** (*Iowa State University*) *
- **Aviation in American Life** (*University of Missouri – St. Louis*)
- **Principles of Transportation Economics** (*University of Missouri - St. Louis*)
- **Traffic and Transportation Management** (*University of Missouri - St. Louis*)
- **Logistics & Supply Chain Strategic Modeling** (*University of Missouri*)
- **Transportation Safety** (*University of Missouri - Columbia*)
- **Logistics & Supply Chain Strategic Modeling** (*University of Missouri - St. Louis*)

* Reinstated

Courses Deleted:

- **Introduction to Railroad Planning and Design** (*Iowa State University*)
- **Introduction to Airport Planning and Design** (*Iowa State University*)
- **Information Technologies for Construction** (*Iowa State University*)
- **Remote Sensing and Digital Photogrammetry** (*Iowa State University*)
- **Advanced Highway Design** (*Iowa State University*) *****
- **Traffic Engineering** (*Iowa State University*) *
- **Transportation Systems Development and Management Laboratory** (*Iowa State University*) *
- **Surveying and Advanced Surveying** (*University of Missouri - Columbia*)

Performance Indicator 1b. Provide the following information about your Center's transportation education program for the academic year being reported (Yr 7), in comparison with the baseline data (Base) you provided in the Appendix to your Strategic Plan:

Transportation Education	Undergraduate		Graduate		Total	
	Base	Yr 7	Base	Yr 7	Base	Yr 7
1b.1 Number of Courses Offered	43	52	30	31	73	83
1b.2 Number of Academic Departments Offering Them	14	6	9	6	15	12
1b.3 Number of Students* Completing Above Courses	3,501	2932	150	263	3,651	3195
1b.4 Number of Students* Involved in Transportation Research Projects	46	63	81	112	127	175

**Do not track individual students. One student completing three courses or involved in three research projects counts as three students.*

Goal 2 - *Human Resources*: *An increased number of students, faculty and staff who are attracted to and substantively involved in the undergraduate, graduate and professional programs of the Center.*

Performance Indicator 2a. In the Appendix to your Strategic Plan, you provided a baseline list of the advanced degrees that you considered transportation-related and which were awarded by the institution[s] comprising your Center. Provide a list of advanced degrees that have been added or deleted since your submission of the baseline list.

- **Supply Chain Management Track added to MBA/MIS Program** (*University of Missouri – St. Louis*)
- **Ph.D. in Logistics** (*University of Missouri – St. Louis*)

Performance Indicator 2b. Provide the following information about your Center's transportation education program for the academic year being reported (Yr 7), in comparison with the baseline data (Base) you provided in the Appendix to your Strategic Plan:

Advanced Transportation Students	Transportation-Related Degree Programs					
	Masters		Doctorate		Total	
	Base	Yr 7	Base	Yr 7	Base	Yr 7
2b.1 Number of Students* Enrolled	51	87	14	30	65	117
2b.2 Number of Students* Receiving Degrees	22	55	4	6	26	61

**Count individual students. One student pursuing or receiving a dual degree counts as one student.*

Performance Indicator 2c. For each of the individuals who received advanced transportation degrees from the institutions comprising your Center since the start of the grant, provide the following information concerning their first career move after receiving the advanced degree.

Identifier[1]	Citizenship		Title/Position	Is the Position Transportation-Related?		Organization	Type of Organization	
	U.S [2]	Other		Yes	No		Description	Sector[3]
IS01	X		Staff Engineer	X		Snyder	Consultant	I
IS02	X		Staff Engineer	X		Kittleson	Consultant	I
IS03		X	Staff Engineer	X		Benshoof	Consultant	I
IS05	X		Staff Engineer	X		Iowa DOT	State DOT	G
IS06	X		Staff Engineer	X		Wisc DOT	State DOT	G
IS06		X	Staff Engineer	X		O.R. George	Consultant	I
IS07	X		Staff Engineer	X		HNTB	Consultant	I
IS08	X		Staff Engineer	X		HR Green	Consultant	I
IS09	X		Staff Engineer	X		Oregon DOT	State DOT	G
IS10	X		Ph.D Studies	X		U.C. Davis	State University	A
IS11	X		Unknown	X		BRW	Consultant	I
IS12	X		Trans Planner	X		Des Moines	MPO	G
IS13	X		Trans Planner	X		LSC, Inc.	Consultants	I
MC01		X	Unknown	X		Unknown	Consultant	I
MC02		X	Unknown	X		Unknown	Consultant	I
MC03	X		Unknown	X		U of Missouri	Engineering	T
MC05		X	Unknown		X	Greek Military	Military	G
IS14		X	Unknown	X		Wisconsin	Info Tech	I
IS15		X	Unknown	X		Colorado	GIS Firm	I
IS16	X		Unknown	X		Iowa	Construction	I
IS17		X	Unknown			Unknown	Unknown	U
IS18		X	Unknown			Unknown	Unknown	U
IS19	X		Unknown	X		Terracon	Consultant	I
IS20	X		Unknown	X		CH2M Hill	Consultant	I
IS21	X		Unknown	X		Burns, McDon	Consultant	I
IS22		X	Unknown	X		Canada	Unknown	U
MC06		X	Unknown	X		U. of Missouri	Engineering	T
MC06	X		Unknown	X		Corps of Eng.	Design	G
MC07	X		Unknown	X		Corps of Eng	Design/Const	G
MC08		X	Unknown	X		Consultant	Traffic Eng	I
MC09		X	Unknown	X		Consultant	Civil Eng/GIS	I
MC10	X		Unknown	X		Industry	Sup Chain Mgt	I
NI01	X		Law Student		X	U. of Iowa	Law Program	A
NI02	X		Geo Research		X	UNI	Research	T
IS23		X	Unknown			Unknown	Unknown	U
IS24		X	Unknown			Unknown	Unknown	U
IS25	X		Ph.D Student	X		ISU	Research	A
IS26		X	Trans Plan	X		SIMPCO	MPO	G
IS27			Unknown			Unknown	Unknown	U
IS28			Unknown			Unknown	Unknown	U
IS29			Unknown			Unknown	Unknown	U
IS30			Unknown			Unknown	Unknown	U
IS31		X	Unknown			Unknown	Unknown	U
MC11		X	Unknown	X		consultant	Traffic	I
MC12		X	Unknown	X		consultant	Trans.	I
MC13		X	Unknown	X		Univ.Missouri	Civil Eng.	T
MC14	X		Unknown	X		StateDOT	TransEng	G
MC15		X	Unknown	X		Reg.Planning	Trans.Plan	G
MC16	X		Unknown	X		consultant	Trans	I
MC17	X		Unknown	X		Industry	Logistics	I

Identifier[1]	Citizenship		Title/Position	Is the Position Transportation-Related?		Organization	Type of Organization	
	U.S [2]	Other		Yes	No		Description	Sector[3]
MC18		X	Unknown	X		SLConsultant	Software	I
MC19		X	Unknown		X	Atlanta	Consulultant	I
MC20	X		Unknown	X		Industry	Supply Mgt	I
MC21		X	Unknown		X	University	MIS degree	T
MC22		X	Unknown	X		Ukraine	Mkt.Anal.	I
MC23	X		Unknown	X		Industry	Mgt.Spec.	I
MC24		X	Unknown	X		consultant	Trans	I
MC25		X	Unknown		X	Taiwan	Account	I
MC26	X		Unknown		X	university	Research	A
MC27	X		Unknown	X		Industry	Logistics	I
IS32	X		Unknown	X		Unknown	Unknown	U
IS33	X		Staff Engineer	X		Kimley-Horn	Consulting	I
IS34	X		Analyst	X		Iowa DOT	DOT	G
IS35		X	Unknown	X		Unknown	Unknown	U
MC28		X	Unknown	X		Industry	Logistics	I
MC29	X		Unknown	X		Consulting	Consult	G
MC30	X		Unknown	X		Consulting	Distribution	I
MC31		X	Unknown	X		Turkey	Distribution	I
MC32		X	Unknown	X		University	MIS	T
MC33		X	Unknown	X		Consulting	Traffic Eng	I
MC34	X		Unknown	X		State DOT	Civil Eng.	G
MC35		X	Unknown	X		Consulting	Traffic Eng.	I
MC36	X		Unknown	X		Consulting	Civil Eng.	I
MC37		X	Unknown	X		Consulting	Traffic Eng.	I
MC38		X	Unknown	X		Consulting	Traffic Eng.	I
MC39	X		Unknown	X		Consulting	Civil Eng.	I
MC40	X		Unknown	X		Consulting	Civil Eng.	I
MC41	X		Unknown	X		Unknown	Civil Eng.	I
MC42	X		Unknown	X		MPO	Planning	G
MC43		X	Unknown	X		Consulting	Civil Eng.	I
NI3	X		Cartographer	X		FAA	Fed Agency	G
NI4	X		GIS Program	X		IMAP, LLC	GIS Consult	I
NI5	X		GIS Specialist	X		Union Pacific	Railroad	I
IS36		X	Unknown	X		Unknown	Unknown	U
IS37		X	Unknown	X		Unknown	Unknown	U
IS38	X		Unknown	X		Unknown	Unknown	U
IS39	X		Unknown	X		Unknown	Unknown	U
IS40		X	Unknown	X		Unknown	Unknown	U
IS41	X		Unknown	X		Unknown	Unknown	U
IS42		X	Unknown	X		Unknown	Unknown	U
IS43		X	Unknown	X		Unknown	Unknown	U
IS44	X		Unknown	X		Unknown	Unknown	U
MS1		X	Unknown	X		Industry	Distribution	I
MS2	X		Unknown	X		Consulting	Consult	I
MS3		X	Unknown	X		Industry	Distribution	I
MS4	`	X	Unknown	X		Consulting	Traffic Eng	I
MS5	X		Unknown	X		Consulting	Government	G
MS6	X		Unknown	X		University	Teaching	T
MS7	X		Unknown	X		Industry	Distribution	I
MS8		X	Unknown	X		State DOT	Civil Eng.	G
MS9	X		Unknown	X		Consulting	Consult.	I
MS10	X		Unknown	X		Consulting	Consult.	I
MS11		X	Unknown	X		Consulting	Distribution.	I
MS12		X	Unknown	X		Consulting	Traffic Eng.	I
MS13		X	Unknown	X		Industry	Logistics	I

Identifier[1]	Citizenship		Title/Position	Is the Position Transportation-Related?		Organization	Type of Organization	
	U.S [2]	Other		Yes	No		Description	Sector[3]
MS14	X		Unknown	X		Consulting	Civil Eng.	I
MC44		X	Unknown	X		Consulting	Geotech	I
MC45	X		Unknown	X		State DOT	Traffic.	G
MC46	X		Unknown	X		State DOT	Traffic	G
MC47		X	Unknown	X		Consulting	civil	I
MC48		X	Unknown	X		State DOT	traffic	G
MC49		X	Unknown	X		Consulting	civil	I
MC50		X	Unknown	X		Consulting	Trans.	I
MC51		X	Unknown	X		Consulting	Civil	I
MC52		X	Unknown	X		Consulting	Traffic	I
MC53		X	Unknown	X		Consulting	Civil	I
MC54		X	Unknown	X		Consulting	Civil	I
MC55		X	Unknown	X		Consulting	Civil	I
MC56		X	Unknown	X		Consulting	Civil	I
MC57		X	Unknown	X		Consulting	Traffic	I
IS45		X	PhD student	X		UC Berkeley	PhD student	T
IS46		X	Unknown			Unknown	Unknown	U
IS47	X		Unknown	X		Kimley Horn	Consulting	I
IS48		X	Unknown			Des Moine MPO	MPO	G
IS49		X	Instructor	X		DMACC	Com College	T
IS50	X		Lecturer	X		Iowa State	University	T
IS51	X		Researcher	X		Montana State	University	T
IS52	X		Unknown	X		Barr Nunn	Trans.	I
IS53	X		QA Coordinator		X	Burke Corp.	Food Distributor	I
IS54	X		Unknown		X	ATK Thiokol	Aerospace	I
IS55	X		Logistics Dev.	X		Anderson Wind	Mfg	I
IS56		X	Distrib Analyst	X		Emerson Mgmt.	Mfg	I
IS57	X		SCM Program	X		Swift & Co.	Food Manufact	I
IS58		X	Planner	X		Climax Moly	Mfg	I
IS59		X	Unknown			Unknown	Unknown	U
IS60	X		SCM Program	X		John Deere	Mfg	I
IS61	X		IE Ops Leader	X		Rockwell Collins	Defense	I
IS62	X		SCM Program	X		John Deere	Mfg	I
IS63		X	Unknown			Unknown	Unknown	U
NI6	X		GIS Associate	X		Overland Park	City Government	G
NI7		X	Ph.D. Student	X		Oklahoma State	University	T
MS15	X		Unknown	X		Industry	Logistics	I
MS16		X	Unknown	X		Consulting	Distribution	I
MS17		X	Unknown	X		Industry	Distribution	I
MS18	X		Unknown	X		University	Phd	A
MS19	X		Unknown		X	University	Change	T
MS20	X		Unknown	X		University	MIS	T
MS21		X	Unknown	X		Distrib Center	Distribution	I
MS22	X		Unknown	X		Conulting	Independent	I
MS23	X		Unknown	X		Industry	Distribution	I
MS24	X		Unknown	X		Greece	Mkg. Anal.	I
MS25	X		Unknown	X		State dot	Traffic	G
MS26		X	Unknown	X		India	Logistics	I
MS27	X		Unknown		X	University	Phd	T
MS28	X		Unknown	X		Unknown	Unknown	U
MS29	X		Unknown	X		Consultant	Consulting	I
MS30	X		Unknown	X		Consultant	Trans.	I
MS31	X		Unknown			Unknown	Unknown	U
MS32		X	Unknown	X		Ukrain	Distribution	I
MS33		X	Unknown	X		Consulting	Consulting	I

Identifier[1]	Citizenship		Title/Position	Is the Position Transportation-Related?		Organization	Type of Organization	
	U.S [2]	Other		Yes	No		Description	Sector[3]
MS34		X	Unknown			Unknown	Unknown	U
MS35		X	Unknown			Unknown	Unknown	U
MS36		X	Unknown			Unknown	Unknown	U
MC58	X			X		Consultant	Civil Eng	I
MC59	X			X		Consultant	Civil Eng	I
MC60	X			X		State DOT	Civil Eng	G
MC61		X		X		Consultant	Traffic	I
MC62		X		X		Consultant	Civil Eng	I
MC63		X		X		Consultant	Civil Eng	I
MC64		X		X		Consultant	Traffic	I
MC65		X		X		Consultant	Civil Eng	I
MC66	X			X		State DOT	Traffic	G
MC67	X			X		Industry	Civil Eng	I
MC68	X			X		Consultant	Traffic	I
MC69	X			U		U	U	U
MC70		X		U		U	U	U
MC71		X		X		University	Civil Eng	A
MC72		X		X		Consultant	Civil Eng	I
MC73	X			X		DOT	Civil Eng	G
MC74		X		X		University	Civil Eng	A
MC75	X			U		U	U	U

[1] Do not report the graduates' names, student numbers or other information that could identify individuals. Instead use some simple identifier that will prevent double-counting of, e.g., a recipient of a Masters degree who then goes on to get a Ph.D.

[2] Includes graduates who are U.S. citizens or Permanent Residents when they make their first career move.

[3] Sector:
A - Advanced Degree Program
G - Government
I - Industry
T - Teaching / Academic Research
U – Unknown

Performance Indicator 2d. Using the information you provided as Performance Indicator 2c, break out by sector the total number of individuals who are U.S. citizens (or permanent residents of the United States) and whose first career moves have placed them in transportation-related positions.

Sector	Number
2d.1 Advanced Degree Program (A)	3
2d.2 Government (G)	20
2d.3 Industry (I)	47
2d.4 Teaching/Academic Research (T)	5
2d.5 Unknown (U)	6

Goal 3 - *Diversity: Students, faculty and staff who reflect the growing diversity of the U.S. workforce and who are substantively involved in the undergraduate, graduate and professional programs of the Center.*

Performance Indicator 3. Provide the following data for the students receiving transportation-related advanced degrees (as shown in Performance Indicator 2b.2) and for all students receiving any advanced degree awarded by the institution[s] comprising your Center.

Diversity of Those Receiving Advanced Degrees	Transportation-Related Advanced Degrees Only		All Advanced Degrees	
	Base	Yr 7	Base	Yr 7 *
3.1 Non-Hispanic White	16	31	2,067	2201
3.2 Hispanic	0	2	31	51
3.3 African-American	0	0	116	119
3.4 Asian/Pacific Islander	8	1	48	54
3.5 Native American	0	0	8	13
3.6 Other	2	27	753	908
Total	26	61	3,023	3346
3.7 Male	22	45	1,631	1543
3.8 Female	4	16	1,392	1803
Total	26	61	3,023	3346
3.9 U.S. Citizens and Permanent Residents	20	34	2,292	2546
3.10 Non-U.S. Citizens	6	27	731	800
Total	26	61	3,023	3346

** Note: Because institutional research data for University of Missouri was not available at the time of this report, data from the previous year was substituted for "All Advanced Degrees" (for Missouri only).*

Goal 4 - *Research Selection: An objective process for selecting and reviewing research that balances multiple objectives of the program.*

Performance Indicator 4a. Provide the following information about your Center's transportation research selection process during the academic year being reported (Year 7):

Transportation Research Selection	Yr 7
4a.1 Number of Transportation Research Project Proposals Submitted to Center	4
4a.2 Number of Transportation Research Projects Awarded by Center	4
4a.3 Total Budgeted Costs for Those Projects	$83,253
4a.4 Number of Individuals Listed as Principal Investigators* in Those Projects Awarded	4

**Count individual Principal Investigators (PIs). One PI overseeing several projects is counted as one PI.*

Performance Indicator 4b. Provide the number and budgeted costs of all research projects which your Center has funded during the year being reported, broken out according to the primary subject of the research.

Primary Subjects of Center-Funded Research in Year 7 (Report each project only once)	Number of Projects	Budgeted Costs (All Sources)
TRANSPORTATION SYSTEM PERFORMANCE:		
4b.1 Measurement, characterization and modeling of system performance and impacts measurement.		
4b.2 Transportation and logistics system operations and management.		
4b.3 Behavioral sciences and human performance.		
4b.4 Transportation planning, economics, and institutional issues.		
4b.5 R&D resource base.		
PHYSICAL INFRASTRUCTURE:		
4b.6 Construction - Improved design and construction practices, processes, structures, and materials.		
4b.7 Maintenance and operations - Technologies and procedures associated with operational efficiency, safety, security, durability, and renewal and maintenance of all categories of transportation infrastructure.		
4b.8 Intermodal facilities - Design and construction principles and technologies specifically relevant to modal connection points.		
INFORMATION INFRASTRUCTURE:		
4b.9 Traffic management - Technologies and systems to maximize infrastructure capacity and improve safety and efficiency, while minimizing environmental impacts.		
4b.10 Fleet operational management - Technologies that facilitate optimal use of vehicles and other assets.	3	$63,253
4b.11 Intermodal operations - Information technologies that facilitate efficient movement of cargo and people among modes and provide needed information to shippers and travelers.		
VEHICLES:		
4b.12 Design and manufacture - Design of new vehicles; development of design tools and principles; application of new materials and technologies, including the investigation of their impacts on safety and security.		
4b.13 Fuels - Vehicle fuels and energy sources, including production and delivery systems.	1	$20,000
4b.14 Technologies involved in inspection, maintenance, repair, disposal and recycling of vehicles.		
OTHER		
4b.15 (Describe)		
TOTAL CENTER RESEARCH		$83,253

Performance Indicator 4c. Provide the number and budgeted costs of the research projects which your Center has funded during the year being reported, broken out according to special focus area. Unlike the previous break-out by research subject, this assessment expects some double-counting, as projects may involve more than one goal, issue or mode.

Center-Funded Research Relating to Special Focus Areas in Year 7	Number of Projects	Budgeted Costs (All Sources)
GOALS:		
4c.1 Safety		
4c.2 Mobility		
4c.3 Economic Growth and Trade		
4c.4 Human and Natural Environment		
4c.5 National Security	1	$20,823
ENABLING RESEARCH:		
4c.6 Human Performance and Behavior		
4c.7 Advanced Materials		
4c.8 Computer, Information and Communication		
4c.9 Energy and Environment	4	$83,253
4c.10 Sensing and Measurement		
4c.11 Tools for Modeling and Design		
MODAL ORIENTATION:		
4c.12 Air		
4c.13 Highway	4	$83,253
4c.14 Maritime		
4c.15 Rail		
4c.16 Transit		

Goal 5 - *Research Performance: An ongoing program of basic and applied research, the products of which are judged by peers or other experts in the field to advance the body of knowledge in transportation.*

Performance Indicator 5. Provide the following information about your Center's transportation research performance during the academic year being reported (Year 7):

Transportation Research Performance	Yr 7
5.1 Number of Peer-Reviewed Transportation Research Reports and Books Published	0
5.2 Number of Transportation Research Papers Accepted for Presentation at Academic / Professional Meetings	6
5.3 Number of External Awards Received for Transportation Research	0

Goal 6 - *Technology Transfer: Availability of research results to potential users in a form that can be directly implemented, utilized or otherwise applied.*

Performance Indicator 6. Provide the following information about your Center's technology transfer and outreach efforts during the academic year being reported (Year 7):

Transportation Technology Transfer and Outreach	Year 7
6.1 Number of Visitors to Transportation Center Website	73,025
6.2 Number of Peer-Reviewed Transportation Research Publications Available on Website	0
6.3 Number of Transportation Outreach Events Conducted for Pre-College Students	6
6.4 Number of Pre-College Students Participating in Those Events	365
6.5 Number of Transportation Seminars, Symposia, Distance Learning Classes, etc., Conducted for Practicing Professionals	40
6.6 Number of Practicing Professionals Participating in Those Events	1265
6.7 Number of Transportation Center Newsletters and Other Transportation Periodicals Published	1
6.8 Number of Issues Produced	2
6.9 Total Circulation	550
6.10 Number of Transportation Technology Products Deployed	5