The Infrastructure Technology Institute

UNIVERSITY TRANSPORTATION CENTER STRATEGIC PLAN: 2007 - 2011
# Table of Contents

**Section I – Program Overview**
- I.A Glossary .................................................................................................................. 3
- I.B Center Theme ............................................................................................................. 4
- I.C Center Director’s Summary .......................................................................................... 5

**Section II – Program Activities**
- II.A Research Selection .................................................................................................... 11
- II.B Research Performance ............................................................................................. 14
- II.C Education .................................................................................................................. 15
- II.D Human Resources .................................................................................................... 17
- II.E Diversity .................................................................................................................... 18
- II.F Technology Transfer ................................................................................................. 19

**Section III – Management Approach**
- III.A Institutional Resources ........................................................................................... 21
- III.B Center Director ....................................................................................................... 21
- III.C Center Faculty and Staff ......................................................................................... 22
- III.D Multiparty Arrangements ....................................................................................... 22
- III.E Matching Funds ....................................................................................................... 22

**Section IV - Budget Details**
- IV.A Grant Year ............................................................................................................... 24
- IV.B Salaries ..................................................................................................................... 24
- IV.C Scholarships ............................................................................................................ 24
- IV.D Permanent Equipment ............................................................................................. 24
- IV.E Expendable Property & Supplies ............................................................................ 24
- IV.F Domestic Travel ...................................................................................................... 24
- IV.G Foreign Travel ......................................................................................................... 25
- IV.H Other Direct Costs .................................................................................................. 25
- IV.I Facilities & Administrative (Indirect) Costs .............................................................. 25
- IV.J Institute Budget Plan ................................................................................................. 26

**APPENDIX A Baseline Measures for University Transportation Centers** .......... 27

**APPENDIX B Request for Research Proposals** ........................................................... 29
Section I – Program Overview

I.A Glossary

BAC  The Business Advisory Committee of the Northwestern University Transportation Center

CAD  Computer-Aided Design

CCITT  The Center for Commercialization of Innovative Transportation Technologies Northwestern’s SAFETEA-LU “Tier II” center

CEE  The Department of Civil and Environmental Engineering at Northwestern University (also refers to courses taught in the Department)

CEET  Northwestern University’s Center for Energy-Efficient Transportation

HSIEC  Northwestern University’s Homeland Security Innovation Entrepreneurship Center

ISHM  Intelligent Structural Health Management

ISTEA  The Intermodal Surface Transportation Efficiency Act, 1991

ITI  The Infrastructure Technology Institute at Northwestern University

KTC  Kentucky Transportation Center

MPM  The Master’s of Project Management program within the Department of Civil and Environmental Engineering

MBWG  The Midwest Bridge Working Group

NDE  Non-Destructive Evaluation

NSF  National Science Foundation

NUCu Steel  A specially-alloyed steel containing copper (Cu) developed at Northwestern with ITI support

PI  Principal Investigator

PIRE  Partnerships for International Research and Education

REG  The ITI Research Engineering Group

REU  Research Experience for Undergraduates

RIP  The Research in Progress database of the Transportation Research Board

RITA  The Research and Innovative Technologies Administration of USDOT

RFP  Request For Proposals

SAFETEA-LU  The Safe, Accountable, Flexible, Efficient Transportation Equity Act – a Legacy for Users, 2005

SHM  Structural Health Management

TC  The Transportation Center of Northwestern University.


TRIS  Transportation Research Information System

TRB  Transportation Research Board

USDOT  The US Department of Transportation

UTC  University Transportation Center
### I.B Center Theme

The theme of the Infrastructure Technology Institute is to develop strategies and tools to protect and improve the condition, capacity and performance of the nation’s highway, railroad, and mass transit infrastructure systems.

The Institute does this through the development and deployment of (1) advanced technologies for structural health monitoring, (2) advanced infrastructure materials, analysis and testing techniques, and (3) new tools for integrating infrastructure condition and performance information into system management, investment, and policy decision processes. It is our objective to make ITI the national focal point for the development and exchange of ideas and methods for assessing and assuring the structural and functional health of the nation’s transportation infrastructure.

Leveraging its relationships with both the broad and capable Northwestern faculty community and transportation leaders at the local and national levels, the Institute seeks to match the priorities of the national strategy for surface transportation with the unique abilities of Northwestern University researchers. The work of ITI has consistently supported these priorities as shown by the examples of past research activities in Table 1. With support from SAFETEA-LU, the Institute will continue to track and respond to national research priorities consistent with our theme and expertise.

<table>
<thead>
<tr>
<th>UTC Research Mandates</th>
<th>ITI Area of Expertise</th>
<th>ITI Research Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>USDOT Research Goals</td>
<td></td>
<td></td>
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<tr>
<td>Safety</td>
<td>Geotechnical engineering, nondestructive testing, remote monitoring, fragmentable concrete, concrete design codes</td>
<td>Time domain reflectometry, acoustic emission, scour and displacement monitoring, wireless data transmission, resilient materials, advanced design codes for size effect and shrinkage</td>
</tr>
<tr>
<td>Reduce Congestion</td>
<td>Materials for rapid repair and durability, management &amp; policy studies</td>
<td>Concrete and steel research and development, models and policy studies, Illinois State Toll Highway Authority strategic plan</td>
</tr>
<tr>
<td>Environmental Stewardship</td>
<td>Vibration monitoring</td>
<td>Monitored aggregate quarry blasting, construction vibrations</td>
</tr>
<tr>
<td>Security, Preparedness, and Response</td>
<td>Advanced materials, disruption management</td>
<td>Fragmentable concrete, network modeling for incident management, development of templates to facilitate the mitigation of the impact of transportation system disruptions</td>
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</tbody>
</table>

#### National Strategy for Surface Transportation Research

<table>
<thead>
<tr>
<th>Infrastructure Renewal</th>
<th>Nondestructive testing</th>
<th>Deployment of novel NDE techniques, NDE compendium, wireless data transmission, web-based data management, NDE-aided bridge retrofits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous remote monitoring</td>
<td>Structures, vehicles, tunnels, pipelines, excavations, etc</td>
<td></td>
</tr>
<tr>
<td>Structural modeling</td>
<td>Infrastructure performance, pin &amp; hangar connections, concrete structures</td>
<td></td>
</tr>
<tr>
<td>Life cycle cost</td>
<td>Analysis of maintenance data from over 50 bridges and tunnels</td>
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#### Federal Transit Administration Research Goals

| Equipment and Infrastructure    | Urban infrastructure monitoring                                                        | Monitoring of deep excavations near subways, elevated rail, and pipelines                                                      |

#### Advanced Transportation Research

| Concrete materials              | Ultrasonic concrete curing sensor, cement information web site, low CO₂ cements, concrete for slipform paving |                                                                                                                                  |
| Instrumentation                 | New sensors and techniques, such as TDR and tiltmeters for scour monitoring              |                                                                                                                                  |
| Wireless sensor networks        | Designed award-winning wireless “mote” based monitoring system                           |                                                                                                                                  |

Table 1: ITI activities and UTC research mandates
I.C Center Director’s Summary

Throughout its fifteen-year history, the Institute has developed a program of both short-term and long-term research that has produced significant technological and scientific advances. ITI’s continuous federal funding under ISTEA and TEA-21 has allowed it to make unique long-term commitments to its researchers, who in turn formed a strong and vibrant transportation infrastructure community at Northwestern University and beyond. This community has made great strides in the areas of material research and nondestructive testing and evaluation of transportation infrastructure with an emphasis on remote monitoring of facilities such as the Sturgeon Bay (Wisconsin) lift bridge, shown in Figure 1.

Figure 1: The Michigan Street Lift Bridge in Sturgeon Bay, Wisconsin
Remotely monitored by the ITI Research Engineering Group (REG) since 1995

With the Institute’s support, Northwestern researchers have trained an able cadre of students, assembled laboratories, procured advanced technology and equipment, identified experimental sites around the nation, and enlisted practitioner partners to deploy and test non-destructive evaluation (NDE) technologies for transportation infrastructure. These partnerships have greatly improved both the breadth and depth of sponsored research, and they have increased the ranks of infrastructure practitioners and academics.

ITI researchers have developed and implemented a new steel formulation with characteristics particularly suited for use in bridges. This has already been used to modify a major bridge across the Mississippi River in St. Louis and to build an entire bridge in Lake Villa, Illinois (Figure 2). Derivatives of this steel are being developed for application to railroad tank cars and elsewhere where strength and weldability properties are required.

Figure 2: Route 83 Bridge over the Canadian National Railroad, Lake Villa, Illinois
Used 500 tons of the NUCu steel created by ITI researcher Morris Fine
We have demonstrated our commitment to partnerships with transportation infrastructure practitioners in the technology innovation, application, and commercialization processes from the beginning, thus increasing the likelihood of successfully moving new and better techniques developed in the University into the transportation infrastructure marketplace. Some of our partners have adopted ITI-originated methods in their routine infrastructure monitoring and management programs, and some ITI technologies have been commercialized and made available for broader applications.

Our reputation for advanced infrastructure monitoring has grown through our web site (1.8 million page views in TEA-21 Year 7), conference presentations, and word of mouth, so that infrastructure managers frequently invite us to develop and apply our advanced monitoring technology to their troubled systems or to new construction in sensitive areas (Figure 3 and Figure 4). Our applications to new construction are especially important for facilitating the implementation of transportation infrastructure capacity expansion projects. These same applications are also used to preserve and protect existing transportation infrastructure during nearby construction activities.
ITI has brought innovative technology applications to over sixty sites around the nation, representing twenty states and the District of Columbia, as illustrated in Figure 5. We are especially proud of the growing number of ITI-developed technologies that are being deployed by infrastructure practitioners.

Figure 5: More than sixty deployments across twenty states and the District of Columbia between 1992 and 2006

ITI has further advanced the management of the nation’s bridges by sponsoring the establishment and operation of the highly-regarded Midwest Bridge Working Group (MBWG). The MBWG brings together bridge maintenance and inspection engineers from over 16 states (see Figure 6), as well as federal officials and researchers to learn, share experiences, and solve common problems. These semiannual meetings have proven to be so effective that many states outside the Midwest now send delegates. We are helping other regional peer exchange groups to organize and network at a national scale, including the Northwest and Northeast Bridge Working Groups.

Figure 6: States (in green) actively participating in the MBWG
The Institute has commercialized a number of successful innovations, most notably through Civil Data Systems, a company started by two former Institute student employees, to market new techniques for displaying and analyzing data from remote infrastructure monitoring projects utilizing the Internet. Figure 7 shows an example of a website for infrastructure monitoring produced by Civil Data Systems.

Figure 7: Civil Data Systems' web display of remote monitoring data
To fulfill its commitment to the education of K-12 students, the Institute created a weeklong summer program to interest high school students in infrastructure engineering. This program was offered in 2006 and 2007 as a residential camp for high school juniors. Figure 8 shows high school students on a field trip to inspect an elevated train overpass, as well as a newspaper story about their 2006 design project. The Institute has also experimented with a variety of approaches to teaching lower elementary students about infrastructure technologies and issues.

ITI is in the process of re-evaluating how it will move its K-12 education program forward. While the summer residential camp was a major success, ITI will continue to explore ways to deliver such experiences to assure that the program is consistent with the mission of ITI and USDOT priorities and that it is cost-effective.

At the university level, ITI has developed and taught graduate and undergraduate courses in public infrastructure management and infrastructure facilities and systems. We have also supported the skill development of undergraduate engineering students by offering practical training in surveying, welding, computer-aided design, site visits and career planning (see Figure 9). Through these educational activities we are helping to prepare future generations of transportation infrastructure professionals.
ITI has also made major contributions to inform regional and national debate on transportation infrastructure policy and management. The Director has been a sought-after speaker on infrastructure topics, especially those involving infrastructure project successes. Along with his colleagues, he has published policy statements in both the Midwest and nationally on a variety of infrastructure topics, and he has also provided technical and policy advisory services to over half a dozen transportation infrastructure entities. In October, 2007, ITI co-sponsored the First Annual William O. Lipinski Transportation Symposium on Transportation Policy, which addressed regional congestion with the theme “Focusing on Moving the [Chicago] Region in a New Direction.”

Our vision is that, over the next five years, the Institute will provide national leadership in the development of strategies and tools to protect and improve the condition, capacity and performance of the nation’s highway, railroad, and mass transit infrastructure systems. We will accomplish this by:

- Extending, integrating, and applying ITI’s diverse advanced remote infrastructure monitoring technologies, pursuing emerging infrastructure condition and management problems, new application opportunities, and strategies and tools to bring objective infrastructure condition and performance information into policy and decision processes.

- Sharing and exchanging knowledge of the critical issues of surface transportation infrastructure as well as our own capabilities in structural health monitoring and non-destructive evaluation through the use of the Institute’s web-site as well as active engagement in selected regional and national conferences.

- Expanding ITI’s impact on the policy process, the practice of transportation infrastructure engineering, and scholarship through policy studies, active leadership and participation in symposia and fora that examine and elucidate transportation issues and needs, and media contacts.

We will implement our vision within Northwestern by:

- Enhancing educational programs that introduce and train students at all levels about issues and tools for infrastructure assessment and management, through courses, workshops, and meaningful engagement in research.

- Collaborating with the Department of Civil and Environmental Engineering to hire a clinical professor of structural engineering to bring more advanced structural analysis capabilities to the ITI Research Engineering Group (REG) and to expand the teaching program for undergraduate and graduate students.

- More effectively unifying the broad and unique community of transportation infrastructure researchers at Northwestern with continued monthly research associates luncheon meetings, new communication tools on the Institute’s web site, and active participation in a University-wide Transportation Council created to coordinate the broad diversity of transportation research and educational activities at Northwestern. The Council includes ITI, the Transportation Center, the Center for Commercialization of Innovative Transportation Technology, the Center for Energy Efficient Transportation, the Institute for Sustainable Practices, and the Homeland Security Innovation and Entrepreneurship Center.

- Applying new practices and policies to meet or exceed USDOT requirements:
  - ITI has hired a full time business manager with the primary responsibility of documenting all matching funds.
  - ITI is creating a database to document and report matching resources in a detailed and timely manner.
  - Research proposals and match documentation are now reviewed by the research administrator for the McCormick School of Engineering and Applied Science and the Offices of Sponsored Research and Accounting Services for Research and Sponsored Projects.
  - ITI has hired a communications coordinator to keep the Institute’s web site updated with the latest news, research, and publications which will facilitate compliance with SAFETEA-LU reporting requirements.
**Section II – Program Activities**

**II.A Research Selection**

**Research Selection Goal:** We will continue to apply and refine the objective process for selecting and reviewing research that balances multiple objectives of the program. This process is described in detail in Appendix B.

**II.A.1 Research Selection Baseline Measures**

The Institute awarded funding for nine research projects in Year 8 of TEA-21, six of which were considered to be applied research. During Year 8, ITI invested $1.3 million on research. Detailed baseline measures are listed in Appendix A.

**II.A.2 Research Selection Program Outcome**

The Institute has historically guided its research thrusts based on both direct and indirect guidance from USDOT and transportation infrastructure professionals, as well as from its experienced research team. Figure 10 illustrates the sources of our research priorities. Infrastructure research opportunities increasingly come from system managers who learn about ITI from our web site, publications, or presentations. This not only speaks to our expanding reputation in this field, but also ensures that the work of the Institute is salient to the problems of today.

![Figure 10: Sources of research topic selection](image-url)
II.A.3 Planned Research Selection Activities

**Strategy 1:** Refine the Institute’s longstanding research selection process.

**Initiative 1A:** Expand membership of the Institute’s Research Advisory Panel to include federal representatives.

The Institute currently solicits research proposals and considers unsolicited proposals from Northwestern faculty. The SAFETEA-LU year two request for proposals (RFP) is provided as Appendix B. As detailed in the RFP, the Research Advisory Panel, comprised of four outside experts, including academics, researchers, and/or transportation infrastructure practitioners, reviews the proposals and makes recommendations regarding project approval to the Institute Director who selects projects for funding based on panel guidance, available funds, matching monies, and project costs. For the first SAFETEA-LU research cycle, the Institute has expanded its Research Advisory Panel to include Sheila Duwadi, Team Leader for Bridge Safety, Reliability, and Security at Turner-Fairbanks Highway Research Center.

Review of proposals for continuing research is based first on a careful assessment of the research progress to date, with emphasis on the quality of the work, its applicability to meeting infrastructure needs, its degree of successful transfer to practice, and its ability to attract deployment partners. This review comprises an annual evaluation of research progress and assessment of plans for the next year.

New proposals are evaluated in terms of correspondence to the mission of the Institute, importance and generality of the problem (both locally and nationally), logic of the research plan, qualifications of the researcher, potential for commercialization or other forms of dissemination and implementation, and assurance of matching funds.

The recommendations of the Advisory Panel are based on the criteria stated above, plus the relationship to ongoing research, the proposed budget -- annual as well as multi-year -- related to the Institute's overall research budget, and the correspondence of the work to the USDOT research priorities.

**Strategy 2:** Combine the legislatively-specified research guidelines with our own theme and research strengths to develop a coherent and focused program of transportation infrastructure research.

**Initiative 2A:** Build on the base of the ITI research team’s core competencies in structural health monitoring to craft a research program driven by the needs of transportation infrastructure owners and operators, such as retrofit evaluation, life-extension efforts, and new construction in challenging environments. We will expand on our core knowledge base on continuous remote monitoring of civil infrastructure facilities to gain a more detailed understanding of the effects of the input or causal factors that influence facility performance (e.g., traffic volume, vehicle weights, weather conditions) as well as the direct performance metrics we are already obtaining in the form of engineering measurements. An important thrust of this work will be integrating these data with other intelligence to create and improve decision support systems for action, rehabilitation, and enforcement. In refining these decision support systems, we will seek broader engagement with the interdisciplinary transportation community at Northwestern. We will make more intensive use of the Institute’s already-successful monthly research associates meetings to explore connections among research activities and opportunities for cross-linking; furthermore, we will expand our connection to practitioners through such organizations as FHWA and the Midwest Bridge Working Group to identify needs for new research activities and deployments and to share our expertise.

**Initiative 2B:** More explicitly support national transportation needs – within our theme, core competencies, and matching capabilities - by linking our work more directly to high-priority areas identified by USDOT and its operating administrations. Our faculty leaders will attend and participate in national conferences where such priorities are addressed. These needs will be explicitly set out in the Institute’s yearly RFP (illustrated in Appendix B), and funding decisions will consider project contributions to national needs. As indicated in Table 1, there are already strong connections between our work and USDOT priorities.

**Initiative 2C:** Reach out to policy and modeling researchers at Northwestern to identify opportunities to invest strategically in studies that respond to USDOT priorities, take advantage of our strengths, and offer realistic matching prospects, while maintaining the Institute’s leadership position in SHM. Among the opportunity areas are the following:
• **Decision tools for infrastructure maintenance and rehabilitation:** Our work on continuous remote monitoring generates large amounts of data that can support evaluation and decisions for individual facilities. There are opportunities to link these data streams to decision support tools for infrastructure program management. There is some evidence that even timely data on facility condition may not always motivate effective decision making that not only ensures continued, efficient facility operations, but also reduces the probability of catastrophic failures. Such work may involve the development and application of advance decision support models, as well as studies of the use of data, information, and modeling results in agency decision processes. Research in this area would be applicable to all modes of transportation. Faculty in Civil and Environmental Engineering and Industrial Engineering and Management Sciences may contribute to this work.

• **Transportation network reliability and security:** Incidents on road and rail networks - interruptions in service due to component failures, crashes, spills, maintenance activities, or intentional attacks - are costly in terms of delays, fuel consumption, pollution emissions, and secondary crashes involving injuries and fatalities. Rapid incident response, quick clearance, and network-scale traffic management can moderate the consequences of these disruptions. A broad perspective is necessary, because when a transportation facility suffers a major interruption (in terms of scale and/or duration), the consequences can cascade across the network. Northwestern possesses some of the strongest network modeling and analysis capabilities in the United States, including the development and application of dynamic traffic models, logistics routing and scheduling methods, and simulation and optimization tools. Faculty and students in the Transportation Center, the Departments of Civil and Environmental Engineering, Industrial Engineering and Management Sciences, Electrical Engineering and Computer Science, and Managerial Economics and Decision Sciences in the Kellogg School of Management may be able to contribute to such research.

• **Congestion Management Strategies:** Congestion reduction – and its associated benefits for safety, energy, and environment, is a top USDOT priority. Use of advanced sensors to monitor network flows, analysis tools to support operating decisions, and pricing offer innovative ways to maximize the effectiveness of existing infrastructure. Pricing is receiving increased attention as a tool for moderating congestion, energy consumption, pollution emissions, and crashes. Applications in London and Stockholm have brought considerable success and popular support, and a large scale project is developing in Manhattan. Congestion pricing and tolling in general offer the prospects of an alternative source of funding for transportation that is of special interest as the Highway Trust Fund is consumed. Tolling opens up the prospect for public private partnerships to fund and operate transportation facilities. Travel behavior, network modeling, and policy analysis capabilities at Northwestern, in Civil and Environmental Engineering, the Transportation Center, and Industrial Engineering and Management Sciences offer promising resources for addressing a variety of issues related to pricing and congestion reduction.

• **Centers for Structural Health Management:** Northwestern University, under the leadership of Professor Sridhar Krishnaswamy and Professor Jan Achenbach (recent winner of both the National Medal of Science and the National Medal of Technology) is heading an NSF-funded five-year program to establish a global partnership of universities, laboratories and companies engaged in advanced research and education in Intelligent Structural Health Management (ISHM) of safety-critical aerospace, civil and mechanical structures. This is funded under NSF’s program of Partnerships for International Research and Education (PIRE). This partnership includes research teams in India, China, and Korea, as well as industry partners.

ISHM is an emerging concept aimed at preventing catastrophic structural failure through the use of diagnostic sensors that provide information to support informed predictions about the probable evolution of structural degradation, to provide an estimate of the remaining lifetime of the structure, and if necessary, to identify appropriate remediation actions. ISHM integrates knowledge of sensor technology, smart structures, materials science, structural analysis, nondestructive characterization, failure and damage mechanics, and probabilistic lifetime prognosis.

The work of this new center is closely related to ITI’s SHM, NDE, and remote monitoring theme. Faculty affiliated with the NSF-ISHM program have been developing intelligent SHM systems for aircraft and marine structure applications. ITI has been a leader in developing and implementing strategies for SHM of civil infrastructure systems. The NSF project provides an opportunity for these groups to collaborate on the development of advanced ISHM strategies for civil infrastructure maintenance. This collaboration will include research, education and outreach activities.
Collaborative research will include such activities as developing:

- Sensors with known probability of detection of damage suitable for monitoring bridge condition
- Models to evaluate the current state of the structure based on probabilistic diagnostic data
- Probabilistic failure models appropriate for bridge structures
- Statistical tools to predict the remaining lifetime of the structure
- Probabilistic techniques to determine optimal schedules for inspection

Education and outreach will include such activities as:

- Linking NSF-ISHM researchers with bridge professionals in the ITI constituency (through fora such as the Midwest Bridge Group) to identify technology needs and guide development of new methods for diagnosis, prognosis, and optimization of the decision-making process for infrastructure health management
- Hosting international ISHM researchers and practitioners to share ideas and methods
- Engaging NSF-ISHM graduate students in ITI K-12 outreach efforts

Connecting ITI to this neighboring Center brings us into contact with a broader group of local and distant researchers with whom we share interests. This will enhance our understanding of cutting edge sensor technologies and decision support tools that are being deployed in other applications and locations. At the same time this relationship may present ITI with new application ideas and opportunities and encourage the sharing of our own developments in new systems and settings. By increasing the critical mass of SHM work at Northwestern, the NSF-ISHM center may attract more students to Northwestern and to study and research in the SHM field. This will benefit ITI and the programmatic activities in the field of transportation system management that ITI supports.

To take full advantage of the opportunity this new program presents, we plan to invest up to $200,000 annually in the program which will be matched with Northwestern’s non-federal contribution to this grant. This investment is scaled to support some of the research efforts of the NSF-ISHM Principal Investigators, a research fellow, and two graduate students. Additional funds will be used for equipment, supplies and domestic travel expenses meeting the Federal contract guidelines under which ITI operates.

**II.A.4 Research Selection Performance Indicators**

Approved research proposals will be documented in the new ITI project management database that will include the proposals, budgets, classification (basic, advanced, and/or applied), as well as all reports, presentations, publications, and matching fund commitments. This database will be used to track progress and support federal reporting requirements (see section II.B.4).

**II.B Research Performance**

**Research Performance Goal:** Advance and broaden the program of research on new tools and techniques for infrastructure monitoring, management, and decision making. Where appropriate, the products will be deployed in the field to support practical infrastructure management, with emphasis on new problems, methods, and applications that build on our past successes. Research projects will be presented and published to disseminate knowledge and invite peers and expert assessment to verify their contributions to the body of knowledge in transportation.

**II.B.1 Baseline Measures**

The Institute published 32 transportation research reports in Year 8 of TEA-21. Twelve papers were presented at academic and professional meetings. Detailed baseline measures are listed in Appendix A.

**II.B.2 Research Performance Program Outcome**

The research program will produce an integrated multi-disciplinary research portfolio that best utilizes Northwestern’s capabilities to respond to national transportation infrastructure priorities and needs.
II.B.3 Planned activities

Strategy 3: Subject ITI research to appropriate peer review through publication and presentations.

Initiative 3A: Systematically encourage all ITI PIs to publish their findings in academic and/or professional journals and conference proceedings, and to present them at suitable conferences. This will invite journal-based peer review and subject our work to professional scrutiny, as well as supporting dissemination of results. A complete record of publications and presentations will be maintained in the research database and a web-accessible database on the ITI web site, and project descriptions will be submitted to TRB’s Research in Progress (RIP) web site.

Strategy 4: Continue to improve the quality of ongoing and new research

Initiative 4A: Continue and intensify the monthly research associates luncheon meetings by encouraging fewer and more in-depth, seminar-like presentations, followed by discussions among researchers. Where appropriate, invite practitioners to join these meetings.

Initiative 4B: Leverage and expand researcher-practitioner relationships to open new opportunities for innovation deployment (and matching funds). Target new applications and extensions beyond the range of ITI’s current applications, to push the development and deployment of new, advanced, and more responsive technologies.

Initiative 4C: Increase the quality of funded projects and proposals by more closely monitoring project progress using the research database and raising the threshold for continued and new project funding. For example, both continuing and new projects will be expected to demonstrate their contributions to one of the Institute’s focal research program areas. Insist that practitioners be involved, products specified and managed, and, where appropriate, a technology innovation deployment goal specified and achieved.

II.B.4 Research Performance Indicators

We will use as performance indicators the collection of publications produced during the course of Institute-funded research projects, including but not limited to:

- Project Reports
- MS Theses
- PhD Dissertations
- Conference Presentations
- Conference Proceedings Papers
- Journal Articles

The Institute will maintain a web-accessible database of all research publications and presentation material produced during the course of all research projects. Submission of these publications is a requirement of those receiving Institute funding, as shown in the RFP in Appendix B. Where journal copyright agreements preclude posting published papers, citations and links to those papers will be provided.

We will also measure research performance by the number of new deployments and the number of deployments of new technology applications.

II.C Education

Education Goal: Continue to offer a multidisciplinary program of course work and experiential learning that reinforces the transportation infrastructure theme of ITI.

II.C.1 Baseline Measures

Three transportation-related courses were added to Northwestern’s course catalog since the beginning of TEA-21. During Year 8 of TEA-21, 28 graduate students and two undergraduate students participated in Institute research projects. Detailed baseline measures are listed in Appendix A.
II.C.2 Education Program Outcome

An educational program which increases both the quantity and quality of transportation infrastructure practitioners, researchers, and educators.

II.C.3 Planned Education Activities

Strategy 5: Conduct required education activities

Initiative 5A: Support an educational program that includes multidisciplinary course work and student engagement in research. The content of the Institute-sponsored educational program will be designed to support the national strategy for surface transportation research as summarized in Table 3.

Initiative 5B: Each year the Institute will choose an outstanding student of the year and award that student $1,000 and a trip to attend the award ceremony in Washington, DC during the annual winter meeting of the Transportation Research Board.

Strategy 6: Maintain and expand course offerings and the support of student educational experiences

Initiative 6A: Continue to improve Institute-sponsored courses: Continue to grow CEE 382: Infrastructure Facilities and Systems into a “capstone” team design project course that includes an extensive overview of infrastructure facilities and systems as well. Engage additional faculty experts, as well as outside professionals, in mentoring students in the design projects required for this course. Provide other specific training (computer-aided design, presentation assistance, etc.) as needed. Continue to encourage non-engineering students to join this course to broaden the educational experience.

Initiative 6B: Expand course offerings in transportation systems analysis: Through its contributions to the start-up costs of the new William L. Patterson Distinguished Professor of Transportation, increase and extend the course offerings in transportation systems analysis, modeling, and simulation.

Initiative 6C: The Institute will work with faculty in Civil and Environmental Engineering and elsewhere to select and post on the web site a multi-disciplinary set of courses, at both the undergraduate and graduate levels, in and outside of engineering, that offer essential or special value for those interested in focusing their studies on infrastructure systems engineering.

Initiative 6D: Continue to offer a summer experience to excite students about infrastructure issues and careers. This effort may target high school students, building on the success of our residential infrastructure summer camp. We will also consider a summer infrastructure experience for undergraduate students, along the lines of the well-known National Science Foundation Research Experience for Undergraduates (REU) programs. This might include not only research but some time spent in site visits and internship activities in conjunction with local agencies and infrastructure consultants.

Initiative 6E: Provide modest staff and resource support to student groups engaged in infrastructure-related pre-professional activities, particular design projects and field trips, through undergraduate professional societies, most notably Northwestern’s Student Chapter of the American Society of Civil Engineers.

Strategy 7: Redesign the former Institute-supported Infrastructure Knowledge Services program.

Initiative 7A: Reconfigure the Institute’s communications with our external constituency. The revolution of the Internet has led us to redirect resources previously applied to our Knowledge Services Program to a high profile web-based information system. We have relocated the base for this program from the University Library to ITI. We will continue to invest in library collection enhancement to the extent that matching funds are provided, but the bulk of our knowledge program will be directed to the web. This includes a much enhanced, dynamic web site that better illustrates programs and capabilities of the Institute, provides more substantive information on projects in progress and competed, and includes discussions of new methods and technologies we (and others) are using. In this way we expect to make the ITI web site the place to visit for timely information and ideas about infrastructure condition monitoring and policy.

The web site, in both public and secure divisions, will become the channel for ITI status and progress reporting, making it easy for RITA professional and others to follow our work more closely. Thus, the ITI
web site will provide expanded reporting as required by RITA and desired by ITI. We are confident that a more vibrant and descriptive web presence will attract more deployment opportunities and partners. Web visits will be closely tracked to assess the reach of the site, the interests of visitors, and needs for enhancements.

II.C.4 Education Performance Indicators

Using the University catalog, program and University enrollment information, and the list of student publications in its database (see Section II.B.4), the Institute will track and report on its education performance indicators.

II.D Human Resources

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

II.D.1 Human Resources Baseline Measures

During Year 8 of TEA-21, 16 master’s degrees and 9 doctoral degrees were awarded to students involved in transportation-related degree programs. Detailed baseline measures are listed in Appendix A

II.D.2 Human Resources Program Outcome

An educational program which increases both the quality and quantity of transportation infrastructure practitioners, researchers, and educators.

II.D.3 Planned Human Resources Activities

Strategy 8 - Conduct required human resources activities.

Initiative 8A: Required human resources activities: The Institute will support an average of four scholarships each year for students involved in Institute-supported research.

Strategy 9: Increase the supply and quality of transportation infrastructure professionals, as well as general knowledge of infrastructure technologies and issues through expanded educational efforts both within the University and through the already-successful high school summer program.

Initiative 9A: Expand support for the Department of Civil and Environmental Engineering in skills areas such as computer-aided design, welding, surveying, field and laboratory measurement techniques, and career planning. Utilize the new team project design space in the ITI quarters to support and facilitate team design projects and CEE student community building.

Initiative 9B: Explore alternative means to expand the Infrastructure Management specialty within the Master’s of Project Management program, including enhanced course offerings, alternative course delivery mechanisms, innovative promotion efforts, etc.

Initiative 9C: Share costs of hiring a clinical professor who can contribute to fulfilling aspects of the Institute mission not possible with current faculty. A clinical professor is an experienced professional who can bring unique ideas and skills to the university. The Institute plans to share costs with the Department of Civil and Environmental Engineering for a clinical professor of structural engineering to assist in the Institute’s nondestructive testing and evaluation research, as well as teach practical courses in structural design.

Strategy 10: Use the evolving research plan to draw in new faculty resources from both within and outside the University

Initiative 10A: Form working groups in promising areas. Sponsor seminars, retreats, conference travel, and other activities to help build the working groups.
Initiative 10B: Provide seed money for conferences, proposals, and other community building through the working groups.

Initiative 10C: Sponsor occasional seminars and round tables on multi-disciplinary approaches to transportation infrastructure. Possible early topics include transit and infrastructure security, investment planning, and public-private partnerships. As described above, ITI just co-sponsored a Chicago-focused symposium on congestion – the problem and promising solutions - in conjunction with Northwestern’s Transportation Center and the Metropolitan Planning Council, a highly-respected civic interest organization. This was attended by about 200 people, and it is intended to be an annual event. This event was also available as a web-cast made possible by members of the ITI REG. Presentations from this symposium are now available on the ITI website at: http://www.iti.northwestern.edu/lipinski2007.

II.D.4 Human Resources Performance Indicators

Using program and University enrollment information, the Institute will track and report on its human resources performance indicators.

II.E Diversity

Diversity Goal: Students, faculty and staff who reflect the growing diversity of the nation’s workforce and are substantively involved in the undergraduate, graduate, and professional programs of the Institute.

II.E.1 Diversity Baseline Measures

RITA policy no longer requires collection of diversity data.

II.E.2 Diversity Program Outcome

The Institute’s desired diversity program outcome is to have a student profile enrolled in its curriculum which meets or exceeds the University-wide proportions of minorities and women enrolled in graduate programs.

II.E.3 Planned Diversity Activities

Strategy 11: Ensure diversity in all Institute activities

Initiative 11A: Through its research, education, and technology transfer activities, the Institute will reach out to a diverse set of possible participants

II.E.4 Diversity Performance Indicators

RITA policy no longer requires collection of diversity data.
II.F Technology Transfer

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

II.F.1 Technology Transfer Baseline Measures

During Year 8 of TEA-21, ITI sponsored 27 meetings and symposia for transportation infrastructure professionals with a combined attendance of approximately 868 persons. Detailed baseline measures are listed in Appendix A.

II.F.2 Technology Transfer Program Outcome

The Institute’s desired technology transfer outcome is to promote the commercialization of new technology developed under Institute-sponsored research.

II.F.3 Planned Technology Transfer Activities

Strategy 12: Increase the Institute’s output of scholarly publications

Initiative 12A: Strongly encourage researchers to publish their results in peer-reviewed publications and conference proceedings. Provide incentives in the form of conference travel expenses for faculty and students.

Initiative 12B: Capture all papers, theses, conference presentations, and other research products prepared under ITI sponsorship for posting on our web site as full text or links. Post listings of completed work on the TRB TRIS web site.

Strategy 13: Move Institute-developed technology innovations from the laboratory to the marketplace.

Initiative 13A: Provide assistance to Institute-supported researchers in commercializing innovations developed with Institute support. Such support might take the form of start-up company incubation (as in the case of Civil Data Systems), help in moving inventions through the patenting/intellectual property processes of the University, securing interest of practitioner agency technology deployment partners, and other means. The Institute is especially excited about the new Tier II SAFETEA-LU university transportation center at Northwestern, the Center for Commercialization of Innovative Transportation Technologies (CCITT). CCITT has the potential to substantially augment the Institute’s technology commercialization efforts for late-stage inventions, and it promises to be a vital part of Northwestern’s growing expertise in transportation infrastructure.

Initiative 13B: Expand the efforts of the Midwest Bridge Working Group, a gathering of bridge maintenance and inspection engineers which meets semiannually to discuss common problems and share experiences and solutions. Support formation of new groups, such as newly formed Northwest and Northeast Bridge Working Groups which ITI is incubating informally. Explore ways to extend the reach of this program to a national scale by partnering with other regional groups and organizations. Use web-based knowledge management techniques to capture and communicate meeting results more effectively.
Strategy 14: Actively seek out opportunities for applied research partnerships with practitioners

Initiative 14A: Reach out to practitioner agencies and individuals to partner on innovation deployments. Develop a short document on the Institute’s deployment successes and distribute it to practitioners. Raise the Institute’s profile nationally through networking, the Midwest Bridge Working Group, attendance at conferences and trade shows, participation in activities of the Transportation Research Board and American Association of State Highway and Transportation Officials and other organizations, and direct outreach efforts.

Strategy 15: Increase the Institute’s visibility and reputation with elected leaders and the general public

Initiative 15A: Actively seek out and respond to opportunities to work with media and organizations to provide information about, and advocacy for, transportation infrastructure.

Initiative 15B: Increase activity of ITI leadership in professional organizations, particularly TRB, through papers, presentations, and conference attendance.

II.F.4 Technology Transfer Performance Indicators

Using our own data and information gathered from research principal investigators and conference partners, the Institute will track and report on its technology transfer performance indicators.
Section III – Management Approach

III.A Institutional Resources

Northwestern University is a world-class research institution with strength in a variety of disciplines critical to transportation infrastructure systems; it is also small enough to allow researchers from different disciplines to interact easily and effectively. The McCormick School of Engineering and Applied Science is among the top engineering research institutions in the world and its Department of Civil and Environmental Engineering is consistently rated in the top dozen departments in the United States. The Departments of Materials Science and Engineering and Industrial Engineering and Management Sciences also play active roles in the Institute’s SAFETEA-LU activities, and are each rated in the top five in the nation. The Kellogg Graduate School of Management is consistently rated in the top three in the United States, and its program of Public and Not-For Profit Management enjoys a strong relationship with the Institute. The Institute has also worked with the Medill School of Journalism, the Department of Economics and the School of Law, among others. The University Library, especially the Seeley G. Mudd Library for Science and Engineering and the Transportation Library provide unparalleled reference and document delivery services to Institute-affiliated faculty and staff, as well as to outside users.

The Infrastructure Technology Institute has a strong and developing relationship with Northwestern’s Transportation Center (TC), which has more than a half-century history of research and education focusing on policy, economic, operations and management studies, emphasizing private sector and freight transportation. The Center’s 70-member Business Advisory Committee (BAC), made up of senior executives from shippers, carriers, manufacturers, and financial institutions, provides a strong connection to the transportation industry. Congestion, capacity, and infrastructure condition challenges faced by that industry are central to the mission of ITI. TC and ITI have been working together to study such problems and their solutions. The ITI REG is pursuing partnerships to develop new remote monitoring concepts for some BAC companies that own and operate aging infrastructure systems. Thus, these two strong centers are working together on shared interests.

Northwestern’s USDOT Tier II Center for Commercialization of Innovative Transportation Technology (CCITT) is designed to help bridge the gap between innovation and commercialization in transportation. CCITT was created in close coordination with ITI, and its structure and location within the McCormick School of Engineering facilitate the two organizations working closely together.

Our Homeland Security Innovation and Entrepreneurship Center (HSIEC) has support from the State of Illinois to help commercialize a broad range of security technologies, including those targeting transportation facilities and systems.

Northwestern’s new Center for Energy Efficient Transportation (CEET) focuses on fuels, power plants, and energy storage systems and has an interest in energy conservation through more efficient system management.

An umbrella Transportation Council is under development to integrate this strong collection of transportation research units at Northwestern more effectively. This will be a coordinating body to link the work of ITI, TC, CCITT, CEET, and HSIEC in a unified framework intended to identify and promote inter-unit synergies.

III.B Center Director

As the head of an interdepartmental center within Northwestern’s McCormick School of Engineering and Applied Science, the Director of the Institute is appointed by and reports to the Dean of the McCormick School. The Director is responsible for the day-to-day management and administration of the activities of the Institute, including but not limited to developing, implementing and monitoring the Institute’s annual budget, interacting with federal officials responsible for administering the Institute’s grant funding, and carrying out all other aspects of the Institute’s program.

The Director is responsible for overseeing the Institute’s program of research and development projects, including but not limited to monitoring current research opportunities and needs, establishing and maintaining liaison with transportation infrastructure practitioners who are potential partners in research projects, helping to build research project teams to respond to those needs and opportunities, managing the research project selection process, and administering research projects once they are awarded.
The Director manages the Institute’s technology transfer process through oversight of the Institute’s web site and technology transfer mechanisms, monitoring of commercialization activities of research projects and providing assistance as necessary, and establishing and maintaining liaison with transportation infrastructure practitioners who are targets of technology transfer.

The Director establishes and leads the public information program for the Institute, including but not limited to management of the preparation and dissemination of publications and the conduct of conferences and workshops. Finally, the Director is responsible for securing additional sources of support, including but not limited to research contracts, research partnerships, and grant support.

III.C Center Faculty and Staff

In addition to the Director, the Institute employs three other people to support its administrative and operational activities: Assistant Director, Ms. Elizabeth Brasher; Business Manager, Ms. Colleen Hull; and Creative Coordinator Ms. Melissa Mattenson.

The Institute also employs a four-person research team with experience in non-destructive evaluation and remote monitoring. The Research Engineering Group (REG) includes Chief Research Engineer Mr. Dan Marron and three Research Engineers: Mr. Dan Hogan, Mr. David Kosnik, and Mr. Mat Kotowsky.

The Institute does not directly employ any faculty. Project-related research funding supports all faculty, research staff, and graduate students employed on Institute-supported research projects.

III.D Multiparty Arrangements

The Institute is wholly contained within Northwestern University, and therefore coordination with other universities on other than a technical correspondence basis is not required. The Institute does contract with the Kentucky Transportation Center of the University of Kentucky for management of the Midwest Bridge Working Group, for which KTC provides one-for-one matching funds.

III.E Matching Funds

For match, the Institute has relied heavily on its public and private sector technology innovation deployment partners, and we plan to continue this direction through SAFETEA-LU. Figure 11 illustrates the sources of match earned during Years 6 and 7 of TEA-21. This proven performance leads to confidence in the Institute’s ability to address the match challenge successfully during the 2007-2011 time period.

Figure 11: Sources of match for federal funds for combined TEA-21 Years 6 and 7
Over the life of the SAFETEA-LU grant, the source and amount of matching funds will vary. The Institute is deriving its matching funds for the current fiscal year from a variety of sources. The largest sources of matching funds are the Institute’s technology deployment partners. Figure 11 shows that during Years 6 and 7 of TEA-21, over two thirds of the Institute’s total match came from technology deployment partners. To date, the Institute has undertaken successful research deployment activities at over sixty test sites in twenty states and the District of Columbia (see Figure 5). Beginning in June, 1998 with the enactment of TEA-21, the Institute asked its technology deployment partners to account for their costs of working with the Institute on these deployments. Some of these partner-derived matching funds include earned revenue in the form of direct payments to the Institute for services rendered by the Institute. Others are in-kind contributions including partner expenditures without which the Institute work could not have taken place such as third-party contractor installation of trenches, conduit, power, communications, and other accommodations; the provision of equipment and traffic control; and professional and technician staff time spent on the project. Technology deployment project managers in the Institute’s partner agencies are asked to complete forms detailing and documenting these in-kind contributions, the data from which are then entered into an Institute-maintained database.

While many of the Institute’s faculty researchers also accumulate matching funds from deployment partners, they also use contributed salary and matching from other related non-federal projects. This matching contribution is budgeted as $125,000 for SAFETEA-LU Year 1.

Another source of matching funds is in-kind contributions from the Master’s of Project Management program in the Department of Civil Engineering ($150,000 of match is budgeted for SAFETEA-LU Year 1). Since its inception, the Institute has used the framework of the MPM program to fashion its undergraduate and graduate education program. MPM students take Institute-supported courses, participate in Institute-funded research, and enjoy Institute-provided educational enhancements. MPM and the Institute are strong partners in many aspects of their mutually beneficial education and research activities.

Northwestern University has recently appointed Dr. Hani Mahmassani as the new William A. Patterson Distinguished Chair in Transportation. His work includes dynamic transportation network modeling and simulation and other areas closely linked to the new strategy of ITI under SAFETEA-LU. This includes work on Network Reliability and Security and Congestion Management Strategies (Section II.A.3). Prof. Mahmassani will expand the teaching program in transportation analysis in the Department of Civil and Environmental Engineering and attract more graduate students to transportation studies. He is expected to play a leadership role in Northwestern’s Transportation Center, which will help us integrate the spectrum of transportation research and education resources on our campus. For these reasons, the Institute has committed $98,000 during SAFETEA-LU Year 1 to the start-up package for Prof. Mahmassani, which may cover such costs as support for students and post doctoral scholars, equipment and supplies, and domestic travel. This will be matched with a similar or greater investment of University funds for his research.

As indicated above, the Institute’s subcontractor, the Kentucky Transportation Center, has committed to provide matching funds for the program it manages equaling funding from the Institute ($106,000). Also as indicated above, the nascent NSF Center for Structural Health Management has obtained a commitment for hard and soft University match over the amount of its requested support from the Institute ($250,000 of match per year). Match from the University’s Transportation Library is provided in the amount at least equal to its anticipated support by the Institute ($10,000 is budgeted for SAFETEA-LU Year 1).
**Section IV - Budget Details**

**IV.A Grant Year**

During its six-plus years as a University Research Institute under ISTEA and its six-plus years as a University Transportation Center under TEA-21, the Institute and RITA staff came to the determination that the use of Northwestern University’s September 1-August 31 fiscal year best met both RITA’s and the Institute’s needs. Therefore, the Institute will continue to use the University fiscal year as the program year, and the first-year budget provided under SAFETEA-LU is for the period September 1, 2007 to August 31, 2008, utilizing federal fiscal 2006 funds.

**IV.B Salaries**

**Center Staff:** The Institute staff includes the Director, Assistant Director, Business Manager and Communications Coordinator under Administrative Staff together with a Chief Research Engineer and three Research Engineers under Research Staff. With the exception of the Director, these employees all work 100% for the Institute. Funding is also included under “Other Staff” category for part-time (work-study) student and temporary employee help.

In response to the untimely death of our friend and colleague, founding Executive Director David Schulz, Dean Julio Ottino of Northwestern’s McCormick School of Engineering and Applied Science has appointed Prof. Joseph L. Schofer to serve as Director of ITI. As a long time mentor and colleague of Director Schulz, Prof. Schofer is closely familiar with the work of ITI, and his own expertise is central to the policy activities of the Institute. Initially Prof. Schofer will devote at least 30% of his annual effort to the Institute.

**Faculty and Student:** Projections of faculty and student salaries were based upon the TEA-21 Year 8 “legacy” research budget plus projections of new research initiatives.

**Benefits:** A fringe benefit rate of 22.4% is applied to full-time staff salaries and 1.7% to student salaries.

**IV.C Scholarships**

The Institute will offer four full-time equivalent research assistantships annually, including tuition and stipend.

**IV.D Permanent Equipment**

The Institute does not currently plan to purchase any equipment with a unit cost exceeding $5,000. If this changes, it is understood that prior written permission must be obtained from RITA. Researchers may determine to purchase items of equipment with a unit cost greater than $5,000 as part of their projects. The Institute will continue its past practice of obtaining prior written permission for such purchases.

**IV.E Expendable Property & Supplies**

The Institute is budgeting $183,574 for expendable property and supplies. This amount includes $80,800 for research, $14,874 for undergraduate and graduate educational programs, $87,900 for administration.

**IV.F Domestic Travel**

The Institute is budgeting $99,295 for domestic travel. This amount includes $69,395 for research and $29,900 for administration.
IV.G Foreign Travel

The Institute does not currently plan any foreign travel. If this changes, it is understood that prior written permission must be obtained from RITA.

IV.H Other Direct Costs

The Institute is budgeting $505,000 for other direct costs, including $106,000 for services of the Kentucky Transportation Center to manage the Midwest Bridge Working Group, $35,000 for the K – 12 educational program, $6,000 for undergraduate and graduate educational enrichment, $10,000 for the Library, $40,000 for transportation infrastructure policy conferences, $5000 for Research Associates monthly luncheon meetings, $200,000 for the Intelligent Structural Health Management of Safety-Critical Structures, $5000 for Research Advisory Panel fees and $98,000 for the William A. Patterson Distinguished Professor’s research related to the ITI strategic plan.

IV.I Facilities & Administrative (Indirect) Costs

Northwestern University’s approved federal indirect cost rate is 51%. This is applied to all direct expenses with the exception of tuition and the portion of subcontracts over $25,000.
### IV.J Institute Budget Plan

The Institute’s budget plan in the requested format is provided as Table 2.

<table>
<thead>
<tr>
<th>CATEGORIES</th>
<th>Budgeted Amount</th>
<th>Explanatory Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center Director Salary</td>
<td>$75,000</td>
<td>Includes initial salary for director at 30% time commitment. New ITI director appointed to take the place of past director who passed away unexpectedly. Still in the process of transitioning current responsibilities to include ITI.</td>
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<tr>
<td>Faculty Salaries</td>
<td>$179,515</td>
<td>Includes all Principal Investigator faculty proposed salary.</td>
</tr>
<tr>
<td>Administrative Staff Salaries</td>
<td>$146,678</td>
<td>Includes Assistant Director, Business Manager and Communications Coordinator.</td>
</tr>
<tr>
<td>Other Staff Salaries</td>
<td>$408,230</td>
<td>Includes ITI Chief Research Engineer, three research engineers, all proposed research assistants, one work study student, one temporary student employee, and one temporary employee.</td>
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<tr>
<td>Student Salaries</td>
<td>$167,900</td>
<td>Includes student stipend support for proposed SAFETEA-LU projects.</td>
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<tr>
<td>Staff Benefits</td>
<td>$181,498</td>
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<tr>
<td><strong>Total Salaries and Benefits</strong></td>
<td>$1,158,821</td>
<td></td>
</tr>
<tr>
<td>Scholarships/Tuition</td>
<td>$111,808</td>
<td>Includes student tuition support for proposed SAFETEA-LU projects.</td>
</tr>
<tr>
<td>Permanent Equipment</td>
<td>$0</td>
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<tr>
<td>Expendable Property, Supplies, and Services</td>
<td>$183,574</td>
<td>Includes expendable property, supplies and services for ITI administrative and research operating costs.</td>
</tr>
<tr>
<td>Domestic Travel</td>
<td>$99,295</td>
<td>Includes travel for ITI administrative staff, research staff and faculty, ITI Outstanding Student of the Year and guest to attend awards ceremony at TRB conference in Washington DC.</td>
</tr>
<tr>
<td>Foreign Travel</td>
<td>$0</td>
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<td>Other Direct Costs</td>
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<td>F&amp;A (Indirect) Costs</td>
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<td><strong>Total Expenditures</strong></td>
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<td>Match</td>
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<tr>
<td>Research Partners</td>
<td>$2,231,000</td>
<td>Includes all SAFETEA-LU research proposals submitted for approval, RAS tuition scholarships from the graduate school and waived indirect costs as appropriate.</td>
</tr>
<tr>
<td>University Library</td>
<td>$50,000</td>
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<tr>
<td>NU In-Kind (Faculty Salaries)</td>
<td>$125,000</td>
<td>Includes faculty effort, related fringe benefits and waived indirect costs.</td>
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<tr>
<td>NU In-Kind (Structural Center)</td>
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<td>Intelligent Structural Health Management of Safety-Critical Structures.</td>
</tr>
<tr>
<td>NU In-Kind (Patterson Professorship)</td>
<td>$98,000</td>
<td>William A. Patterson Distinguished Chair in Transportation</td>
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<td>MPM Program</td>
<td>$150,000</td>
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<tr>
<td>Kentucky Transportation Center</td>
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<td>Bi-annual Midwest Bridge Working Group meeting</td>
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<td><strong>Total Match</strong></td>
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<td><strong>TOTAL PROGRAM COSTS</strong></td>
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<td>Matching Share</td>
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Table 2: University Transportation Center (UTC) Budget Plan SAFETEA-LU Grant Year 1: 9.1.07 – 8.31.08
APPENDIX A

Baseline Measures for University Transportation Centers

The following represents baseline measures using data from TEA-21 Year 8 which corresponds to the 2006-2007 academic year at Northwestern University.

Research Selection

1. Number of transportation research projects selected for funding.
   - Basic Research: 0
   - Advanced Research: 9
   - Applied Research: 6

2. Total budgeted costs for the projects reported in 1 above.
   - $1,296,589

Research Performance

3. Number of reports issued that resulted from transportation research projects funded by the UTC grant:
   - 32

4. Number of transportation research papers presented at academic/professional meetings that resulted from projects funded by the UTC grant:
   - 12

Education

5. Cumulative number of transportation-related courses added since the beginning of TEA-21 as of the end of Year 8:
   - Undergraduate: 1
   - Graduate: 2

6. Number of students participating in transportation research projects, counted as individual students (one student participating in two research projects counts as one student):
   - Undergraduate: 28
   - Graduate: 2
Human Resources

7. Cumulative number of transportation-related advanced degree programs that have been added since the beginning of the grant as of the end of Year 8:

   Master's Level: 0
   Doctoral Level: 0

8. Number of students enrolled in transportation-related advanced degree programs

   Master's Level: 34
   Doctoral Level: 34

9. Number of students who received degrees through those transportation-related advanced degree programs

   Master's Level: 16
   Doctoral Level: 9

Technology Transfer

10. Number of transportation seminars, symposia, distance learning classes, etc. conducted for transportation professionals during Year 7.

    27

11. Number of transportation professionals participating in those events.

    868
APPENDIX B

Request for Research Proposals

SAFTEA-LU Year 2
May 1st, 2008

Anticipating approval of its budget for Year 2 of its funding under SAFETEA-LU from the US Department of Transportation, Research and Innovative Technology Administration, ITI is now soliciting proposals for follow-on funding for research and development projects from principal investigators (PIs) whose projects are currently funded by the Institute. Please note that awards for these proposals will depend on: (1) review by the Institute’s Research Advisory Panel, (2) review and approval by Institute Director, (3) approval by the University’s Office of Sponsored Research with regard to match, and (4) release of funds by US DOT.

The Institute will also accept and consider -- subject, of course, to proposal merit and funding availability -- unsolicited proposals from Northwestern faculty for projects which address the Institute’s research objectives. Researchers wishing to submit new proposals should contact me directly to discuss the substance of the proposed research.

The funding period for this solicitation is September 1, 2008 to August 31, 2009. Proposals should follow the outline provided and respond to the Institute’s policies presented. Proposals are to be submitted electronically in Microsoft Word for PC with tables in Microsoft Excel for PC. Proposals are due by 5:00 p.m. on Friday, June 27th, 2008. Maximum proposal length is 25 pages, although this should definitely be viewed as a maximum, not a requirement. PIs are encouraged to be as succinct as possible.

PIs submitting proposals should also complete and submit a paper version of the OSR-1 form for their project(s). This form should be brought or campus-mailed to the ITI office on or before June 27th, 2008.

I. Proposal Outline - at minimum, proposals should provide the following:

1. If a request for renewal funding, the progress and current status of the work performed under the currently-funded project, including adherence to schedule and budget, production of deliverables, prospects for successful commercialization of research results, publications, meetings and conferences, interaction with the practitioner community, and any other evidence of progress deemed relevant by the PI.

2. The objectives of the proposed follow-on research, including a supportable description of the problem to be addressed and how the research would address it.

3. The context of the proposed research as it relates to the research currently underway, the current state of the art, related past or present research at Northwestern and elsewhere, and the direct experience of the PI and his/her team. Qualifications of team members should be briefly outlined. Vitae for members of the research team provided in previous proposals can be included by reference.

4. A work plan for the proposed follow-on research, including a quarter-by-quarter schedule of the work. The work plan should identify measurable research milestones and outline the nature and timing of project deliverables (interim reports, publishable papers, final reports, patents, etc.) sufficient to frame progress reports. The work plan should be for a twelve-month period, with a more general description of later years of the research and funding likely to be necessary to support it.

5. In specific terms, how market feasibility of research results will be assessed, achieved, and assured. A key objective of the Institute is to support the development of infrastructure technologies which move quickly into practice and which improve the performance and management of our transportation infrastructure. Efforts to ensure market feasibility should be demonstrated through:

   a. A user community involvement plan which shows how user involvement will assure the relevance and marketability of the expected research results. This plan should identify who will be involved, including such public and private partners as infrastructure facility owner/operators, design firms, construction companies, and material and equipment suppliers. The plan should also show how and when these community partners will be involved in the effort. Partnering can take many forms, from passive allowance of use of a facility or construction project for testing new materials or procedures, to active involvement in
the proposed research. Active involvement by the partner(s) including cost sharing is strongly encouraged. The proposal should include documentary evidence of partner commitment.

b. A technology commercialization and transfer plan designed to move the results of the proposed research from the University to the infrastructure "industry," discussing likely barriers to be encountered in transferring the technology, and identifying specific mechanisms to be utilized to overcome those barriers.

Strong user community involvement is a critical element in the likely success of technology transfer, and therefore it may be appropriate to integrate the user community involvement plan and the technology transfer plan to prepare a convincing argument that the results of the research have a high probability of being moved into practice.

6. The proposal should present a budget derived from the work plan showing the anticipated expenditure of resources by quarter. The budget should include the elements identified below. In order to support the Institute’s programmatic goals and administration, it is strongly suggested that PIs proposals contain a target cost share of 125%. It is important to note that, because of matching fund requirements in the Institute's funding, PIs are required to identify a minimum cost share of 100% of the amount requested from the Institute (50-50 match). The cost share can consist of non-Institute funded work on the project, in-kind partner contributions, faculty time, and other sources. Please note that matching funds must be specifically identified by source and amount, and will be subject to review by OSR and ITI prior to award. Also, please be aware that match must be sufficiently documented to withstand a post-audit.

II. Research and Development Policies

1. It is the policy of the Institute to support research, development and demonstration projects targeted at important current problems of the nation's infrastructure in ways that take advantage of the unique capabilities of Northwestern University and its private and public partners. More specifically, all ITI funded research must be supportive of the national strategy for surface transportation research and U.S. DOT goals. Table 3 on page 31 summarizes these goals as they relate to ITI's Center theme.

2. Although it is understood that most Institute projects may require several years, the Institute will fund projects on a one-year renewable basis. All projects to be renewed will be viewed against objectives, planned deliverables, and proposed work in the final quarter of their funding year.

3. PIs on Institute-supported projects will be required to provide monthly progress reports at the meetings of the Institute Research Associates. PIs must define, at or before the start of their projects, a specific set of objectives and deliverables, and these should frame their subsequent progress reports.

4. All projects supported by the Institute must include meaningful involvement of user communities, private and/or public. Each PI should appoint a small advisory committee, made up of University and non-University professionals, to facilitate this involvement.

5. Each project must include and carry out a specified technology commercialization and transfer plan.

6. Each project must include cost sharing, consisting of cash or in-kind contributions to the project, desirably through contributions from external partners. The cost sharing target shall equal 125%, with a required minimum equal to 100% of the support requested from the Institute (50-50 match). The cost share can consist of non-Institute funded work on the project, in-kind technology deployment partner contributions, faculty time, and other tangible and quantifiable sources. Less quantifiable contributions such as perceived value of prior research or intellectual property will not be considered as cost sharing.
<table>
<thead>
<tr>
<th>USDOT Research Goals</th>
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<tbody>
<tr>
<td><strong>Safety</strong></td>
<td>Elimination of transit-related deaths, injuries and property damage</td>
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<tr>
<td><strong>Reduce Congestion</strong></td>
<td>Mitigate chokepoints, extend system life and improve durability, congestion reduction policy research and technologies</td>
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<tr>
<td><strong>Global Connectivity</strong></td>
<td>Harmonize standards</td>
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<tr>
<td><strong>Environmental Stewardship</strong></td>
<td>Understand and mitigate transportation impacts</td>
</tr>
<tr>
<td><strong>Security, Preparedness, and Response</strong></td>
<td>Reduce vulnerability and improve preparedness</td>
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<tr>
<th>National Strategy for Surface Transportation Research</th>
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<tr>
<td><strong>Infrastructure Renewal</strong></td>
<td>Information Management: Decision support tools, implementation, education</td>
</tr>
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<td></td>
<td>Pavements: Designs and materials, construction and maintenance techniques and technologies, safer, environmentally friendly pavements, promotion and delivery of innovation in pavement technology</td>
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<td></td>
<td>Highway Structures: Enhanced materials, structural systems, and technologies, efficient maintenance, rehabilitation, and construction, safety assurance of highway structures for extreme events, assessment and management of bridges and other structures, enhanced specifications for improved structural performance, information and automation for structures design, construction, and maintenance</td>
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<tr>
<th>Federal Transit Agency Research Goals</th>
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<tr>
<td><strong>Equipment and Infrastructure</strong></td>
<td>Decrease the use of imported petroleum, improve energy efficiency of transit operations, help protect the environment, and improve passenger service and comfort through technological development</td>
</tr>
<tr>
<td><strong>Fleet Operations</strong></td>
<td>Vehicle technology, intelligent transportation systems, coordinated services, traffic engineering enhancements, metropolitan/rural policy development, planning and project development</td>
</tr>
<tr>
<td><strong>Advanced Transportation Research</strong></td>
<td>Research that involves and draws upon basic research results to provide a better understanding of phenomena and develop innovative solutions - sometimes referred to as exploratory research in order to convey its more fundamental character, its broader objectives, and the great uncertainty in expected outcomes compared to problem-solving research.</td>
</tr>
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</table>

Table 3: USDOT research goals
III. Proposal Evaluation Procedure and Schedule

1. The Research Advisory Panel, comprised of four outside experts, including academics, researchers, USDOT staff, and/or infrastructure practitioners, will review the and make recommendations to the Institute Director for each proposal. Target Date: Week of July 28th, 2008.

   The Research Advisory Panel will base their recommendations to the Director on the relevance of the proposal to the national strategy for surface transportation research, the likelihood of achieving a commercializable end-product from the research and the likely market for it, the relationship to other ongoing research, the experience and qualifications of the researchers, the strength of the proposed technology commercialization and transfer plan, the sufficiency of the practitioner-involvement strategy, the proposed budget -- both annual and multi-year -- related to the Institute's overall research budget, and the success of the research to date in terms of end-products, technology commercialization and transfer, development of potentially-commercializable products, and budget and schedule adherence.

2. The Institute Director will review the Research Advisory Panel's recommendations and authorize continued funding for projects the Panel deemed worthy of support. Target date: Week of August 4th, 2008.

3. PIs submitting proposals will be notified by the Institute. Target date: Week of August 4th, 2008.

4. Project accounts available. Target date: Week of August 18th, 2008.

IV. Proposal Budget Elements

Note: Budgets are for the 12-month period: September 1, 2008 through August 31, 2009. Budgets not conforming to the format below will be returned to the PI.

Northwestern University Direct Project Expenditures

1. Northwestern personnel (by name or title), hourly or monthly rate, and time commitment
2. Fringe benefits
3. Consultants
4. Equipment (equipment with unit cost exceeding $5,000 must be itemized)
5. Supplies, communications, and other consumables (printing and duplicating, telephone and fax, postage, etc.)
6. Computer time
7. Travel
   Please note planned foreign travel should be identified both in the budget and the transmittal so the Institute can initiate federally-mandated approvals.
8. Non-Northwestern Direct Project Expenditures (itemized as appropriate)
9. Total Direct Project Expenditures (sum of 1 through 8)
10. Indirect costs at 51%
11. Requested Infrastructure Technology Institute Project Support (9 plus 10)

Non-Institute Project Support

12. Cash Contributions (specify source)
13. In-Kind Contributions (specify source)
14. Total Matching funds (12 plus 13 - Total must equal or exceed 11)
15. Total Project Budget (11 plus 14)

1 Faculty should budget for Institute staff work on their projects. Institute staff members represent a scarce resource, and their involvement in faculty projects must be negotiated quantitatively with Dan Marron, Chief Research Engineer, prior to proposal submittal. Mr. Marron's signature will be required for consideration of any proposal which would utilize Institute staff.

2 Cost-sharing in an amount equal to or exceeding 100% of the requested ITI support is required.