

Center for Infrastructure Engineering Studies (CIES) AY2020-AY2024 Strategic Plan

Introduction and Overview

The National Academy of Engineering (NAE) has identified critical aspects related to the safety, productivity, quality, and sustainability in operation and maintenance of national infrastructure systems as one of the grand challenges that our nation faces today. The NAE has called for expedient development of novel construction materials, new construction and monitoring methods, and automation in construction, repair, and maintenance, to restore and improve the urban infrastructure and advance transportation and energy, water, and waste systems and create more sustainable urban environments.

The Center for Infrastructure and Engineering Studies (CIES) at the Missouri University of Science and Technology is an interdisciplinary research center that was established by the UM System in 1998 that is well-aligned with this Grand Challenge. It provides leadership in research and education aimed at nurturing the cutting-edge knowledge associated with transportation and building infrastructure. Transportation infrastructure represents multi-modal transportation, including highways, roads, airfields, bridges, tunnels, and railways.

The CIES seeks to be the primary conduit for communication and collaboration among faculty members at Missouri S&T and other institutions at the University of Missouri interested in infrastructure engineering studies. Over the last 5 years, the CIES has involved 35 faculty members from 11 different departments from Missouri S&T with expertise in the areas of the design of advanced materials and structural systems of buildings and transportation infrastructure, infrastructure management and data analytics, transportation engineering, construction engineering and management, non-destructive testing, and structural health monitoring.

The CIES employs three staff positions at 100% FTE. Collectively these three staff members have over 50 years of experience working for infrastructure-related grant programs. At this time, the staff working for CIES include:

- Jason Cox, Senior Research Specialist – responsible for managing all CIES laboratory and field project operations
 - Has worked for CIES since April 2001
- Abigayle Sherman, Program Support Coordinator – responsible for program oversight as well as events and communications
 - Has worked for CIES since August 2001
- Gayle Spitzmiller, Office Support Assistant IV – responsible for tracking accounts
 - Has worked for CIES since April 1999

Unique capabilities and strengths of the CIES include:

- Reputation of Center and faculty
- Diversity and complementation of specialization of affiliated faculty members
- Track record of collaboration with USDOT, State DOTs, and public and private sectors
- High-quality research facilities
- Highly qualified staff supporting the CIES
- Expansion of ACML to house state-of-the-art equipment
- Office space for 25 graduate students and visiting scholars
- Track record with the UTC program, including senior faculty with leadership experience
- Association with an AMSI Signature Research Area
- Certificate program associated with AMSI
- Opportunity for graduate students to be part of world-class research teams
- Annual Transportation Infrastructure Conference in collaboration with MoDOT

The purpose of this strategic plan is to articulate the vision, establish overall objectives, formulate and prioritize specific themes, and define necessary action items for significantly advancing the CIES for 5 years. The strategic plan outlines the various operational plans in-place and those that will be developed at the Center.

The Strategic Plan is focused on achieving quantitative and targeted improvements in scholarly activities, research funding, as well as technology transfer activities. The Strategic Plan reflects input from CIES faculty and staff.

The CIES is well aligned with the Missouri S&T Strategic Plan's Compact for Excellence in Research and Creative Works. Within this Compact, CIES "emphasizes a culture of research and scholarship even further through highly focused and goal-driven recruitment and retention strategies for research-active faculty, improved processes to increase faculty engagement, and increased quality and impact of published scholarship in a wide range of disciplines." Strategy B within the S&T Strategic Plan involves "Pursuing the establishment of nationally recognized, externally funded research centers." The CIES has administered University Transportation Center grants funded by the U.S. Department of Transportation since 1998. The Center continues to lead efforts to align itself for further success within that program.

Vision

The CIES aspires to be the epicenter of transformative research, creative scholarship, and education at the Missouri S&T to shape the future of the nation's sustainable, resilient, and smart infrastructure. The CIES seeks to become the nation's leading research center to address complex problems of the design, construction, renewal, and management of the physical infrastructure.

Mission

The mission of the CIES is to encourage high impact, fundamental and applied research in the science and engineering related to the transportation and building infrastructure in support of existing and emerging technologies that will address the current and future needs of society. More specifically, the CIES seeks to:

1. Provide leadership in research for solving society's problems affecting the nation's infrastructure systems, including infrastructure sustainability.
2. Work towards leading consortia of national-level research programs to grow the leadership of the University in strategic areas pertaining to building and transportation infrastructure.
3. Foster Multi-disciplinary R&D activities in infrastructure engineering with well-focused projects tailored to address the needs of local, state, and federal agencies, and the private sector.
4. Promote technology transfer and continuing education opportunities to the engineering community.

Values

- *Sustainability* - We emphasize resilient and sustainable practices in all our endeavors.
- *Creativity* - We incorporate innovative and entrepreneurial approaches, and curiosity to discover and explore new solutions.
- *Partnership* - We focus on adding value and creating mutually beneficial partnerships and seek to build a creative learning environment marked by openness, understanding, and valuing all people and perspectives.

Research Themes

1. Advanced Materials for Sustainable Infrastructure

Missouri S&T has identified Advanced Materials for Sustainable Infrastructure (AMSI) as one of its top investment priorities. In this signature area of research, efforts are made to develop innovative and sustainable materials that will be used to reconstruct and rehabilitate our country's aging infrastructure, as well as design the next generation of resilient transportation and building infrastructure materials. These efforts seek to improve the durability and extending the life of the nation's infrastructure. This research theme also aims to facilitate the development of smart and green infrastructure which would result in lower environmental impact and carbon footprint of the built infrastructure over its lifetime. This initiative addresses a Grand Challenge involving the restoration of urban infrastructure that necessitates the development of novel construction materials, new construction and monitoring methods, and automation in construction, repair, and maintenance.

2. Advanced Design and Management Methods to Resist Extreme Events

Finding economical alternatives to construction and maintenance of critical infrastructures, such as bridges, roads, and dams is crucial for the economy of the U.S. CIES focuses on the structural design of building and transportation infrastructure using advanced materials and construction methodologies for harsh environments. For structures such as bridges, alternative design

methodology, and construction methods are being investigated to sustain extreme loadings, such as earthquakes, blasts, tornadoes, and vehicle impacts. Moreover, these alternative structures need to sustain harsh natural environment without significant degradation in their performance. For example, CIES investigators are using innovative techniques of rapid construction of bridge columns, coupled with large-scale testing under cyclic and dynamic loads to prove the viability and higher performance of these systems. CIES investigators are also studying novel methods and mitigation technologies for improving disaster response of structures to extreme events, such as earthquakes and flooding.

3. Asset Management and Data Analytics

The Center is aspired to develop decision-making frameworks as well as data-driven models for life-cycle cost analysis to manage critical infrastructure systems and develop transportation organizational decision making tools. . CIES researchers also focuss on dynamic modeling, organize effectiveness, transportation and construction management, and mobile data management, sensor computing, and cyber security. These expertise tie in well with efforts geared at remote sensing, wireless sensor networks, GPS-IoT, assets management, Big Data Analytics, and cloud computing.

4. Advanced Construction Methods

The current evolutions in additive manufacturing have opened the possibility for automation in construction. Missouri S&T has significant expertise in robotics, computer science, and engineering management to develop more efficient construction methods in terms of time, design of novel materials, and performance. Research is also conducted to evaluate the impact of these innovative construction methods on construction efficiency, automation, safety as well as alterations in traffic flow, driving behavior, work zone safety, and societal impact.

5. Novel Non-destructive Structural Health Monitoring

Assessment of aging civil infrastructure attacked by increasing natural hazards is critically important to maintain the welfare of citizens and increase the resiliency of affected communities. CIES investigators are researching to detect and quantify damage and deterioration for cost-effective preservation of infrastructure and prompt post-disaster recovery, both economically and psychologically. Due to multiple failure conditions, transportation infrastructure must be evaluated with multiple nondestructive testing and sensing techniques, such as ground-penetrating radar, microwave, and various types of embedded and remote sensors and GPS systems. These studies will have a profound impact on the safety of infrastructure.

Strategic Objectives and Action Items

1. Pursue multi-PI funding opportunities from diversified sources and broaden multidisciplinary/cross-disciplinary research and applications to address the needs of local, state, and federal agencies and the private sector.

- Make a concerted effort to identify research funding and partnership opportunities and form research clusters in existing strength areas.
- Promote multidisciplinary/cross-disciplinary research proposals at Missouri S&T to enhance collaborations among faculty and URCs.
- Facilitate and lead national opportunities involving multi-institutional consortia and form competitive teams consisting of leading experts to enhance visibility and national stature.
- Assist affiliated center members in preparing major infrastructure proposals, budget tracking, purchasing, etc.
- Organize regular seminars to present research work and expertise to provide a platform for faculty to present their work, identify collaboration opportunities, and enhance student recruitment.
- Collaborate with CEC and academic departments on a lectureship series to host leading experts, including NAE members, to promote our research enterprise.
- Work with the University leadership to invite representatives from federal agencies, program directors, and politicians to campus.

2. Broaden research capabilities and maintain and coordinate the Center's state-of-the-art testing infrastructure to support faculty and student success.

- Collaborate with all stakeholders to support laboratory development, maintenance, and improvement.
- Improve operational procedures for lab use in consultation with faculty and students.
- Identify essential research equipment that can be acquired jointly and pursue major initiatives, such as NSF MRI regularly.
- Assist affiliated center members in conducting research activities through technical support in the lab and on-site.
- Develop an online inventory tool (database) of all existing physical infrastructure components.
- Develop high-priority needs a list of facilities, equipment, and instrumentation and—advocate for new sources of funding for purchasing and maintenance.

3. Promote technology transfer to the engineering community and industry and enhance industry collaboration.

- Continue to support and grow the annual Transportation Infrastructure conference with Missouri DOT that was started in 2012 and strive to attract a higher number of participants from industry and outside Missouri.
- Support faculty in organizing national and international conferences.

4. Support student education and delivery and reduce time to graduation.

- Increase the publication rate and other research products through research infrastructure and mentoring aiming at improving student success and graduation rate.
- Recruit and retain students from underrepresented groups.
- Foster and enhance cross-disciplinary and cross-campus research programs to involve undergraduate and graduate students in research.
- Facilitate MOUs with leading universities and similar opportunities to attract world class graduate students and visiting scholars.
- Seek externally funded fellowships for graduate students affiliated with the Center.
- Promote partnerships with industry to enable rapid integration of students into engineering careers.

Program Efficacy

An External Advisory Committee (EAC) will be established to advise the Center’s leadership on strategic planning and the intellectual merits of CIES research and technology transfer programs and to assess the level of the Center’s accomplishments. At this time it is envisioned that the EAC will be comprised of the following members: CEC Associate Dean for Research; CASB Associate Dean for Research, three Center Directors, and a representative from Missouri DOT.

Performance against Measurable Goals and Success Criteria

The tables below indicate the performance against the measurable goals and success criteria set forth for the next 5 years. The baseline for the data shown below is also indicated.

Number of Externally Sponsored Interdisciplinary Research Projects

Baseline (2017)	2020 Target	2024 Target
10	11	15

Research Expenditures

Baseline (2015-18)	2020 Target	2024 Target
\$2.1M	\$3.2M	\$4.0M

ROI of Research Center (i.e., research expenditures divided by GRA funding to Center, excluding BIC)

Baseline (2014-17)	2020 Target	2024 Target
9	10	11

ROI of Research Center as per new funding model (including BIC)*

Baseline (2018)	2020 Target	2024 Target
2.4	2.5	3.0

* ROI: usage fees + F&A + gifts, etc. *divided by* base funding + F&A return + other centralized funding.

Number of Faculty and Students Using Center Resources

Baseline (2013-17)	2020 Target	2024 Target
94	100	120

Number of MS and Ph.D. Students affiliated with Center

Baseline (2013-17)	2020 Target	2024 Target
60	61	65

Peer-Review Journal Papers

Baseline (2013-17)	2020 Target	2024 Target
89	92	100

Peer-Review Conference Proceedings

Baseline (2013-17)	2020 Target	2024 Target
87	90	100

Organize seminars

Baseline	2020 Target	2024 Target
	6/year	9/year

Lectureship series to host leading experts

Baseline	2020 Target	2024 Target
0	1	3

Invite representatives from federal agencies, program directors, and politicians to campus

Baseline	2020 Target	2024 Target
0	1	3

Develop an online inventory tool (database)

Baseline	2020 Target	2024 Target
0	1	1

Develop high-priority needs a list of facilities, equipment, and instrumentation

Baseline	2020 Target	2024 Target
0	1	1

Annual Transportation Infrastructure conference attendees

Baseline	2020 Target	2024 Target
100	110	135

MOUs with leading universities

Baseline	2020 Target	2024 Target
1	1	2

Externally funded fellowships for graduate students

Baseline	2020 Target	2024 Target
1	2	5

Partnerships with industry

Baseline	2020 Target	2024 Target
4	6	10