



Transportation Consortium of South-Central States

Solving Emerging Transportation Resiliency, Sustainability, and Economic Challenges through the Use of Innovative Materials and Construction Methods: From Research to Implementation

Semi-Annual Progress Report #4

Submitted to: US Department of Transportation
Office of the Assistant Secretary for Research and Technology

Sub. Date: Apr. 30, 2019

Grant: 69A3551747106

Grant Period: Nov. 30, 2016 – Nov. 30, 2022

Project Title: University of Transportation Centers Program – Region 6

DUNS: 075050765

EIN: 726000848

Account: GR-00000627

Reporting Period: Oct. 1, 2018 – Mar. 31, 2019 (semi-annual)

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1. Accomplishments

Major Goals and Objectives of the Program

The **Vision** of Tran-SET is to “address the accelerated deterioration of the transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes”.

The **Mission** of Tran-SET is to “conduct all phases of research, technology transfer, education, workforce development, and outreach activities as to solve transportation challenges in Region 6 and support implementation”.

The following 14 objectives are at the heart of *all* Tran-SET activities¹:

Table 1. Major Objectives of Tran-SET.

ID ¹	Objective
RESEARCH	
R1	Improve the durability and extend the service life of transportation infrastructure [IF2, IN1 ²]
R2	Preserve the environment [IF1, IN1]
R3	Preserve the existing transportation system [IF2, IN1]
R4	Address immediate transportation priorities in Region 6 [S1, IF2, IF3, IF4, IN1]
TECHNOLOGY TRANSFER	
TT1	Ensure that scientific and technological developments are accessible, disseminated, and transferred to a wide range of users including state agencies, universities, and industries [IN2]
TT2	Ensure that scientific and technological developments have long-term research value and significant impact to the transportation industry by direct collaboration with all levels of government and nonprofit institutions [IN2]
EDUCATION	
E1	Improve and support existing academic programs at Tran-SET’s partnering institutions [IF4, A2]
E2	Improve and support transportation non-degree programs at Tran-SET’s partnering institutions (architectural, business, mechanical, electrical, industrial engineering, etc.) [IF4, A2]
WORKFORCE DEVELOPMENT	
WF1	Ensure research outcomes are disseminated through educational and workforce development activities by supporting the development of seminars, workshops, and training courses [IF4, A2]
EMPHASIS AREAS	
EL1	Develop the next generation of leaders and graduate students of the transportation field by supporting mentoring, networking, training, and other development activities [IF4, A2]
EL2	Provide leadership to regional stakeholders and communities (state agencies, universities, and industries) and provide national leadership to applicable research communities [IN1, IN2]
EC1	Encourage and foster collaboration between partnering institutions and external stakeholders as to: (1) maximize sharing of human expertise and facilities among partners and stakeholders, (2) tackle transportation challenges only solvable by multi-disciplinary teams, (3) facilitate knowledge transfer among the team institutions and stakeholders, and (4) minimize duplicative research to optimize the use of available funds [IN2, A2]
ED1	Integrate diversity-related activities into Tran-SET’s efforts as to increase participation of underrepresented students in STEM fields, particularly the transportation field [IF4, A2]
MANAGEMENT	
M1	Operate and manage Tran-SET as to ensure the highest degree of accountability, cost-efficiency, and optimum use of available funds, facilities, and capabilities [A2]

¹All activities, outputs, outcomes, and impacts are categorized under Tran-SET’s objectives (in blue).

²All Tran-SET objectives, activities, outputs, outcomes, and impacts are categorized under objectives of the US DOT Strategic Plan for FY2018-2022 (in green). Regarding ID abbreviations: S refers to Safety, IF refers to Infrastructure, IN refers to Innovation, and A refers to Accountability objectives, respectively.

Accomplishments (During this Reporting Period)

RESEARCH

Final Reports and Project Datasets for First-Cycle Projects: Final reports and project datasets for Tran-SET’s first-cycle projects were finalized (Oct. 2018), disseminated per the UTC reporting requirements (Nov.–Dec. 2018), distributed via Tran-SET’s listserv (Nov.–Dec. 2018), and archived according to Tran-SET’s “Data Management Plan” (Nov.–Dec. 2018). They are available on [Tran-SET’s website](#), with the main archival location being the Tran-SET page of [LSU Digital Commons](#). LSU Digital Commons provides tools to track downloads and readership characteristics. [TT1, IN2]

Project Closeout of First-Cycle Projects: Each Tran-SET project consists of a 12-month technical phase, followed by a 6-month implementation phase. Tran-SET’s first-cycle projects ended their implementation phase, submitted their implementation reports, and were successfully completed/closed out (Nov. 2018). [M1, A2]

Proposals for Third-Cycle Projects: 74 problem statements submitted for the third-cycle of funding were ranked by regional transportation leaders/experts (Nov. 2018) and request for proposals (RFPs) was solicited for 35 projects (Dec. 2018). Projects are categorized below, by Tran-SET research objective and transportation area, respectively. 36 proposals were received (Feb. 2019) and are currently under review by subject matter experts. [R1, R2, R3, R4, S1, IF2, IF3, IF4, IN1]

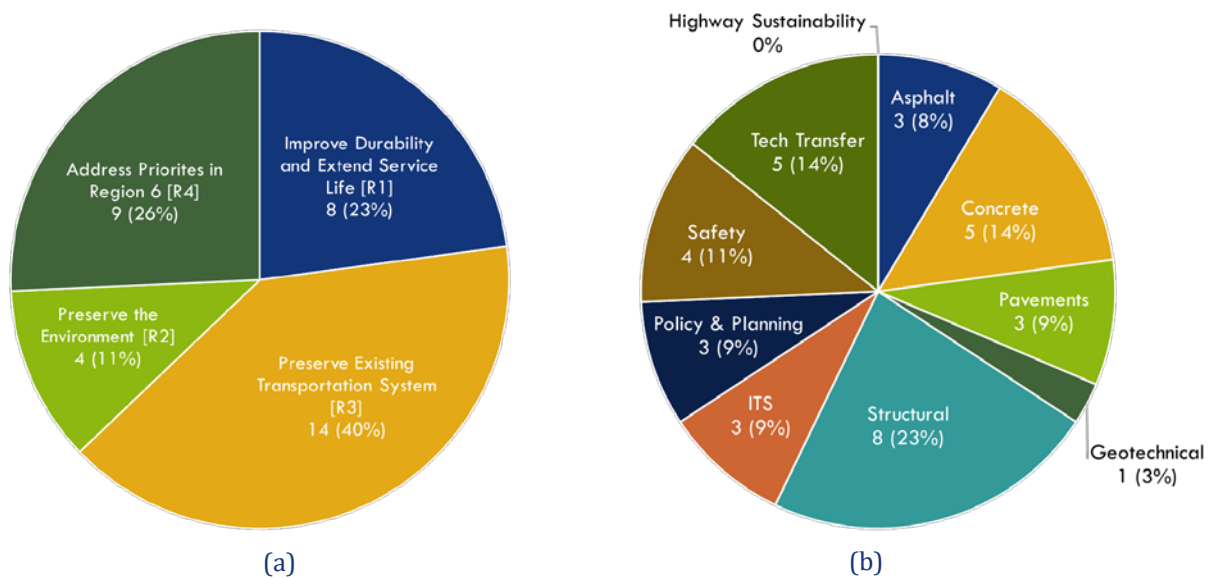


Figure 1. Third-Cycle RFPs Categorized by: (a) Research Objective and (b) Transportation Area.

Final Reports and Project Datasets for Second-Cycle Projects: Tran-SET’s second-cycle projects ended their technical phase (Mar. 2019) and submitted their draft final reports and project datasets (Mar. 2019). Reports are currently under review by Tran-SET staff and will subsequently be reviewed by their respective project review committees. [TT1, IN2]

TECHNOLOGY TRANSFER

Technology Transfer (T2) Plan: Tran-SET continues to take significant steps to implement their T2 Plan, including: developing a template for the implementation report (Oct. 2018), submission/review of revised project-specific T2 plans (Jan. 2019), developing a template for the PI Questionnaire to assist in the technology readiness level (TRL) assessments (Feb. 2019), conducting a [webinar](#) to

communicate Tran-SET's T2 process and reporting requirements to PIs (Feb. 2019), and submission/review of PI Questionnaires (Feb. 2019). Tran-SET's T2 Coordinator is currently scheduling TRL assessments for each second-cycle project (to be conducted May – Jun. 2019). During the implementation phase, Tran-SET will continue to support individual PIs to successfully conduct the engagement activities specified in their project-specific T2 plans. T2-related templates and additional information is available on [Tran-SET's website](#). [TT1, TT2, EC1, IN2, A2]

Newsletter: Tran-SET continued to develop and disseminate its quarterly newsletter with the winter 2018 issue (Dec. 2018) and spring 2019 issue (Mar. 2019). Newsletters are disseminated locally, regionally, nationally, and internationally via Tran-SET's listserv. Current and past newsletters are available on [Tran-SET's website](#). [TT1, IN2]

Educational Videos: Tran-SET recorded, edited, and uploaded **30** educational videos to their YouTube page (Jan. 2019), consisting of presentations of each first-cycle project. [TT1, IN2]

Paving and Transportation Conference: Four Tran-SET research projects were presented at a dedicated Tran-SET session at the 56th Annual Paving and Transportation Conference on **Jan. 10, 2019**. The Conference was hosted by the University of New Mexico with the theme of "Transformation and Revolution in the Transportation Industry". Over 500 participants attended the Conference. [TT1, TT2, EL2, IN2]

Joint Tran-SET Webinar Series: Tran-SET conducted its third webinar (in its quarterly webinar series) on **Mar. 28, 2019** over "Innovative Approaches to Characterize Asphalt Binders and Mixtures". The webinar was jointly hosted by Region 8's UTC, Mountain-Plains Consortium, and the Center for Transportation Research (CTR). Recorded webinars, presentation slides, and other outreach materials are available on [Tran-SET's website](#). [TT1, TT2, EL1, EL2, EC1, IF4, IN2, A2]

Project Highlights: Tran-SET created two-page fact sheets, or "Project Highlights", for each of its 36 second-cycle projects (Mar. 2019), providing updated progress and preliminary results. They have been a great outreach tool and have been disseminated/advertised on Tran-SET's website and as printed hand-outs at conferences. They are available on [Tran-SET's website](#). [TT1, IN2]

2019 Tran-SET Conference: Tran-SET hosted the 2019 Tran-SET Conference on **Apr. 11-12, 2019** in San Antonio, TX and held its annual meeting with the Center Advisory Board. Many activities have occurred during this reporting period to make the Conference a success: soliciting Conference papers and poster abstracts (Nov. 2018), organizing review of the **59** submitted papers by the Scientific Committee (Dec. 2018), finalizing papers for the Conference proceedings (Jan. 2019), finalizing keynote speakers (Jan. 2019), finalizing venue and activity contracts (Feb. 2019), finalizing the detailed Conference program (Mar. 2019), and arranging the publication of the papers after the conference (Mar. 2019). All accepted papers from the Conference will be published in [MATEC Web of Conferences](#) and submitted to EI (Compendex), CPCI (Web of Science), DOAJ, Scopus, ProQuest, Google Scholar for additional indexing. The Program included **2** keynote speakers (Professor Hainian Wang, Associate Dean of the School of Highway at Chang'an University and Professor Dallas Little, Snead Chair Professor and Regents Professor at Texas A&M University), **two** additional guest speakers, **68** lectern presentations (covering all second-cycle projects), and **38** student posters. More information is available on [Tran-SET's website](#). [TT1, TT2, EL2, IN2]

EDUCATION

Navajo Technical University Internship: Tran-SET will host a one-month summer internship supporting Navajo Technical University students to participate in Tran-SET-funded research at Louisiana State University (LSU) on **June 3-28, 2019**. Several activities have occurred during this reporting period to make the Internship a success: ensuring funding for the student's travel, housing, and stipend (Feb. 2019), finalizing the technical program with PIs (Feb. 2019), and interviewing

student applicants (Mar. 2019). More information regarding the Internship is on [Tran-SET's website](#). [E1, EL1, EC1, ED1, IF4, A2]

Project-Level STEM Events: Tran-SET and its affiliates sponsored, organized, and participated in several STEM events. Illustrative examples are listed below. [E1, E2, EL1, IF4, A2]

- *Nettleton STEAM School* – Dr. Zahid Hossain (Associate Director) and his research team of undergraduate and graduate students delivered lectures to two sixth grade classes at the Nettleton STEAM School (Oct. 2018). Students were introduced and exposed to the engineering profession and engaged in several hands-on, engineering-related activities.
- *Hector Garcia Middle School* – Dr. Samer Dessouky (Associate Director) presented at the Hector Garcia Middle School “Career Day” (Nov. 2018). Dr. Dessouky presented to sixth and eighth grade students the role of transportation engineers in the community as well as various civil engineering-related fields. He also presented recent advances in the future of roadway engineering in promoting traffic safety and harvesting energy.
- *ASCE LSU Student Chapter* – Dr. Gabriel Arce (PI) aided the LSU student chapter with their concrete mix design for the ASCE Concrete Canoe Competition (Oct.–Dec. 2018). Dr. Arce developed a lightweight strain-hardening cementitious composite (SHCC) to be used in their canoe. Students acquired hands-on experience by producing and testing lightweight SHCC materials in the laboratory.

WORKFORCE DEVELOPMENT

Project-Level Involvement: Tran-SET has sponsored, organized, and participated in various workshops, developed and presented revised course materials, and contributed to several professional societies. Illustrative examples are listed below. [WF1, TT1, TT2, EL2, IF4, A2, IN2]

- *Deep South ITE* – Mr. Christopher Melson (Program Manager) presented at the 2018 Deep South ITE Fall Meeting (Oct. 2018). Mr. Melson presented on the “Operational and Safety Attributes of an Alternative Design, Space-Efficient, One-Sided Interchange” and led a tour of transportation-related laboratories at LSU.
- *“Lunch and Learn” on Flowable Fill Concrete* – Dr. Zahid Hossain (Associate Director) arranged a “lunch and learn” session on flowable fill concrete (FFC) mixes (Nov. 2018). Dr. Hossain presented on the feasibility of the use of rice hull ash in FFC and showcased a small field demonstration. Attendees included representatives from local ready-mix plants, admixture suppliers, ArDOT, and Jonesboro City officials.
- *Webinar on Augmented Reality for Structural Inspections* – Dr. Fernando Moreu (PI) presented at a TRB-sponsored webinar on Tran-SET-related research, “Infrastructure Inspection and Augmented Reality: State of the Art and Implementation Opportunities” (Dec. 2018). The webinar identified how augmented reality can assist state DOTs to collect data from the field more accurately and cost-effectively.
- *Sim-Cap Louisiana* – Mr. Christopher Melson (Program Manager) organized and presented at the second (Oct. 2018) and third (Mar. 2019) educational meetings by the Simulation and Capacity Analysis Users Group of Louisiana (SimCap Louisiana). SimCap Louisiana is a workforce development entity that promotes best practices in the application of traffic simulation and capacity analysis.

MANAGEMENT

Data Management Plan: At the request of LSU, Tran-SET updated their “Data Management Plan” to include specific provisions and references to issued subawards and to clarify information regarding the two archival locations/systems. The Plan was approved and posted to [Tran-SET's website](#) (Nov. 2018). [M1, A2]

Tran-SET Mid-Year Meeting: Tran-SET held its annual in-person, mid-year meeting with its Associate and Program Directors (Jan. 2019). Tran-SET communicated important Center-wide updates, discussed current reporting requirements, and identified “lessons learned” from recently completed first-cycle projects. [M1, all, A2]

Section 508/Accessibility: Tran-SET has been working diligently to ensure all public facing content (submitted to NTL and all content residing on the Tran-SET website) is 508 compliant. Content includes: **30** previously submitted first-cycle final reports and project datasets (50% complete), **173** documents on Tran-SET’s website (72% complete), and providing captioning for over **12** hours of video content (50% complete). Tran-SET also created its own [accessibility guide](#) to assist PIs and revised its final report template accordingly (Feb. 2019). Tran-SET will strive to have all applicable content 508 compliant as soon as possible. [M1, A2]

Dissemination of Results

Please see the “Technology Transfer” subsections of Sections 1 (above) and 3 (below) documenting Tran-SET’s main outreach activities. More generally, results have been disseminated via: social media (Tran-SET website, Facebook, LinkedIn, Twitter, and YouTube), newsletters, other promotional documents (i.e., project briefs), conferences, educational materials (courses, seminars/workshops), and peer-reviewed publications.

Activities Planned (for Next Reporting Period)

RESEARCH

- Complete review of (Apr. 2019), revise and finalize proposals for (May 2019), and award third-cycle projects (Jun. 2019). [R1, R2, R3, R4, S1, IF2, IF3, IF4, IN1]
- Finalize and disseminate final reports for second-cycle projects (Jul. 2019). [TT1, IN2]
- Issue call for problem statements for fourth-cycle projects (Aug. 2019) and begin review of problem statements. [R1, R2, R3, R4, S1, IF2, IF3, IF4, IN1]
- Conduct T2 activities during the implementation phase of second-cycle projects, develop and finalize implementation reports, and successfully closeout second-cycle projects (Sep. 2019). [TT1, TT2, IN2]

TECHNOLOGY TRANSFER

- Conduct TRL assessments for each second-cycle project (Jun. 2019). [TT1, TT2, EC1, IN2, A2]
- Develop and disseminate Tran-SET newsletter for summer 2019 (Jun. 2019) and fall 2019 (Sep. 2019). [TT1, IN2]
- Organize and jointly host two webinars in the “Joint-Tran-SET Webinar Series” (Jul. 2019, Sep. 2019). [TT1, TT2, EL1, EL2, EC1, IF4, IN2, A2]
- Continue to develop, promote, and expand Tran-SET’s educational video portfolio (on-going); develop and upload videos from the 2019 Tran-SET Conference (Jul. 2019). [TT1, IN2]
- Develop/disseminate “Project Highlights” for each third-cycle project (Aug. 2019). [TT1, IN2]
- Begin planning activities for the 2020 Tran-SET Conference, tentatively planned for mid-April 2020 in Albuquerque, NM, including: establishing Conference Steering Committee (Apr. 2019), selecting and finalizing a venue and date (May 2019), developing Conference program (May 2019), creating Conference website (Jun. 2019), announce the call for papers (Jul. 2019), etc. [TT1, TT2, EL2, IN2]

EDUCATION

- Finalize planning for, hire two Navajo students, and host the Navajo Technical University Internship (Jun. 2019). [E1, EL1, EC1, ED1, IF4, A2]

- Finalize planning for and conduct a jointly sponsored STEM event with [WTS Louisiana](#) – aimed at exposing diverse LSU undergraduate and graduate students to the transportation field and possible transportation-related careers (Sep. 2019). [E1, E2, EL1, IF4, A2]
- Continue sponsoring, organizing, and participating in STEM events (on-going). [E1, E2, EL1, IF4, A2]

WORKFORCE DEVELOPMENT

- Host a WTS Louisiana luncheon and corresponding laboratory tour at LSU (Aug. 2019). [WF1, IF4, A2]
- Continue sponsoring, organizing, and participating in workshops, developing and presenting revised course materials, and involvement in professional society activities (on-going). [WF1, TT1, TT2, EL2, IF4, A2, IN2]

MANAGEMENT

- Solicit surveys to the CAB and PRCs to receive feedback on how well Tran-SET activities are addressing regional needs and impacting state-of-the-practice (Apr. 2019). [M1, all, A2]
- Finish conversion process to make first-cycle final reports and project datasets (May 2019), website documents (Jun. 2019), and video content (Jul. 2019) 508 compliant. [M1, A2]

2. Participants & Collaborating Organizations

During this reporting period, Tran-SET partnered with **79** organizations (20 academic institutions, 19 government agencies, 31 industrial firms, 8 nonprofits, and 1 school) to accomplish and oversee its research, technology transfer, education, and workforce development activities. Please see Table 2 for details.

Tran-SET collaborated with **19** organizations/individuals (from 8 academic institutions, 3 government agencies, 4 industrial firms, and 4 nonprofits.). As shown in Table 3, these collaborations embody interdisciplinary approaches.

Partners

Table 2. Tran-SET Partners.

Organization Name	Type	Location	Description of Contribution [Tran-SET Affiliation]
Alliance Safety Council	Nonprofit	Baton Rouge, LA	Collaborative research [CAB]
Alma Plantation	Industrial firm	Lakeland, LA	In-kind support [second-cycle]
Amec Foster Wheeler	Industrial firm	Albuquerque, NM	Collaborative research [PRC]
American Concrete Pavement Association	Nonprofit	Rosemont, IL	Collaborative research [PRC]
American Concrete Pipe Association	Nonprofit	Irving, TX	Collaborative research [PRC]
Arkansas Department of Transportation	State government	Little Rock, AR	In-kind support; collaborative research [CAB; second-cycle]
Arkansas Ready Mix Concrete Association	Nonprofit	Jonesboro, AR	Collaborative research [second-cycle]
Army Corps of Engineers	US government	Washington, DC	Collaborative research [PRC]
Association of American Railroads (AAR)	Nonprofit	Washington, DC	Collaborative research [second-cycle]
Barriere Construction Co.	Industrial firm	Baton Rouge, LA	Collaborative research [CAB]
Bechtel Power Corporation	Industrial firm	Frederick, MD	Collaborative research [PRC]

Organization Name	Type	Location	Description of Contribution [Tran-SET Affiliation]
Bernalillo County Public Works	Local government	Albuquerque, NM	Collaborative research [PRC]
Boise State University	Academic institution	Boise, ID	Collaborative research [PRC]
BNSF Railway	Industrial firm	Fort Worth, TX	Facilities; collaborative research [second-cycle]
Canadian National (CN) Railway	Industrial firm	Montreal, Canada	Facilities; collaborative research [second-cycle]
Capitol Regional Planning Commission	Local government	Baton Rouge, LA	Collaborative research [CAB]
Carmeuse Lime and Stone	Industrial firm	Baton Rouge, LA	Collaborative research [CAB]
Chang'an University	Academic institution	Xi'an, China	Collaborative research [CAB]
Chicago Testing Laboratory, Inc.	Industrial firm	Warrenville, IL	Collaborative research [CAB]
City of Albuquerque	Local government	Albuquerque, NM	Financial support; collaborative research [second-cycle]
City of Houston	Local government	Houston, TX	Collaborative research [PRC]
City of San Antonio	Local government	San Antonio, TX	Financial support; in-kind support [second-cycle]
Columbia University	Academic institution	New York, NY	Collaborative research [PRC]
Composite Rebar Technologies	Industrial firm	Minneapolis, MN	In-kind support [second-cycle]
Concrete and Aggregates Association of LA	Nonprofit	Baton Rouge, LA	Collaborative research [second-cycle]
Edwards Aquifer Authority	Local government	San Antonio, TX	Collaborative research [PRC]
Ericsson Canada, Inc.	Industrial firm	Mississauga, Canada	Collaborative research [PRC]
Fort Wayne Metals	Industrial firm	Fort Wayne, IN	In-kind support; collaborative research [PRC; second-cycle]
Georgia Southern University	Academic institution	Statesboro, GA	Collaborative research [PRC]
Greater Baton Rouge Industry Alliance	Nonprofit	Baton Rouge, LA	Collaborative research [CAB]
HVJ Associates	Industrial firm	Houston, TX	Collaborative research [CAB]
Jacobs Engineering	Industrial firm	Dallas, TX	Collaborative research [PRC]
Johnson, Mirmiran, & Thompson	Industrial firm	Austin, TX	Collaborative research [PRC]
Jonesboro High School STEM Academy	School	Jonesboro, AR	Collaborative research [second-cycle]
Kansas State University	Academic institution	Manhattan, KS	Collaborative research [PRC]
Kozeliski Consulting	Industrial firm	Gallup, NM	Collaborative research [PRC]
Los Alamos County	Local government	Los Alamos County, NM	Facilities; collaborative research [second-cycle]
Los Alamos National Laboratory	US government	Los Alamos, NM	Collaborative research [second-cycle]
Louisiana Community and Technical College System	Academic institution	Baton Rouge, LA	Collaborative research [CAB]
Louisiana Economic Development	State government	Baton Rouge, LA	Collaborative research [CAB]
Louisiana Transportation Research Center	State government	Baton Rouge, LA	Financial support; in-kind support; facilities; collaborative research [CAB; PRC; second-cycle]
Louisiana Workforce Commission	State government	Baton Rouge, LA	Collaborative research [CAB]
Modjeski and Masters, Inc.	Industrial firm	New Orleans, LA	Collaborative research [PRC]
MMFX	Industrial firm	Irving, TX	In-kind support [second-cycle]

Organization Name	Type	Location	Description of Contribution [Tran-SET Affiliation]
NEAR Ready Mix Concrete	Industrial firm	Brookland, AR	In-kind support [second-cycle]
New Mexico Department of Transportation	State government	Albuquerque, NM	Financial support; in-kind support; collaborative research [CAB; PRC; second-cycle]
NASA	US government	Washington, DC	Collaborative research [PRC]
Oklahoma Climatological Survey	Academic institution	Norman, OK	In-kind support [second-cycle]
Oklahoma Department of Transportation	State government	Oklahoma City, OK	Collaborative research [CAB]
Paragon Technical Services, Inc.	Industrial firm	Richland, MS	In-kind support; facilities; collaborative research [second-cycle]
Pavetex	Industrial firm	Lubbock, TX	Collaborative research [CAB]
Ports Association of Louisiana	Nonprofit	Baton Rouge, LA	Collaborative research [CAB]
Qualcomm, Inc.	Industrial firm	San Diego, CA	Collaborative research [PRC]
Quality Concrete	Industrial firm	Baton Rouge, LA	In-kind support; facilities [second-cycle]
Raw Energy Materials Corp.	Industrial firm	Pompano Beach, FL	In-kind support [second-cycle]
Riceland Foods	Industrial firm	Stuttgart, AR	In-kind support [second-cycle]
RJ Daigle Construction	Industrial firm	Baton Rouge, LA	In-kind support [second-cycle]
San Antonio River Authority	Local government	San Antonio, TX	In-kind support [second-cycle]
Schock USA, Inc.	Industrial firm	Princeton, NJ	Collaborative research [PRC]
Sorrento Lumber Company, Inc.	Industrial firm	Baton Rouge, LA	In-kind support [second-cycle]
South Dakota University	Academic institution	Vermillion, SD	Collaborative research [PRC]
Terracon	Industrial firm	Oklahoma City, OK	Collaborative research [PRC]
Texas Department of Transportation	State government	Austin, TX	Collaborative research [CAB; PRC; first-, second-cycle]
Texas Local Technical Assistance Program	State government	Arlington, TX	Collaborative research [CAB]
The Lemoine Company	Industrial firm	Baton Rouge, LA	In-kind support [second-cycle]
The Mineral Lab, Inc.	Industrial firm	Golden, CO	In-kind support [second-cycle]
Union Pacific (UP)	Industrial firm	Omaha, NE	Facilities; collaborative research [second-cycle]
University of Central Oklahoma	Academic institution	Edmond, OK	Collaborative research [PRC]
University of Connecticut	Academic institution	Mansfield, CT	Collaborative research [PRC]
University of Florida	Academic institution	Gainesville, FL	Collaborative research [PRC]
University of Houston	Academic institution	Houston, TX	Collaborative research [PRC]
University of Idaho	Academic institution	Moscow, ID	Collaborative research [PRC]
University of New Orleans	Academic institution	New Orleans, LA	Collaborative research [PRC]
University of Louisiana at Lafayette	Academic institution	Lafayette, LA	In-kind support [second-cycle]
University of Victoria	Academic institution	Victoria, British Columbia	Collaborative research [PRC]
University of Virginia	Academic institution	Charlottesville, VA	Collaborative research [PRC]
Utah State University	Academic institution	Logan, UT	Collaborative research [PRC]
Worcester Polytechnic Institute	Academic institution	Worcester, MA	Collaborative research [PRC]
West Virginia University	Academic institution	Morgantown, WV	Collaborative research [PRC]

Collaborators

Table 3. Tran-SET Collaborators.

Organization/Name	Type	Description of Collaboration [Tran-SET Affiliation]
BNSF Railway Co.	Industrial firm	Participated in survey/interview [second-cycle]
FEMA	Federal government	Participated in survey/interview [second-cycle]
Harbin Institute of Technology Dr. Eduardo Mario Mendiondo Heilongjiang Sheng, China	Nonprofit	Contributed to the development and application of rainfall generator models [second-cycle]
HDR, Inc. Mr. Danton Beam	Industrial firm	Speaker at sponsored seminar [second-cycle]
Institute of Engineering Mechanics Dr. Jim Ji Harbin, China	Nonprofit	Aided in selection and evaluation of image processing [second-cycle]
Louisiana Transportation Research Center Dr. Walid Alaywan	State government	Provided Wave Force calculator sheet [second-cycle]
Louisiana State University - Department of Veterans Affairs	Academic institution	Advocate, aided Tran-SET in establishing scholarship program for US veterans
Mountain-Plains Consortium – South Dakota State University Dr. Rouzbeh Ghabchi	Academic institution	Speaker at sponsored webinar [second-cycle]
National Cave and Karst Research Institute	Academic institution	Provided laboratory facilities and guidance on large-scale testing [second-cycle]
New Mexico Department of Transportation - Bridge Design Section	State government	Provided expertise in bridge engineering, construction practices, and rehabilitation techniques [second-cycle]
Ozyegin University Dr. Murat Uysal, Dr. Farshad Miramirkhani	Academic institution	Aided with simulation of vehicle headlamps light intensity models [second-cycle]
SimCap Louisiana	Nonprofit	Identified research needs in the area of simulation and capacity analysis, coordinated outreach
Shanghai Normal University	Academic institution	General collaboration on artificial reality and structural inspections [second-cycle]
TenCate Geosynthetics	Industrial firm	Provided materials [second-cycle]
University of Texas at Austin – Center for Transportation Research Dr. Amit Bhasin	Academic institution	Speaker at sponsored webinar [second-cycle]
University of Texas at Tyler Dr. Michael McGinnis	Academic institution	Speaker at sponsored seminar [second-cycle]
Visual Working	Industrial firm	Aided in seminar for use of drone-based technology for structural inspections [second-cycle]
WTS Louisiana	Nonprofit	Organizing upcoming luncheon and STEM event
Yangzhou University	Academic institution	Study and facility exchange on applications of new technologies for structural inspections [second-cycle]

3. Outputs

Tran-SET has developed performance metrics and targets for outputs, outcomes, and impacts of their research, technology transfer, education, and workforce development programs. These recently developed metrics/targets are discussed below and in Sections 4 and 5. *Please note: research-related*

performance metrics for outcomes and impacts are not specified, since such outcomes and impacts are achieved through T2.

RESEARCH

Table 4 lists Tran-SET’s performance metrics for research-related outputs. In total, **3** new technologies/techniques were developed. They are briefly summarized below.

Table 4. Research Performance Metrics: Outputs.

ID	Objective ID	Metric	Value ¹	Ann. Value ²	Ann. Target ³	Percent Compl. ⁴
	R4, S1, IF2, IF3, IF4, IN1	Number of projects specifically addressing regional challenges:				
R-01		Metropolitan growth and congestion	-	6	5	120%
R-02		Future transportation challenges	-	11	15	73%
R-03		Declining public revenues	-	7	3	230%
R-04		Underserved communities	-	1	2	50%
R-05		Safety	-	4	5	80%
R-06	EC1	Number of collaborative (multi-institution) projects	-	7	11	64%
R-07	R1, R2, R3, R4, IN1	Number of new technologies or techniques developed	3	8	15	53%

¹Metric value for reporting period; ²Best estimate for annualized metric value; ³Annual, per funding cycle, target;

⁴Percent completion of annual target; same column definitions for Tables 4 – 13.

Developed Technologies or Techniques

1. Drs. Supratik Mukhopadhyay, Yimin Zhu, and Ravindra Gudishala (PIs) developed a causal model for understanding driver’s route choice based on a variety of context factors (such as traffic condition, urgency, familiarity with environment, etc.) (Project No. 18ITSLSU09).
2. Drs. Changbum Ahn and Chao Wang (PIs) developed a smart phone application that allows drivers to collect vibration, GPS, and speed information for automated road damage detection and reporting (Project No. 18PLSU08).
3. Drs. Ibrahim Karaman and Darren Hartl (PIs) developed a technique to simulate the tensile transformation of iron-based shape memory alloys (SMA) with a magnet and sensor. This property can be utilized to develop transportation infrastructure with cost-effective self-sensing capabilities (Project No. 18STTAM02).

TECHNOLOGY TRANSFER

Table 5 lists Tran-SET’s performance metrics for T2-related outputs. In total, **8** journal publications, **40** conference papers/presentations, **31** other presentations, and **5** webinars were published/delivered. Please see the selected output examples below.

Please note: these counts do not include journal papers under review (to date: 7) nor accepted conference presentations that will be delivered beyond the reporting period (to date: 65).

Table 5. Technology Transfer Performance Metrics: Outputs.

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
	TT1, TT2, IN2	Number of stakeholders identified, specifically ¹ :				
TT-01		Early potential adopters	70	70	30	233%
TT-02		Late potential adopters	75	75	30	250%

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
	TT1, TT2, IN2	Number of times research products (technology) are disseminated via the following channels:				
TT-03		Featured in Tran-SET newsletter	12	24	25	96%
TT-04		Featured on Tran-SET social media	17	43	50	86%
TT-05		Peer-reviewed publications and presentations	79	198	130	152%
TT-06		Webinars	5	7	5	140%
	TT1, IN2	Tran-SET website traffic:				
TT-07		Number of visitors to website	18k	35k	30k	117%
TT-08		Number of visits to website	124k	247k	250k	99%
	TT1, TT2, IN2	Number of times disseminated research products have informed/been viewed:				
TT-09		Social media engagement levels(s)	8/1.5	10/1.7	9 ² /2.5 ³	111/67%
TT-010		Number of times reports (or related) are downloaded	1,276	1,276	495	258%
TT-011		Number of citations from publications	34	42	120	35%
TT-012		Presentation attendees or views	1,910	3,260	1,000	326%
	TT1, TT2, IN2	External funds:				
TT-013		Industrial partners providing funds	-	3	4	75%
TT-014		Public agency partners providing funds	-	9	10	90%
TT-015		Total funds from industrial partners	-	\$102k	\$200k	51%
TT-016		Total funds from public agency partners	-	\$479k	\$300k	156%

¹Individual stakeholders as specified in second-cycle, project-specific T2 plans; may contain multiple (but distinct) stakeholders within same agency; ²Average "post engagement" (Facebook); ³Average "engagement rate" (Twitter).

Discussion of Performance Metrics: Building an Audience

- Number of Times Reports (or Related) are Downloaded (TT-010):** Since first-cycle final reports and project datasets have been uploaded to LSU Digital Commons, in only three months, the reports have been downloaded 1,276 times and datasets downloaded 76 times. Readers come from 64 countries (strong majority from the US) and comprise of educational institutions (79%), commercial entities (12%), and government agencies (9%). The number of downloads was higher than expected, showcasing high interest in Tran-SET research; Tran-SET will likely increase the target for the next reporting period.
- Number of Citations from Publications (TT-011):** The number of citations from peer-reviewed publications and final reports have increased significantly from last reporting period (8 to 34). Since all publications and final reports were recently published, Tran-SET believes the number of citations will continue to grow (likely exponentially) and progressively achieve our target of 120 (based on 4 citations per funded project). This metric helps assess how Tran-SET is influencing/guiding related research fields.

Peer-Reviewed Journal Publications

- Aguero, M., Ozdagli, A., and F. Moreu (2019). Measuring reference-free total displacements of piles and columns using low-cost, battery-powered, efficient wireless intelligent sensors (LEWIS2). *Sensors*, 191(7), 1549. [Published] [Federal support acknowledged] [Accessible [here](#)]
- Aguirre, A., Hassan, M., Shirzad, S., Cooper, S., Mohammad, L., and I. Negulescu (2019). Laboratory testing of self-healing fibers in asphalt mixtures prepared with recycled materials. *Journal of Transportation Research Record*, 0361198119836978. [Published] [Federal support acknowledged] [Accessible [here](#)]

3. Ahsan, M. and Z. Hossain (2018). Effect of particle size of rice husk ash (RHA) in mitigating alkali silica reaction (ASR) in concrete pavement. *International Journal of Pavement Research and Technology*. [Published] [Federal support acknowledged] [Accessible [here](#)]
4. Ahsan, M. and Z. Hossain (2018). Supplemental use of rice husk ash (RHA) as cementitious material in concrete industry. *Construction and Building Materials*, 178, 1-9. [Published] [Federal support acknowledged] [Accessible [here](#)]
5. Omranian, E., Sharif, H., and S. Dessouky (2018). Exploring rainfall impacts on the crash risk on Texas roadways: A crash-based matched-pairs analysis approach. *Accident Analysis & Prevention*, 117, 10-20. [Published] [Federal support acknowledged] [Accessible [here](#)]
6. Rashi, F., Hossain, Z., and A. Bhasin (2019). Nanomechanistic properties of reclaimed asphalt pavement modified asphalt binders using an atomic force microscope. *International Journal of Pavement Engineering*, 20(3), 357-365. [Published] [Federal support acknowledged] [Accessible [here](#)]
7. Tahami, S., Cholikhani, M., Nasouri, R., Dessouky, S., and A.T. Papagiannakis (2019). Developing a new thermoelectric approach for energy harvesting from asphalt pavements. *Applied Energy*, 238, 786-795. [Published] [Federal support acknowledged] [Accessible [here](#)]
8. Visage, E., Weldon, B., and D. Jauregui (2019). Flexural performance of ultrahigh-performance concrete developed using local material. *Journal of Materials in Civil Engineering*, 31(5). [Published] [Federal support acknowledged] [Accessible [here](#)]

Conference Papers/Presentations (Selected)

1. Al-Basha, A., Toledo, W., Newton, C., and B. Weldon (2019). "Ultra-high performance concrete overlays for concrete bridge decks". In *IPO Conference Series: Materials Science and Engineering*, 471(3). [Published] [Federal support acknowledged] [Accessible [here](#)]
2. Corning-Padilla, A. and G. Rowangould, "Sustainable and equitable financing for pedestrian infrastructure maintenance". Transportation Research Board Annual Meeting, January 2019, Washington, DC. [Federal support acknowledged]
3. Davis, A., Mirsayer, M., and D. Hartl (2019). "Structural health monitoring using embedded magnetic shape memory alloys for magnetic sensing". In *Nondestructive Characterization and Monitoring of Advanced Materials, Aerospace, Civil Infrastructure, and Transportation XIII*, Conference 10971, International Society for Optics and Photonics. [Published] [Federal support acknowledged] [Accessible [here](#)]
4. Hasan, M. and Z. Hossain. "An overview of corrosion of soils in Arkansas". 2019 Northeast Agricultural and Soil Conference, January 2019, Jonesboro, AR. [Federal support acknowledged]
5. Islam, K.T. and Z. Hossain. "Evaluation of rice husk ash (RHA) as an asphalt modifier". Arkansas Academy of Science, March 2019, Conway, AR. [Federal support acknowledged]
6. Krishnan, D. and T. Liu. "Freight consolidation problem with pickup and delivery sequence and loading constraints". INFORMS Annual Meeting, November 2018, Phoenix, AZ. [Federal support acknowledged]
7. Maharjan, D. Wyckoff, E., Aguero, M., Martinzes, S., Zhou, L., and F. Moreu (2019). "Monitoring induced floor vibrations: Dance performance and bridge engineering". In *Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace System*, Conference 10970, International Society for Optics and Photonics. [Published] [Federal support acknowledged] [Accessible [here](#)]
8. Manning, M., Weldon, B., and C. Newton. "Flexural behavior of a prestressed channel girder with a nonproprietary ultra-high performance concrete overlay". Transportation Research Board Annual Meeting, January 2019, Washington, DC. [Federal support acknowledged]

9. Metro, K., Hernandez, J., Harper, C., Bogus, S., Kommalapati, R., and D. Choe. "Recruitment, retention, and promotion for careers at transportation agencies". Transportation Research Board Annual Meeting, January 2019, Washington, DC. [Federal support acknowledged]
10. Morshed, M.M.T., and Z. Hossain. "Assessment of ordinary PG plus tests for modified asphalt binders." 4th Annual LSUS Regional Students Scholars Forum, March 2019, Shreveport, LA. [Federal support acknowledged]

Websites or other Internet Sites (Selected)

The [Tran-SET website](#), [Facebook](#), [LinkedIn](#), [Twitter](#), and [YouTube](#) pages are continuously updated and leveraged for outreach initiatives and activities.

Partnering institutions have reported on Tran-SET-sponsored activities through their own social media outlets. Selected, demonstrative examples are shown below:

- [Article](#) from the University of Texas at Arlington (UTA) summarizing Dr. Anand Puppala's (PI) research on geopolymers for soil modification and sustainable cement materials to strengthen highway embankments (Project Nos. 18GTL SU10, 18CTAM03);
- [Article](#) from LSU, [news video](#) from WBRZ, and [video featurette](#) from Louisiana Public Broadcasting documenting Dr. Gabriel Arce's, Dr. Marwa Hassan's, and Dr. Tyson Rupnow's (PIs) research and field implementations of engineered cementitious composites (ECC) or "bendable concrete"(Project No. 17CLS U05); and
- [Newsletter](#) from Deep South ITE featuring Mr. Christopher Melson's (Program Manager) presentation and laboratory tour at the Deep South ITE Fall Meeting.

EDUCATION

Table 6 lists Tran-SET's performance metrics for education-related outputs. In total, Tran-SET supported **79** students and produced **16** educational modules. Select modules are described below.

Table 6. Education Performance Metrics: Outputs.

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
E-01 E-02 E-03	E1, E2, EL1, IF4, A2	Number of students supported from Tran-SET research:				
		Undergraduate students	25	25	25	100%
		Masters students	29	29	25	116%
E-03		Doctoral students	25	25	25	100%
E-04 E-05	E1, E2, EL1, ED1, IF4, A2	Number of research opportunities for under-representative groups:				
		Undergraduate students	25	25	15	167%
E-05		Graduate students	34	34	15	227%
E-06	E1, E2, EL1, ED1, IF4, A2	Total budgeted costs for women and minorities	\$0.401M	\$0.401M	\$1.1M	36%
E-07	E1, E2, EL1, IF4, A2	Number of new transportation-related educational modules delivered	16	27	35	77%
E-08	E1, E2, EL1, IF4, A2	Number of STEM events sponsored by Tran-SET or that participated in	12	19	15	127%

Educational Modules (Selected)

1. An educational module on advanced asphalt testing methods/analyses was added to Louisiana Tech courses “CVEN427: Design of Highway Pavements” and “CVEN517: Advanced Civil Engineering Materials” (Project No. 17BLSU01).
2. An educational module was developed and integrated into LSU course “CE7310: Advanced Geotechnical Engineering” (Project No. 17GTLSU04).
3. An educational module on the quantification of damage to pavement structures caused by Hurricane Harvey was developed and integrated into UTA course “CE5336: Pavement Design” (Project No. 18PUTA02).
4. An educational module was developed and presented to NMDOT engineers over the use of HoloLens (AR Headset) technology for more efficient, faster, and safer methods for bridge inspections (Project No. 18STUNM03).
5. An educational module entitled “Control of Thermal Deflection in Concrete Structures through Implementation of Prestrained Shape Memory Alloy Roads” was presented in TAMU course “SPIE19: Nondestructive Characterization and Monitoring of Advanced Materials, Aerospace, Civil Infrastructure, and Transportation” (Project No. 18STTAM01).
6. An educational module was developed and integrated into UNM course “CE424/524: Steel Design” over state-of-the-art structural inspection methods (Project No. 18STUNM03).
7. An educational module was developed on the application of rice hull ash in FFC mixtures and presented at a “lunch and learn” event (Project No. 18CASU03).
8. An educational module was developed and integrated into LSU course “ENGG 4200: Autonomous Vehicles” based off project results (Project No. 18ITSLSU09).

WORKFORCE DEVELOPMENT

Table 7 lists Tran-SET’s performance metrics for workforce development-related outputs. During this reporting period, **8** revised courses and **4** seminars/workshops were delivered. Seminars/workshops are listed below.

Table 7. Workforce Development Performance Metrics: Outputs.

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
WF-01	WF1, IF4, A2	Number of new or revised transportation-related courses	8	17	25	68%
WF-02	WF1, IF4, A2	Number of seminars/workshops presented	4	11	15	73%
WF-03	WF1, IF4, A2	Number of professional society-related events ¹ sponsored or participated in	15	19	15	127%

¹Events include local and regional meetings of various professional societies (e.g., AASHTO, ASCE, ITE, SAE, etc.); Tran-SET believes these local groups are a critical link in developing the transportation workforce.

Seminars/Workshops

1. Jafari, N. and A. Puppala. “Rehabilitating slopes with incurred surficial failures”. November 2, 2018. Paris, TX. [Federal support acknowledged]
2. Hossain, Z. and K.T. Islam. “Rice husk ash (RHA) is concrete.” November 27, 2018, Jonesboro, AR. [Federal support acknowledged]
3. Moreu, F. and H. Noh. “Quantifying human-infrastructure interfaces for decisions: Theory, applications, and hands-on experiments using data.” January 27, 2019, Orlando, FL. [Federal support acknowledged]
4. Moreu, F. and C. Lippit. “AFRL-UNM agile manufacturing center showcase.” February 28, 2019, Albuquerque, NM. [Federal support acknowledged]

4. Outcomes

Given that first-cycle projects recently completed their implementation phase, second-cycle projects recently completed their research phase, and the significant time required to realize *actual* outcomes, the following subsections detail how select outputs are *expected to lead* to meaningful outcomes.

TECHNOLOGY TRANSFER

Table 8 lists Tran-SET’s performance metrics for T2-related outcomes. As shown, products from first-cycle projects are gradually being adopted and are continually moving towards implementation.

Table 8. Technology Transfer Performance Metrics: Outcomes.

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
TT-C1 TT-C2	TT1, TT2, IN2	External, derivative initiatives spurred by research products ¹				
		Number of additional research projects	1	3	1	300%
		Total funding of additional research projects	\$125k	\$319k	\$100k	319%
TT-C3	TT1, TT2, IN2	Number of commercialized/patented/licensed research products	1	1	1	100%
TT-C4	TT1, TT2, IN2	Number of stakeholders MOUs	1	1	1	100%
TT-C5 TT-C6	TT1, TT2, IN2	Number of stakeholders who have:				
		Committed to adopt research products	2	2	3	67%
		Adopted research products	2	2	1	200%

¹Sponsored research projects (external to Tran-SET) initiated as a direct result of research products developed from a Tran-SET-sponsored project.

Discussion of Performance Metrics: Adoption of Research Products

- **Number of Commercialized/Patented/Licensed Research Products (TT-C3):** The patent submitted last reporting period on speed estimation, detection, and ranging using visible light in vehicles (Project No. 18ITSOKS01) has been fully disclosed. Two additional patents have been filed this reporting period (Project Nos. 17STUNM02, 17CLSU05) and three are currently under preparation (Project Nos. 17STUNM02, 18ITSTSA03, 18STUNM03).
- **Number of Stakeholders Who Have Adopted Research Products (TT-C6):** The developed method utilizing ultra-high performance fiber-reinforced concrete (UHP-FRC) for repair of concrete pavement (Project No. 17STUTA03) has led to installation of three 18’-4”x7’-10”x1’-5” precast UHP-FRC slabs at Dallas Fort Worth Airport. The developed mixture of ECC (Project No. 17CLSU05) was utilized in a sidewalk installation on the campus of LSU. This has led to a larger-scale field implementation of ECC for a section of roadway at LSU, planned for the next reporting period.

Increased Understanding and Awareness of Transportation Issues (Selected)

- The conducted survey and analysis (in Project No. 18PPUNM02) led to a better understanding of how the quality of pedestrian infrastructure and the pedestrian environment, particularly on residential streets, affects the decision to walk. It is expected that the guidance produced will be used by local governments to improve pedestrian infrastructure and local roadway design.
- The environmental lifecycle assessment of the proposed Houston-Dallas high speed rail system led City planners and officials to have a better understanding of its impact on regional

air quality, sustainability as a transportation mode, and overall environmental benefits/costs (Project No. 18PPVU014). The gained information may be used/influence future decision making of the system’s implementation.

- The developed context-aware framework, subject testing, and corresponding analysis (in Project No. 18ITSLUS09) has led to improved understanding of driver’s route choice decision making, especially in dynamic, extreme conditions (such as a weather emergency).

New Policies, Regulations, Rulemaking, or Legislation (Selected)

- The investigation of various test methods for characterizing modified asphalt binders, corresponding recommendations, and developed guidelines may lead to improved state DOT processes and the adoption of simpler and more effective test methods (Project No. 18BASU02).
- The evaluation along roadsides and developed processes to evaluate the potential of roadside vegetation for carbon sequestration will result in steps toward establishing a simple, reliable, and replicable methodology for assessing carbon stocks in vegetation along federal highways (Project No. 18HSTSA01).
- The experimental study and numerical simulation of the performance of drilled shafts showed that vertical load has tangible effects on lateral deflection (Project No. 18GTTSA02). These findings may lead to improvement of current drilled shaft design procedures.

Adoption of New Technology, Techniques, or Practices (Selected)

- A new pavement interlayer consisting of high-performance fiber reinforced concrete (HPFRC) has been designed and experimental investigations show that the new interlayer is effective in suppressing reflective cracking in pavement overlay (Project No. 18PLSU13). Design guidelines of the new interlayer system has been developed, further encouraging and assisting adoption of the new technology.
- The evaluation of the application of ECC for jointless ultrathin white-topping (UTW) overlay includes developing preliminary guidelines for a specification in the state of Louisiana, assisting LaDOTD in adoption of the new technique (Project No. 18CLSU01).

EDUCATION

Table 9 lists Tran-SET’s performance metrics for education-related outcomes. In total, **141** students participated in Tran-SET-sponsored research.

Table 9. Education Performance Metrics: Outcomes.

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
E-C1	E1, E2, EL1, ED1, IN4, A2	Number of students participating in Tran-SET research:				
E-C2		Undergraduate students	54	54	75	72%
E-C2		Graduate students	87	87	100	87%
E-C3	E1, E2, EL1, IN4, A2	Number of times educational modules have been viewed	300	600	700	86%
E-C4	E1, E2, EL1, ED1, IN4, A2	Number of students attending sponsored or involved STEM events	220	440	300	147%

Increased Body of Scientific Knowledge (Selected)

- The developed self-healing concrete using encapsulated bacterial spores, production processes, lab investigations, and analysis will aid in advancing the state-of-the-art in the application of this emerging technology in concrete materials (Project No. 18CLSU02).

WORKFORCE DEVELOPMENT

Table 10 lists Tran-SET’s performance metrics for workforce development-related outcomes. In total, **124** attendees participated in new/revised transportation-related courses, seminars, or workshops.

Table 10. Workforce Development Performance Metrics: Outcomes.

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
WD-C1	WF1, IF4, A2	Number attending offered new or revised courses	44	241	500	48%
WD-C2	WF1, IF4, A2	Number attending presented seminars/workshops	80	160	225	71%
WD-C3	WF1, IF4, A2	Sponsorship: Number of stakeholders sponsoring seminars/workshops/conferences	4	6	3	200%
WD-C4		Total funds of sponsorship	\$3k	\$4k	\$15k	27%

Enlargement of Trained Transportation Workforce (Selected)

- The development of low-cost sensors and artificial reality (AR) applications to assist field inspection of transportation infrastructure (Project No. 18STUNM03) has been integrated into several trainings to educate practitioners on such technology, including: an interactive program with NMDOT bridge engineers and inspectors over the potential use of AR, demonstration of low-cost strain gauge sensors to NMDOT engineers, and a public demonstration of data visualization of wireless sensors in AR headsets.

5. Impacts

As with outcomes, project impacts will be updated as they become available. The following subsections detail how select project outcomes are *expected to impact* the transportation system and workforce.

TECHNOLOGY TRANSFER

Table 11 lists Tran-SET’s performance metrics for T2-related impacts.

Table 11. Technology Transfer Performance Metrics: Impacts.

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
TT-I1	TT1, TT2, R1, IF2, IN1, IN2	Improve the durability and service life of transportation infrastructure ¹	35%	35%	20%	175%
TT-I2	TT1, TT2, IN2	Reduce costs associated with repair and upgrade of transportation infrastructure ²	\$75k	\$75k	\$10k	750%

¹Represents the average percent improvement to service life estimated by second-cycle project PIs of their specific infrastructure component of study, assuming a full-scale implementation and all other factors constant; ²Represents the average cost savings per lane-mile estimated by second-cycle PIs associated with repairs using their specific infrastructure component of study, assuming all other factors constant.

Discussion of Performance Metrics: Impact of Research Products

- Improve the Durability and Service Life of Transportation Infrastructure (TT-I1):** This metric comprises of a wide-range of applicable products from second-cycle projects (products aimed at improving durability and service life; **23** in total). Please note the difficulty and challenge of the estimate; it represents the likely upper limit of potential implementation and not an *actual* measured impact. However, it shows the great potential of Tran-SET research to produce meaningful impacts to its main focus area (**R1**).
- Reduce Costs Associated with Repair and Upgrade of Transportation Infrastructure (TT-I2):** Likewise, this metric comprises of a wide-range of applicable products (**9** in total). It is perhaps even more challenging to estimate due to cost discrepancy of transportation infrastructure repairs (e.g., cost of a lane-mile of a rural pavement structure vs. a bridge structure). It shows the great cost savings potential of Tran-SET research, which is critical in the current condition of aged infrastructure and limited maintenance funds.

Impact on Effectiveness of the Transportation System (Selected)

- The developed and investigated technique of using ultra-high performance concrete (UHPC) as a grout to fill shear keys between pre-stressed girders is expected to significantly extend the lives of rehabilitated bridge superstructures (Project No. 18CNMS01). The impact of the technique may result in substantial improvements in economic efficiency of the transportation system.
- 90% of the long-term durability issues of reinforced concrete structures are due to steel rebar corrosion and concrete cracking. The newly developed UHP-FRC with fiber-reinforced polymer (FRP) structural members (Project No. 18STUTA01) provides a non-corrosive reinforcement, eliminating these issues, with the capability of significantly enhancing the service life of these structures.

Impact on Adoption of New Practices and Commercialization (Selected)

- The developed crowdsourcing method to identify road pavement damage through vehicle vibration data (Project No. 18PLSU08) is expected to reduce the frequency of detection of major road damages from three months on average to within one day. Given the savings attributed to early maintenance, this may increase the service of life of transportation by 10%. Additionally, this process may replace 30% of current manual inspection tasks, leading to significant cost savings.
- The developed LiDAR-based sinkhole detection and mappings tools will be transferred to state DOTs for their free use, and a guidebook and professional trainings may be further developed to assist DOTs in deploying these tools (Project No. 18GTUNM01). The expected impact is a reduction in cost/labor and an increase in accuracy for sinkhole detection and mapping.

EDUCATION

Table 12 lists Tran-SET’s performance metrics for education-related impacts. As shown, funded projects have led to the graduation of a number of students that will effectively contribute to the transportation sector.

Table 12. Education Performance Metrics: Impacts.

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
E-I1	EL1, EL2, IF4, A2	Number of graduated, supported students entering the transportation field	1	23	30	77%

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
E-I2	EL1, EL2, IF4, A2	Feedback ¹ of graduated, supported students who've entered the transportation field	+	+	*	-

*Target equivalent to a "satisfactory" rating; +New metric to be reported by 10/30/19; same notations for Table 13;

¹Feedback related to how well educational experiences prepared student for workforce; solicited from electronic surveys or in-person/phone interviews.

Impact on Scientific Knowledge (Selected)

- The developed casual model for understanding driver's route choice (Project No. 18ITLSU09; see Section 3) included new causality-based techniques and techniques for optimal mixing in nonparametric mixture models. This has contributed to the body of knowledge in the field of machine learning and led to a new machine learning algorithm for a diverse set of applications beyond the transportation field.
- The investigation of smart and innovative charging techniques using renewable energy sources available on roadways (Project No. 18ITSTSA03) included the evaluation of different nanomaterials/piezoelectric materials in energy harvesting applications and novel converters for power transfer of low power and storage. These techniques will advance sciences related to energy and energy harvesting systems.

WORKFORCE DEVELOPMENT

Table 13 lists Tran-SET's performance metrics for workforce development-related impacts.

Table 13. Workforce Development Metrics: Impacts.

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
WD-I1 WD-I2	WF1, IF4, A2	Feedback ¹ of seminar/workshop/ Conference attendees: Related to skills gained	+	+	*	-
		Related to improved practices			*	-

¹Feedback solicited from electronic surveys or in-person/phone interviews

Impact on Transportation Workforce Development (Summarized)

- Tran-SET research has supported a high number of students, especially those from under-representative groups – educating and training the future workforce with the needed skills and capabilities to meet the current and future needs of the transportation industry.
- The developed educational modules, revised transportation-related courses, and provided seminars/workshops have educated and trained the current and future workforce on emerging innovations – supplementing its capabilities and increasing its competitiveness.

6. Changes/Problems

Nothing to report.

7. Special Reporting Requirements

Not applicable.