Transportation Consortium of South-Central States

Tran-SET

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 #10

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

Sub. Date: Apr. 15, 2022

Grant: 69A3551747106

Grant Period: Nov. 30, 2016 – Sep. 30, 2023

Project Title: University of Transportation Centers Program – Region 6

DUNS: 075050765

EIN: 726000848

Account: GR-00000627

Reporting Period: Oct. 1, 2021 – Mar. 31, 2022 (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 activities[1]:

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]

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

Project Closeout of Fourth-Cycle Projects: Each Tran-SET project consists of a 12-month technical phase, followed by a 6-month implementation phase. Out of the total 40 fourth-cycle projects, 34 projects were successfully completed and closed out **(Feb. 2022).** For the remaining 6 projects, Tran-SET staff conducted an initial review of submitted final reports and datasets **(Dec. 2021)**, requested revisions **(Feb. 2022)**, and received revisions **(Mar. 2022)**. The finalized reports and datasets will be archived and disseminated per UTC reporting requirements **(Apr. 2022).** [M1, A2]

Fifth-Cycle Projects in Progress: As of **Mar. 2022**, **35** projects from Tran-SET's fifth funding cycle successfully completed 8 months of the technical phase. Figures 1a and 1b present the distribution of projects by research objective and transportation area, respectively. Detailed information can be found in Appendix A. [R1, R2, R3, R4, S1, IF2, IF3, IF4, IN1]

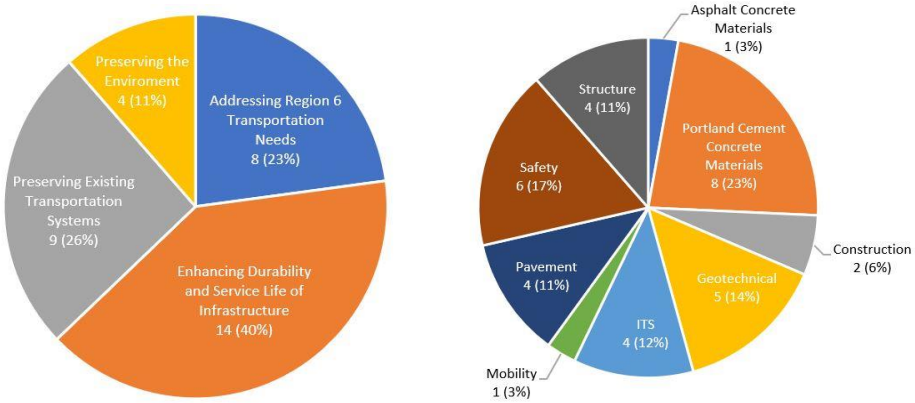

Figure 1. Fifth-Cycle Projects Categorized by: (a) Research Objective and (b) Transportation Area.

Proposals for Sixth-Cycle Projects: A total of **68** problem statements that were submitted for the sixth-cycle of funding were ranked by regional transportation leaders/experts **(Oct. 2021)** and requests for proposals (RFPs) were solicited for **40** projects **(Nov. 2021)**. Projects are categorized in Figures 2a and 2b, by Tran-SET research objective and transportation area, respectively. A total of **40** proposals were received **(Jan. 2022)** and are currently under review by subject matter experts. [R1, R2, R3, R4, S1, IF2, IF3, IF4, IN1]

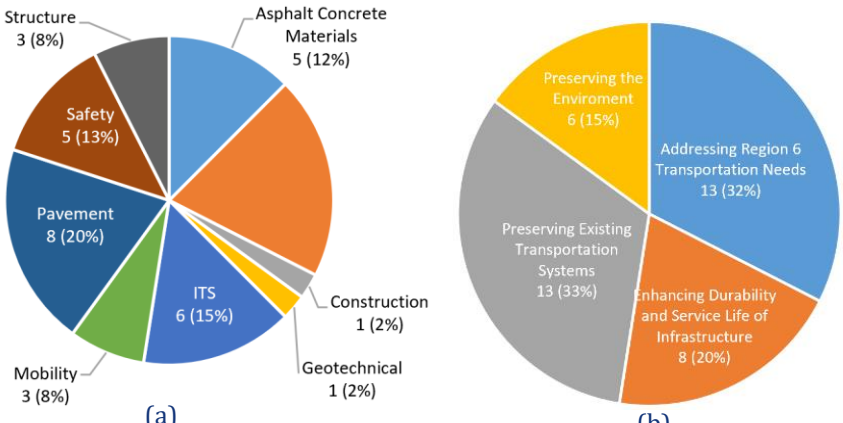

Figure 2. Sixth-Cycle Proposals Categorized by: (a) Research Objective and (b) Transportation Area.

TECHNOLOGY TRANSFER

2022 Tran-SET Conference: Tran-SET will hold its fifth annual conference on **Aug. 31-Sep. 2, 2022** in Austin, Texas. The Conference will be hosted and organized by the University of Texas at San Antonio (UTSA). The purpose of the annual conference is to educate, engage, and work with varied stakeholders (academics, industry professionals, state DOTs, and other government agencies) to discuss and solve transportation challenges facing the South-Central United States. The conference is also an opportunity to update stakeholders on Tran-SET's research, education, workforce development, and technology transfer activities. Several activities have occurred during this reporting period in preparation including establishing the Conference Planning Committee **(Dec. 2021)**, creating the conference website **(Jan. 2022)**, and soliciting call for papers and student poster abstracts **(Feb. 2022)**. More information is available on Tran-SET's website. [TT1, TT2, EL2, IN2]

2021 TriDurLE Symposium: Tran-SET partnered with TriDurLE UTC to collaborate as a co-sponsor in the 2021 TriDurLE Symposium that was held virtually on **Dec. 6-7, 2021**. The symposium's main theme was "Transportation Infrastructure Innovations for Durability and Resilience." More information about this symposium is available through the following link. In this symposium, Tran-SET provided two back-to-back presentations featuring Tran-SET's key research findings. [TT1, TT2, EL2, IN2]

2022 TRB Annual Meeting: Tran-SET had a strong presence at the 2022 TRB Annual Meeting held on **Jan. 2022.** More than 40 Tran-SET researchers and students attended the annual meeting and presented results and findings from Tran-SET projects. Over 13,000 transportation professionals were in attendance. [TT1, TT2, EL2, IN2]

Joint Tran-SET Webinar Series: Tran-SET continued its quarterly webinar series with its 15th **(Dec. 2021)** and 16th webinars **(Mar. 2022).** The 15th webinar was on the topic of "*Improving Safety and Reliability of Rails"* and was offered in collaboration with Oklahoma State University, University of New Orleans, and Florida Atlantic University. The 16th webinar was on the topic of *"Warm Mix Asphalt to Improve Pavement Sustainability*" and was offered in collaboration with Arkansas State University and Oklahoma State University. About 150 attendees participated in these webinars. Recorded webinars, presentation slides and other outreach materials are available on the Tran-SET's website. [TT1, TT2, EL1, EL2, EC1, IF4, IN2, A2]

Newsletter: Tran-SET continued to develop and disseminate its quarterly newsletter with the winter issue **(Dec. 2021)** and spring issue **(Mar. 2022).** Newsletters are disseminated via the Tran-SET's list serve. Current and past newsletters are available on the Tran-SET's website. [TT1, IN2]

Technology Transfer (T2) Plan: Tran-SET continues to implement its T2 plan, specifically: requiring sixth-cycle proposals to include project-specific T2 plans and utilizing these plans in the review/selection process **(Mar. 2022).** [TT1, TT2, EC1, IN2, A2]

EDUCATION

Tran-SET Transportation Veteran Scholarship: As part of Tran-SET's initiative to advance the transportation workforce and to develop its next generation of leaders, Tran-SET offered a scholarship to three veterans. The scholarship awards $10,000 to each student over a period of two years. During this reporting period, three students were awarded the scholarship and are conducting their graduate studies as part of Tran-SET-funded research projects. [E1, EL1, EC1, ED1, IF4, A2]

LSU High School Student Research (HSSR) Intern Program: As part of Tran-SET's commitment to engage high school students in transportation-related research, Tran-SET is participating in the HSSR Intern program organized by LSU to involve high school students in research in **summer 2022**. More information regarding the Internship is available on the LSU's website. [E1, EL1, EC1, ED1, IF4, A2]

eCybermission Competition: As part of Tran-SET's commitment to enhance education and workforce development, Tran-SET is collaborating with the U.S. Army Educational Outreach Program (AEOP) in their eCybermission. eCybermission is a web-based STEM competition for students in grades six through nine. More information about this competition could be found on their website. In this reporting period, Dr. Mousa (Tran-SET Program Manager) is continuing to serve as a volunteer ambassador to the program, where he had regular meetings with the organizers to discuss and plan future outreach activities. [E1, EL1, EC1, ED1, IF4, A2]

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

- On November 20, 2021, LSU PIs participated in the Back-to School STEM Festival, which took place at the Southeastern Louisiana University campus in Hammond, Louisiana. Topics such as engineered cementitious composites, engineered geopolymer composites, and bio-concrete were presented using hands-on materials. Fact sheets about all projects were handed out to interested students and staff.
- Dr. Brendy Rincon (Tran-SET PI) from the University of Texas at San Antonio (UTSA) is serving as a First-Gen STEM Scholars Faculty Mentor at UTSA since October 2021.
- Dr. Maryam Hojati (Tran-SET PI) from the University of New Mexico (UNM) presented as a Keynote speaker in the IEEE Women in Engineering, IEEE ABQ Section.
- Dr. Ali Kazemian (Tran-SET PI) from Louisiana State University participated and contributed to Kenilworth Science Fair, Kenilworth Science and Technology School, Dec 2021.

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]

- Dr. Kate Hyun (Tran-SET PI) from the University of Texas at Arlington (UTA) presented in the National Training Center (NTC) webinar to educate the attendees about Mobility, Accessibility, and Resiliency of Community-Dwelling Older Adults.
- Dr. Momen Mousa (Tran-SET PI) from Louisiana State University provided a 30-min. educational session (Feb. 2022) in the American Traffic Safety Services Association (ATSSA)'s Annual CONVENTION & TRAFFIC EXP in Tampa, Florida. In this session, emerging machine learning techniques were presented as promising techniques to predict the performance of pavement markings.
- Dr. Amit Kumar (Tran-SET PI) from the University of Texas at San Antonio (UTSA) delivered a presentation in a graduate student seminar at UTSA.
- Dr. Raghava R. Kommalapati (Tran-SET PI) from Prairie View A&M University (PVAMU) participated in the ASCE meeting on February 2022 in Houston, Texas.

MANAGEMENT

Project Data Management Plan: Tran-SET required all sixth-cycle proposals to include project-specific data management plans. These plans are considered as part of the review/selection process **(Mar. 2022).** [M1, A2]

Section 508/Accessibility: Tran-SET has been working diligently to ensure all public facing contents (submitted to NTL and all content residing on the Tran-SET website) are 508-compliant. Completed contents include documents and reports on Tran-SET's website, Tran-SET's website and social media page, and video contents. [M1, A2]

Dissemination of Results

Please see the "Technology Transfer" subsections of Sections 1 (above) and 3 (below) documenting Tran-SET's main outreach and dissemination activities. As detailed in these sections, results have been disseminated via social media (Tran-SET website, LinkedIn, Twitter, and YouTube), newsletters, other promotional documents (i.e., project briefs), conferences, educational materials, and peer-reviewed publications.

Activities Planned (for Next Reporting Period)

RESEARCH

- Archive and finalize remaining fourth-cycle project deliverables **(April 2022).** [TT1, IN2]
- Complete review of proposals **(Apr. 2022),** revise and finalize proposals for **(April 2022),** and award sixth-cycle projects **(May 2022).** [R1, R2, R3, R4, S1, IF2, IF3, IF4, IN1]
- Issue call for problem statements for seventh-cycle projects **(Aug. 2022)** and begin review of problem statements (pending renewal of the Center). [R1, R2, R3, R4, S1, IF2, IF3, IF4, IN1]

TECHNOLOGY TRANSFER

- Develop and disseminate Tran-SET newsletter for summer 2022 **(Jun. 2022)** and fall 2022 **(Sep. 2022).** [TT1, IN2]
- Organize and jointly host two webinars in the "Joint-Tran-SET Webinar Series" **(Jun. 2022, Sep. 2022).** [TT1, TT2, EL1, EL2, EC1, IF4, IN2, A2]
- Continue planning activities for the 2022 Tran-SET Conference planned on **Aug. 31-Sep. 2, 2022**. [TT1, TT2, EL2, IN2]
- Continue to develop, promote, and expand Tran-SET's educational video portfolio **(on-going)**; and upload videos from the 2021 Tran-SET Conference **(Apr. 2022).** [TT1, IN2]
- Promote and disseminate fourth-cycle reports and project datasets via Tran-SET listserv and social media **(Apr. 2022).** [TT1, IN2]
- Continue developing/disseminating "Project Highlights" for fourth-cycle projects **(May 2022).** [TT1, IN2]

EDUCATION

- Continue to offer the Tran-SET Scholarship for Veterans and award it to three recipients in the **2022 fall** semester. [E1, EL1, EC1, ED1, IF4, A2]
- Continue sponsoring, organizing, and participating in STEM events **(on-going).** [E1, IF4, A2]
- Continue engaging high school students in the 2022 CoE HSSR Program at LSU **(Apr.-Jul. 2022)**. [E1, EL1, EC1, ED1, IF4, A2]
- Continue coordinating with the U.S. Army Educational Outreach Program (AEOP) to recruit future virtual judges **(Sep. 2022)** to participate in eCybermission. [E1, EL1, EC1, ED1, IF4, A2]
- Continue coordinating with the PIs to develop new educational modules and publishing these educational modules on Tran-SET's website **(on-going).** [E1, EL1, EC1, ED1, IF4, A2]

WORKFORCE DEVELOPMENT

- Integrate developed educational modules and revised courses into the recently created LSU Construction Management online programs: B.S., Post Baccalaureate Certification, and M.S. degree programs **(on-going).** [WF1, TT1, TT2, EL2, IF4, A2, IN2]
- 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]

- Continue organizing and participating in STEM events **(on-going).** [WF1, TT1, TT2, EL2, IF4, A2, IN2]
- Collaborate with the Transportation Research Forum (TRF) to organize new workforce development events as a part of the new student chapter at LSU **(May 2022).** [WF1, TT1, TT2, EL2, IF4, A2, IN2]

MANAGEMENT

- Provide 508 compliant captions for Tran-SET videos **(Jun. 2022).** [M1, A2]
- 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. 2022).** [M1, all, A2]

2. Participants & Collaborating Organizations

During this reporting period, Tran-SET partnered with **136** organizations (51 academic institutions, 37 government agencies, 38 industrial firms, and 10 nonprofits) to accomplish and oversee its research, technology transfer, education, and workforce development activities. Please see Table 2 for details.

Tran-SET collaborated with **39** organizations/individuals (from 11 academic institutions, 10 government agencies, 5 industrial firms, and 13 nonprofits.). As shown in Table 3, these collaborations embody interdisciplinary approaches and numerous industrial partnerships.

Partners (Selected)

Table 2. Tran-SET Partners.

Organization Name	Type	Location	Description of Contribution [Tran-SET Affiliation]
Accenture Endowed Professorship in Mechanical Engineering	Industrial firm	Austin, TX	Collaborative research [PRC]
Admas Engineering	Academic institution	Purkynova, Czechia	Collaborative research [PRC]
AECOM	Industrial firm	Los Angeles, CA	Collaborative research [PRC]
Air Force Research Laboratory	Government	Albuquerque, NM	Early potential adopters and problem owners
Alabama Transportation Institute - University of Alabama	Academic institution	Tuscaloosa, AL	Collaborative research [PRC]
Alliance Safety Council (Industry)	Nonprofit	Baton Rouge, LA	Collaborative research [CAB]
Appalachian State University	Academic institution	Boone, NC	Collaborative research [PRC]
APS Engineering and Testing LLC	Industrial firm	Baton Rouge, LA	Collaborative research [PRC]
ARA	Industrial firm	Albuquerque, NM	Collaborative research [PRC]
Arkansas Concrete Pavement Association	Academic institution	Little Rock, AK	Collaborative research [PRC]
Arkansas Department of Energy & Environment	Government	Little Rock, AK	Collaborative research [PRC]
Arkansas Highway and Transportation Dep. (AK)	Government	Little Rock, AK	Collaborative research [CAB]

Organization Name	Type	Location	Description of Contribution [Tran-SET Affiliation]
Association of American Railroads	Nonprofit	Washington, D.C.	Input about practicality and barriers of using tapping robots for the railroad industry
Atlas Asphalt Inc.	Industrial firm	Jonesboro, AR	In-kind support; Atlas Asphalt Inc. has supplied testing materials for this project.
Barriere Construction Company (Industry)	Industrial firm	New Orleans, LA	Collaborative research [CAB]
Black Buffalo 3D Corporation	Academic institution	New York, NY	Collaborative research [PRC]
Boral Resources	Industrial firm	South Jordan, UT	Supply alternative SCMs

Collaborators (Selected)

Table 3. Tran-SET Collaborators.

Organization/Name	Type	Description of Collaboration [Tran-SET Affiliation]
AECOM	Industrial firm	Shared data pertaining to CRPC vanpool program development and inflow-outflow analysis
American Society of Civil Engineering (ASCE)	Nonprofit	Trade organization
ARDOT	Government	ARDOT District 10 helped to identify the RAP sources.
AREMA	Nonprofit	Discussing of new technologies for their use on railway safety
Arkansas Asphalt Pavement Association (AAPA)	Nonprofit	AAPA helped to identify another local paving company API as a research collaborator.
Asia-Pacific-Euro Summer School on Smart Structures Technology	Nonprofit	Trade organization
Automated Railroad Maintenance Systems (ARMS)	Industrial firm	Provide feedback and assessment of the work
Build Baton Rouge (East Baton Rouge Redevelopment Authority)	Government	Shared unpublished plan documents and information pertaining to station area development planning and strategy
Chinese Earthquake Administration (CEA)	Nonprofit	Laboratory for testing LiDAR in large scale facilities and input on large scale applications
City of Jonesboro	Government	City of Jonesboro engineer has been briefed about the project.
City of San Antonio	Government	Discussed field implementation
CPS Energy	Government	Presented harvesting results
DOTD	Government	Shared data pertaining to FTA and DOTD support of existing and previous intercity services (i.e., LA Swift and regional Greyhound service)
ESPOL University	Academic institution	Process bagasse ash, prepare SCBA-ECC mixtures and evaluate its properties; Conduct research on zeolite-based EGC materials.
FHWA	Government	Discussed application of the vehicle classification software (Debbie Walker)

Organization/Name	Type	Description of Collaboration [Tran-SET Affiliation]
Frontiers Journal	Nonprofit	Trade organization
Greyhound	Industrial firm	Collaboration in in-person data collection for existing intercity passenger service customers
Institute of Engineering Mechanics (IEM) China	Nonprofit	Student to provide input on LiDAR for SHM of structures
Jonesboro High School (JHS)	Academic institution	The STEM Academy of JHS will select qualified students for the internship program
LaDOTD	Government	Help the PIs visit bridge construction sites
Megabus	Industrial firm	Collaboration in in-person data collection for existing intercity passenger service customers

3. Outputs

Performance metrics and targets for outputs, outcomes, and impacts of Tran-SET's research, T2, education, and workforce development programs are discussed below.

RESEARCH

Table 4 lists Tran-SET's performance metrics for research-related outputs. In total, **49** 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-O1		Metropolitan growth and congestion	5	5	5	100%
R-O2		Future transportation challenges	12	12	15	80%
R-03		Declining public revenues	5	5	3	167%
R-04		Underserved communities	1	1	2	50%
R-05		Safety	8	8	5	160%
R-06	EC1	Number of collaborative (multi-institution) projects	8	8	11	73%
R-07	R1, R2, R3, R4, IN1	Number of new technologies or techniques developed	49	88	80	110%

[1]Metric value for reporting period; [2]Best estimate for annualized metric value; [3]Annual, per funding cycle, target; [4]Percent completion of annual target; same column definitions for Tables 4 – 13.

Discussion of Performance Metrics: Number of New Technologies or Techniques Developed

In this reporting period, various new technologies and methods were developed resulting from the successful research conducted during the fourth-cycle and fifth-cycle projects. Examples of developed technologies or techniques are presented below.

1. Dr. Ali Kazemian (PI) and the project team at LSU developed a steel-fiber reinforced 3D printable material
2. Dr. Kate Hyun (PI) and her project team at UTA developed a model to analyze the impacts of network disruption during disaster events.

3. Dr. Yongcheol Lee (PI) and his project team at LSU developed a model to organize transportation recovery and maintenance projects by using agent-based modeling and deep reinforcement learning.
4. Dr. Maryam Hojati (PI) and her project team at UNM designed 3D-printable Engineering Cement Composite (ECC) mixtures and successfully adjusted their fresh properties.
5. Dr. Mena Souliman (PI) and his research team at the University of Texas at Tyler (UTT) developed a simplified pavement health categorization chart utilizing the Falling Weight Deflectometer (FWD) simulated deflection bowls and deflection parameters.
6. Dr. Shan (PI) and his research team in OSU developed a resource guide for state DOTs to use their equipment fleet management data to support informed decisions for the replacement as well buy-vs-rent of equipment.

TECHNOLOGY TRANSFER

Table 5 lists Tran-SET's performance metrics for T2-related outputs. Selected output examples are presented below.

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	46	46	30	153%
TT-02		Late potential adopters	26	26	30	87%
	TT1, TT2, IN2	**Number of times research products (technology) are disseminated via the following channels:**				
TT-03		Featured in Tran-SET newsletter	12	24	24	100%
TT-04		Featured on Tran-SET social media	9	41	50	82%
TT-05		Peer-reviewed publications and presentations	153	309	130	238%
TT-06		Webinars	2	4	5	80%
	TT1, IN2	**Tran-SET website traffic:**				
TT-07		Number of visitors to website	17k	34k	30k	113%
TT-08		Number of visits to website	122k	244k	250k	98%
	TT1, TT2, IN2	**Number of times disseminated research products have informed/been viewed:**				
TT-09		Social media engagement levels(s)	8.2/1.4	8.2/1.4	4.5[2]/2.5[3]	182/57%
TT-010		Number of times reports (or related) are downloaded	6,160	11,987	6,000	200%
TT-011		Number of citations from publications	279	553	200	277%
TT-012		Presentation attendees or views	5,102	10,726	10,000	107%
	TT1, TT2, IN2	**External funds:**				
TT-013		Industrial partners providing funds	5	5	4	125%
TT-014		Public agency partners providing funds	5	5	10	50%
TT-015		Total funds from industrial partners	$112k	$112k	$200k	56%
TT-016		Total funds from public agency partners	$301k	$301k	$300k	100%

[1]Individual stakeholders as specified in fifth-cycle, project-specific T2 plans; may contain multiple (but distinct) stakeholders within same agency; [2]Average "calculated as clicks/impressions" (LinkedIn); [3]Average "engagement rate" (Twitter).

Discussion of Performance Metrics: Building Audience

- **Number of Times Reports (or Related) are Downloaded (TT-010):** This metric has significantly increased in this reporting period from 5,827 to 6,160. Readers originated from 130 countries (with a strong majority from the US) and included educational institutions (55%), commercial entities (32%), and government agencies (13%).
- **Number of citations from publications (TT-011):** The target for this metric was re-evaluated and was raised to 200 (from 120). The increase is due to the significant impact of Tran-SET research publications.

Peer-Reviewed Journal Publications (Selected)

1. Hyun, K., Sattler, M.L., Bhatt, A.H., Nasirian, B., Behseresht, A., Chakraborty, M. and Chen, V.C., 2021, August. Development of a Cost Optimization Algorithm for Food and Flora Waste to Fleet Fuel (F 4). In INFORMS International Conference on Service Science (pp. 141-153). Springer, Cham.
2. Subedi S., Arce G., Hassan M., Huang O., Radovic M., Hossain Z. (2022) "Evaluation of Alternative Sources of Supplementary Cementitious Materials for Concrete Materials." Transportation Research Record: Journal of the Transportation Research Board, 1-15. DOI: https://doi.org/10.1177/03611981221074373
3. Mia F., Dessouky S., Weissmann J., Sharif H., and Billah K. (2021) "Geo-Locating and Identifying Wrong-Way Driving Entrance Points in Bexar County Highways by Implementing Mathematical Modeling and Land-Use Impact Assessment" Sustainability, 14(1), 33; https://doi.org/10.3390/su14010033
4. Hossain, Z., Bairgi, B., Zaman, M., Bulut, R., & Sumpter, B. (2021). Evaluation of Stripping Resistance of Organoclay-modified Asphalt Binder and Aggregate Systems Using an Optical Contact Angle Analyzer. In Developments in Sustainable Geomaterials and Environmental Geotechnics.

EDUCATION

Table 6 lists Tran-SET's performance metrics for education-related outputs. In total, Tran-SET supported **151** students and produced **20** educational modules. Select modules are described below.

Table 6. Education Performance Metrics: Outputs.

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
	E1, E2, EL1, IF4, A2	**Number of students supported from Tran-SET research:**				
E-01		Undergraduate students	47	47	50	94%
E-02		Masters students	48	48	50	96%
E-03		Doctoral students	56	56	50	112%
	E1, E2, EL1, ED1, IF4, A2	**Number of research opportunities for under-representative groups:**				
E-04		Undergraduate students	27	27	15	180%
E-05		Graduate students	32	32	30	107%
E-06	E1, E2, EL1, ED1, IF4, A2	Total budgeted costs for women and minorities	$0.28M	$0.28M	$1.1M	25%
E-07	E1, E2, EL1, IF4, A2	Number of new transportation-related educational modules delivered	20	64	50	128%

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
E-08	E1, E2, EL1, IF4, A2	Number of STEM events sponsored by Tran-SET or that participated in	23	52	20	260%

Discussion of Performance Metrics

- **Number of research opportunities for under-representative groups-graduate students (E-05):** The target for this metric was re-evaluated and was raised to 30 (from 15). The increase is due to Tran-SET's success in engaging minorities in graduate programs.

Educational Modules (Selected)

1. In OSU, an educational module on lithium-ion battery safety was developed in the undergraduate capstone design course.
2. In LSU, an education module was developed on pile downdrag for LSU course "CEE 4330 Geotechnical Design."
3. In UTA, a lecture was given featuring cultural response lessons; two sessions were conducted with engineering students (through WTS) and a science education course ELED 4312, section 001, SCIENCE/HEALTH EARLY & ELEM ED.
4. In UNM, an educational module on 3D-printing of ECC mixtures was presented in CE305 and CE160 as part of class lectures.
5. Three virtual lectures were given to undergrad students at UTSA and Mansourah University, Egypt on a new topic in pavement sustainability.
6. At LSU, an educational module on Construction 3D printing for Transportation infrastructure was delivered in Spring 2022 (CM4206: Advanced Construction Technologies).

WORKFORCE DEVELOPMENT

Table 7 lists Tran-SET's performance metrics for workforce development-related outputs. During this reporting period, **110** revised courses and **26** seminars/workshops were delivered. Tran-SET re-evaluated the target for metrics WF-01 below and increased it from the previous reporting period (from 100 to 150).

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	110	204	150	136%
WF-02	WF1, IF4, A2	Number of seminars/workshops presented	26	52	90	58%
WF-03	WF1, IF4, A2	Number of professional society-related events[1] sponsored or participated in	54	100	100	100%

[1]Events 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 (Selected)

1. Ali Kazemian, "Concrete 3D Printing for Accelerated Bridge Construction: Possibilities and Challenges," ASTM International Conference on Additive Manufacturing, California, Nov 2021.

2. Miryousefi Ata, S., "Application of Concrete 3D Printing for Bridge Construction: Current Challenges and Future Directions", ASCE Construction Institute (CI) and Construction Research Council (CRC) Joint Conference, March 9-12, 2022, Arlington, Virginia.
3. Jang J., "Utilization of Metakaolin-based Geopolymers for Stabilization of Sulfate-rich Expansive Soils" Geocongrss 2022, March 22, 2022.
4. G. Vennam, "State of health inclusive aging model of lithium-ion batteries," International Mechatronics Conference, Stillwater, OK, Oct 2021.
5. Yi Lu, "An experimental methodology for Determination of Chloride Threshold (CT) of steel rebars in simulated concrete pore solution (SCPS) based on AC and DC electrochemical methods," AMPP 2022, San Antonio.

4. Outcomes

While some of the outcomes will materialize in the long-term, the following subsections detail how current efforts are driving select outputs towards implementation and towards future and meaningful outcomes.

TECHNOLOGY TRANSFER

Table 8 lists Tran-SET's performance metrics for T2-related outcomes.

Table 8. Technology Transfer Performance Metrics: Outcomes.

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
	TT1, TT2, IN2	**External, derivative initiatives spurred by research products**				
TT-C1		Number of additional research projects	22	49	20	245%
TT-C2		Total funding of additional research projects	$4.8M	$14.2M	$8.0M	177%
TT-C3	TT1, TT2, IN2	Number of commercialized/patented/ licensed research products	1	2	6	33%
TT-C4	TT1, TT2, IN2	Number of stakeholders' MOUs	5	10	6	167%
	TT1, TT2, IN2	**Number of stakeholders who have:**				
TT-C5		Committed to adopt research products	12	21	25	84%
TT-C6		Adopted research products	4	10	15	67%

Discussion of Performance Metrics: Further Development and Adoption of Research Products

- **Number of Additional Research Projects (TT-C1, TT-C2):** A total of **22** sponsored research projects (external to Tran-SET) were initiated as a direct result of research products developed from a Tran-SET-sponsored project. The funding agencies for these projects included but not limited to National Cooperative Highway Research Program (NCHRP), Texas Department of Transportation (TxDOT), Federal Rail Administration, and City of San Antonio.
- **Number of Stakeholders who have committed to Adopt Research Products (TT-C5):** A total of 12 stakeholders have committed to adopt research products resulting from Tran-SET-sponsored projects. As an example:
    (1) Dr. Newtson's research team delivered an educational outreach presentation to New Mexico Department of Transportation (NMDOT) about Concrete Containing Natural Pozzolan as a Supplementary Cementitious Material. NMDOT was excited about this material and committed to consider it in their future applications.

(2) Dr. David Spivak and his research team developed a novel approach of introducing a catalyst that can modify asphalt binder's chemical composition; particularly to alter the oxidized molecules and reduce the number/content of aggregated structures. This approach is currently evaluated by the Louisiana Transportation Research Center (LTRC) in actual asphalt samples.
(3) A toolbox was developed in UNM to detect and assess bridge deck wearing surface and subsurface distresses for New Mexico Department of Transportation, District 2.

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

- Dr. Mena Souliman developed a simplified pavement health categorization chart utilizing the Falling Weight Deflectometer (FWD) simulated deflection bowls and deflection parameters. This will significantly facilitate pavement evaluation and pavement assets management at the network level in Texas.
- Dr. Samer Dessouky developed and optimized a prototype that successfully harvests thermal energy from asphalt pavements. Such prototype will result in steps toward increasing pavement sustainability.
- Dr. Nick Ferenchak developed longitudinal bicyclist, driver, and pedestrian perceptions of autonomous vehicle communication strategies. These findings will result in steps toward the implementation of autonomous vehicles.
- Dr. Momen Mousa developed machine-learning models that predict the performance of thermoplastic pavement markings. These findings will result in steps toward reducing the potential for under-stripped or over-striped roads.

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

- A system to monitor the flood water level was developed, and the results of real-time data collection and processing technology were utilized by the state of Texas.
- The New Mexico DOT started using the wildlife monitoring techniques proposed by Tran-SET researchers to prevent wildlife-vehicle collisions.
- NMDOT is implementing Ultra-High-Performance Concrete developed in NMSU (Project No. 19CNMS0) in bridge deck overlays.

EDUCATION

Table 9 lists Tran-SET's performance metrics for education-related outcomes. In total, **151** students participated in Tran-SET-sponsored research.

Table 9. Education Performance Metrics: Outcomes.

ID	Objective ID	Metric	Value	Ann. Value	Ann. Target	Percent Compl.
	E1, E2, EL1, ED1, IN4, A2	Number of students participating in Tran-SET research:				
E-C1		Undergraduate students	47	47	75	63%
E-C2		Graduate students	104	104	100	104%
E-C3	E1, E2, EL1, IN4, A2	Number of times educational modules have been viewed	186	526	1,000	53%
E-C4	E1, E2, EL1, ED1, IN4, A2	Number of students attending sponsored or involved STEM events	998	1,557	1,300	120%

Increased Body of Scientific Knowledge (Selected)

- The Tran-SET Transportation Veteran Scholarship attracted three students to the transportation field and provided unique opportunities to better prepare veterans for the workforce. The *actual* outcome of such a program is yet to be assessed; however, the aim is to develop the next generation of transportation leaders and to advance the transportation workforce in target communities (i.e., veterans).
- Tran-SET is currently engaging high school students in transportation-related research in Louisiana State University. Such engagement provides information, exposure, and positive experiences at an influential stage in students' career trajectory.
- Tran-SET presented innovative asphalt and concrete materials for high school students at the STEAM Night held by Oak Grove Primary. The objective of the presentation was to teach students the basics of highway materials and attract them to transportation engineering.

WORKFORCE DEVELOPMENT

Table 10 lists Tran-SET's performance metrics for workforce development-related outcomes. In total, **4,426** 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	3,281	6,179	4,000	154%
WD-C2	WF1, IF4, A2	Number attending presented seminars/workshops	1,145	2,070	4,000	52%
WD-C3	WF1, IF4, A2	Sponsorship: Number of stakeholders sponsoring seminars/workshops/conferences	5	14	20	70%
WD-C4		Total funds of sponsorship	$125k	$200k	$200k	100%

Increase the Trained Transportation Workforce (Selected)

- Dr. Momen Mousa (PI) from Louisiana State University provided a 30-minute educational session in the American Traffic Safety Services Association (ATSSA)'s Annual CONVENTION & TRAFFIC EXPO 2022 in Tampa, Florida. This session educated the attendees about optimizing the performance of pavement markings in order to enhance drivers' safety.
- Dr. Newtson delivered an educational outreach presentation to New Mexico Department of Transportation (NMDOT) that educated the attendees about Concrete Containing Natural Pozzolan as a Supplementary Cementitious Material.
- An educational module was developed summarizing results of a conducted survey by a diverse group of Louisiana organizations gauging their awareness and perception of CAV technologies, likelihood of impacts, and importance in preparing for such technologies. The module was featured at the 2021 TRB Annual Meeting and posted to the PI's website.
- Gabriel Arce G. participated in the 58th Annual Samuel P. Maggard Quality Concrete School, Las Cruces, NM and educated the attendees about self-healing concrete.

5. Impacts

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

TECHNOLOGY TRANSFER

Table 11 lists Tran-SET's performance metrics for T2-related impacts. These metrics cover related products from third-cycle projects.

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]	36%	36%	20%	180%
TT-I2	TT1, TT2, IN2	Reduce costs associated with repair and upgrade of transportation infrastructure[2]	$203k	$203k	$100k	203%

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

Discussion of Performance Metrics: Impact on Effectiveness of the Transportation System

- **Improve the Durability and Service Life of Transportation Infrastructure (TT-I1):** This metric encompasses **23** applicable products. For example:
  - The service life of the pavement structures constructed with Reclaimed Asphalt Pavement (RAP) and Warm Mix Asphalt (WMA) additives is expected to increase significantly. Based on the results of the WMA-RAP mixtures against rutting, the percentage increase in service life is expected to be 10 to 30%.
  - The implementation of small unmanned aircraft system based airborne imaging techniques in bridge inspection will improve the durability and service life of the transportation infrastructure by about 50%.
- **Reduce Costs Associated with Repair and Upgrade of Transportation Infrastructure (TT-I2):** This metric encompasses **16** applicable products. For example:
  - The site-specific ground motion response analyses (SSGMRA) conducted at ASU will increase the resilience of the transportation infrastructure against catastrophic weather events with an expected cost reduction associated with repair and upgrade of the transportation infrastructure of about $25,000/lane-mile.
  - The implementation of Engineered Cementitious Composites (ECC) in the pavement structure is expected to result in cost reduction of about $11,000/lane-mile.

Impact on Adoption of New Practices and Commercialization (Selected)

- The developed Ultra-High-Performance Concrete (UHPC) from local materials in New Mexico is expected to provide an increase in service life of about 300% compared to normal strength concrete.
- The developed restriping strategy for 4-inch wide markings is expected to save Louisiana about $20 million annually when restriping the whole network without jeopardizing user

safety. The developed strategy for 6-inch wide markings is expected to save the State about $2 million annually when restriping the whole network in addition to enhancing the user safety. The research team received additional funds from the NCHRP IDEA program to commercialize and implement the developed strategy.

EDUCATION

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

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	31	71	100	71%
E-I2	EL1, EL2, IF4, A2	Feedback[1] of graduated, supported students who've entered the transportation field[2]	4.6	4.6	5	92%

[1]Feedback solicited from students' advisors; [2]Scale: 0 to 5 (5 being perfect); same definitions for Table 13

Impact on Scientific Knowledge (Selected)

- A model was developed in UTA to analyze the impacts of network disruption during disaster events. This has contributed to the body of knowledge in the field of coastal resilience and led to a better understanding of the impacts of flooding on the transportation infrastructure.
- A remote robot was developed that is capable of recording data from the rock surface to identify unstable rocks prior to a rock fall. This has led to a better understanding of the rocks that are prone to fall in order to remove them.

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.
	WF1, IF4, A2	Feedback of seminar/workshop/ Conference attendees:				
WD-I1		Related to skills gained	4.5	4.5	5	90%
WD-I2		Related to improved practices	4.5	4.5	5	90%

Impact on Transportation Workforce Development (Selected)

- Over 50 researchers and industry leaders from many states and different countries attended an educational session led by Dr. Momen Mousa (PI) in the American Traffic Safety Services Association (ATSSA)'s Annual CONVENTION & TRAFFIC EXPO 2022 in Tampa, Florida. This session successfully educated the attendees about optimizing the performance of pavement markings to enhance drivers' safety. The attendees provided an average session rating of 4.5 out of 5 and an average speaker rating of 4.4 out of 5. Interest from this session resulted in a collaboration between LSU and Franklin Paint, Inc. to develop an enhanced tool to predict the performance of future pavement markings.
- Tran-SET's webinar on using warm mix asphalt to enhance pavement sustainability engaged a diverse audience of designers, state DOTs personnel, contractors, industry suppliers, and

researchers. More than 50 professionals attended this webinar. The webinar successfully transferred knowledge and educated the audience on enhancing the sustainability of asphalt pavements. The number of attendees, positive feedback, and post-webinar engagement indicate its success.

6. Changes/Problems

Nothing to report

7. Special Reporting Requirements

Not applicable.

Appendix A

Table 14. Awarded Fifth-Cycle Projects.

Project No.	Title	Total Cost	Leading Institution	Research Objective	Topical Area
21GTASU02[1]	Seismic Hazard Analysis for the City of Jonesboro and Surrounding Counties within Northeast Arkansas (NEA)	$68,324	ASU	R3	Geotechnical
21GTASU01	Using of Rice Husk Ash (RHA) as Stabilizing Agent for Poor Subgrade Soils and Embankments	$80,691	ASU	R1	Geotechnical
21BLSU11[1]	Development of a Machine Learning-Based Model to Determine the Optimum and Safe Restriping Timing of Thermoplastic Pavement Markings in Hot and Humid Climates	$75,179	LSU	R1	Pavements
21CLSU12[2]	Resilient 3D-Printed Civil Infrastructure with Ultra-High Performance Engineered Cementitious Composites (UHPECCs)	$60,000	LSU	R1	Portland Cement Concrete Materials
21CLSU13[2]	Development and Implementation of Low-Cost Engineered Cementitious Composites (ECCs) in Rural Roads in the State of Louisiana	$217,822	LSU	R1	Portland Cement Concrete Materials
21PLSU15[2]	Development of Distress Index Prediction Models for Rehabilitation Treatments in Louisiana Using Advance Machine Learning Techniques	$95,179	LSU	R1	Pavements
21CLSU01	An Innovative Reinforcement Approach for Rebar-Free 3D Printing of Transportation Infrastructure	$90,000	LSU	R1	Structural
21STLSU04	Comparative Analysis of 3D Printed Bridge Construction in Louisiana	$60,000	LSU	R4	Structural
21GTLSU02	Development of Soil-Biochar Mixtures as a Sustainable and Multi-Functional Roadway Fill Material	$60,000	LSU	R2	Geotechnical
21COLSU14	A Deep Learning Tool for the Assessment of Pavement Smoothness and Aggregate Segregation during Construction	$60,000	LSU	R1	Construction
21ITSLSU16	Examining drivers' behaviors to connected and automated vehicles	$75,279	LSU	R4	ITS
21STLSU08	A Bridge Digital Twin for Enhancing Transportation Resilience and Asset Management	$60,000	LSU	R3	Structural
21BLSU03[2]	A New Generation of Dense-Graded Asphalt Mixtures with Superior Performance against Stripping and Moisture Damage	$135,000	LSU	R1	Asphalt Concrete Materials
21CLSU18	Development of Ultra-High Performance Engineered Geopolymer Composites (UHP-EGCs)	$285,000	LSU	R1	Portland Cement Concrete Materials
21CLSU19	Low-Cost Sustainable Engineered Geopolymer Composites (EGCs) for Repair and New Construction of Transportation	$300,000	LSU	R1	Portland Cement Concrete Materials
21CNMSU60	Alternative Supplementary Cementitious Materials in Ultra-High-Performance Concrete	$120,000	NMSU	R1	Portland Cement Concrete Materials
21ITSOSU01	Intelligent Incipient Fault Detection System for Electric Vehicle Battery: Fault Isolation Schemes and Prototype Development	$130,000	OSU	R4	ITS
21SAOSU02	Public Transportation Safety Performance Measurement Education and Training	$110,000	OSU	R3	Safety

Project No.	Title	Total Cost	Leading Institution	Research Objective	Topical Area
21HSPVAMU1	Potential Use of Renewable Diesel for Transportation in Texas and its Environmental Impacts under Uncertainties Caused by COVID-19	$60,000	PVAMU	R2	Mobility
21GTPVAMU2	Investigation of the Impact of Rainfall Patterns on Highway Slope Instability	$60,000	PVAMU	R3	Geotechnical
21GTLSU05	Resiliency of Transportation Infrastructure and the Environment after Hurricanes	$285,000	LSU	R2	Geotechnical
21COLSU06	Development of Robotics & Automation Roadmap for Road Construction/Maintenance Projects	$120,000	LSU	R4	Construction
21CTAMU01[1]	Characterizing corrosion control and prevention methods for RC elements based on hybrid protection mechanism	$230,000	TAMU	R1	Portland Cement Concrete Materials
21CUTA01	Integrate infrastructure performance monitoring using automatic crack evaluation system and convolutional neural network	$134,000	UTA	R3	Portland Cement Concrete Materials
21ITSUTA02	Effectiveness Assessment of E-Ticketing Technology Adopted to Mitigate Covid-19 Challenges for Inspectors and Field Engineers in Transportation Projects: Guidebook Development for E-Ticketing (Electronic Track of Material Delivery) Implementation	$108,000	UTA	R4	ITS
21ITSUTA03	Data Driven Identification of COVID-19 Impacts on E-Commerce and Freight Movement	$108,000	UTA	R4	ITS
21PUTSA01	Permeable Curb and Gutters for Storm Water Control	$90,000	UTSA	R2	Pavements
21SAUTSA01	Impact of Truck Drivers and Transportation Infrastructure Characteristics on Large Truck Crashes	$90,000	UTSA	R3	Safety
21SAUTSA02	Coupled Situational Awareness System to Improve Transportation Infrastructure Performance during Extreme Events	$117,763	UTSA	R4	Safety
21BLSU07	Monitoring Oxidation in Asphalt Pavements by Portable Infrared Spectroscopy (PIRS) to Establish Optimal Timing for Preservation Treatments	$60,709	LTU	R3	Pavements
21SAUNM03	Slowing COVID-19 Spread – Simulating Bus Seating Strategies	$100,000	UNM	R4	Safety
21SAUNM01	Field Evaluation of E-Ticketing Technologies for Efficient Asphalt Delivery Ticket Collection and Quantity Calculation	$130,000	UNM	R3	Safety
21SAUNM02	COVID-19 and Traffic Safety: Role of Infrastructure and Exposure	$100,000	UNM	R3	Safety
21CUNM05	Evaluation of Fresh and Hardened Properties of 3D-Printed Engineered Cementitious Composites (ECC) Designed for Sustainable and Resilient Infrastructure Systems	$100,000	UNM	R1	Portland Cement Concrete Materials
21STUNM04	Increasing Bridge Durability and Service Life with LIDAR Enhanced Unmanned Aerial Systems (UAS)	$100,000	UNM	R1	Structural

[1]Industrial firm providing matching funds (public-private partnership); [2]Government agency providing matching funds (public-public partnership); [3]Multi-institution project