Title:	Development of Digital Twins for Texas Bridges
The Problem:	TxDOT is responsible for, or supports, the structural planning, design, review, construction, and inspection of over 55,000 bridges in Texas. Several systems store information about bridges in the state. A statewide point dataset of bridge locations in GIS format includes both on-system and off-system bridges from the statewide asset inventory database with all National Bridge Inspection (NBI) data fields. This dataset, which is available on the TxDOT's public website, contains useful attributes, but in practice these attributes are insufficient for inspecting and managing bridges properly. Integrated links of bridge data to SiteManager, OpenRoads Designer (ORD), and other relevant systems are quite limited. TxDOT bridge modeling is transitioning to OpenBridge Designer (OBD), which will allow the department to leverage 3D models more fully in design and construction. This transition is part of the Digital Delivery initiative, which aims at having every square inch designed to achieve the project's design intent. OBD's 3D modeling capabilities include 3D elements such as slabs, beams, abutments, wingwalls, caps, columns, and foundations. Moving forward, this methodology will enable the production and maintenance of 3D digital models, also known as digital twins, for new or reconstructed bridges. Most existing bridges in the state will not be reconstructed soon; nevertheless, must be inspected regularly. Bridge inspections are time consuming and expensive but is critical to collect quality data to make sound bridge management decisions. Recently, a variety of technologies have emerged, which enable 3D mapping and georeferenced nondestructive evaluation (NDE) of bridge elements at levels of resolution and positional accuracy that were not possible just a few years ago. Some state DOTs have experimented with unmanned aerial systems (UASs) equipped with digital cameras in conjunction with structure-from-motion (SfM) photogrammetry software to produce 3D digital surface models of existing bridges and facilitate the inspection of bridge elements through the collection of hundreds of images that can be viewed in many different directions. Some UASs are now equipped with lidar sensors that enable the production of dense point clouds and 3D digital surface models that augment or complement 3D scanning efforts. Increasingly, NDE technologies such as ultrasonic tomography, ground penetrating radar (GPR), and infrared thermography (IRT) include geo-referencing capabilities, which means that 2D and 3D bridge deck information could also be integrated with the rest of the 3D bridge structural data. A challenge with these technologies is the huge amount of data they produce. Recently, TxDOT conducted a pilot data collection using UASs on the Rainbow Bridge in Beaumont, Orange County. The deliverable included a 3D model of the bridge's columns, beams, and connecting elements, as well as hundreds of images; however, the total file size was huge, approximately 59 GBytes of data, which made the deliverable difficult to manage. In addition, image resolution was not sufficient for the detection of cracks. This was a one-time data collection effort. In practice, bridge inspections must be conducted regularly. As a reference, the AASHTO Manual for Bridge Evaluation describes seven types of formal inspections on publicly owned in-service bridges; initial/inventory, routine, in-depth, fracture-critical members, underwater, special, and damage. There is a need for research on procedures and methodologies for the collection of 3D data and production of digital twins of existing bridges, but in such a way that the resulting data is both complete and usable without overtaxing existing computer systems at TxDOT, effectively complements bridge inspection efforts, and can be used to effectively detect and quantify changes over time; i.e., by using multi-temporal digital twin models. Research is also needed on the development of a guidebook and training materials.

Technical Objectives:	This research will lead to more effective and complete bridge inspections, tighter integration with other bridge-related information systems at TxDOT, earlier identification of bridge maintenance needs before they escalate to major repairs, and more effective integration with 3D-based design tools such as OpenBridge Designer. To accomplish the project objectives, the research team shall: • Conduct a literature review of applications of technologies such as UASs, Lidar, and georeferenced NDE technologies for the collection of 3D data on bridges. • Conduct an analysis of information systems at TxDOT that contain information about bridges, as well as plans and initiatives to transition to 3D modeling. • Identify suitable technologies and collect 3D data on a sample of bridges. • Develop and test suitable procedures and methodologies to develop digital twins of the sample bridges. • Assess feasibility and requirements for detecting and quantifying changes over time. • Prepare operational recommendations and guidance on topics such as, but not limited to, data collection plans, reviews and approval, and safety. • Develop a guidebook on how to collect 3D data and develop digital twins of Texas bridges using UASs and other relevant data collection technologies. • Prepare and test training materials to teach project managers, maintenance supervisors, and other personnel on the collection of 3D data and development of digital twins of Texas bridges. Training should include field data collection. The expected technology readiness level (TRL) for this project is 8.
Anticipated Deliverables:	1. Technical memorandum for each activity completed. 2. Monthly progress reports. 3. Value of Research (VoR) that includes both qualitative and economic benefits, to be included in the final research report. This is not a stand-alone deliverable. 4. Product P1: Guidebook documenting how to collect 3D data and develop digital twins of Texas bridges. 5. Product P2: Training materials on the collection of 3D data and development of digital twins of Texas bridges. 6. Research report documenting the findings of the research, including recommendations and guidance on data collection plans, reviews and approval, and safety. 7. Project Summary Report
Proposal Requirements:	1. Proposal Deadline: 12:00 p.m. Central Time, **Monday, March 6, 2023**. 2. RFP#1 Q&A Deadline: 12:00 p.m. Central Time, **Wednesday, February 1, 2023.** 3. Use the current "ProjAgre" and "PA Forms" templates located at the RTI Forms webpage. 4. Proposals will be considered non-responsive and will not be accepted for technical evaluation if they are not received by the deadline or do not meet the requirements stated in RTI's University Handbook. 5. Proposals should be submitted in PDF format; (1) PDF file per proposal. File name should include project name and university abbreviation. 6. This project will be tracked during the life of the project using the Technology Readiness Level (TRL) scale. 7. The 2021 Texas Legislative Session requires that universities be in compliance with Senate Bill 475 by submitting a completed and signed TxDOT Security Questionnaire (TSQ) to RTIMAIN@txdot.gov in advance of a proposal submission. Universities found to not submit a completed and signed TSQ in advance of proposal submitting will be held in non-compliance and unable to participate in the Program.