Exhibit D

Research Project Requirement Template

Risk-Based Assessment of System-Wide Vulnerability and Interdependency of Transportation Infrastructure Networks in a Changing Climate

Recipient/Grant (Contract) Number: 69A3552348306 (CY1-TAMU-OU-03)

Center Name: Southern Plains Transportation Center (SPTC)

Research Priority: Improving the Durability and Extending the Life of Transportation

Principal Investigator(s): Maria Koliou, Texas A&M University; Arif Sadri, University of Oklahoma

Project Partners: Texas A&M University and University of Oklahoma

Research Project Funding: Texas A&M University: $70,000 (Federal) and $70,000 (Match); University of Oklahoma: $74,999 (Federal) and $75,170 (Match)

Proposed Start and End Date: 09/01/2023 to 08/31/2024

Project Description:

Synergistic Project Scope (TAMU/OU): Transportation networks comprise components such as bridges and roadways, which are made up of different subcomponents such as decks, girders, abutments, piles, embankments, and pavements. Many of these components are designed to withstand natural hazards expected with a given probability of recurrence. Given that transportation networks are often impacted by changing conditions and disruptions in the face of changing climate and societal expectations, it is important to prioritize our infrastructure improvements to provide the greatest enhancement to system resilience. Assessing the impacts of system-wide vulnerabilities and interdependencies is critical to prioritizing infrastructure enhancement for optimum system performance. This project will develop a framework based on network science theories and risk-based reliability analysis to account for the following: (1) the relative importance of system components; and (2) the interconnectedness of components and sub-components. While the major focus of the TAMU team will be on hurricanes in coastal regions, the OU team will consider inland flooding, creating a synergy between the lead institutions in looking at diverse weather extremes in the USDOT Region 6.

Individual Scope of Work (TAMU): Transportation infrastructure networks are frequently impacted by changing conditions (e.g., deterioration) and disruptions (e.g., natural hazards – hurricanes having an increased frequency in the Southern United States) and can result in reduced accessibility, delays, and economic losses. In this project, the TAMU research team will address this challenge by developing a risk-based reliability analysis framework for assessing and enhancing the resilience of bridge infrastructure networks in selected coastal regions in Texas susceptible to hurricane loads. This framework will be used as a tool for state DOTs across the country to optimize and prioritize investments while ensuring that the transportation system can absorb shocks, adapt to changing conditions, and rapidly recover from disruptions (e.g., hurricane occurrence). Specific tasks of this project will be focused on the following: (1) defining resilience goals and targets for representative transportation networks; (2) characterizing disruption scenarios (including flood due to hurricane occurrence, bridge deterioration due to aging); (3) estimating consequences (including economic losses, downtime, travel delay, loss of

accessibility); and (4) proposing optimal solutions for potential improvements (including maintenance and mitigation actions).

Individual Scope of Work (OU): Transportation infrastructure systems critically interact with other physical systems to ensure regular functioning and operations in supporting safe, multimodal mobility for people and goods. For example, locations at which stormwater networks intersect with roads and bridges may be subject to frequent flooding. As such, understanding interdependencies and assessing their impact is essential to enhance serviceability i.e., performance and resilience of transportation networks. The research team at OU will develop a new framework of interdependency modeling for Region 6 based on network science theories, sources of uncertainties, critical interaction rules, and guidelines for implementation. The proposed framework is based on topological credentials (i.e., the rank of relative importance) of network components (such as roads, bridges, and pavements) that carry significant implications as it is critical to identify components that contribute the most to the overall network performance. For transportation networks, critical components (roads, bridges, intersections) may become inaccessible to adjacent traffic due to external disruptions (e.g., inland flooding) that significantly reduce the level of service. The goal is to enhance the resiliency (i.e., improved robustness and/or rapidity) of transportation networks in Region 6 based on the topological credentials of road network components as well as systematic design (i.e., lane width, pavement thickness) and/or operational (i.e., one way vs. two-way traffic) interventions made on critical components. Specific tasks include the following: (1) develop an interdependency and vulnerability analysis framework for road and stormwater networks for inland flooding; (2) obtain accurate road and stormwater network data for the study area and identify the scale and scope of the network to be inspected; (3) perform multi-layer network experiments and analyses; (4) compilation of results and reporting.

US DOT Priorities: The proposed project aligns well with the SPTC goals relative to improving the durability of coastal and rural infrastructure, performance-based life cycle assessment, and vulnerability assessment of multi-modal transportation systems. Therefore, the proposed work aligns with USDOT goals on Durability – Maintenance, Preservation, Resilience and Asset Management. This project is expected to produce much-needed data and analyses on enhancing transportation network resilience. There is a potential for the proposed study to develop a network interdependency framework specific to transportation resilience that can be patented as a novel research idea.

Outputs: (1) List of sources of uncertainties and critical interaction rules that govern transportation network vulnerabilities. (2) Risk-based vulnerability assessment tools and guidelines for practical application of transportation network models to quantify impact due to hazards in terms of structural response and functionality of the networks, as well as prioritize investments (e.g., retrofits) considering budget constraints, social economical demographics, etc. (3) Sensitivity of potential solutions adversely affecting marginalized travelers. (4) Number of undergraduate and graduate students supported from under-represented groups in STEM. (5) A decision support tool to run what-if scenarios subject to system vulnerability.

Outcomes/Impacts: The framework and the models developed in this project will help transportation agencies in Region 6 to run hypothetical scenarios and develop contingency plans for future events, as well as prioritize infrastructure enhancements so that the overall performance and resilience of transportation networks can be enhanced in the face of natural hazards. Potential stakeholders will be engaged during the early stages of this project to provide feedback and observe the capabilities and impact of the proposed models once adopted by transportation agencies.

Final Research Report: