**Research Project Name**: Vulnerability assessment and durability of coastal freight networks (UPRM)

Improving the Durability and Extending the Life of Transportation Infrastructure

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**Research Project Funding**:
Federal: $76,414 Match: $51,849 (UPRM)

**Project Start Date**: 01/01/2026 **Project End Date**: 12/31/2026

**Project Description**: Freight networks, including ports, coastal highways, bridges, and distribution hubs, are critical lifelines that sustain regional economies, enable everyday commerce, and support emergency response after catastrophic events. The coastal location of this essential transportation infrastructure makes these assets uniquely vulnerable to extreme natural events such as flooding, storm surge, coastal erosion, and compound hazards. The Puerto Rico's 2050 Long Range Transportation Plan explicitly calls for reducing transportation vulnerabilities to extreme weather effects and improving connectivity. Puerto Rico could serve as a critical logistics hub for U.S. freight operations in the Caribbean, offering strategic access to regional markets and maritime routes. But recent storms Hurricane María (2017) and Hurricane Fiona (2021) have highlighted the freight network's fragility and the urgent need for targeted resilience measures.

The assessment of Puerto Rico's freight network, one that relies solely on the performance of the highway system, can be a case study to evaluate the system vulnerabilities derived from natural flood hazards, aging infrastructure, urbanization in coastal areas, and congestion in strategic corridors. A rigorous vulnerability assessment combines data from hydrologic and coastal flood modeling with traffic flows, asset condition inventories, and safety records to identify critical and single-point-of-failure links. This integrated analysis can provide a method to reveal which corridors and nodes are most likely to fail under different flood scenarios, how congestion and limited redundancy amplify delays, and which assets require immediate reinforcement or operational changes. It can also uncover system-level interdependencies among ports, road networks, and distribution hubs that are not visible from isolated asset inspections. This project can assist local transportation agencies, freight operators, and decision-makers in identifying risks to the freight network, improving the assessment of infrastructure assets by including the interdependence between ports, road networks, and distribution hubs, and prioritize improvements in strategic planning and project development. This project is envisioned as a two-year program. Year 1 will define Puerto Rico's primary freight network anchored at the ports of San Juan and Ponce, map major distribution points, and develop an interactive dashboard showing asset condition, corridor flows, crash hotspots, and flood-vulnerable links and nodes. Four analytical dimensions will be assessed: infrastructure condition, traffic flows, safety, and durability, using official data, operational reports, and geospatial analysis to identify hotspots and critical vulnerabilities. Year 2 will focus on network optimization and investment prioritization, applying stochastic and optimization models to

produce a prioritized, implementable resilience strategy. A Texas State University team will collaborate in the review of stochastic and optimization approaches, the evaluation of data requirements and computational complexity, and provide recommendations about the best model(s) for optimizing freight flows and prioritizing investments from ports to distributors.

**US DOT Priorities:** *Section left blank until USDOT's new priorities and RD&T strategic goals are available in Spring 2026.*

**Outputs**: This project will generate an integrated map of the condition and vulnerability of Puerto Rico's freight transportation system, which will include coastal roads, strategic corridors, and the most relevant logistic nodes. This map will enable the identification and characterization of hotspots with truck flows exceeding 500 vehicles per day operating at deficient service levels (DTOP, 2023). The map will also include data related to flood risk zones that will provide a comprehensive view of infrastructure vulnerability. The project will produce a replicable method for evaluating the performance of freight systems in island and coastal regions, drawing on international experiences and studies. Additionally, it is expected to establish strategic collaborations with entities such as the Puerto Rico Ports Authority, the Department of Transportation and Public Works, the CETL, and freight operators, and organizations specialized in infrastructure durability, which will strengthen the project applicability and reach.

**Outcomes/Impacts**: The results are expected to have a direct impact on the quality and reliability of Puerto Rico's freight transportation network by enabling the identification of critical vulnerabilities in ports and road corridors. By providing local agencies with concrete tools for resilient planning, the risks of logistical disruption during large-scale natural events will be reduced. Furthermore, the information will facilitate the optimization of resource allocation for infrastructure maintenance and investment, prioritizing strategic corridors and nodes essential for the continuity of the supply chain. This will contribute not only to the durability and efficiency of the system, but also to the reduction of costs associated with congestion, detours, and structural failures. The proposed methodological approach will drive changes in transportation planning practices, incorporating system-level resilience and vulnerability assessments rather than limiting the focus to individual components. In the long term, these improvements will ensure the stability of Puerto Rico's freight transportation system and reliable access to essential goods for both the population and industry.

**Final Research Report**: URL to final Report will be provided upon completion.