**Research Project Name:** Identifying and evaluating the most effective actions to prepare Puerto Rico's primary ports and freight road transportation infrastructure for flooding disruptions using stochastic models (TXST)

Improving the Durability and Extending the Life of Transportation Infrastructure

**Principal Investigator:**
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**Project Partners:** Alberto M. Figueroa Medina, Carla López del Puerto and Ismael Pagán Trinidad at University of Puerto Rico at Mayagüez (UPRM)

**Research Project Funding:**
Federal: $100,000                    Match: $50,010 (TXST)

**Project Start Date:** 01/01/2026        **Project End Date:** 06/30/2027

**Project Description:** One of the seven issues listed in the freight assessment section of the 2050 Long Range Multimodal Transportation Plan (LRMTP, approved in 2023) encompasses the need for Puerto Rico's ports and road freight transportation network (RFTN) to be less vulnerable to extreme weather events that affects the durability of the infrastructure and disrupts the movement of goods and services. Puerto Rico has an excellent geographic location for the transshipment of goods to other places in the Americas. Strategies to mitigate infrastructure damage to ports and roads resulting from overuse and to keep the system operating effectively will help Puerto Rico maintain its position as a global logistics hub. The development of an adaptable highway transport system is crucial, as railroads are not well-developed to undertake the freight transport needs, and the use of the marine-based freight M2 route connecting main and secondary ports is only emerging.

The objective of this research project is to quantify and classify the impact of certain operational decisions made before and after flood-related weather events on four performance or optimization criteria: ports and RFTN infrastructure, traffic flows, safety, and flexibility to avoid delays and disruptions. The operational decisions to include are: increasing ports' operating hours, locating regional hub-and-spoke points where freight coming from the ports is transferred from large trucks to smaller vehicles and routed to the distribution points, determining existing or to be developed alternative roads that reduce congestion at hotspots, and routing loads between ports. To accomplish the objective, TXST will develop a preliminary stochastic programming model to optimize a prototype of Puerto Rico's RFTN, considering multiple flooding scenarios, forecasts of freight demand over 5 and 10 years, and the above-mentioned operational decisions and optimization criteria. A variant of the developed model, which represents the current operations of ports and roads without incorporating any of the proposed operational decisions, will be used for comparison purposes. The main freight distribution points and associated demands to input into the models will be identified in cooperation with the listed project partner faculty at UPRM. Puerto Rico's industry, government agencies, and consultants for these agencies will be sources to get the models' input data, as well as information available online. If needed, the distribution points will be clustered. In this preliminary model, the unavailable data will be identified and estimated. The model will demonstrate to the Puerto Rico Department of Transportation and Public Works, the Puerto Rico Highway and Transportation Authority, and other relevant agencies a process they can apply for making informed decisions to enhance the durability and resilience of port and RFTN infrastructure under uncertainty caused by flooding and the relevance of collecting any highly relevant and missing data.

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

**Outputs:** Stochastic programming models are among the state-of-the-art optimization methods for handling uncertainty in model parameters, such as the magnitude of flooding. The result of this project is an up-to-date framework suitable for addressing other ways to improve the RFTN proposed in Puerto Rico's 2050 Long Range Multimodal Transportation Plan, such as utilizing the marine-based M2 freight network to a greater extent or adding last-mile delivery as a new mode for goods delivery. Additionally, the literature review, collected data, model and results are expected to support the subsequent development of a more comprehensive model of Puerto Rico's RFTN to be performed by faculty at UPRM.

    Dr. Novoa anticipates developing partnerships with the Center for Catastrophe Modeling and Resilience at Lehigh University and the Consortium for Enhancing Resilience and Catastrophe Modeling (CERCat). Other partnerships are with representatives of the Puerto Rico Department of Transportation and Public Works, the Puerto Rico Highway and Transportation Authority, US DOT, and partner consultants or private companies working with these government agencies.

**Outcomes/Impacts:** The project's products include a data-driven computerized model and a written document that provides a research methodology for identifying and assessing decisions and responses (i.e., recourse actions) to minimize the impact of coastal flooding, using Puerto Rico's main ports and its RFTN infrastructure as a case study. The results and recommendations from this project will be disseminated in a presentation and a proceedings paper at a conference on transportation, supply chain, logistics, or operations research. The anticipated relatively low running time of the models will permit multiple optimizations to be performed before and during flooding-related events. It will positively impact the durability, reliability, and cost of operating the ports and the RFTN in Puerto Rico during disaster situations. Also, it will be possible to extend this impact to other US ports by updating the model input data and the RFTN to portray other US freight ports.

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