Network analysis to identify critical links for relief activities during extreme weather events

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$112,000

Identifying the most impactful network links for travelers during extreme weather events.

In 2017, the Texas Department of Transportation (TxDOT) closed over 530 disrupted road sections in the Houston area during Hurricane Harvey. Ground transportation for evacuation, motor carriers transporting humanitarian aid, and first responders were rerouted or rescheduled due to road closures. To repair the damaged road infrastructure, the Federal Highway Administration (FHWA) allocated $25 million of federal funds to TxDOT for repairs such as removing debris, bridge inspections, and replacing traffic lights. Generally, network links carrying higher traffic volume and those ensuring connectivity to isolated subnetworks represent critical links because disruptions would impact more vehicles with greater travel time increase from rerouting or rescheduling. However, the individuals and communities that use the infrastructure determines the importance of the road links as community resiliency during the response and recovery phases of extreme weather events vary based on their economic stability and social networks. If a certain link serves at-risk communities (i.e., lower income or older population) for evacuation or humanitarian aid, the link should be considered a critical link regardless of total traffic volume. These links must be resilient to save lives within the neighborhood and increase regional resiliency.

Problem Statement

After Hurricane Harvey inflicted $125 billion in damage in 2017 and consequent impacts on transportation throughout coastal Texas due to flooded roadways and damaged infrastructure, stakeholders came to a consensus to improve existing infrastructure and strengthen community resilience as part of the post-disaster recovery process. Traditional infrastructure operational standards largely focus on reducing structural failures, but they neglect the societal impact and consequences from the underperforming infrastructure system after the failure. Knowledge of community impacts from road network disruptions provides key inputs for drafting operational strategies and risk reduction prioritization for existing infrastructures because community resilience requires careful allocation of scarce resources especially during the response and recovery stages of extreme weather events. The investment decisions stakeholders make prior to the event play a large role in reducing risks and enhancing reliability during the response and recovery process. Although adverse weather events significantly impact transportation infrastructure and networks, a lack of understanding of weather events' impacts on transportation infrastructure remains. The knowledge of network resiliency and its interaction with weather events provides a key input for developing operational strategies in an urgent period such as search-and-rescue. Understanding the criticality of roadway links based on the knowledge of roadway usage (e.g., traffic flow) must be based on knowledge of road users as the consequences of link disruptions vary greatly based on individuals and communities that use the infrastructure.

Figure 1: Extreme weather event

Objectives

This study seeks to create a framework to evaluate road network infrastructure criticality during extreme weather events by considering network topology, traffic flow and user characteristics of the transportation network. The team will assess road network components and quantify the impact on the primary road users' mobility and access during the response and recovery phases of extreme weather events. Research objectives include:

1) Identify and define measures to determine accessibility, operability, and vulnerability in network criticality.
2) Apply the identified measures and evaluate network resiliency for weather events in the Gulf Coast area.
3) Develop GIS-based applications to survey network criticality as a practice-ready application for decision makers, stakeholders, and researchers.

Intended Implementation of Research

Workforce Development and Outreach: The project will provide advanced research experiences and technical skills to prepare students to be leaders in the transportation field. Fundamental research like network analysis and transportation demand forecasts coupled with community impact analysis will give students core knowledge in transportation and practical research development activities to best prepare them. Interactions with other universities in the region, North Central Texas Council of Governments (NCTCOG) and industry will help students understand the use of applied research and foster future collaboration. The research outcomes will be shared through several seminars and workshops in transportation and planning areas to support student engagement in the research development and reporting process.

Education: This project supports learning for one Ph.D student and one MS student from Civil Engineering. UTA has many qualified female and minority Ph.D. and MS students whom the researchers will primarily consider for support in this study. Students will conduct transportation network analysis using transportation planning software, and various data analytic techniques including spatial analysis using a GIS programming, statistical programming using R or Matlab, and database to understand the transportation network infrastructure criticality while considering community impacts from severe weather events. These students will participate in technical transfer activities through campus presentations and national and local conferences including TRB, and local ITE chapters meeting

Web links

- Tran-SET's website https://transet.lsu.edu/research-in-progress/

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.