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Developing an Integrated Risk Assessment Framework to Quantify the Resilience of Critical Railway Infrastructure: Characterization of Risks and Hazards to the U.S. Rail Network Through Empirical Data and Past Events

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Introduction

Natural hazards pose a constant risk to railway infrastructure, leading to widespread outages and disruptions in commodity flow, which in turn reduce the railway's crucial role in supporting U.S. and global economic vitality. While there are ongoing efforts to determine both the risk and resilience of the U.S. railway network towards natural hazards, a first step is to identify the range of historical hazards that have impacted the network. The baseline produced through this report's methods establishes a historic and revolving database that can be leveraged by industry, academia, and governmental agencies. While such a database does not exist specifically for rail, external natural hazard datasets needed to be procured in conjunction with a scientific methodology, specific to each hazard, to assign such hazards directly to segments of rail track.

Study Methods

The An initial investigation went into understanding key natural hazards that would cause disruptions to the U.S. railway network, including those that would directly damage its infrastructure. The research team used the Federal Railroad Administrations (FRA) derailment dataset and specifically reviewed the sets of train accident cause codes that were related to any natural hazard. While this provided rail-specific empirical evidence and translated to expected equipment and track damage costs, it was used as a validation dataset in conjunction with other non-rail-specific datasets that provide natural hazard data. The natural hazard-based datasets include the United States Geological Survey's (USGS) Flood Events Database, Hydrologic Unit Codes (HUC), the National Centers for Environmental Information (NCEI) from the National Oceanic and Atmospheric Administration (NOAA), National Weather Service's (NWS) forecast zones, and lastly USGS's landslide events. Following this, specific geospatial considerations were leveraged for the sets of hazards to arrive at a final dataset that had historical events, their magnitudes, and their inferred damages into a singular shapefile. This included mapping flash flood-based events to specific HUC watersheds, riverine-based flood events to specific river corridors, proximity-based thresholds for landslides, and NWS forecast zones for extreme heat and cold events. The shapefile used the existing FRA railway network links, to which smaller intersections of the hazard datasets generated additional, shorter links, resulting in a shareable dataset.

Findings

Following the procedures, the breakdowns on number of occurrences and expected costs in relation to accident damages were assessed for the identified accident cause codes going back to 2000. Some of these include M103, and T002, "Extreme Environmental Condition – FLOOD," and "(Washout/rain/slide/flood/snow/ice damage to track)." Geospatially, M103 primarily occurred in Louisiana, Texas, Maryland, and Iowa and T002 in Texas and Pennsylvania. While this gave specific coordinates of the events, down to the track link level, it also provided cost estimates from the event. For T002, the total track damage costs amounted to nearly $32 million and for M103 $43 million from 2000–2023. While this was specific to accidents or derailments, the total cost per event was leveraged to understand what an expected track damage cost might be for specific hazards. Furthermore, as the hazards in nature have a range in intensity, the localization of time and space for the event in conjunction with the derailment or accident produces an expected cost as a function of

intensity and type of event itself, which was driven by the hazard datasets and rail infrastructure datasets. Track damage was also chosen as the cost estimation variable as it is known there are much larger volumes of track damage as a result of a natural hazard that did not result in a rail accident or derailment. A similar process was implemented for sun kinks, code T109, which saw track damages up to $85 million from 2000–2023.

A methodological approach, using various national hazard-based datasets, was developed to help create a rail-based national hazard dataset capturing when, where, and how much potential damage might incur across the U.S. rail network.

Policy Recommendations

This report represents an initial attempt at procuring a natural hazards-based dataset that aims to capture the expected costs associated with rail track failures, in addition to characterization on the intensity of the hazard itself. While the process required the utilization of external data sources from the FRA or rail industry, meaningful results were found. Results may be improved upon with additional operational data from other locations where track damage occurred without a derailment (and thus would not be found within FRA's derailment database). In relation to operational data and additional track damage datasets, a future area of work is understanding not only the track damage costs from natural hazards but the economical restrictions that are incurred under the event of track infrastructure disruptions from natural hazards.

About the Authors

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To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2314

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