UTC Project Information	
Project Title	Informing Predictions from Above with Data and Below: AI-Driven Seismic Ground-Failure Model for Rapid Response and Scenario Planning
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Funding Source(s) and Amounts Provided (by each agency or organization)	University of Washington PacTrans $25,000 University of Washington $25,000
Total Project Cost	$ 50,000
Agency ID or Contract Number	69A3551747110
Start and End Dates	September 16, 2020-September 15, 2022
Brief Description of Research Project	Soil liquefaction is a significant threat to post-earthquake mobility across nearly all modes of transportation. This project will develop an open source, high-resolution model to probabilistically predict liquefaction regionally - at no cost to the user - both in future scenario earthquakes (to inform mitigation and planning) or immediately following an event (to inform response and recovery). This model will: (i) predict subsurface test measurements via remotely-sensed predictor variables and machine- and/or deep-learning models; (ii) be anchored to a mechanics-based framework for predicting liquefaction via subsurface test data, thus physically constraining the predictions; and (iii) have rapid capabilities, providing regional predictions minutes after an earthquake. The model would first be implemented in PacTrans Region 10 using PNW data, but would be scalable to a larger study and transferrable globally.

Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Geospatial models for predicting soil liquefaction infer subsurface traits via satellite remote sensing and mapped information, rather than directly measure them with subsurface tests. This project developed geospatial models that are driven by algorithmic learning but pinned to a physical framework, thereby benefiting both from machine and deep learning, or ML/DL, and the knowledge of liquefaction mechanics developed over the last 50 years. With this approach, subsurface cone penetration test (CPT) measurements are predicted remotely within the framing of a popular CPT model for predicting ground failure. This has three potential advantages: (i) a mechanistic underpinning; (ii) a significantly larger training set, with the model principally trained on in-situ test data, rather than on ground failures; and (iii) insights from ML/DL, with greater potential for geospatial data to be exploited. Models were trained using ML/DL and a modest U.S. dataset of CPTs to predict liquefaction-potential-index values via 12 geospatial variables. The models were tested on recent earthquakes and shown – to a statistically significant degree – to perform as well as, or better than, the current leading geospatial model. The developed prediction models were implemented in free, simple-to-use Windows software. The only input is a ground-motion raster, downloadable minutes after an earthquake or available for countless future scenarios. The software predicts the probability of liquefaction-induced ground failure at high spatial resolution over the large regional extents impacted by earthquakes.
Impacts/Benefits of Implementation (actual, or anticipated)	To demonstrate model use, ground failure probabilities were computed for 30 ground-motion simulations of a magnitude 9, Cascadia Subduction Zone earthquake, at every bridge site in Washington State. These analyses, as further detailed and mapped in the project report, indicate that: 13 bridges have at least a 70% probability of ground failure; 218 bridges have at least a 60% probability of ground failure; and 795 bridges have at least a 50% probability of ground failure. These analyses do not consider specific asset designs or site-specific ground improvements. The analyses do, however, provide a ranked list of bridge sites most likely to be damaged by ground failure. Select ground-truthing gives credence to the developed models and results. Thus, the implementation has the potential to better inform transportation planning via improved simulations of extreme events. Similarly, the software can be run minutes after an earthquake, thereby focusing emergency response and reconnaissance to locations most likely to have been damaged.
Web Links • Reports • Project Website	RapidLiq, the software resulting from the project, can be downloaded from https://doi.org/10.17603/ds2-4bka-y039, along with a software user manual and other project data and results.