UTC Project Information	
Project Title	Pilot Study: Learning Fluid-Structure Interaction via Machine Learning
University	Oregon State University
Principal Investigator	Barbara Simpson
PI Contact Information	barbara.simpson@oregonstate.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	University of Washington PacTrans $ 40,000 Oregon State University $ 40,000
Total Project Cost	$80,000
Agency ID or Contract Number	69A3551747110
Start and End Dates	August 16, 2019-August 15, 2021
Brief Description of Research Project	This proposal addresses the content area, improving mobility of people and goods, particularly **ensuring reliable mobility** across bridges after tsunami loading. This work also aligns with ongoing interest in tsunami loading on bridges and machine learning applications by the Oregon Department of Transportation and the Pacific Earthquake Engineering Research (PEER) Center. Although implemented herein for the analysis of bridges, the resulting machine learning framework would be applicable to other computationally-expensive simulations and a larger set of data-driven transportation problems, such as evacuation models, active traffic control, analyzing sensor data, etc. Implementing faster models that maintain the efficacy of the original data would result in prompt feedback for analysis and design, increased feasibility for parametric applications, and better fragility functions based on CFD/FSI rather than equivalent static analysis.

Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	This study illustrated that a machine learning approach is feasible to estimate structural response for both static and dynamic loading. Due to the complexity of the finite-element output, we reduced the model size to study a smaller problem, including static and dynamic loading conditions on a relatively simple model of a single degree-of-freedom oscillator. The model was reminiscent of a bridge pier subjected to dynamic loading conditions.
Impacts/Benefits of Implementation (actual, or anticipated)	Model reduction is desired, if not indispensable, for many parametric and/or computationally expensive applications. Although machine learning can offer significant speedups, the interpretability of ML and DL algorithms can also be lost during the training of the model. The reliability and interpretability of machine learning can be resolved by introducing physics into the machine learning architectures. This work studied the performance of data-driven and physics-informed deep learning algorithms in structural engineering applications. This work showed that if an appropriate neural network architecture can be utilized, the machine learning models can extrapolate well beyond the test data. Although the studied cases were for relatively simple single-degree-of-freedom systems for linear static and dynamic problems, machine learning algorithms have the potential to produce reliable results for multi-degree-of-freedom systems, including the relevant physics. This seed funding was the initial starting point for future extensions with more complex loading conditions (dynamic and including fluid-structure interaction) and complex bridge geometries.
Web Links • Reports • Project Website	• Kasi, Z., Simpson, B., Scott, M. 2022. Pilot Study: Machine Learning and Deep Learning Study for Fluid Structure Interaction Problems. PacTrans Final Project Report. • simpsoba@wordpress.com