

HYSIM19

New Frontiers and Innovative Methods for Hybrid Simulation

ETH Zürich, 13 March 2019

Prototype demo-scale equipment in support of distributed hybrid simulation

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EXperimental & **C**omputational **H**ybrid **A**ssessment of **N**atural
Gas Pipelines **E**xposed to Seismic **R**isk

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WP2 - Hybrid experimentation on principal failure modes of the soil-pipeline system

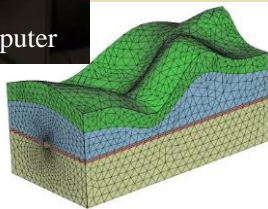
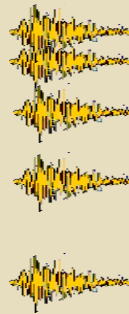
WP02

Hybrid experimentation on principle failure modes of the soil-pipeline system



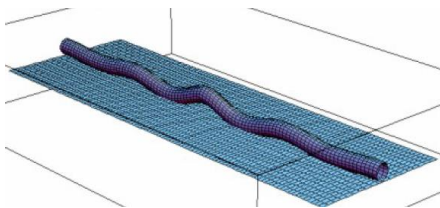
Blue Gene/Q supercomputer

Spatially variable displacement time histories



$$x_i(t) = A_i(t) \cdot 2 \sum_{m=1}^n \sum_{l=1}^N |L_{jm}(\omega_{ml})| \sqrt{\Delta\omega} \cdot \cos[\omega_{ml}t + \theta_{jm}(\omega_{ml}) + \phi_{ml}]$$

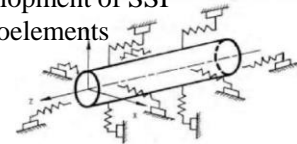
- analytical solutions for spatially variable patterns
- 3D FE modelling



Multi-axial Pipeline Beam Testing



- Preliminary Tests on Sand Box
- Development of SSI macroelements



Pipeline Connection Test



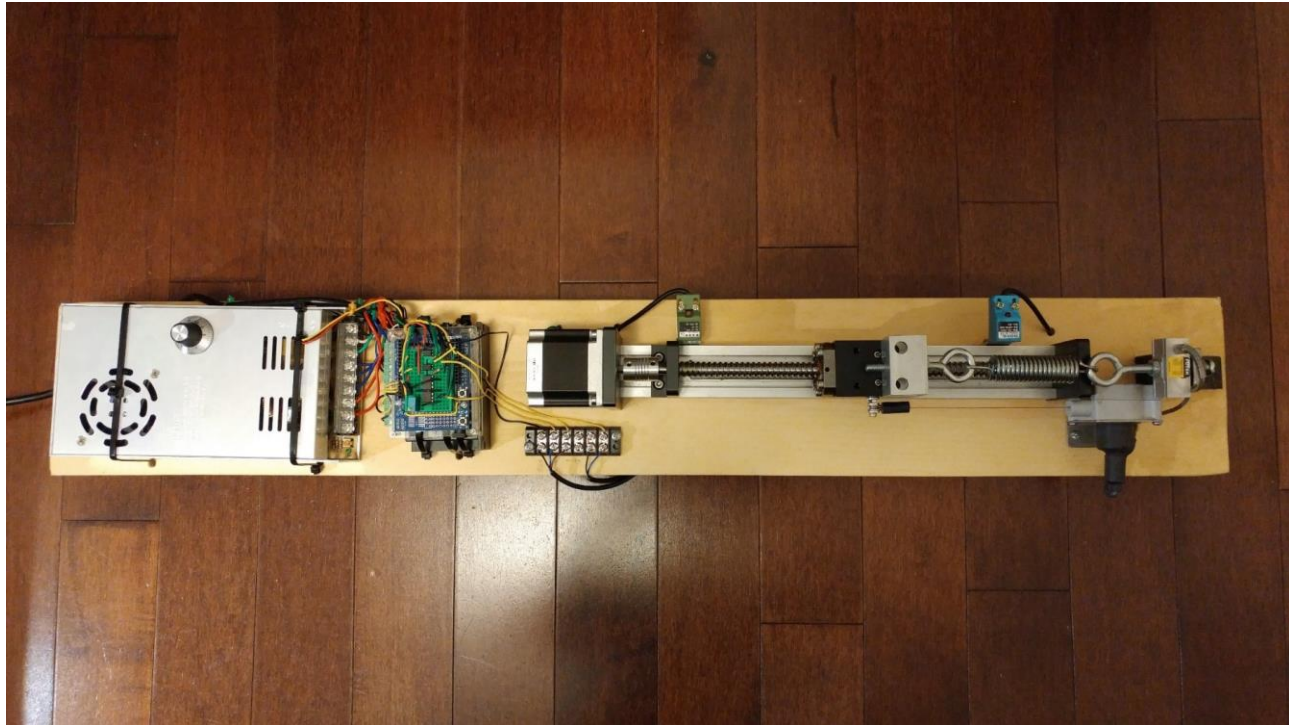
Preparatory Tests on failure modes

ExchangeRisk

EXperimental & **C**omputational **H**ybrid **A**ssessment of **N**atural
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OBJECTIVE

Develop a demonstration-size low-power actuator and write the necessary software for the controller.



CONCEPT

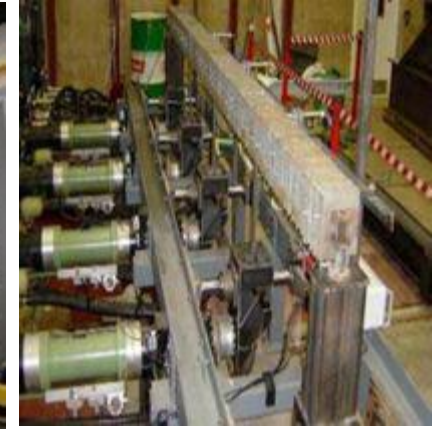
Enable the testing and calibration of hybrid simulation protocol prior to going lab-scale, in support of EXCHANGE-RISK Hybrid experimentation.



Photo from UoT lab, taken during the April 2017 UT-SIM workshop



University of Patras testing facility



University of Bristol



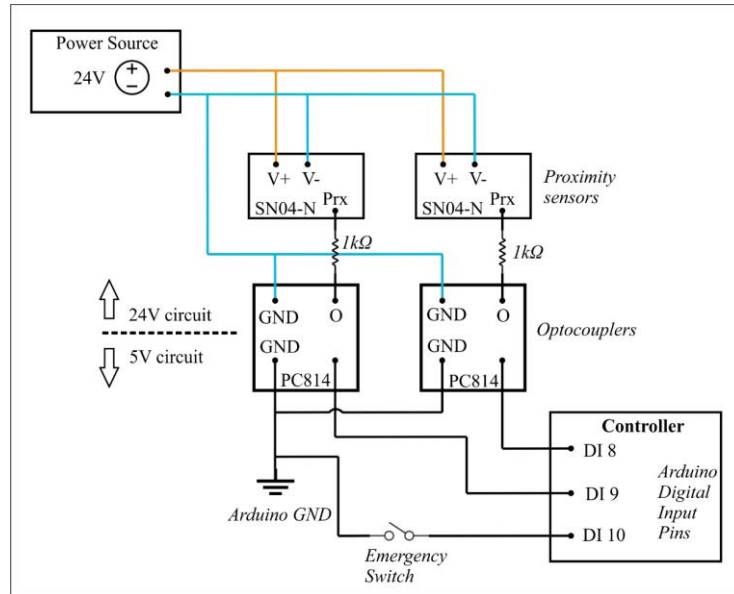
University of Naples new lab under construction in the East Campus (contrast wall visible).



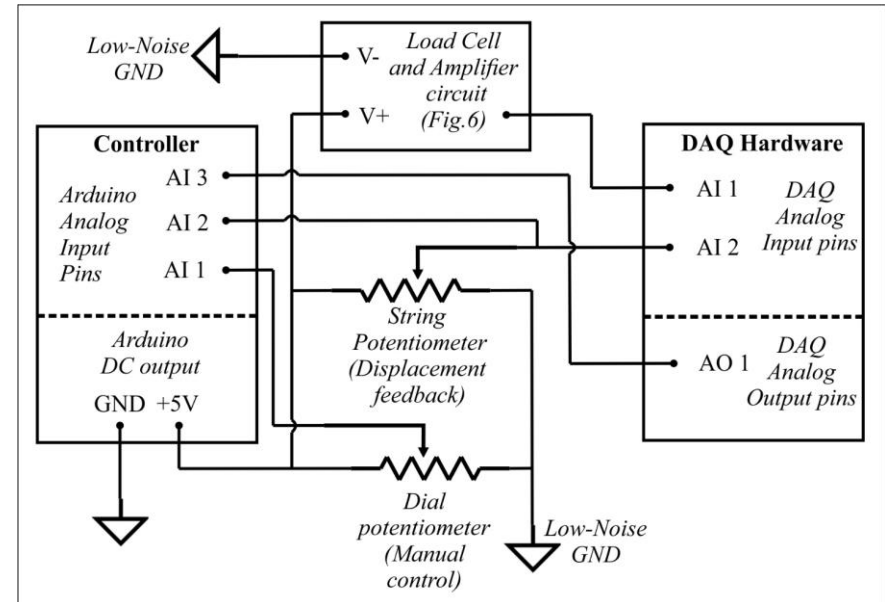
New East Campus of the University of Naples, housing the new heavy-testing engineering labs.

IMPLEMENTATION

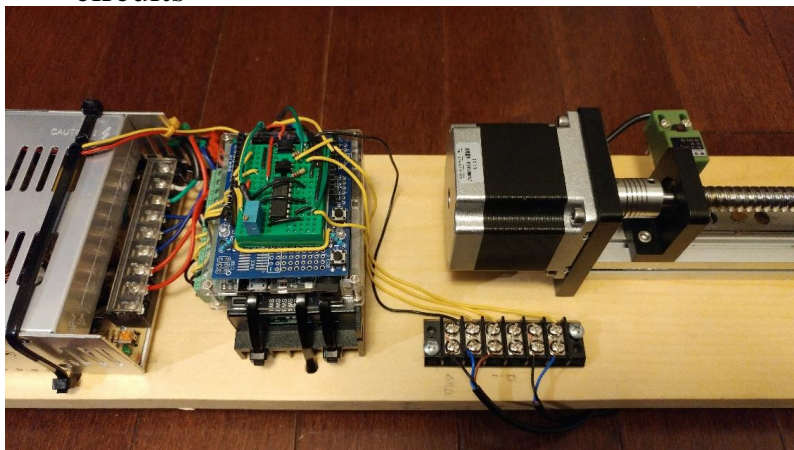
Cost-effectiveness: relatively low-cost components, maintaining accuracy requirements within the scope of the device (total cost in the 1000-1500 euro range).



Separation of medium- and low-voltage circuits



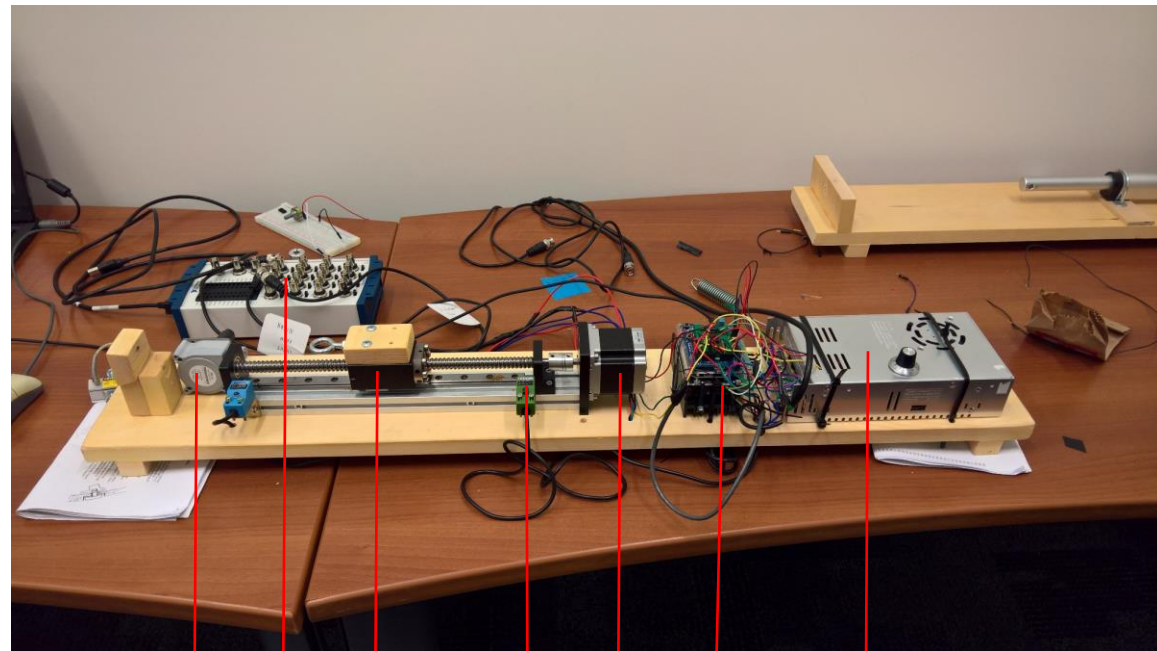
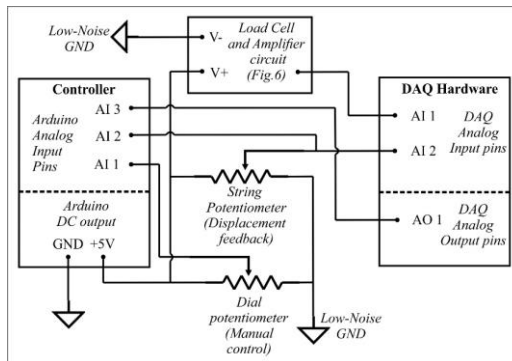
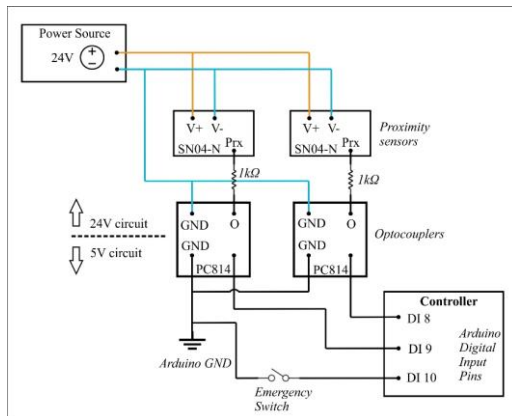
Communication with DAQ, overrides and NICON hybrid simulation protocol.



Mini hybrid setup prototype under development at UoT

IMPLEMENTATION

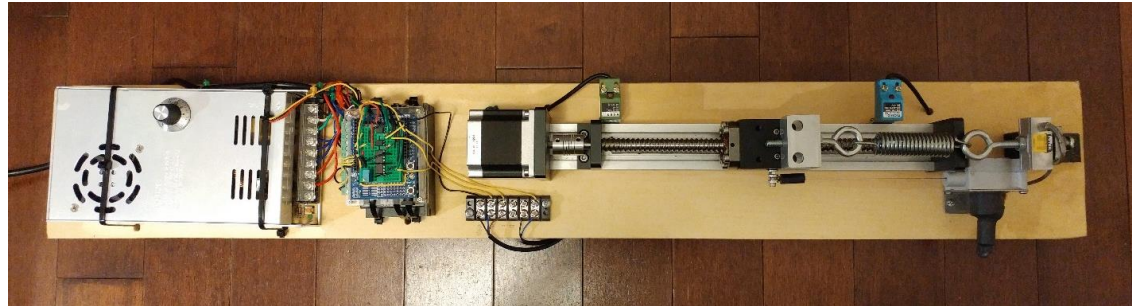
Electric actuator driven by stepper motor and controlled by an Arduino board.



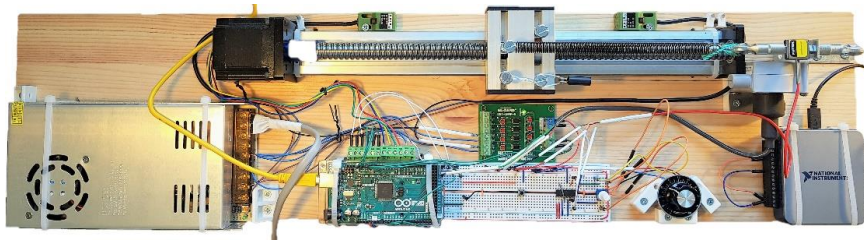
String pot traveller sensor Controller & step driver Power supply

REPRODUCIBILITY

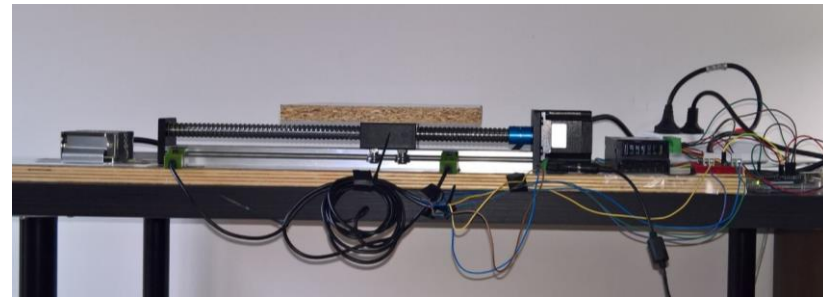
Project deliverable: detailed report permitting replicate mini hybrid setups to be assembled at partner institutions.



Prototype at University of Toronto



Duplicate of the prototype set-up at the university of Bristol

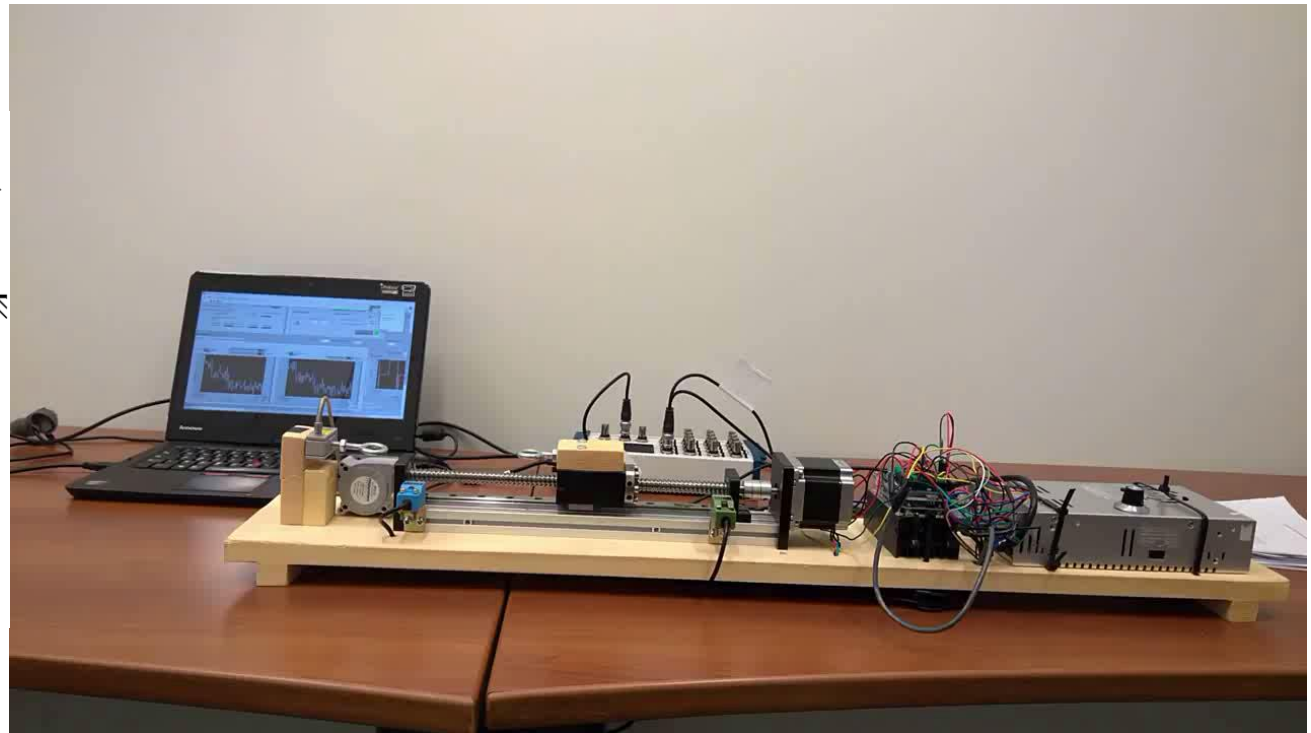
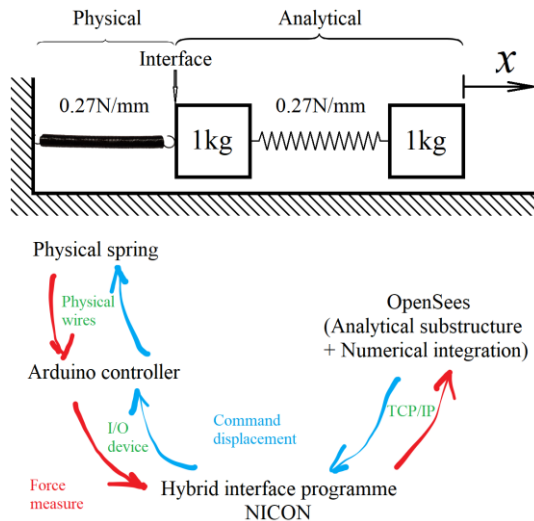


Duplicate of the prototype set-up at the university of Naples

DEMONSTRATION

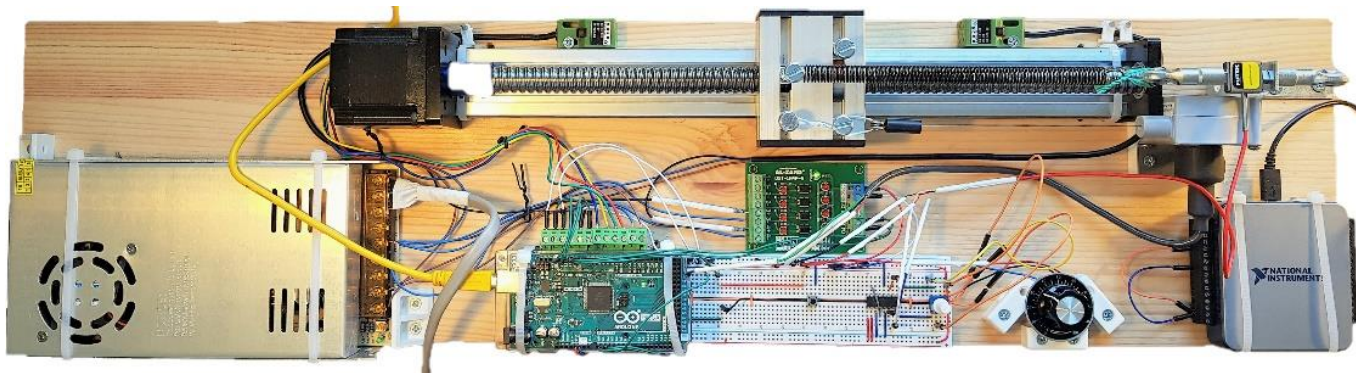
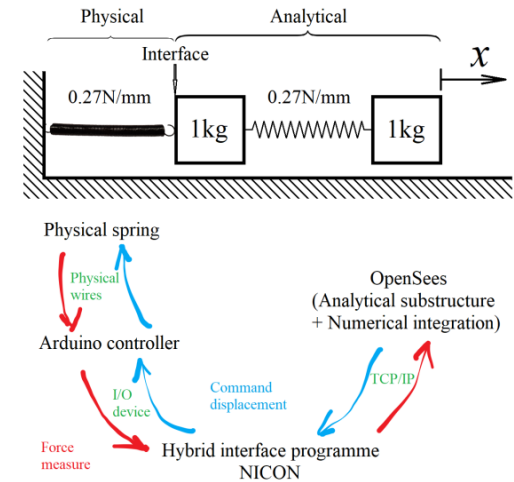
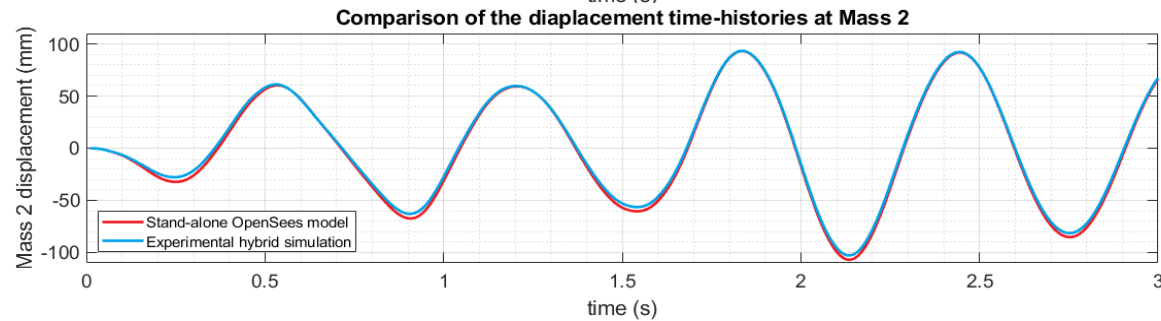
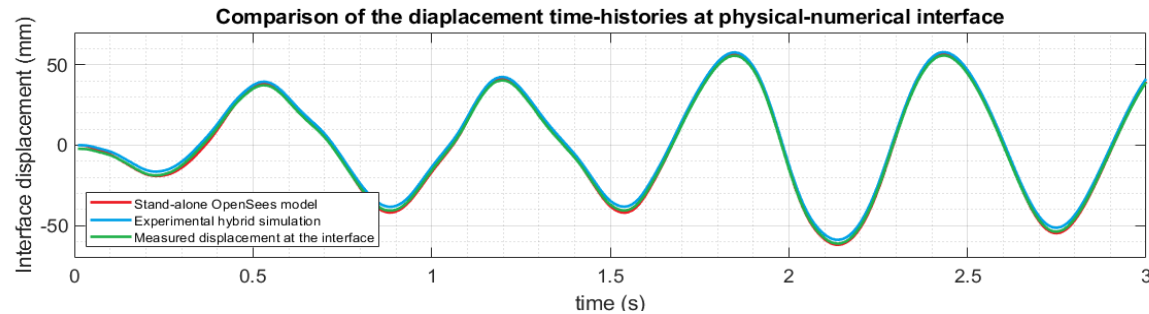
Toronto, October 2017: Demo run of small scale hybrid simulation using NICON and OPENSEES

Video. Demonstration of small-scale hybrid simulation underway. The computer is solving a two-degree-of-freedom system under seismic excitation, using the OPENSEES open finite element analysis platform and communicating with the demo-actuator via NICON labview-based platform developed at UoT. During this demo, there is no physical specimen attached to the actuator; instead the displacement feed is wired into the load-cell feed and converted into force readout via NICON (user-defined nonlinear force-displacement rule).



[Youtube link for the video](#)

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Benchmark test of the Bristol prototype

**THANK YOU FOR YOUR
KIND ATTENTION**

