Prototype demo-scale equipment in support of distributed hybrid simulation

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Within the framework of the EXCHANGE-RISK project (Experimental & Computational Hybrid Assessment of Natural Gas pipelines Exposed to Seismic Risk), it is envisaged to implement the combined experimental-analytical method of *distributed* hybrid simulation for the identification of the principal failure modes of soil-pipeline systems. Given that the objective was to involve several of the partner academic institutions in the hybrid simulation endeavor, it was deemed useful to develop a demonstration-size low-power actuator.

The concept was that of a relatively simple and low-cost device that could be easily replicated at the labs of each project partner, able to interface with the UT-SIM (https://www.ut-sim.ca/) hybrid simulation platform developed at the University of Toronto (UoT) and to perform small-scale experimentation on simplified physical specimens. The purpose of the device (Figure 1) is to provide a testbed for the software implementation of the simulation before moving into the lab and connecting the controllers to hydraulic actuators and, importantly, to facilitate coordinated development of the control and network communication code among the partner institutions. So far, incarnations of this demo-scale scale setup have been assembled at the UoT, the University of Naples Federico II and the University of Bristol.

The activities leading up to the development of the prototype can be divided into two parts: on one hand the actual implementation of the demonstration actuator and the electronic components of the control system and on the other hand, coding the controller's processor for imposing displacement-controlled operation and communication with the hybrid simulation software. The actuator consisted of a ball-screw driven by a stepper motor in a linear guide, equipped with proximity sensors and force/position measurement devices. Control over the actuator and communication with the hybrid simulation software was performed via the micro-controller of an Arduino open-source-electronics board. Additional electronic components involved in measurement analog signal acquisition and issuing control-command digital signals were deployed and integrated into the controller board. Communication with the computer and numerical analysis software and issuing of movement commands for the actuator is achieved via the LabView-based NICON hybrid simulation software platform developed at the UoT.

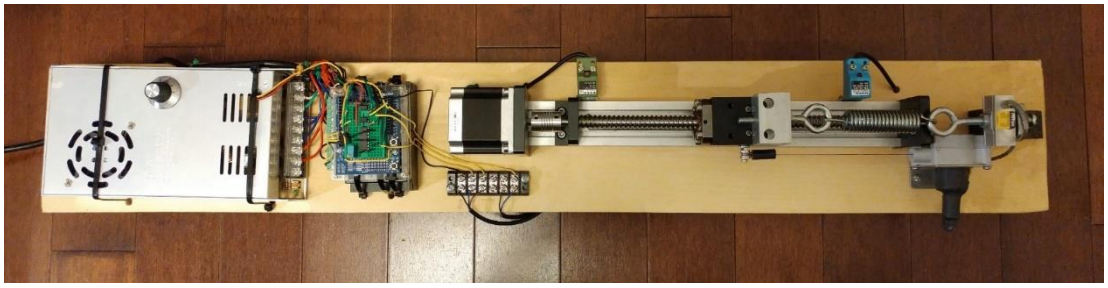

Figure 1 Prototype demonstration-size hybrid simulation equipment.

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