Module 1: Experimental Substructure
NICON: Network Interface for Controllers

Georgios Giotis

MASc Candidate
Department of Civil Engineering
University of Toronto

Civil Engineering
UNIVERSITY OF TORONTO

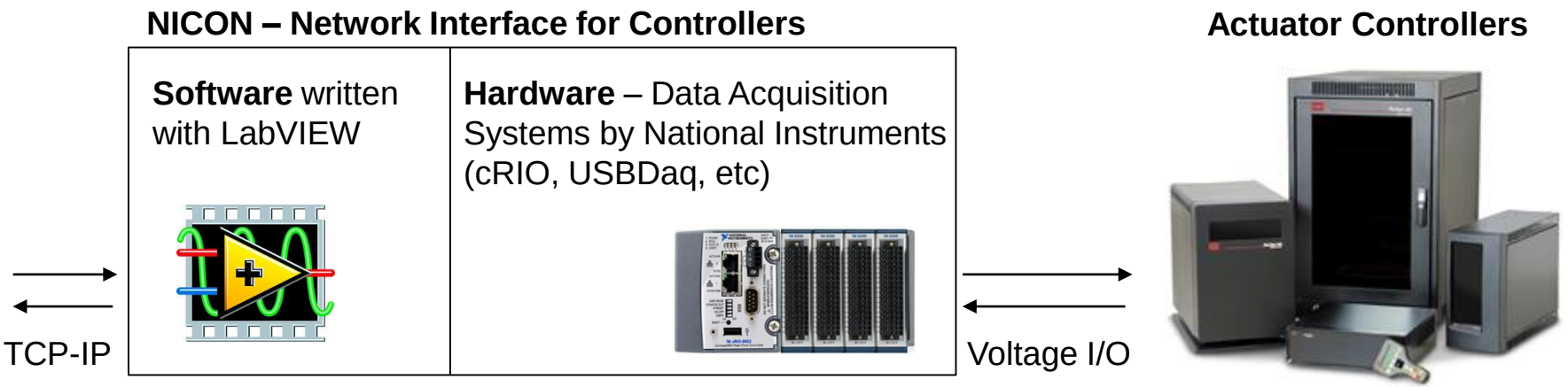
Overview

- **Experimental Substructure – Physical Testing**
  - Introduce NICON: Network Interface for Controllers
  - Experimental Setup Architecture
  - Developed NICON versions in UT-SIM
- **Featured Single Degree of Freedom NICON version**
  - Introduce LabVIEW
  - Featured NICON version: Main functionalities
- **NICON Demonstration: Small Scale Actuator Replica**
  - Connect with the Data Acquisition System (DAQ)
  - Introduction to the Featured NICON environment

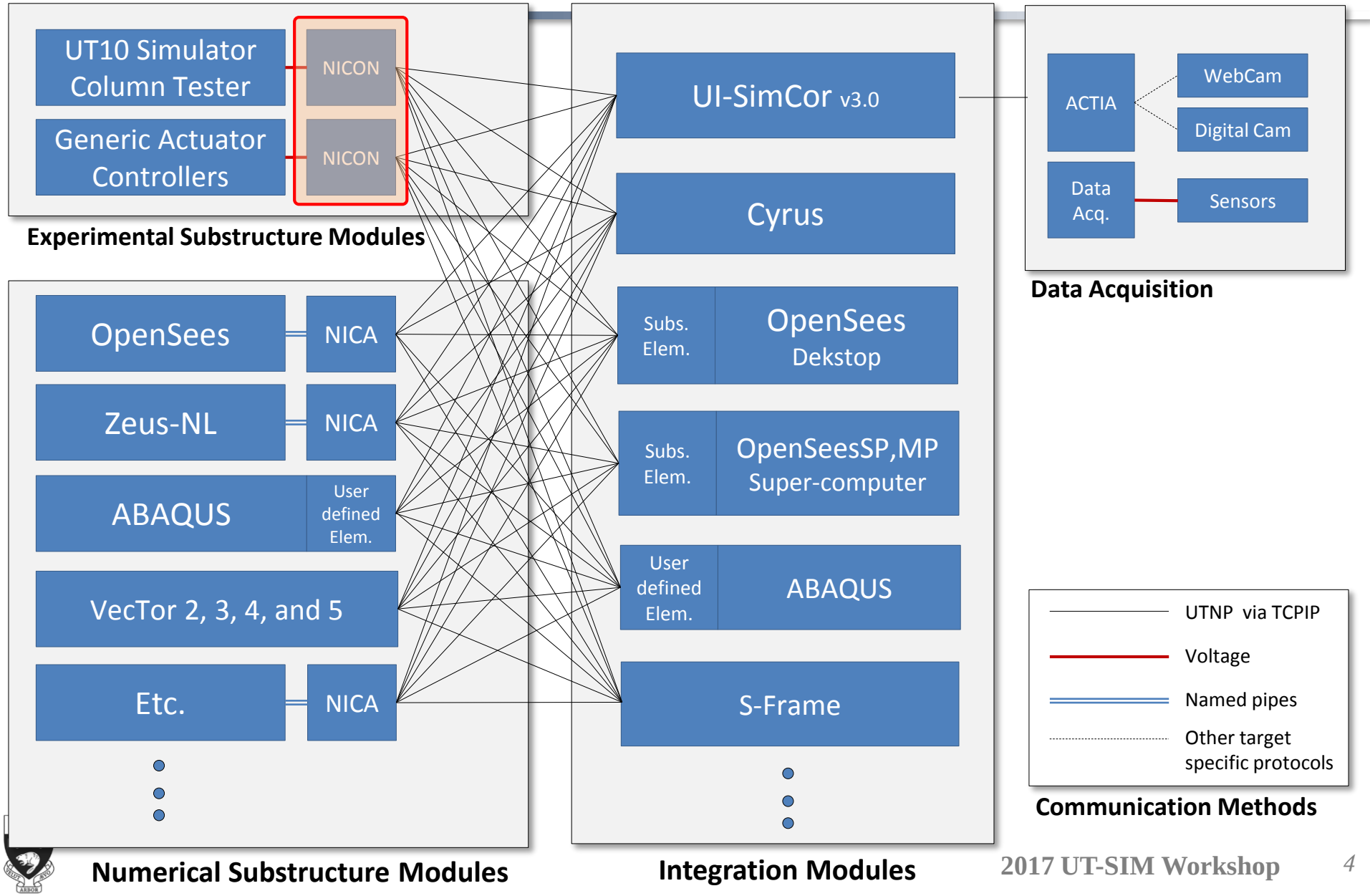
Module 1: Experimental Substructure

Physical Testing Requirement - Communication

- Methods for communication with actuator controllers
  - Shared memory approach: SCRAMNet
  - Analog voltage input/output method
- Analog voltage input/output with the actuator controllers
  - Reliable, portable, easy-to-use and cost-efficient

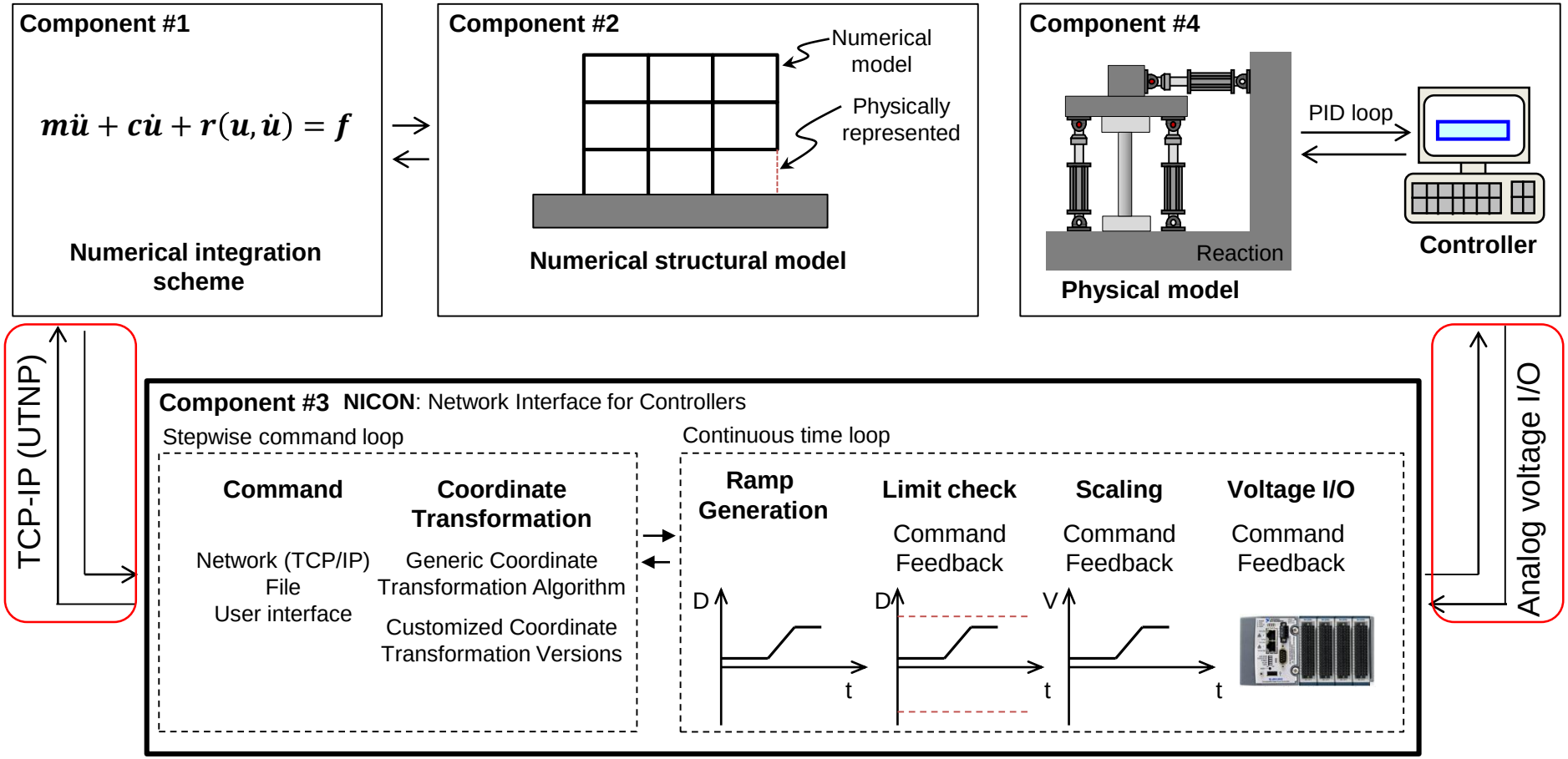


UT-SIM: University of Toronto Simulation Framework



Module 1: Experimental Substructure

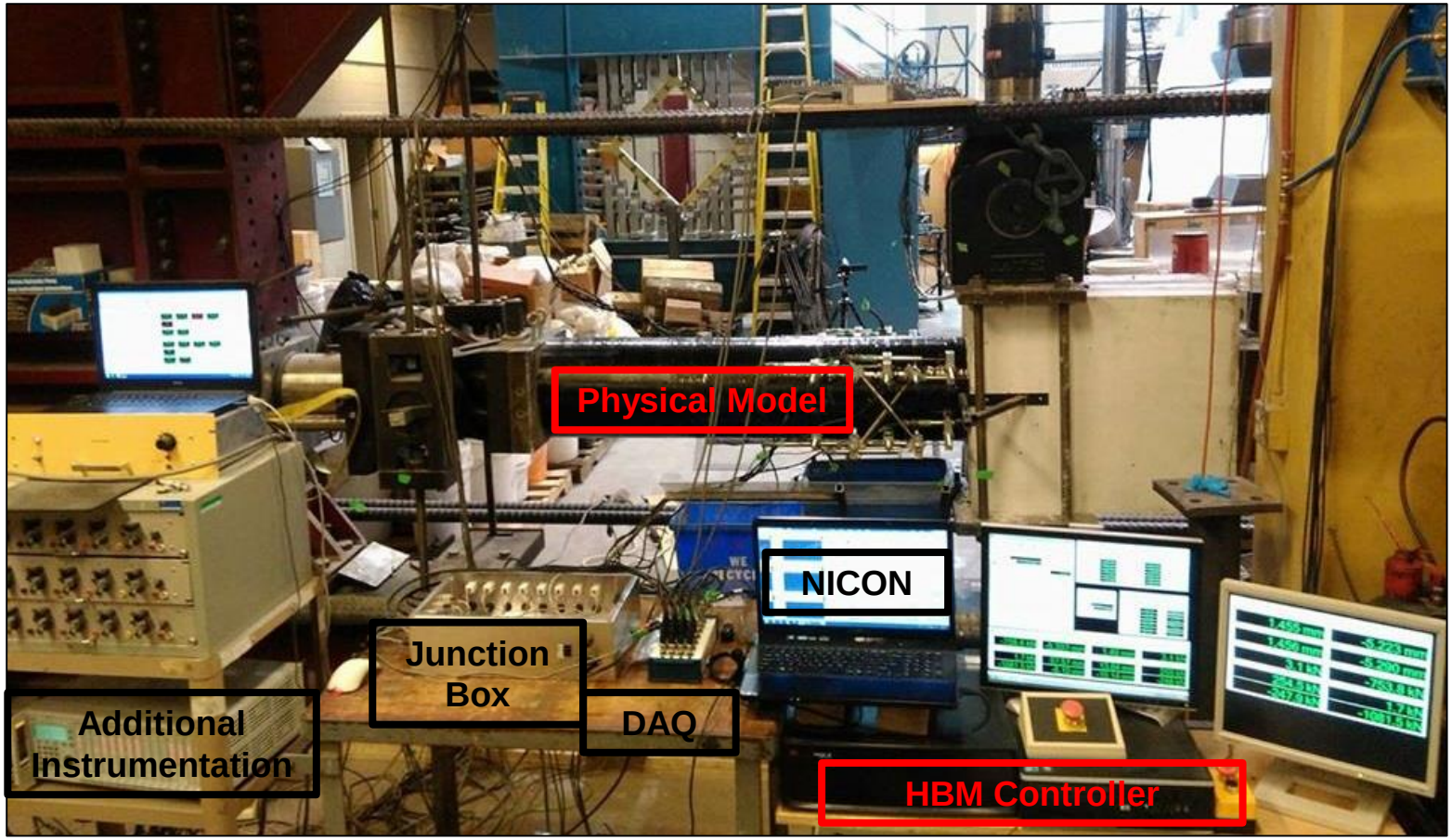
❑ Experimental Setup Architecture



Zhan, H. and Kwon, O. (2015) "Actuator controller interface program for pseudo-dynamic hybrid simulation," Advances in Structural Engineering Mechanics, Songdo, Korea, Aug. 25-29, 2015.

Module 1: Experimental Substructure

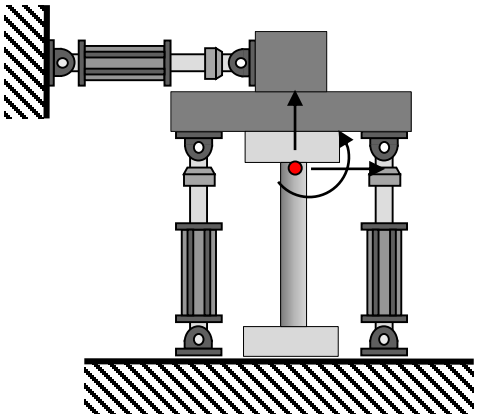
- Experimental Setup Architecture Example



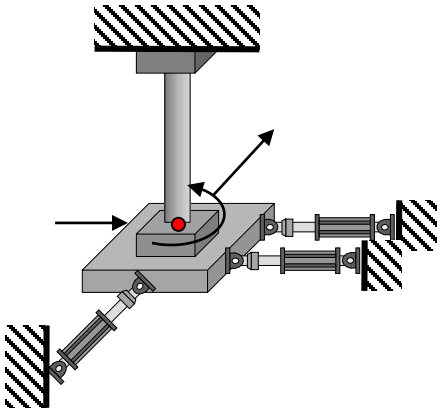
Available NICON versions

- **Generic Network Interface for Controllers (NICON)**
  - Generic algorithm for coordinate and force transformation
  - Currently working with the NI CompactRIO-9022 DAQ
  - Able to host a variety of application examples

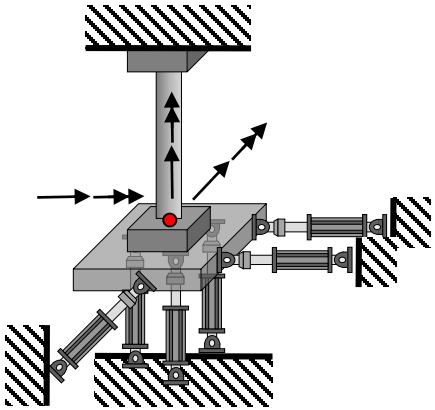
Application Examples



(a) Beam-Column elements: 3 DOFs



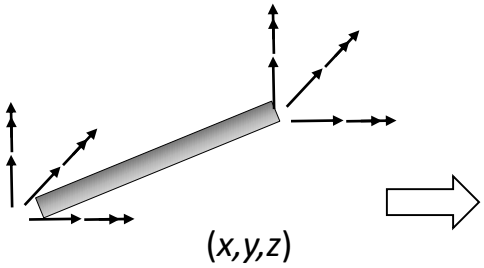
(b) Flexural-Torsional elements: 3 DOFs



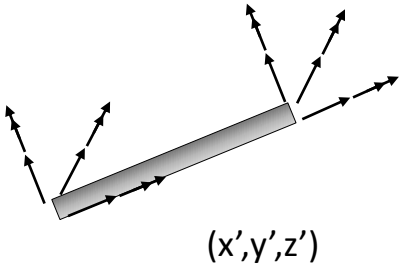
(c) General 6DOFs frame elements

Available NICON versions

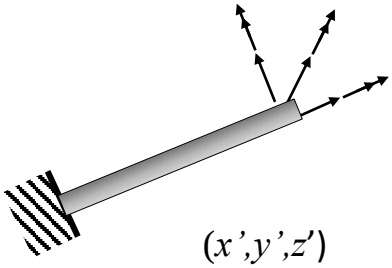
- **Generic NICON: Coordinate Transformation Architecture**



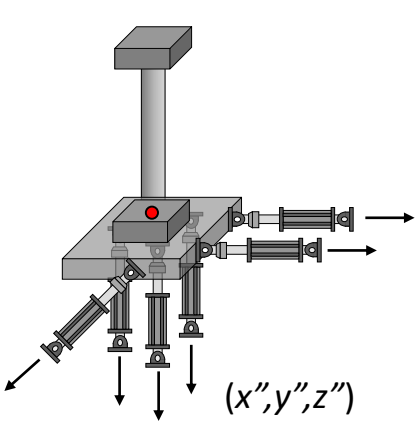
(a) Total displacements in the global coordinate



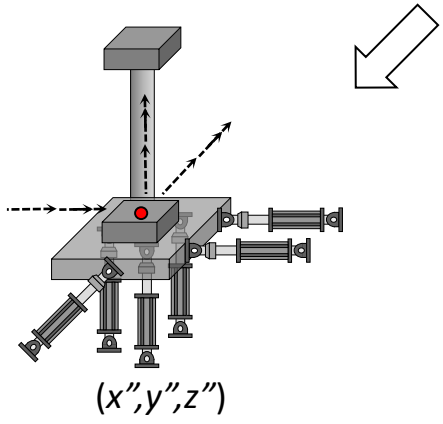
(b) Total displacements in the element coordinate



(c) Relative displacements in the element coordinate



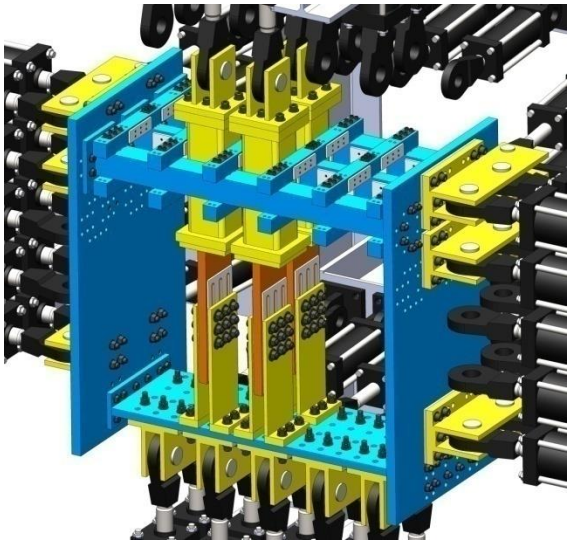
(e) Actuator strokes

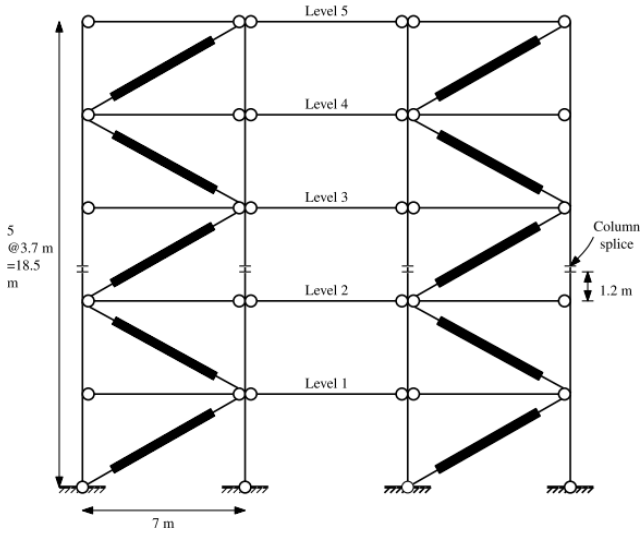


(d) Displacements in the control point's coordinate

Available NICON versions

- **UT10 Simulator**
  - Able to test up to 10 uni-axial elements
  - Developed for testing braces and friction/yielding dampers
  - Performs the required coordinate and force transformation (two dimensional displacement command to uni-axial stroke)
  - Includes error compensation scheme

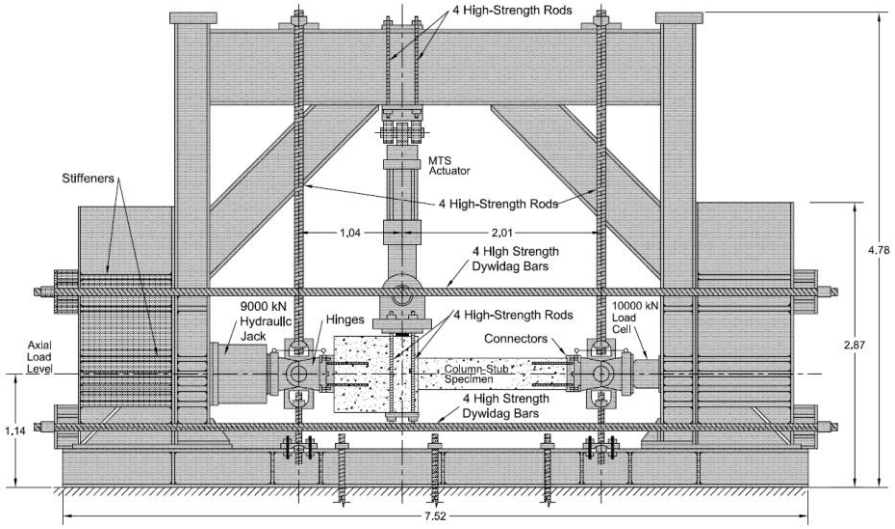


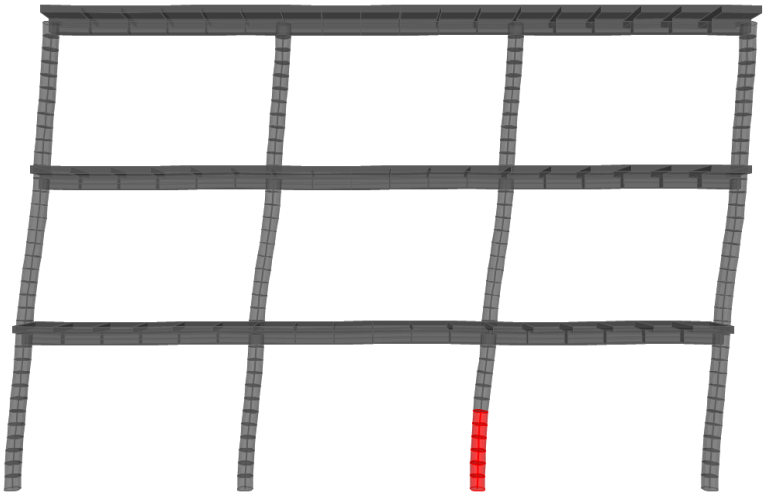


10 Element Hybrid Simulator

Available NICON versions

- **Dedicated Column Tester Hybrid Simulator**
  - Developed for column testing common setups
  - Based on a Weakly-Coupled Hybrid Simulation architecture to address control limitations
  - Performs the required coordinate and force transformation (two dimensional displacement to coupled stroke commands)
  - Includes error compensation scheme

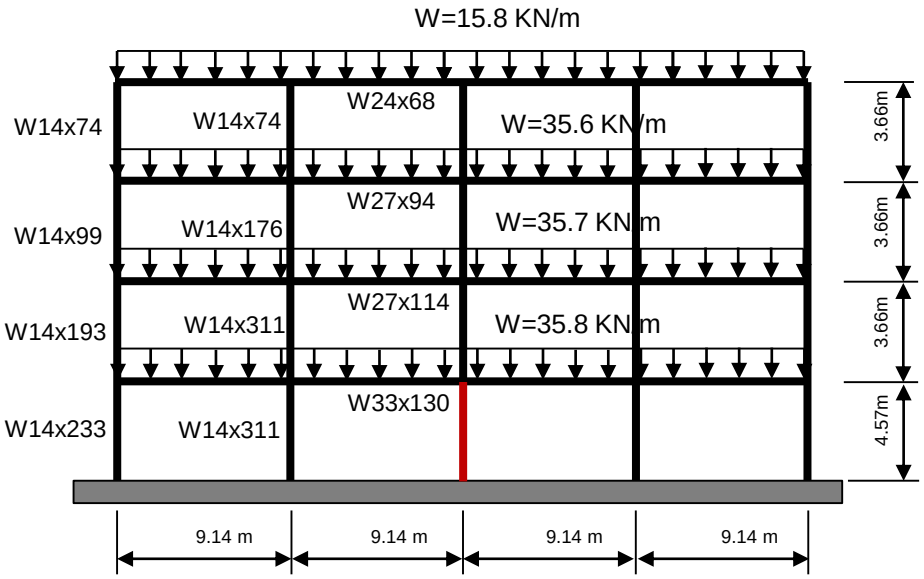




Dedicated Column Tester

Available NICON versions

- **Dedicated version for Hybrid Fire Testing**
  - Developed for steel structure simulation in fire
  - Includes a step-timed control to synchronize the thermal loading with the mechanical testing
  - Includes error compensation scheme

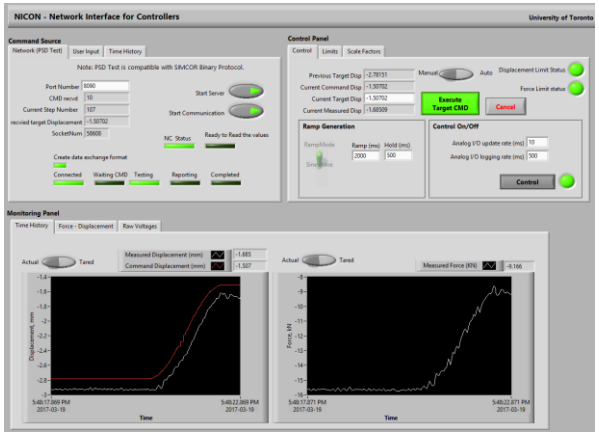


Dedicated NICON for Fire Testing

Featured NICON: Single DOF version

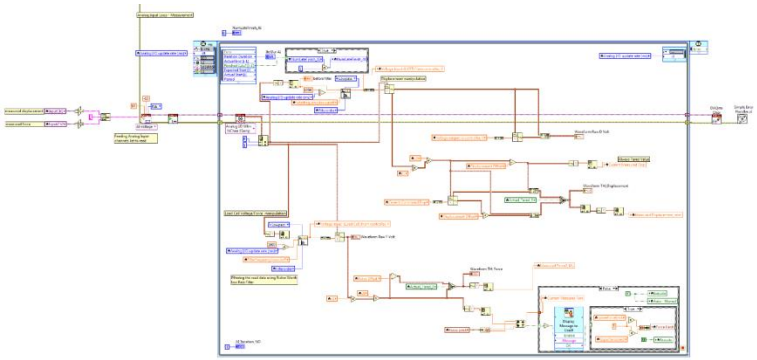
- **LabVIEW System Design Software**
  - User-friendly customizable interface
  - Graphical programming syntax
  - Extensive built-in library for data acquisition and signal processing

Front Panel (NICON.vi)



Command Source, Control & Monitor Panel

Block Diagram



Analog Input (Timed) Loop Measurement Block

Featured NICON: Single DOF version

- **Main Functions Overview**
  - Initialization block diagram
  - Analog input loop – Measurement
  - Analog output loop – Command
  - Network communication block – Hybrid testing
  - Analog I/O logging loop
  - Saving configuration event structure

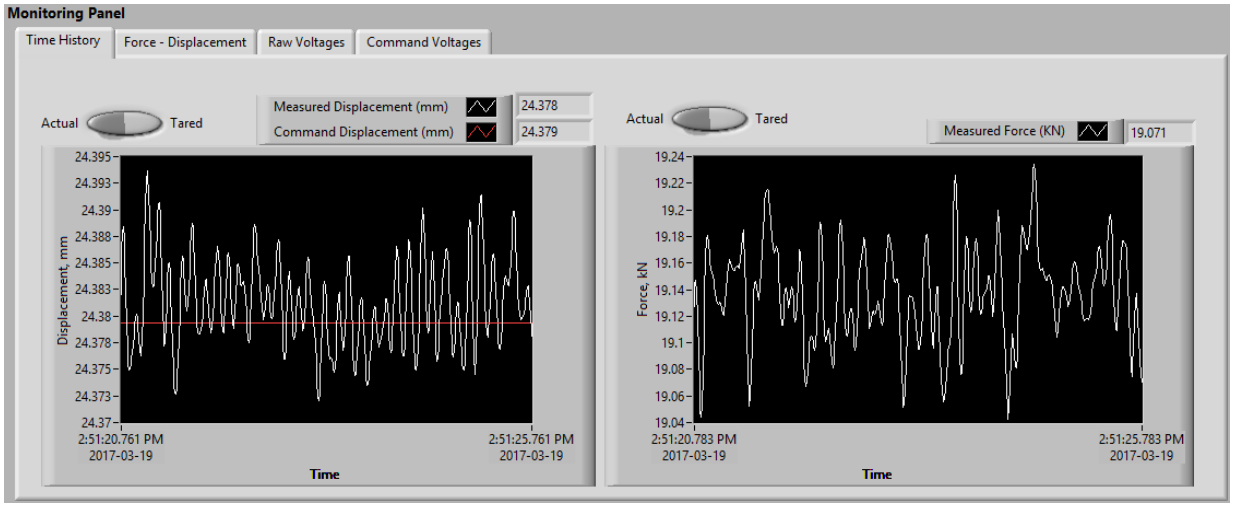
NICON: Initialization

- **Responsible for Initialization of the Configuration Parameters**
  - **Network Port Number**: Communication port with the integration module
  - **Control Parameters**: The ramp and hold time, I/O update and logging rate
  - **Limit Parameters**: Actuator's available stroke and force limits
  - **Scale Factors**: Calibration factors for the voltage to measurements and commands transformation
  - **Physical Channels Definition**: The input and output channels are defined in accordance with the used DAQ

These parameters are defined in NICON_Config.xml (eXtensible Markup Language)

NICON: Analog Input – Measurements

- **Responsible for Measuring the Current Displacement and Force**
  - Transforming the physical channel measurement into 1D-waveform
  - Signal processing using a low-pass Butterworth filter
  - Transforming the input voltage into displacement and force measurements
  - Performing the force limit check



Monitoring Panel: Displacement and Force Measurement

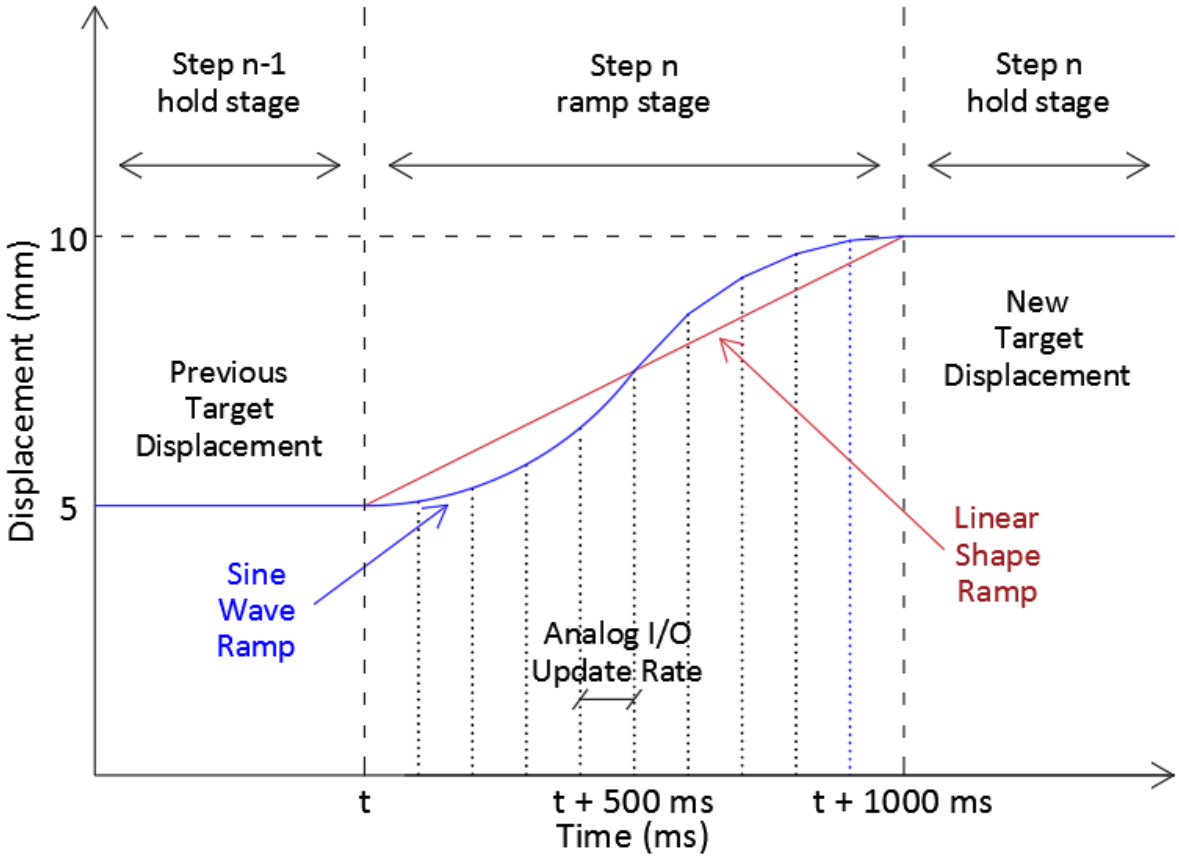
NICON: Analog Output – Command

- **Responsible for Transforming the Command Deformation to Voltage**
  - Performing the stroke limit check
  - Generating the ramp stages*
  - Transforming the stroke commands into excitation voltage

- **Three Different Command Sources Available**
  - User Input – Manual control
  - Network (PSD Test) – Hybrid testing
  - Time History – Predefined deformation command history

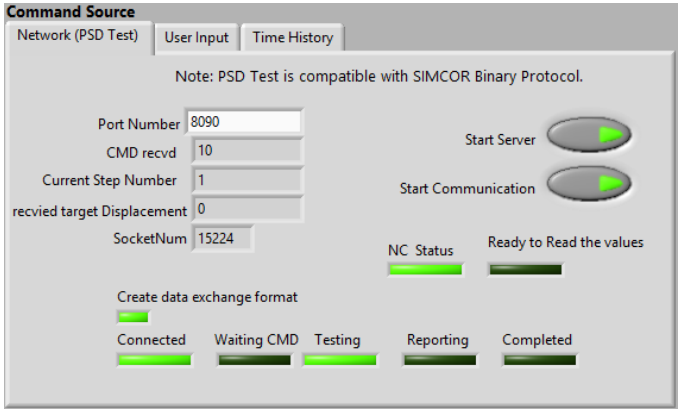
NICON: Analog Output – Command

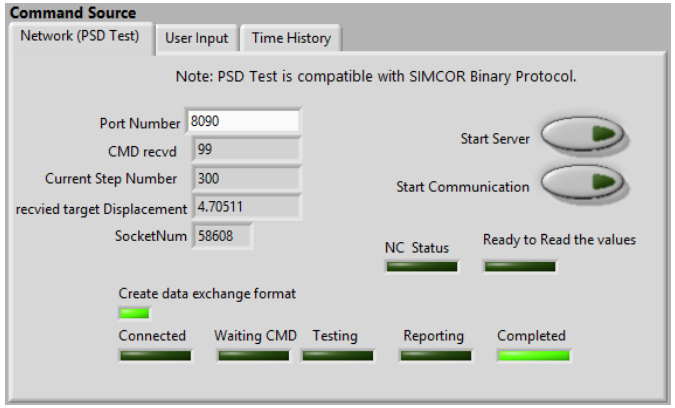
- **Ramp Generation Stages**



NICON: Network Communication

- **Responsible for the Communication with the Substructure Element**
  - Performing the initiation of the server and the setup of the communication
  - Receiving the commands and sending the measurements in TCP-IP format
  - Monitoring the testing status
  - Logging the network communication for post-testing troubleshooting purposes





Network Monitoring and Control Panel

NICON: Additional Features

- **Analog I/O Logging Loop**
  - Recording the voltage, stroke, displacement and force input and output for post testing analysis purposes
  - The logging rate is defined by the user

- **Saving Configuration Event Structure**
  - The configuration file (*NICON_Config.xml)* is updated in accordance with the modifications into the configuration parameters made into the LabVIEW environment

Demonstration of the Featured NICON

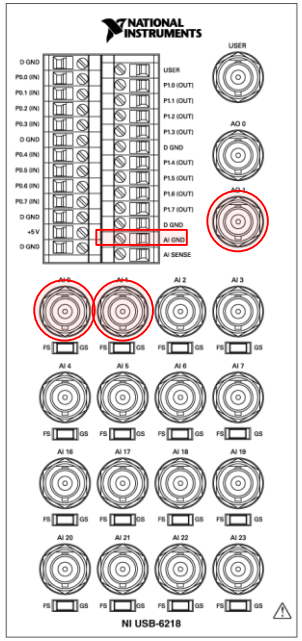
- **Control of a Small Scale Actuator Replica Using the Featured NICON**
  - Connect with the DAQ system
  - Introduction to NICON front panel environment
  - Manual control of the applied stroke
  - Perform hybrid simulation (2nd Day)

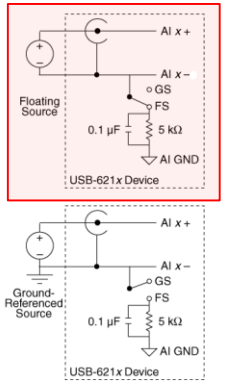
Small Scale Actuator Replica

Demonstration of the Featured NICON

- **Connect with the DAQ (Physical Channels)**
  - Actuator's Stoke Command: Dev1/AO1 (Differential Connection)
  - Referenced Single-Ended (RSE) Connection: AI GND
  - Measured Deformation: Dev1/AI0 (RSE Connection)
  - Measured Force: Dev1/AI1 (RSE Connection)
  - Floating Source: Isolated ground-reference sources

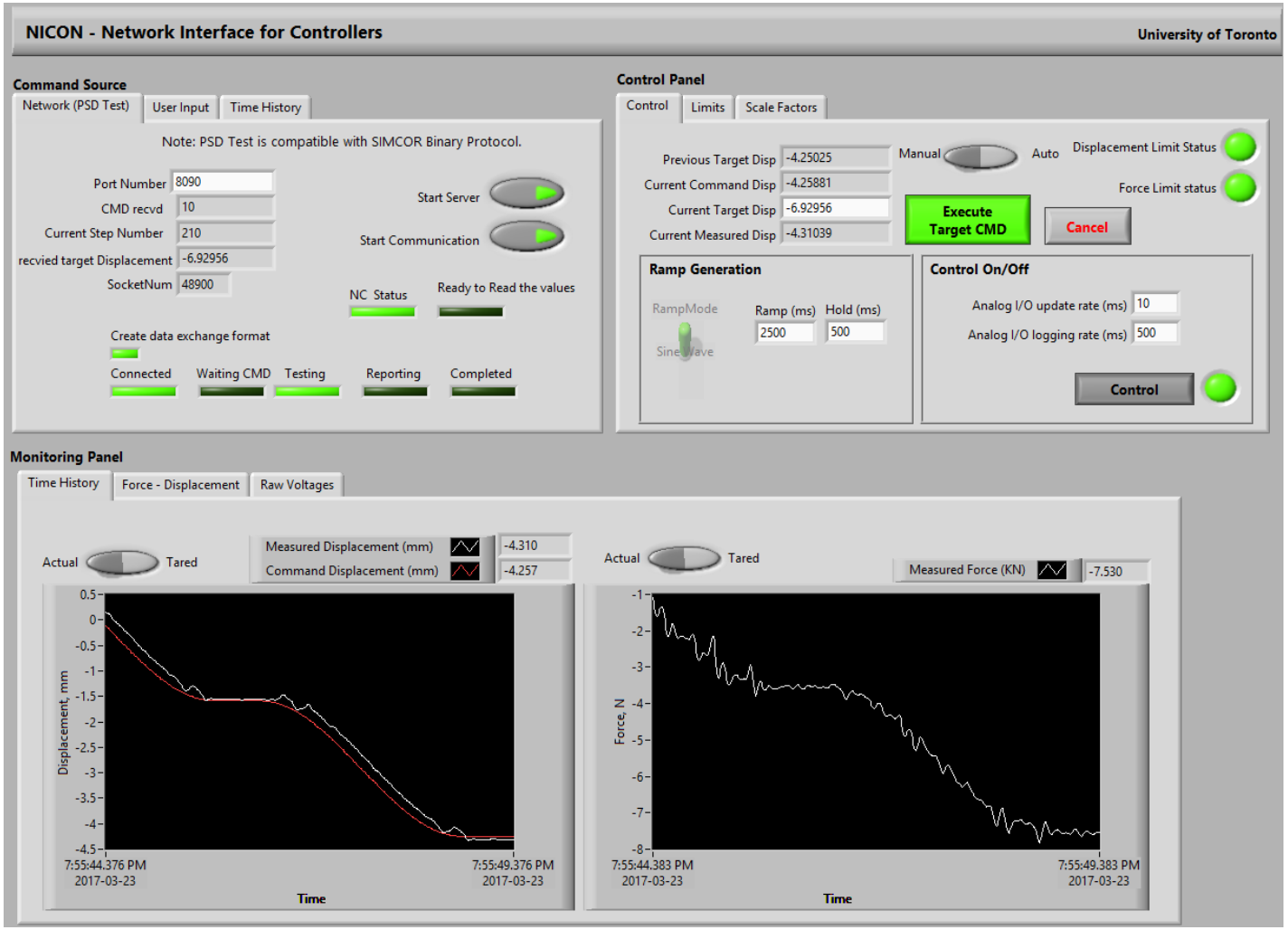
NI USB-6218 BNC
16 Dif. Analog Input (32 S.E)
2 Dif. Analog Output
8 Digital Input
8 Digital Output





Demonstration of the Featured NICON

- Moving to Network Interface for Controllers



Thank you for you attention.
Questions?

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