NHERI@UCSD:
Tools for Shake Table Users

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Outline

- **Shake table simulation and input motion generation tools**
- **Instrumentation**
  - Sensor Inventory and DAQ System
- **Tele-presence and Video Recording System**
  - Camera Inventory
  - Site Drones
- **Live Video Streaming Capabilities**
  - WireCast System
  - DaCast service for zero latency live video streaming
- **IT Infrastructure**
  - Visible and invisible IT networks
- **Our Websites and Social Media Presence**
  - Resources for Researchers

Shake Table Simulation and Input Motion Generation Tools

- **Two different types of tools can be provided**

  1) Shake Table Simulation Tools
     - ✓ For pre-test evaluations and checks

  2) Input Motion Generation Tools
     - ✓ For performing actual dynamic tests on the shake table using the motions generated by these tools

(1) Shake Table Simulation Tools

a. Forward Simulation Tool

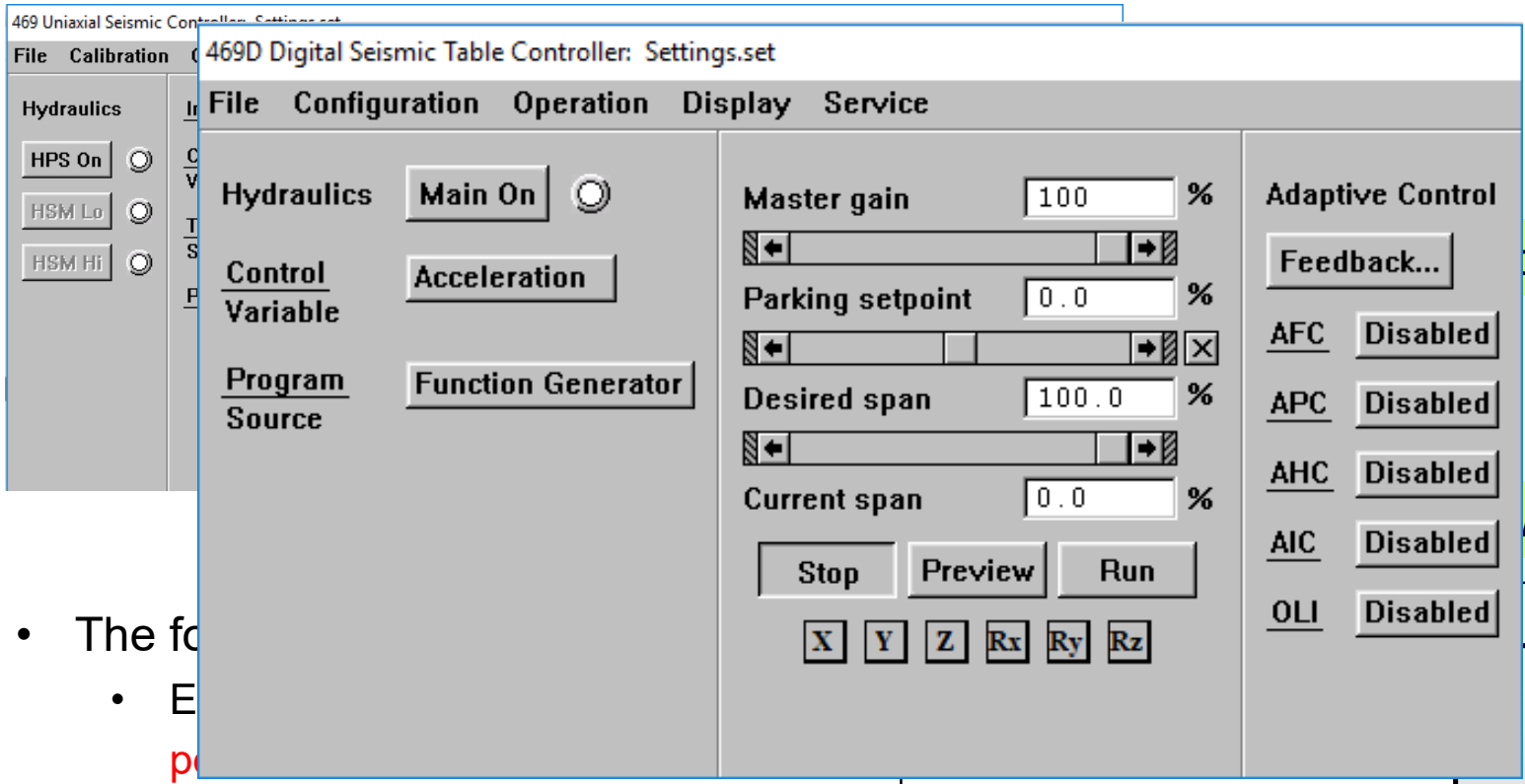
- Pre-test studies using the real controller and a validated model of the shake table
  - ✓ The forward model is like the real system (i.e., when servo-valves are commanded, table motion results)

b. Inverse Simulation Tool

- Checking the suitability of ground motions to be reproduced on the table in term of the table's physical limits (e.g., disp., force etc.)
  - ✓ In the inverse model, cause and effect are reversed (i.e., the system motion is input to the model, servo-valve openings result)

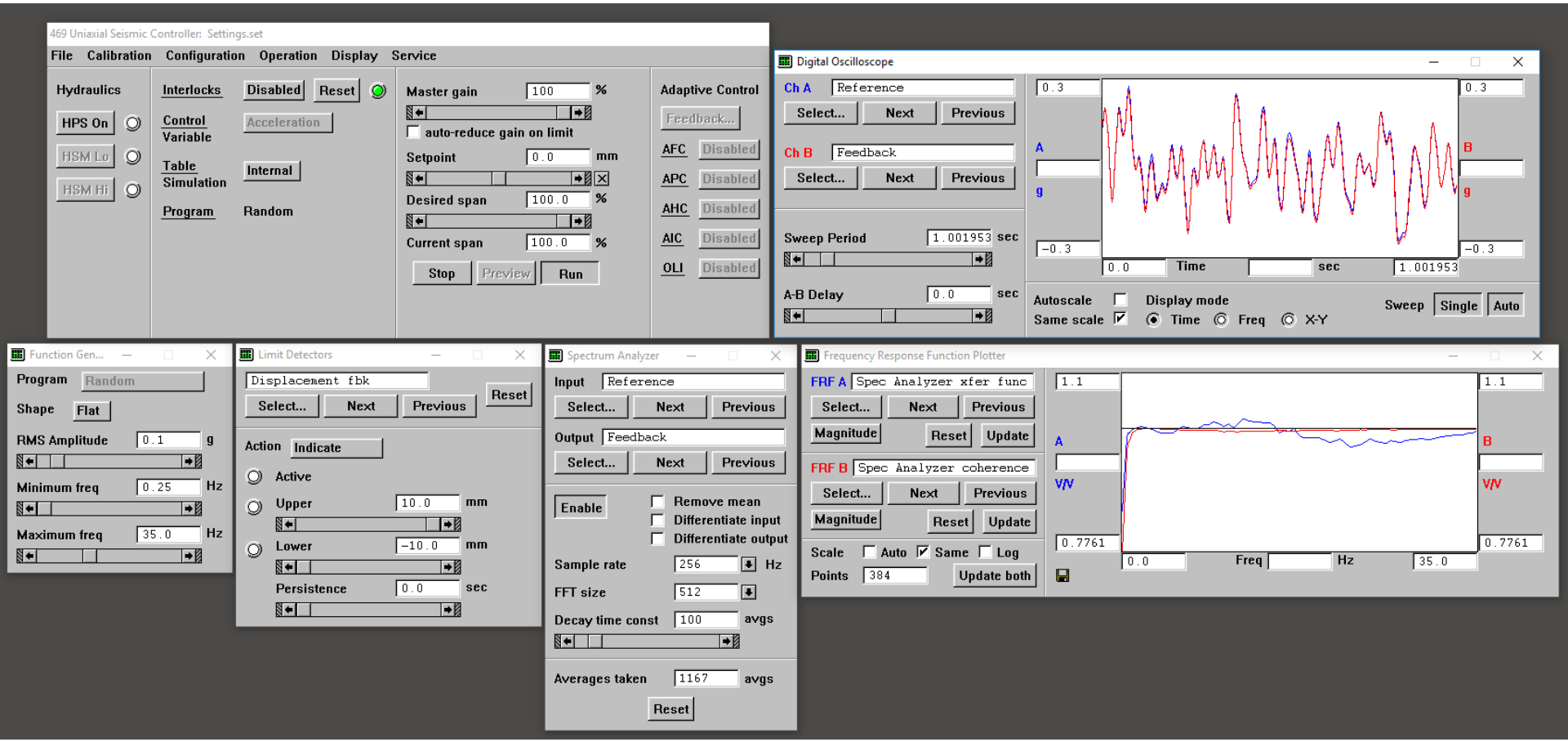
Shake Table Forward Simulation Tool

➢ PC Simulation Mode



- The fo
  - E
    p
  - Offline tuning of the controller

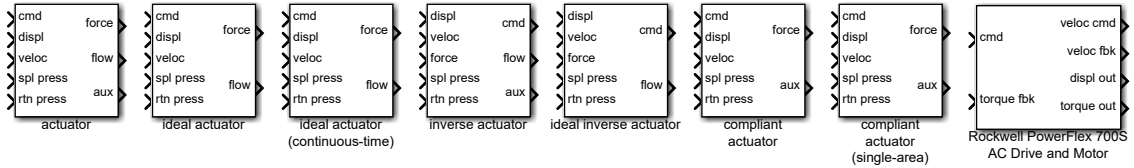
Shake Table Forward Simulation Tool



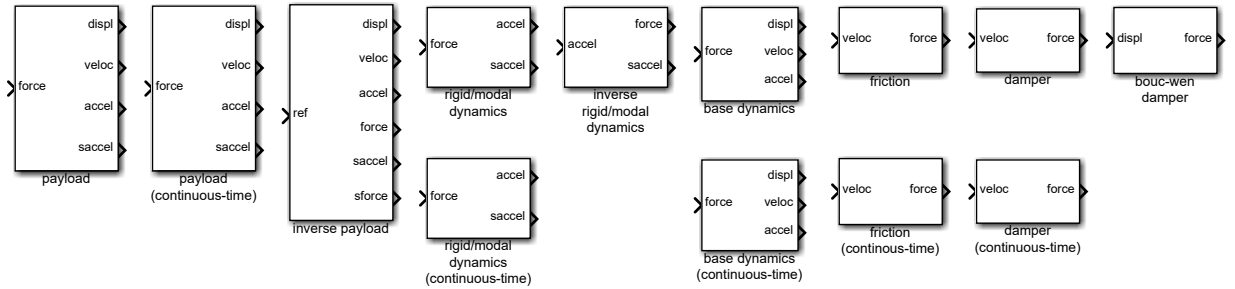
Shake Table Forward Simulation Tool

➢ Forward Model can be enhanced by using an extensive dynamic library

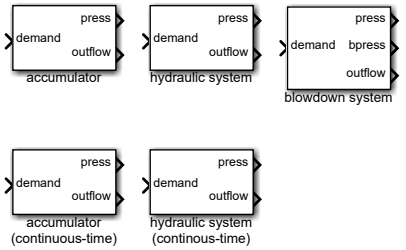
PRIME MOVERS



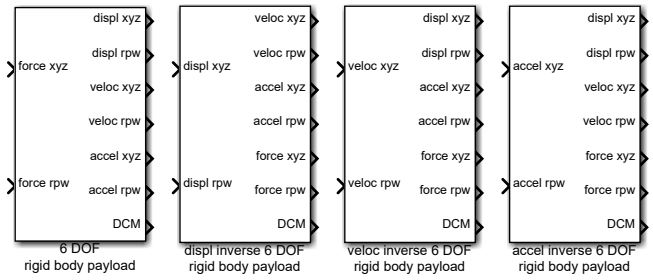
1-DOF PAYLOADS

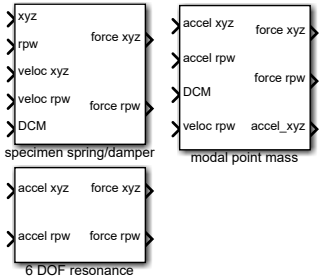


HYDRAULICS

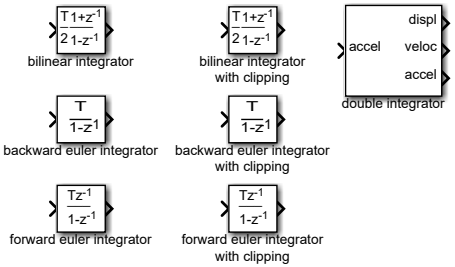


6-DOF PAYLOADS

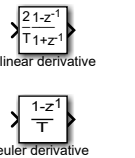




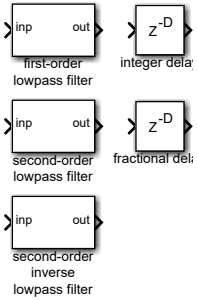
INTEGRATORS



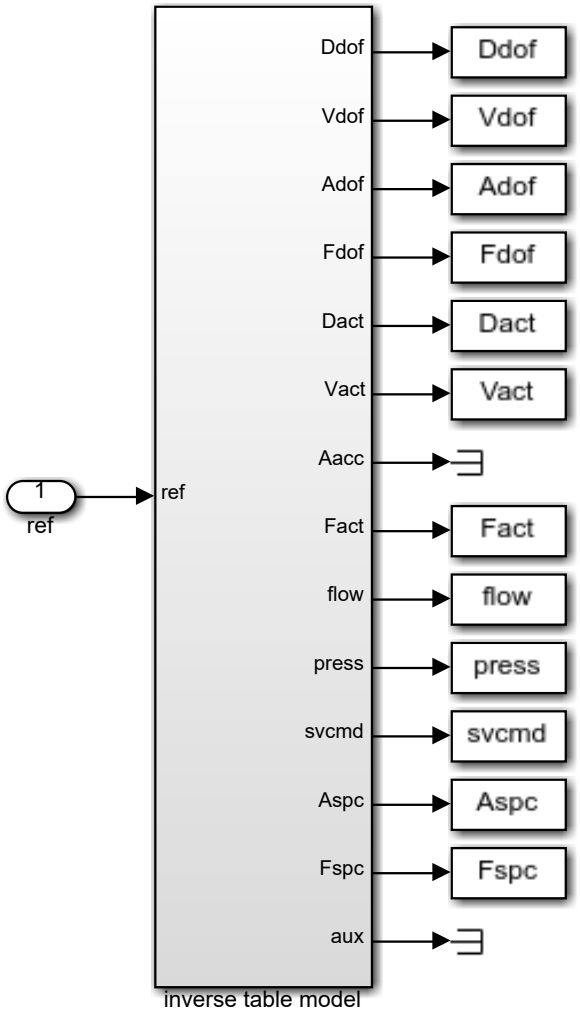
DIFFERENTIATORS



MISC



Shake Table Inverse Simulation Tool



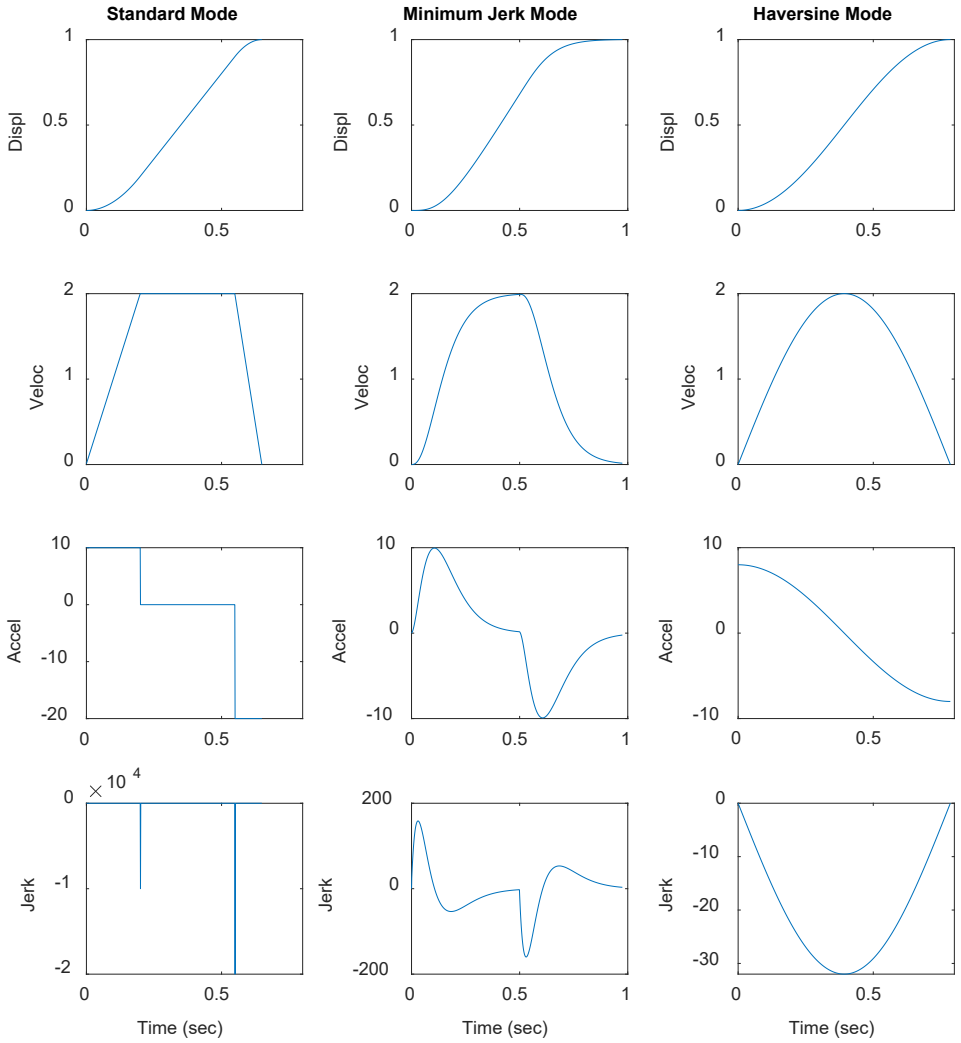
- Allows the user to take a desired motion profile (uni- or tri-axial) and
  - Verify that the system can meet the demands in terms of displacement, velocity, acceleration, force, oil flow and pressure.

(2) Input Motion Generation Tools

- **These tools are needed for**
  - Input ground motion preparations for shake table testing
    - Ramp function, sine-sweep, sine-beat, random time histories
    - Pseudo-random THs
    - Response spectrum compatible THs
    - Base-line correction of THs

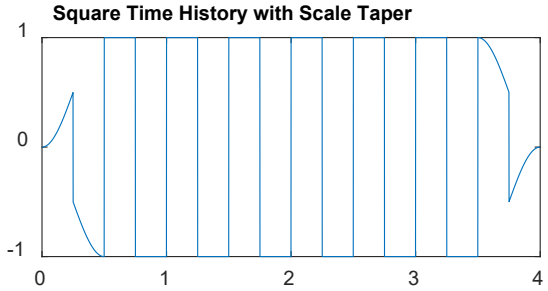
Input Motion Generation Tools

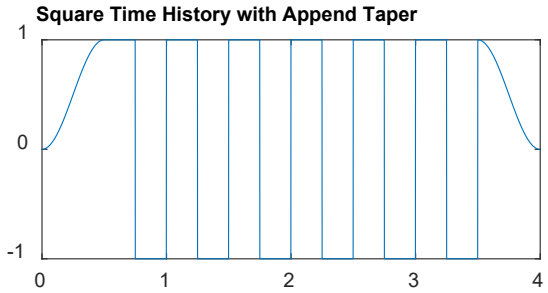
Ramp Time Histories



- We want to make sure that a smooth displacement ramp waveform is generated which has smooth and predictable maximum velocity, acceleration, and jerk (3rd time derivative of displacement).

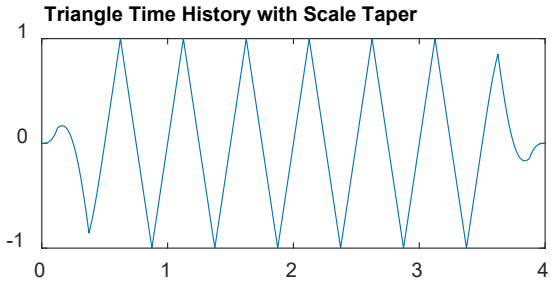
Input Motion Generation Tools
Square/Triangle/Sine THs

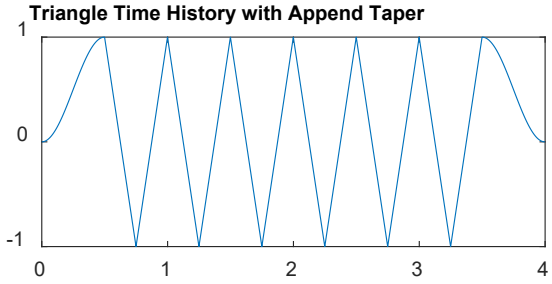




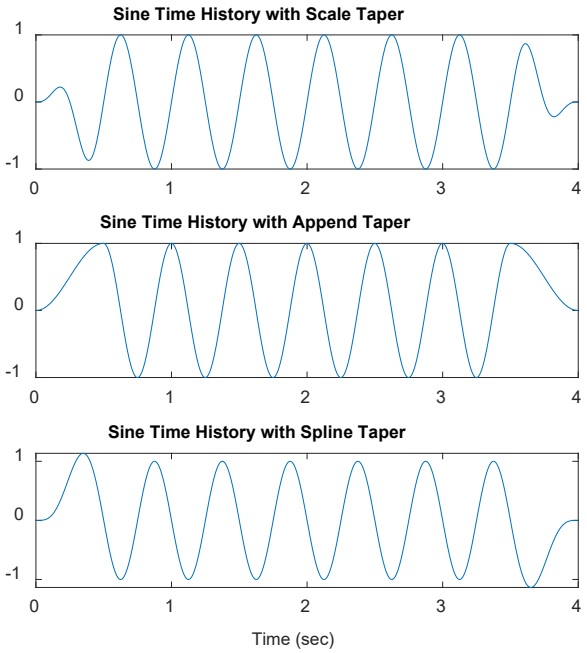
Time (sec)

- When we want to generate a periodic function,
  - Make sure that beginnings and ends must be tapered



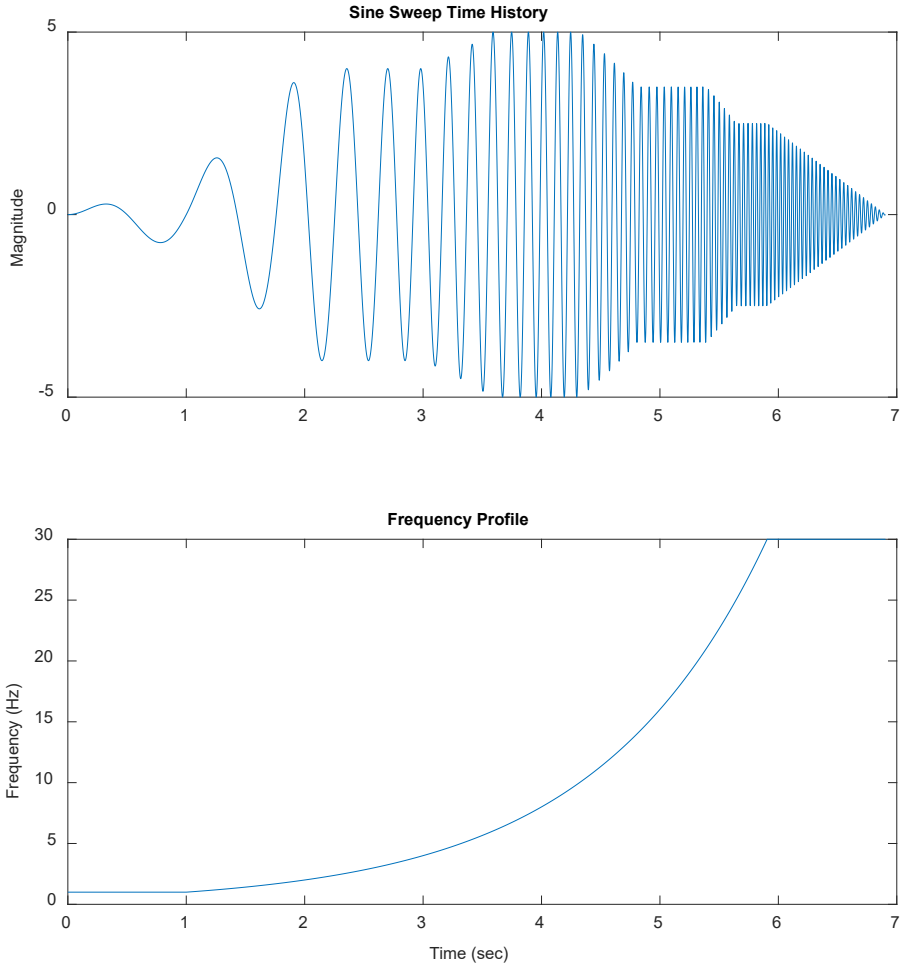


Time (sec)



Input Motion Generation Tools

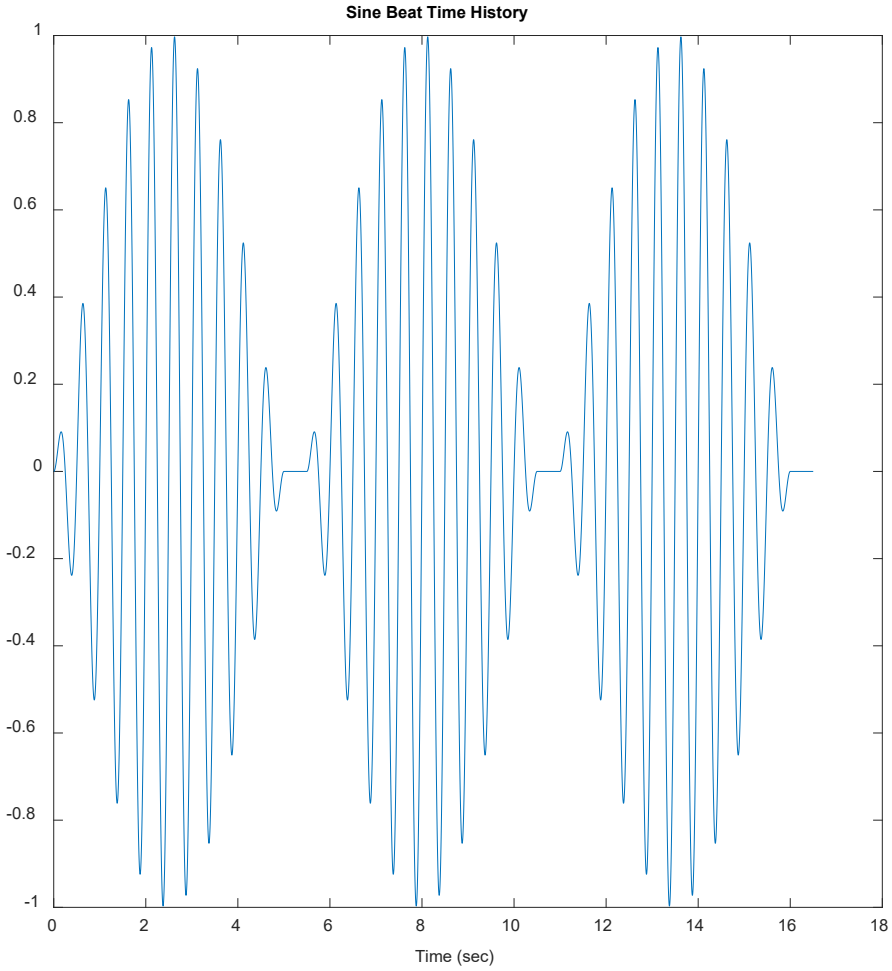
Sine Sweep THs



- Sweep can be linear or logarithmic
- Taper up and down can be specified
- Taper shape can be linear, haversine or spline

Input Motion Generation Tools

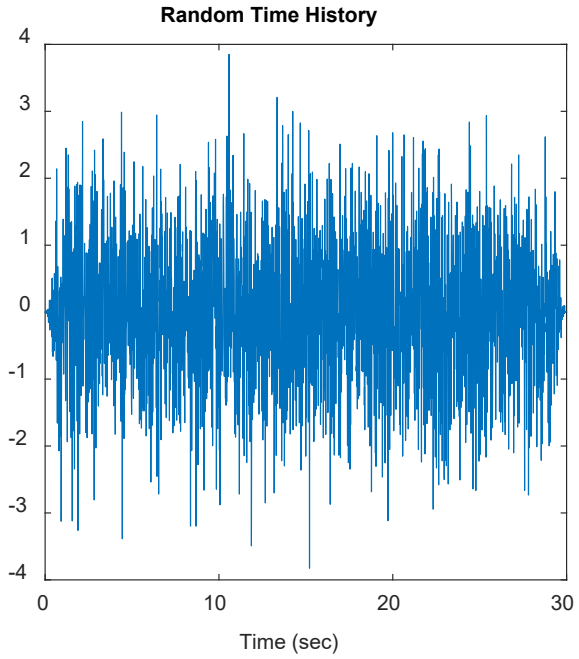
Sine Beat THs

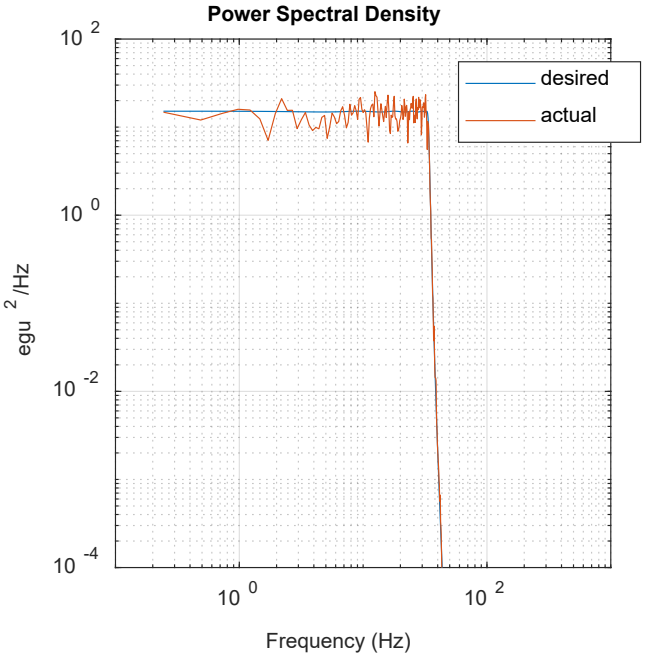


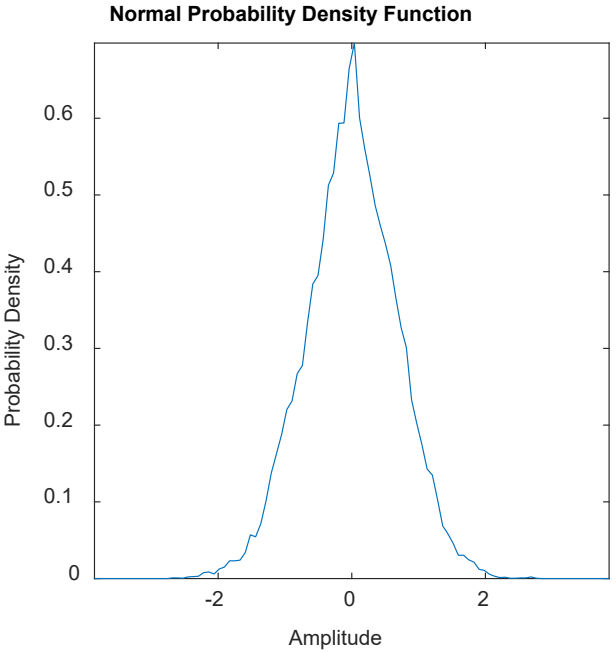
- Number of beats
- Number of cycles per beat
- Pause between beats in sec can be specified

Input Motion Generation Tools

Random THs



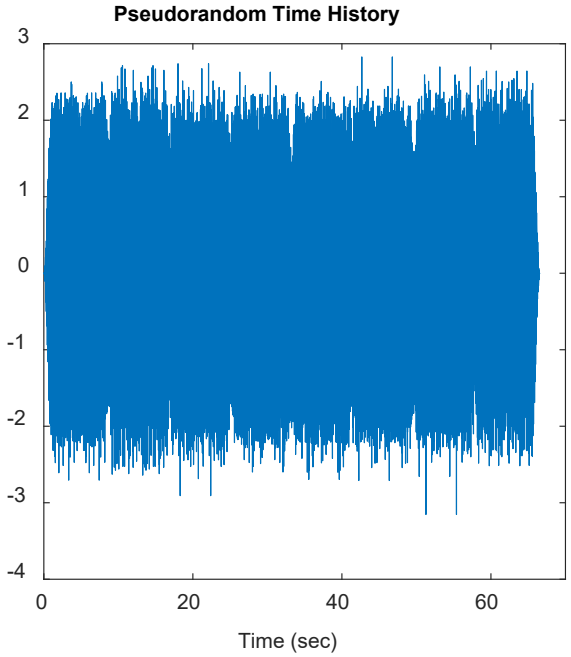


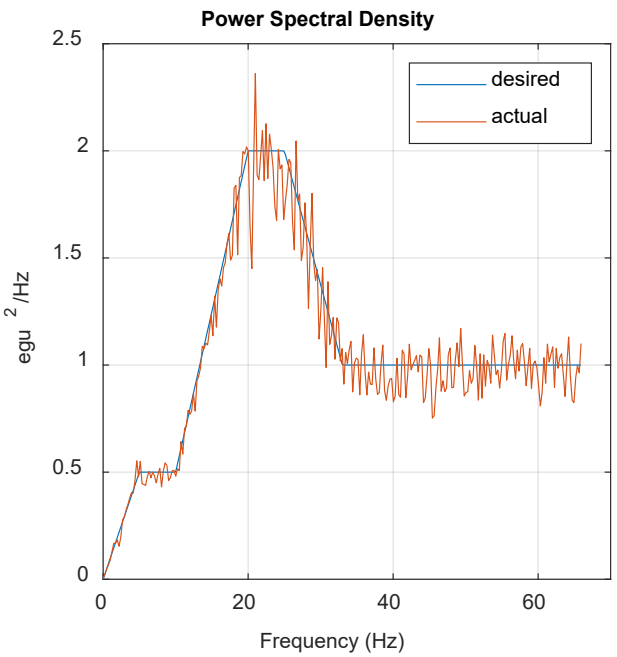


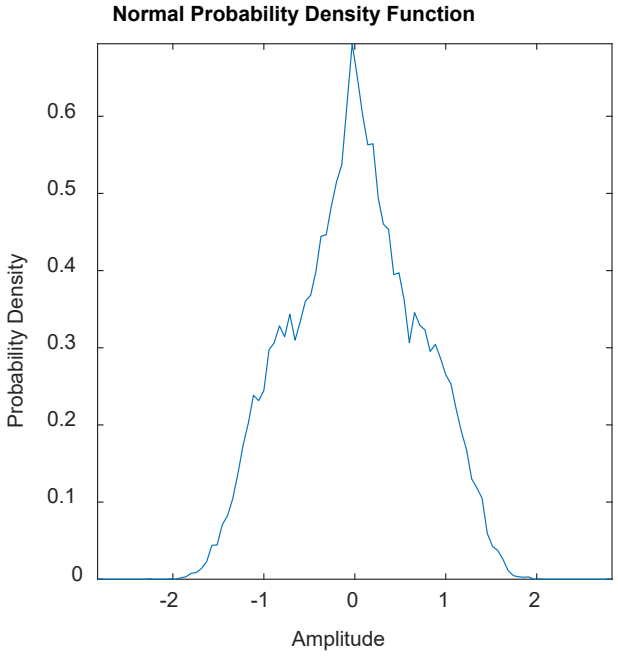
- Creating a non-repeating random TH by passing uniform WN through a filter with desired spectral shape and bandwidth

Input Motion Generation Tools

Pseudo-random THs with Desired Spectral Density

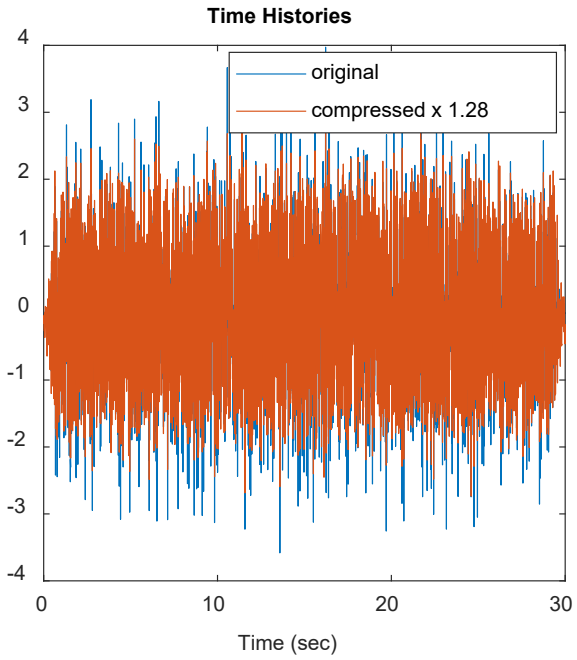


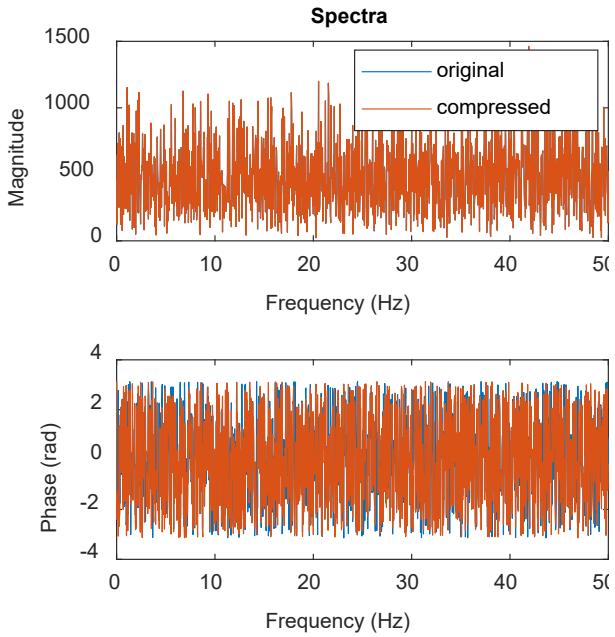


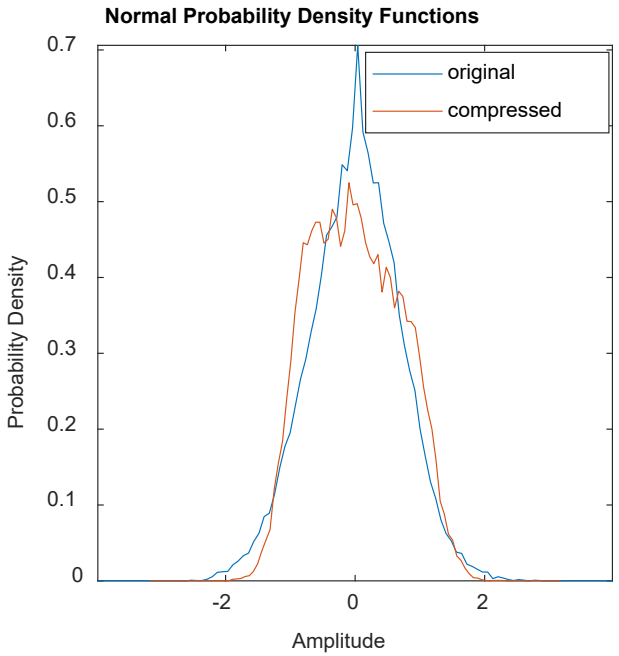


- A different version of this tool can also be used for generating response spectrum compatible acceleration THs.

Input Motion Generation Tools
Compressing Dynamic Range of THs



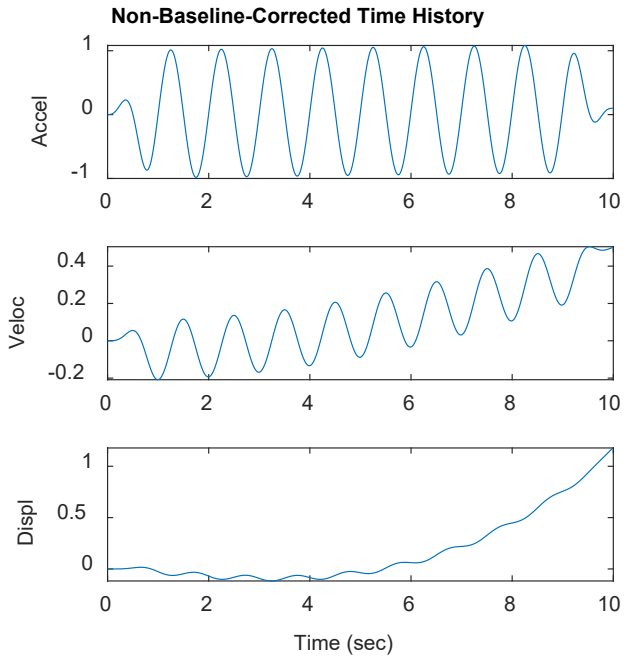


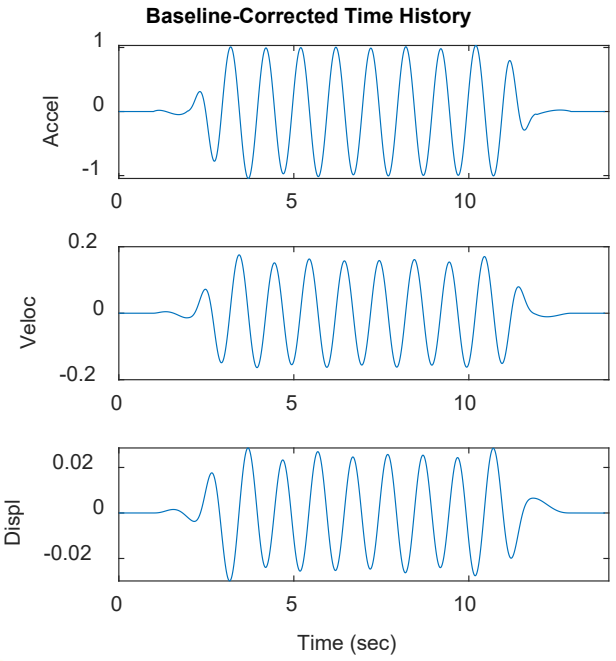


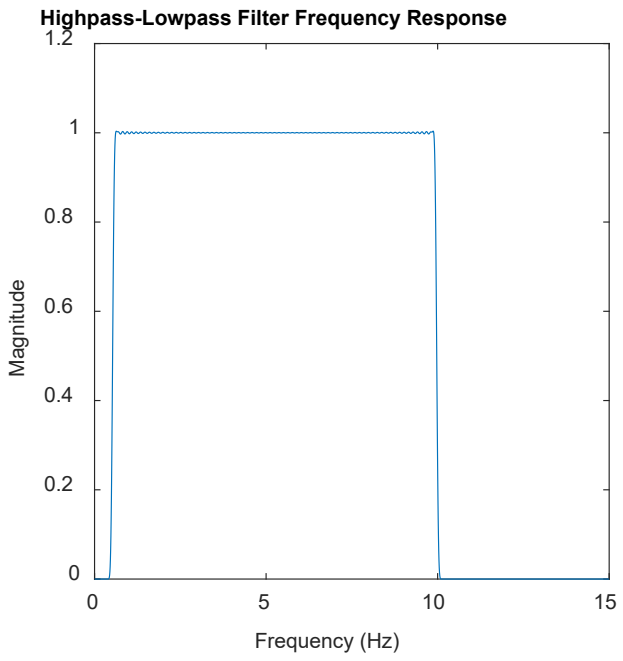
- The compressed signal still has the desired RMS amplitude and flat magnitude response spectrum.

Input Motion Generation Tools

Baseline Correction





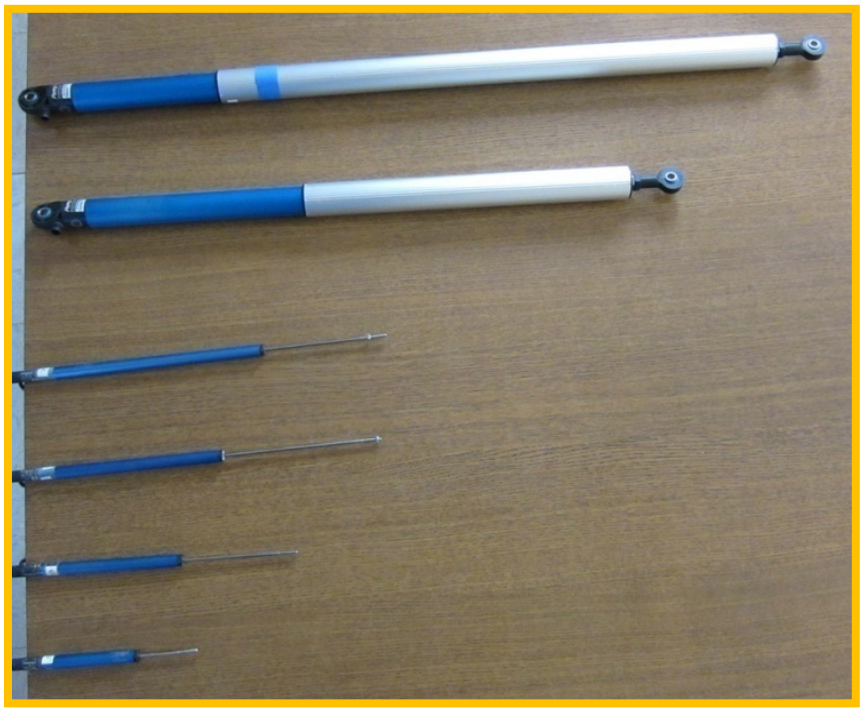


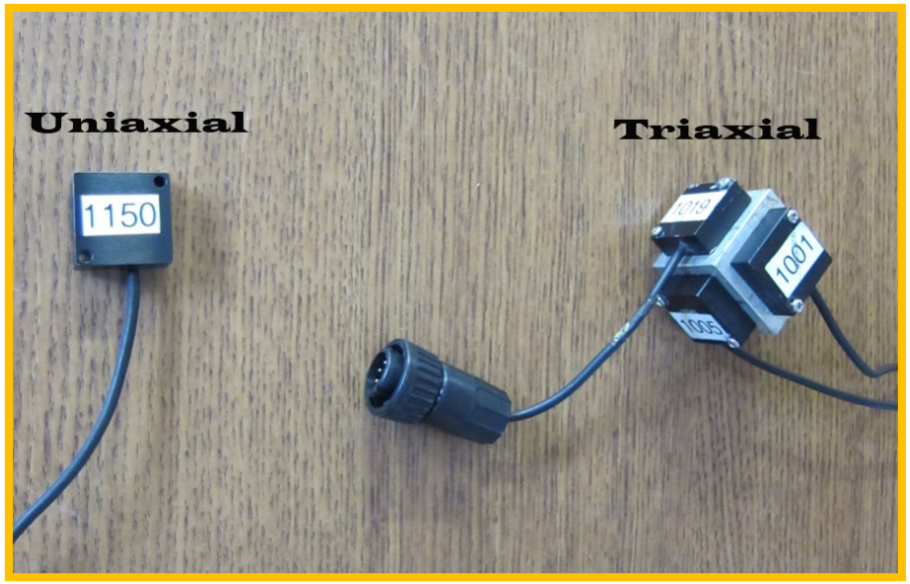
- Modifies acceleration records so that it begins and ends at zero displacement, velocity, and acceleration by series of operations
  - High-pass/low-pass filtering, detrending, padding the beginning and end with zeros

Instrumentation

- **The instrumentation inventory consists of**
  - **200** MEMS type accelerometers
    - ✓ +/- 5g – DC to 200 Hz – Sensitivity 200mV/g
  - **180** linear potentiometers (ranging 2 in to 20 in)
  - **135** string potentiometers (ranging 2 in to 60 in)
  - **10** spring potentiometers (range 1 in)
  - **24** load cells (up to 20,000 lbs)
  - **32** soil pressure transducers
  - Load jacks (various)
  - **1** GPS system with a network of antennae (two mobile and one reference), provides dynamic displacement monitoring in three coordinates, operates at 50 Hz
- All sensors are calibrated (accredited in-house calibration is available)!

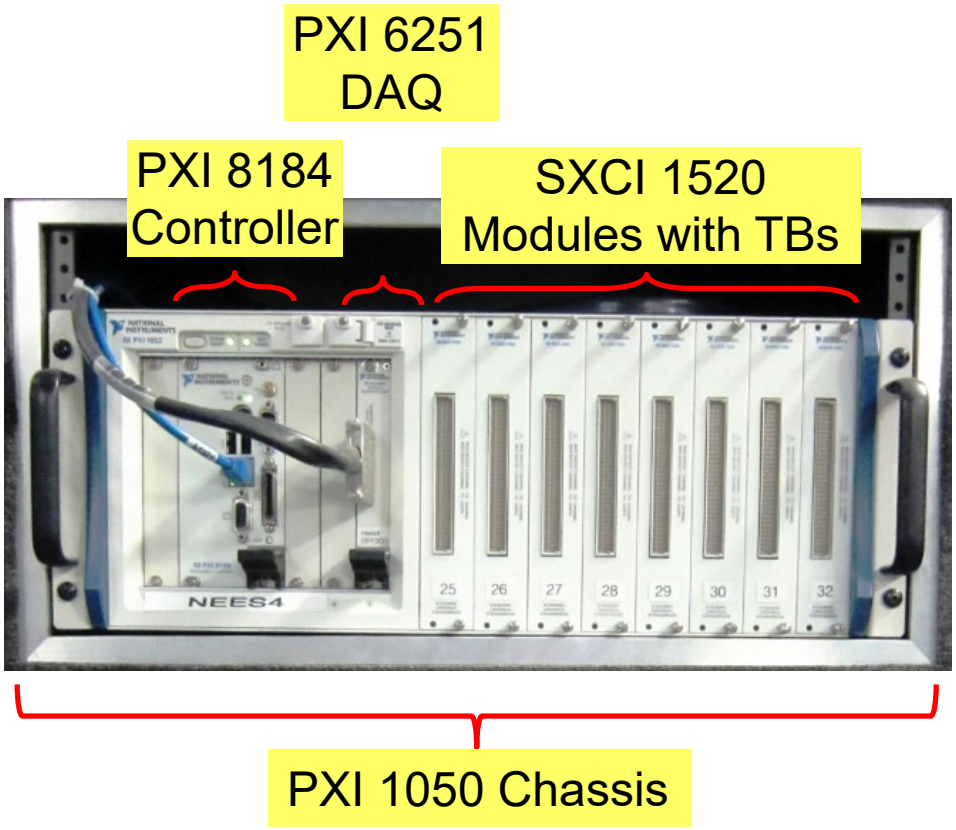
Instrumentation





Data Acquisition System

- **12** Data acquisition nodes (a distributed system) with **64 channels** and **16-bit** resolution each (total of **768 channels**)
- **7** are in active use now (total of **448 channels**)
- Each channel can be configured to accept **any type of sensor** (strain gauges, displacement transducers, accelerometers, pressure cells, load cells, etc.)



Telepresence/Video Recording System

- **Axis P1365 (3 Cameras)**
  - Provide delay-time viewing via web site
  - Provide time-lapse for projects
- **IDVR-Pro H.264 HD CCTV DVR (32 Coax)**
  - Trigger-based recording for synchronization with data
  - 16 channels of digital video recording with immediate playback capabilities (synchronized with data)
- **NUUO Hybrid Video Recorder/IP NVR**
  - Trigger-based recording for synchronization with data
  - 16 channels of digital video recording with immediate playback capabilities (synchronized with data)

Coax Cams
1080p HD

- 32 Coax Cameras

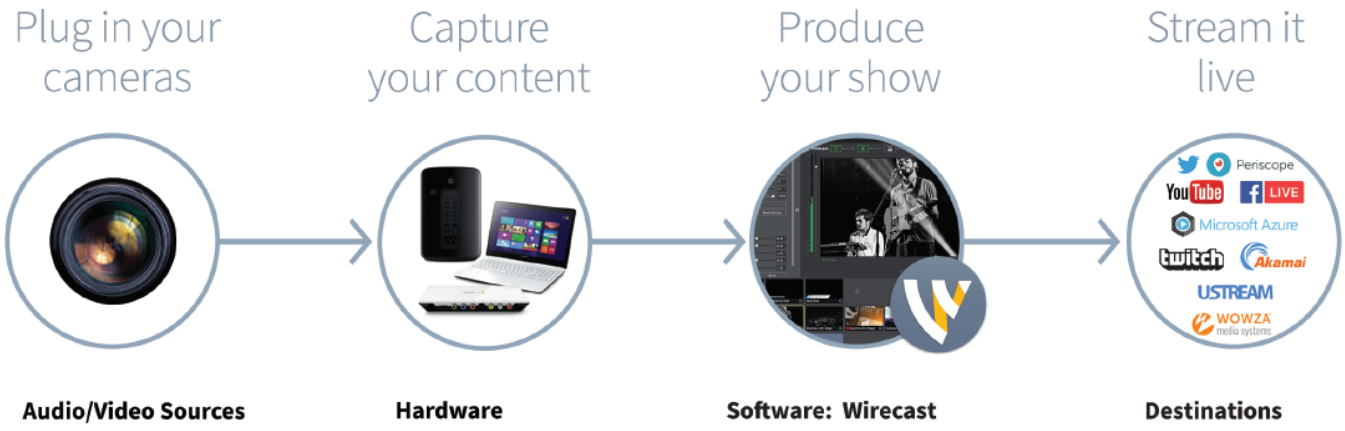
GoPro Cameras

- We have 15 GoPro cameras available (GoPro2, GoPro3+, and Hero4) – True HD
- Recently, they are equipped with external battery packs for longer recording time (approx. 24 hours with single charge, it used to be 1 hour)
- Also, for synchronization purpose they are fitted with a central start/stop feature

Site Drones

Wirecast System for Live Video Streaming

Wirecast Workflow



Wirecast Gear

Live streaming production system

- 4 cameras can be hooked
- Has its own live streaming software
- Live production such as switching between multiple cameras while dynamically mixing with remote live guests, movies, images, audio etc.
- Streaming over popular social media platforms (YouTube, Facebook, Twitter etc.)

Control Center

- Houses host computer for shake table control
- Camera control system
- Data acquisition system
- Data and safety video streaming system
- FlexTest GT System
- Real-time hybrid testing system
  - Host and real-time target computers

Meeting/Conference Room

NHERI@UCSD Site IT Infrastructure

- 1-GB Campus Wide Area Network
  - Internet2 participant
- 802.11g Campus Wireless Network
  - WPA-2 Enterprise security
- Provide guest wireless account for visitors/researchers
- Site dedicated 1GB LAN
- Video/Data backup systems

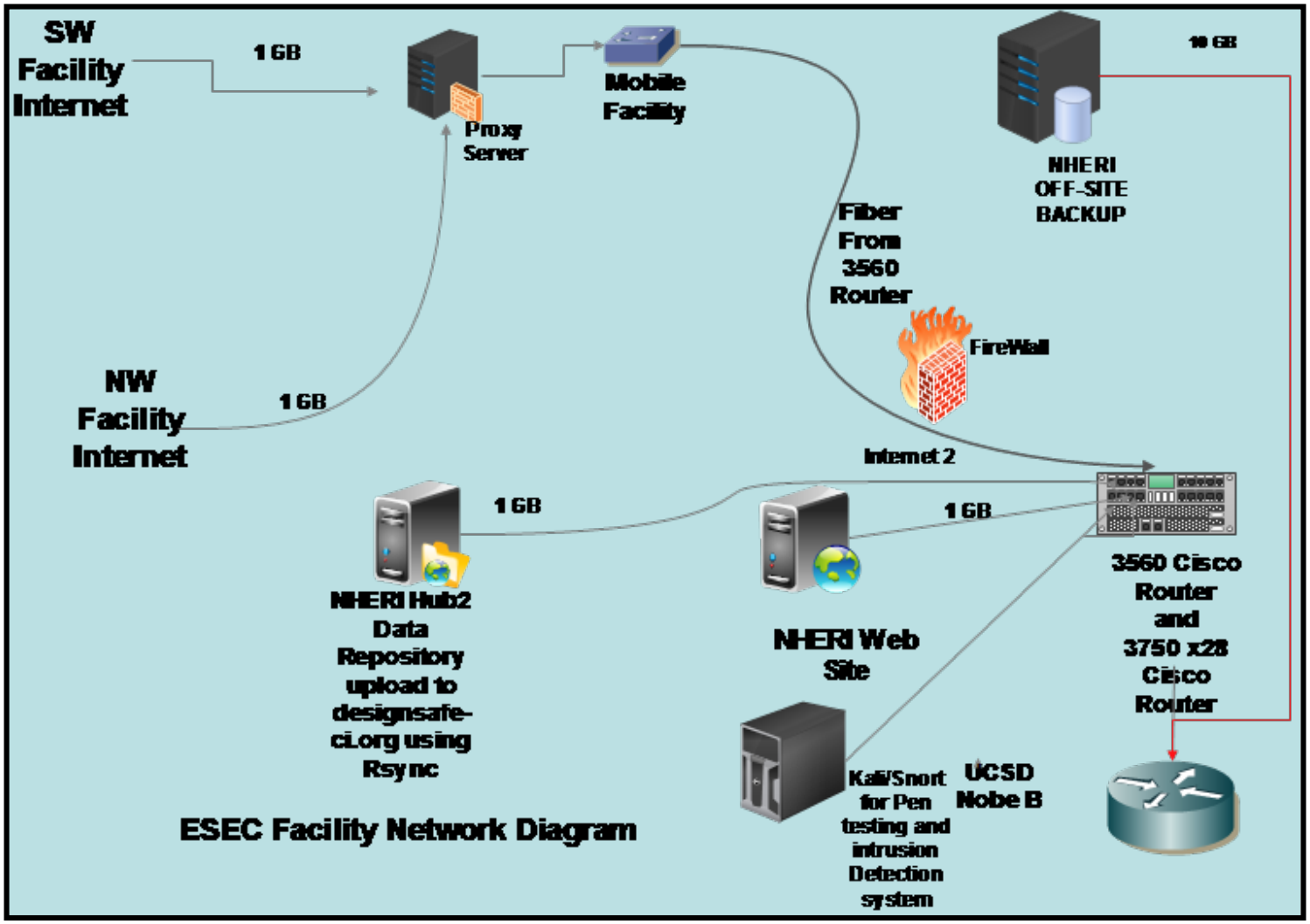
Data/Video Backup System

- On-site data backup system (daily)
  - 16 TB
- Off-site data backup system (daily)
  - 16 TB
- Publish curated data/metadata in DesignSafe Data Depot
  - Web interface of DesignSafe
  - For large files use Globus bulk data transfer

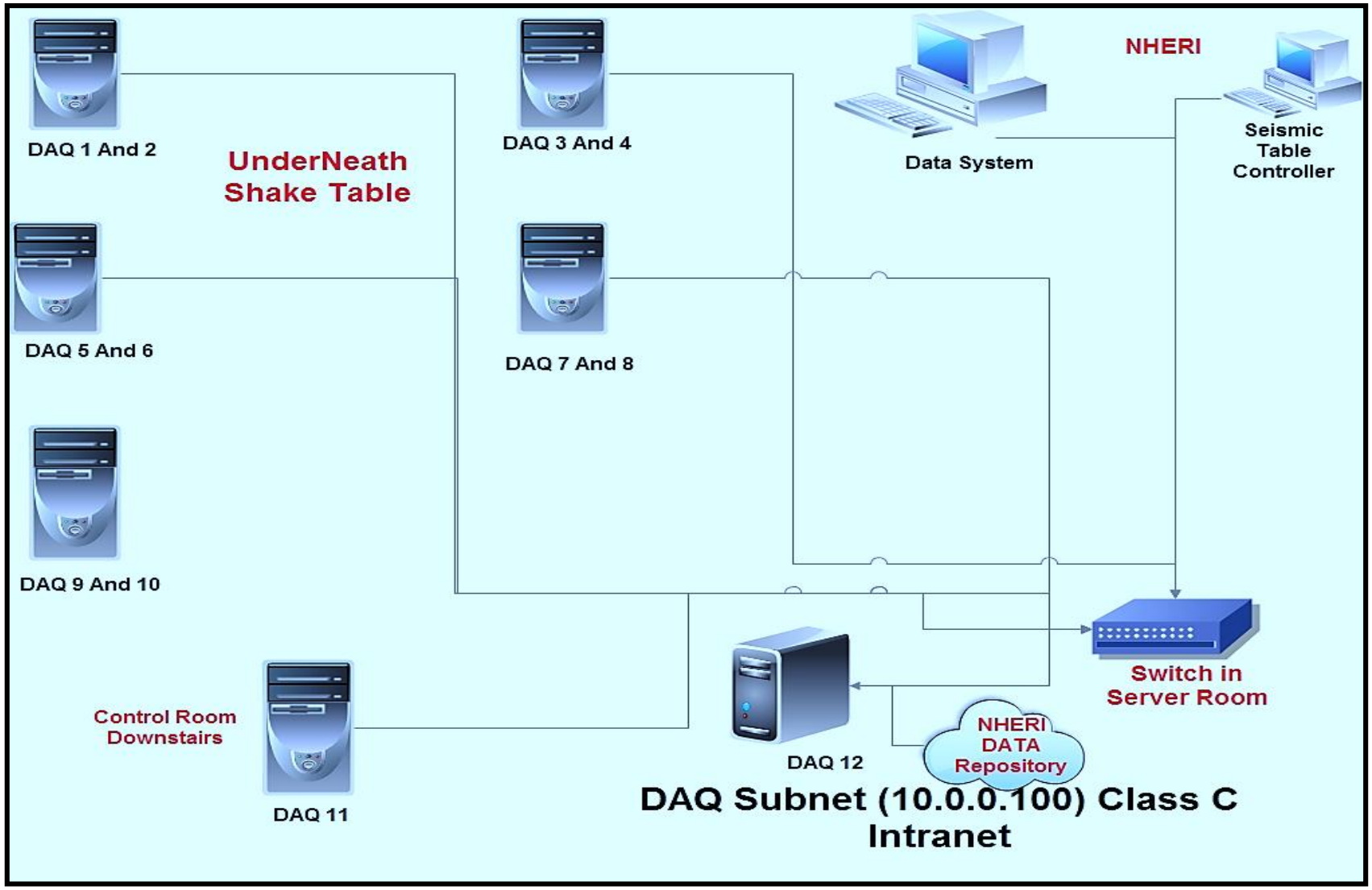
IT Infrastructure

- **The site has two different network systems:**
  - The general site network visible to the outside world
  - The DAQ and Video intranet invisible to outside world

General Site IT Network (visible)



DAQ and VIDEO Intranet (invisible)



NHERI@UCSD Websites

UC SAN DIEGO
EXPERIMENTAL FACILITY

http://ucsd.designsafe-ci.org

DESIGNSAFE-CI
A NATURAL HAZARDS ENGINEERING COMMUNITY

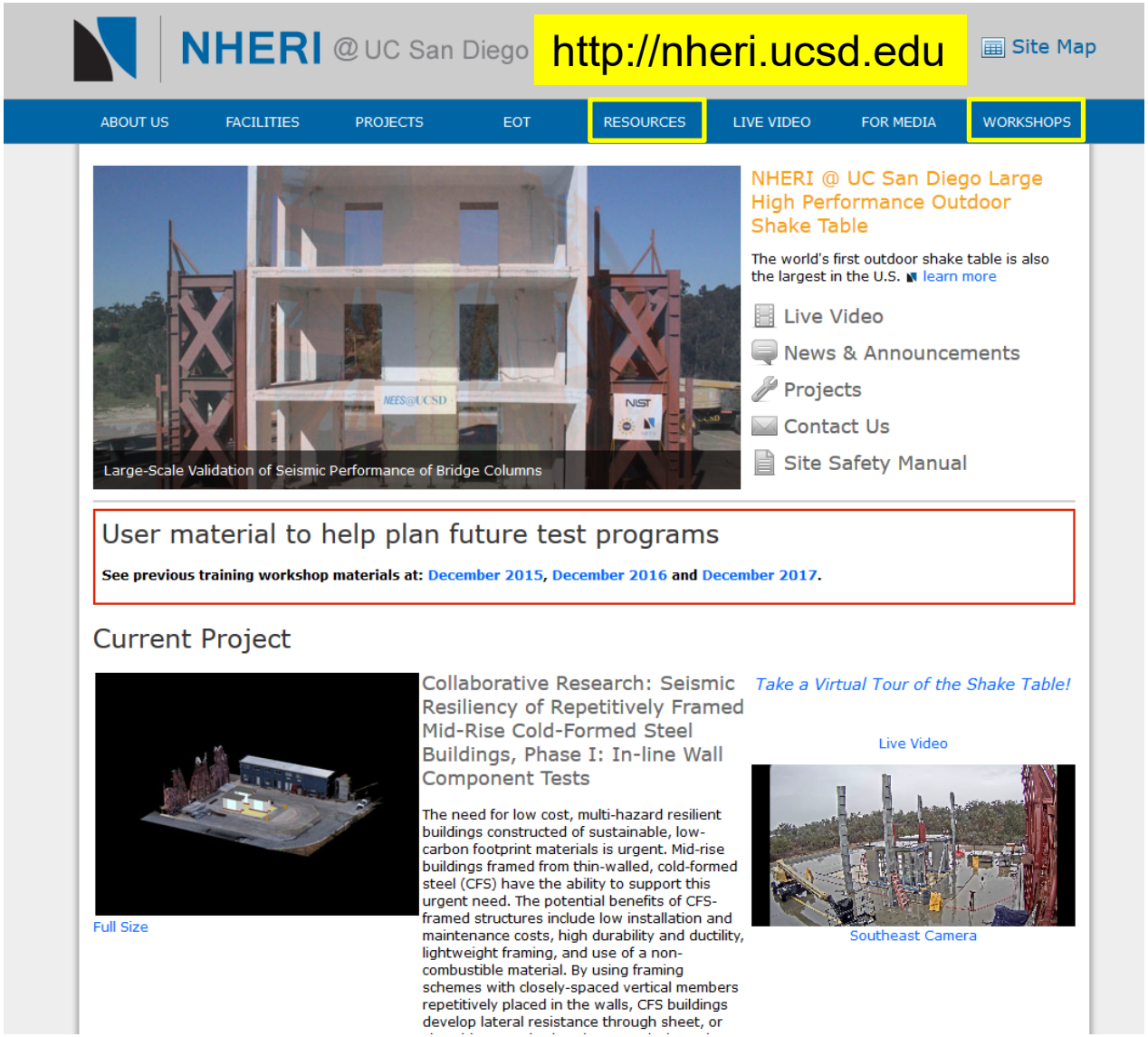
Facility Overview | Equipment Portfolio | Experimental Protocol | Payload Projects | Workshops | Resources | Contact

FACILITY OVERVIEW

The National Science Foundation sponsored Natural Hazards Engineering Research Infrastructure (NHERI) Experimental Facility at the University of California, San Diego will provide a large, high performance, outdoor shake table (LHPOST) to support research in structural and geotechnical earthquake engineering. Earthquakes have had considerable destructive effects on society in terms of human casualties, property and infrastructure damage, and economic losses. Building a multi-hazard, disaster-resilient, and sustainable environment requires the understanding and ability to predict more reliably the system-level response of buildings, critical facilities, lifelines, and other civil infrastructure systems to these extreme events. This facility will enable research, with extensively instrumented large- or full-scale structural, geotechnical, and soil-foundation-structural systems tested under extreme earthquake loads, to produce the experimental data essential to advancing predictive seismic performance tools. Research experiments performed using LHPOST will provide life-size investigation that will transform the practice of earthquake engineering and educate graduate, undergraduate, and K-12 students, as well as the general public, about natural disasters and the national need to develop effective technologies and policies to prevent these natural hazard events from becoming societal disasters.

The LHPOST, with a steel platen that is 12.2 meters long by 7.6 meters wide, has performance characteristics that allow the accurate reproduction of near- and far-field earthquake ground motions. The facility will support seismic testing, under near real-world conditions, of large structural, nonstructural, geotechnical, and geostructural systems, as well as soil-foundation-structural systems, up to a weight of 20 MN. Two large soil boxes can be used in conjunction with the shake table to investigate the seismic response of soil-foundation-structural systems. Software and hardware are available to support hybrid testing with substructures on the shake table. Systems tested at the facility can utilize extensive data acquisition and instrumentation capabilities, including a broad array of state-of-the-art sensors and high-definition video cameras, to support detailed monitoring, through hundreds of data channels, of the system response. The landmark system-level tests performed using this facility will provide fundamental knowledge and data to support the development, calibration, and validation of high-fidelity, physics-based computational models of structural, geotechnical, and soil-foundation-structural systems that will progressively shift the current reliance on physical testing to model-based simulation for the seismic design and performance assessment of civil infrastructure systems. These simulation tools will

NHERI@UCSD Websites



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Social Media Presence (Youtube, Twitter, Facebook)

Questions?

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Dynamic Test Protocol
NHERI@UCSD vs. Nevada Reno Table

UCSD

1. Tune the bare table with TVC (bare table),
2. Train AIC to get an estimate of the inverse model of the plant (bare table)
3. Apply iteration with OLI at 1.0x (bare table),
4. Use the converged drive file from OLI iterations to perform the actual test (loaded table).

Nevada Reno

1. Tune the bare table with TVC (bare table),
2. Put the specimen on the table,
3. No tuning of 469D with the specimen on the table (loaded table),
4. Measure a model with AIC (loaded table),
5. In OLI, run 0.25x (that's a single motion on the specimen),
6. In OLI, run 0.5x (that's a single motion on the specimen),
7. In OLI, run 0.75x (that's a single motion on the specimen),
8. … (up until the verge of collapse)