Joint UCSD-UB-UNR
Shake Table Training Workshop

Instrumentation and Data Acquisition
Dan Radulescu (UCSD)

September 16, 2010
University of California, San Diego

NEES@UC San Diego
NEES@UBuffalo
NEES@UNevada-Reno
Purpose

• To introduce prospective users to Data Acquisition during shake table simulation,

• The basics of what-you-need-to-know to ensure a reliable experimental data:
  – Data recording
  – Storage and retrieval
ENGELEKIRK STRUCTURAL ENGINEERING CENTER

Large High Performance Outdoor Shake Table - LHPOST

http://nees.ucsd.edu/facilities/shake-table.shtml

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ENglekirk Structural Engineering Center

Laminar Soil Box

http://nees.ucsd.edu/facilities/soil-shear-box.shtml

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SOIL PIT

http://nees.ucsd.edu/facilities/site-plan.shtml
Blast Simulator

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Data Acquisition Systems

**Digital Data Acquisition Main Parameters**

- A/D Resolution
- Multiplexed vs. Simultaneous
- Dedicated Channels vs. Universal Channels
- One full-scale range vs. Multiple full-scale ranges
- Maximum sampling rate

**Example**

- 16-bit A/D
  - Full-scale range +/-10V
  - Resolution = 20V / 65,536 = 0.305 mV
- Accelerometer
  - F.S. = 10g
  - Sensitivity 200mV/g
  - System overall resolution = 0.305 / 200 = 0.0015g
  - For +/-2V full-scale A/D overall resolution = 0.0003g
Data Acquisition Systems (cont’d)

• Sensors
  • Accelerometers
    • DC output
    • Natural Frequency
    • Noise level
    • Full-scale
  • Linear Displacement sensors
    • DCDT type
    • String potentiometer type
      • Maximum acceleration (spring related)
  • Pressure Cell
    • Acceleration distortion
Data Acquisiti on Systems (cont’d)

• GPS System
  • Maximum sampling rate (50 Hz)
  • Typical precision (~3 – 5mm)
  • Location (reflected antenna signals)
  • Natural Frequency
  • Noise level
  • Full-scale

• Video System
  • Multiple synchronized cameras
  • Synchronized with data
  • Minimum DVD quality
  • Instant playback
Data Acquisition System (cont’d)

• Digital Data Acquisition Node
Data Acquisition System (cont’d)

• Central Monitoring and Recording Station
Data Acquisition Systems (cont’d)

• Sensors
  • Accelerometers
  • Model 4000A
  • F.S. 10g
  • Nat. Freq = 400Hz

http://nees.ucsd.edu/facilities/docs/4000a.pdf
Data Acquisition Systems (cont’d)

• Sensors
  • Linear Displacement sensors

http://nees.ucsd.edu/facilities/docs/mls130.pdf
Data Acquisition Systems (cont’d)

- GPS System

http://nees.ucsd.edu/facilities/docs/rtdfamily20050304.pdf
Data Acquisition Systems (cont’d)

• Video System
Data Storage

After Test
- Local data storage on each node
- Immediate mirror of Data on Central Monitoring Station
- Immediate copy for researcher evaluation

End of Testing Day
- Organize Raw Data by Node
- Backup Data on-site
- Backup Data off-site
- Provide researcher with a complete set of raw data

End of Project
- Provide researcher a full set of raw data
- Provide researcher a full set of video data
- Provide researcher a full set of pictures
Data Format

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<table>
<thead>
<tr>
<th>CHANNEL</th>
<th>NAME</th>
<th>TYPE</th>
<th>INPUT</th>
<th>MAXVAL</th>
<th>MINVAL</th>
<th>LOPASS</th>
<th>CUTOFF</th>
<th>BRAVO</th>
<th>VECT</th>
<th>GFACTOR</th>
<th>FFACTOR</th>
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<th>UNIT</th>
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<td>100</td>
<td>HALF</td>
<td>F</td>
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Data Format (cont’d)
Data Format (cont’d)

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NEES@UB

KRYPTON SYSTEM

Thomas Albrechcinski (UB)
Krypton hardware

controller

camera

LED strober

Space probe

LED

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Resolution: 0.002 mm at 2.5 mm
Noise (1s): 0.010 mm
Accuracy:
- Single Point: 0.060 mm
- Volumetric: 0.090 mm + 0.010 mm/m

The indicated measurement uncertainty is expressed for a confidence level of 95%, according to the ISO 10360 II, VDI 2617 and ANSI / ASME B89.1.12M standards for acceptance of CMMs.

Acquisition frequency:
*Important notice: The K400 camera system can *not* be used for dynamic measurements.*
The measurement frequency for static measurements is set to 10Hz.

**K600 CAMERA UNIT**
Field-of-view: 17 m³, distributed into three accuracy zones as follows:

```
Field of View
I Zone
II Zone
III Zone

Resolution: 0.002 mm at 2.5 mm
Noise (1s): 0.010 mm
Accuracy:
- Zone Volumetric Accuracy (± 2s)
  - I 90mm + 10mm/m  60mm + 7mm/m
  - II 90mm + 25mm/m  60mm + 17mm/m
  - III 190mm + 25mm/m 130mm + 17mm/m

The indicated measurement uncertainty is expressed for a confidence level of 95%, according to the ISO 10360 II, VDI 2617 and ANSI / ASME B89.1.12M standards for acceptance of CMMs.

Acquisition frequency: depends on the number of LED’s:
- 1 LED: 1 kHz
- 1 frame (3 LEDs): 800 Hz
- 2 frames (6 LEDs): 400 Hz
```
Single Shake Table Testing-NEESR

- 50 Metric 6-DOF, 7mx7m extension platform
- Ton Capacity
- 0-100Hz

Zipper Frames: Dynamic Seismic Response of Steel Braced Frames with Innovative Bracing Configurations

KRYPTON 3D Displacement Measurement System
Thank you
Sensor Calibration

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**IN-HOUSE vs. OUTSOURCED CALIBRATION**

- DAQ Channels ➔ 576
- Accelerometers ➔ 150
- String potentiometers ➔ 100
- Linear potentiometers ➔ 300
- DAQ Cost outsource ➔ 576*100 = $57,600
- Sensors Cost out-source ➔ 550*100 = $55,000
- Reference standard calibration ➔ $1,500
- Labor in-house calibration 1mo ➔ ~$7,000
Sensor Calibration

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Sensor Calibration (cont’d)

In-house Calibration DAQ
Sensor Calibration (cont’d)

In-house Calibration Accelerometer

![Image of calibration software interface and figures 7 and 8]

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Sensor Calibration (cont’d)

In-house Calibration String Potentiometer
Sensor Calibration (cont’d)

In-house Calibration Certificate DAQ

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Sensor Calibration (cont’d)

Date: Thursday, January 11, 2007 9:44:51 AM

Customer Information:
Name: UC San Diego Structural Engineering Dept.
Address: 9500 Gilman Drive
La Jolla Ca. 92093

Sensor Information:
Sensor Type: Displacement
Model No: PT8101-0030-211-1110
Sensor Full Scale Value: 30 in.
Tracking No: 175
Excitation Voltage: +10Vdc

Calibration Information:
Operator Name: Steve Morris
Notes: Temperature: 74.8 °F
Humidity: 45%

In-house Calibration Certificate

Model No: PT8101-0030-211-1110

Sensor Full Scale Value: 30 in.
Tracking No: 175
Excitation Voltage: +10Vdc

Calibration Information:
Operator Name: Steve Morris
Notes: Temperature: 74.8 °F
Humidity: 45%

Equipment used for calibration:
- Trimos V1002+ height stand
  sn: 10312 / A
  calibration date: 07.04.2006
due date: 07.04.2007
- NI PXI 6251 DAQ
  sn: DFF3F0
  tracking no: DFF3F0
  calibration date: 28sep2006
due date: 28sep2007
- NI SCXI 1520
  sn: CFD976
  tracking no: 73
  calibration date: 19oct2006
due date: 19oct2007

Standards:
- Procedure no: SD400030
  Version: 0
  Date: 1/11/07

Measured Data

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<thead>
<tr>
<th>Displacement [inch]</th>
<th>Voltage [volt]</th>
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<tbody>
<tr>
<td>0.000</td>
<td>0.000</td>
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<tr>
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<td>-24.980</td>
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Analysis Results

<table>
<thead>
<tr>
<th>Sensitivity [V/in/Vexc]</th>
<th>MSE</th>
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<tr>
<td>0.031</td>
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Thank you