Instrumentation and Data Acquisition

Rapid visualization and analysis of data

Dan Radulescu, Robert Beckley, Rodrigo Astroza

University of California, San Diego
December 14, 2015

Instrumentation and Data Acquisition

Objectives

- ***Provide quality management system***
- ***Provide National and International recognized testing data and reports***
- ***Maintain a calibrated sensor and equipment inventory***
- ***Provide quality data to industry***

Instrumentation and Data Acquisition

Documentation

- ***Documentation Master Log File***
- ***General Documentation***
- ***Standard Operation Procedures***
- ***In-house Calibration Procedures***
- ***Sensor Inventory***
- ***Equipment Inventory***
- ***Calibration Records***

Instrumentation and Data Acquisition

In-house Calibration

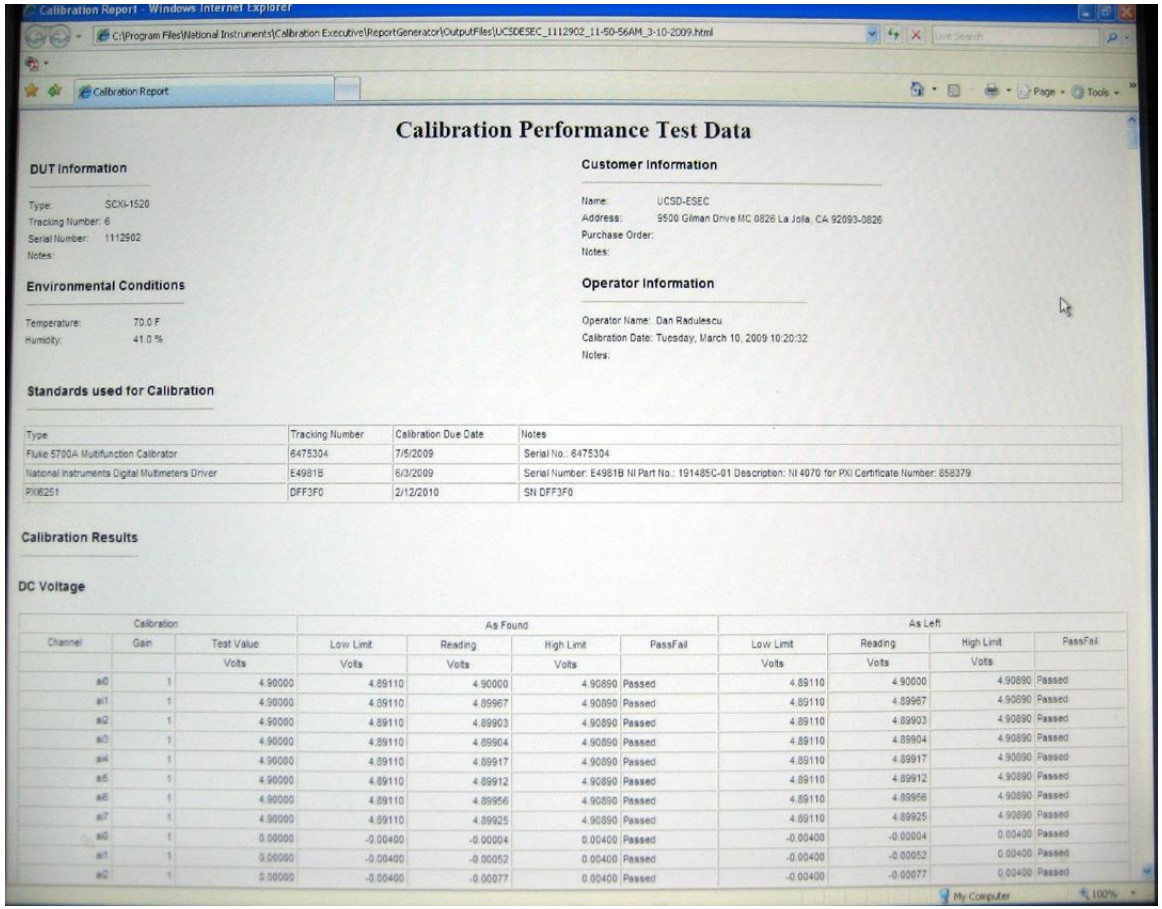
- *DAQ Channels ➔ 768*
- *Accelerometers ➔150*
- *String potentiometers ➔100*
- *Linear potentiometers ➔300*
- *DAQ Cost outsource ➔768*100=$76,800*
- *Sensors Cost out-source ➔ 550*100=$55,000*
- *Reference standard calibration ➔$1,500*
- *Labor in-house calibration 1mo ➔~$7,000*

Instrumentation and Data Acquisition

In-house Calibration DAQ

Instrumentation and Data Acquisition

In-house Calibration Certificate DAQ



Calibration Report - Windows Internet Explorer

C:\Program Files\National Instruments\Calibration Executive\ReportGenerator\OutputFiles\UCSDESEC_1112902_11-50-56AM_3-10-2009.html

Calibration Report

Calibration Performance Test Data

DUT Information

Type: SCXI-1520
Tracking Number: 6
Serial Number: 1112902
Notes:

Customer Information

Name: UCSD-ESEC
Address: 9500 Gilman Drive MC 0826 La Jolla, CA 92093-0826
Purchase Order:
Notes:

Environmental Conditions

Temperature: 70.0 F
Humidity: 41.0 %

Operator Information

Operator Name: Dan Radulescu
Calibration Date: Tuesday, March 10, 2009 10:20:32
Notes:

Standards used for Calibration

Type	Tracking Number	Calibration Due Date	Notes
Fluke 5700A Multifunction Calibrator	6475304	7/5/2009	Serial No.: 6475304
National Instruments Digital Multimeters Driver	E4981B	6/3/2009	Serial Number: E4981B NI Part No.: 191485C-01 Description: NI 4070 for PXI Certificate Number: 858379
PXI6251	DFF3F0	2/12/2010	SN DFF3F0

Calibration Results

DC Voltage

	Calibration		As Found				As Left			
Channel	Gain	Test Value	Low Limit	Reading	High Limit	PassFail	Low Limit	Reading	High Limit	PassFail
		Volts	Volts	Volts	Volts		Volts	Volts	Volts	
ai0	1	4.90000	4.89110	4.90000	4.90890	Passed	4.89110	4.90000	4.90890	Passed
ai1	1	4.90000	4.89110	4.89967	4.90890	Passed	4.89110	4.89967	4.90890	Passed
ai2	1	4.90000	4.89110	4.89903	4.90890	Passed	4.89110	4.89903	4.90890	Passed
ai3	1	4.90000	4.89110	4.89904	4.90890	Passed	4.89110	4.89904	4.90890	Passed
ai4	1	4.90000	4.89110	4.89917	4.90890	Passed	4.89110	4.89917	4.90890	Passed
ai5	1	4.90000	4.89110	4.89912	4.90890	Passed	4.89110	4.89912	4.90890	Passed
ai6	1	4.90000	4.89110	4.89956	4.90890	Passed	4.89110	4.89956	4.90890	Passed
ai7	1	4.90000	4.89110	4.89925	4.90890	Passed	4.89110	4.89925	4.90890	Passed
ai0	1	0.00000	-0.00400	-0.00004	0.00400	Passed	-0.00400	-0.00004	0.00400	Passed
ai1	1	0.00000	-0.00400	-0.00052	0.00400	Passed	-0.00400	-0.00052	0.00400	Passed
ai2	1	0.00000	-0.00400	-0.00077	0.00400	Passed	-0.00400	-0.00077	0.00400	Passed

Instrumentation and Data Acquisition

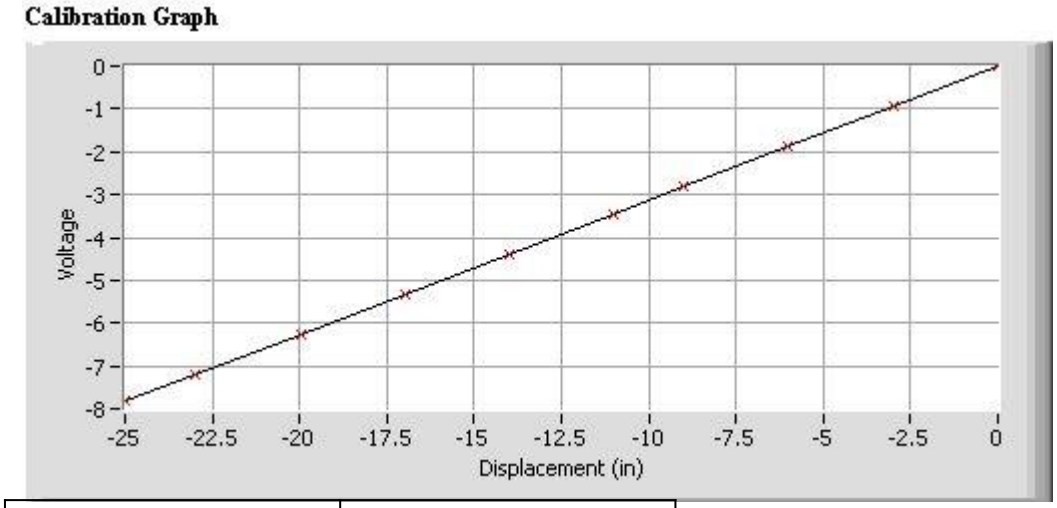
In-house Calibration Certificate

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%
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



Displacement [inch]	Voltage [volt]
0.000	0.000
-2.995	-0.939
-5.993	-1.879
-8.989	-2.817
-10.986	-3.446
-13.984	-4.384
-16.983	-5.318
-19.981	-6.260
-22.980	-7.195
-24.980	-7.820

Sensitivity [V/in/Vexc]	MSE
0.031	5.211E-6

IT Infrastructure

- **1-Gb Campus Wide Area Network**
  - Internet2 participant
- **802.11g Campus Wireless Network**
  - WPA-2 Enterprise security
- **Provide Researchers with meeting room and project room for Project.**
- **Site Provided Guest Wireless Account for Visitors/Researchers**
- **Site dedicated 1Gb Lan**

IT Infrastructure

- **IQeye701/711/755**
  - ✓ Provides real-time viewing via web site
  - ✓ Provide Time-Lapse for Projects
- **Axis 240Q/241Q Video Servers**
  - ✓ Analog-to-digital conversion of 4 cameras per server
  - ✓ Provides real-time viewing via web site
- **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)

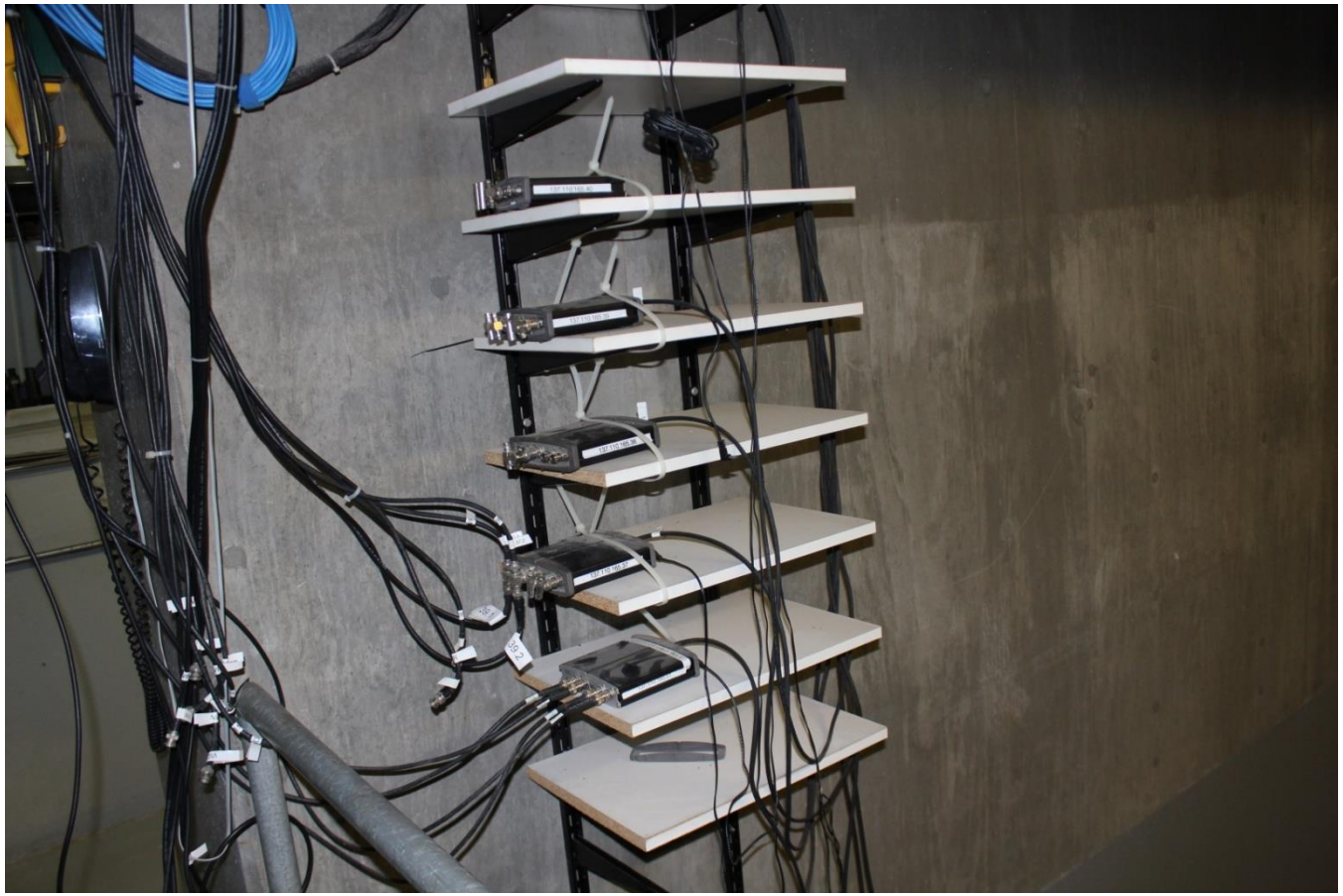
IT Infrastructure

- **NUUO Hybrid Video Recorder/IP NVR**
  - ✓ 4 HD-SDI channels of digital video recording with immediate playback capabilities (synchronized with data)
  - ✓ 20 IP Cameras System recording with immediate playback capabilities

    (synchronized with data)

IT Infrastructure

AXIS VIDEO SERVERS



IT Infrastructure

COAX CAMERAS

IT Infrastructure

GO PRO CAMERAS

IT Infrastructure

VIDEO PROCEDURE

- ***Video***
- **After Test**
  - Backup of cameras that has Data Cards and NVR data
  - Making any adjustment to the cameras
  - Making sure that all cameras has new card and battery

- **End of Testing Day**
  - Organize Raw video for Backup
  - Backup Data on-site(daily)
  - Backup Data off-site(daily)
  - Provide researcher with a complete set of raw video data

- **End of Project**
  - Provide researcher a full set of raw video data
  - Provide researcher a full set of pictures
  - Provide Researcher with help with software to process the video

IT Infrastructure

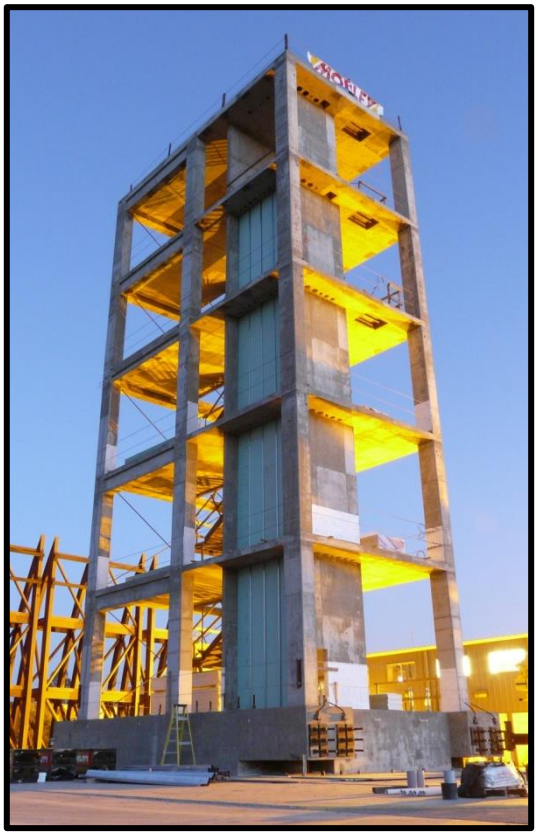
SAFETY / SECURITY VIDEO SERVER

IT Infrastructure

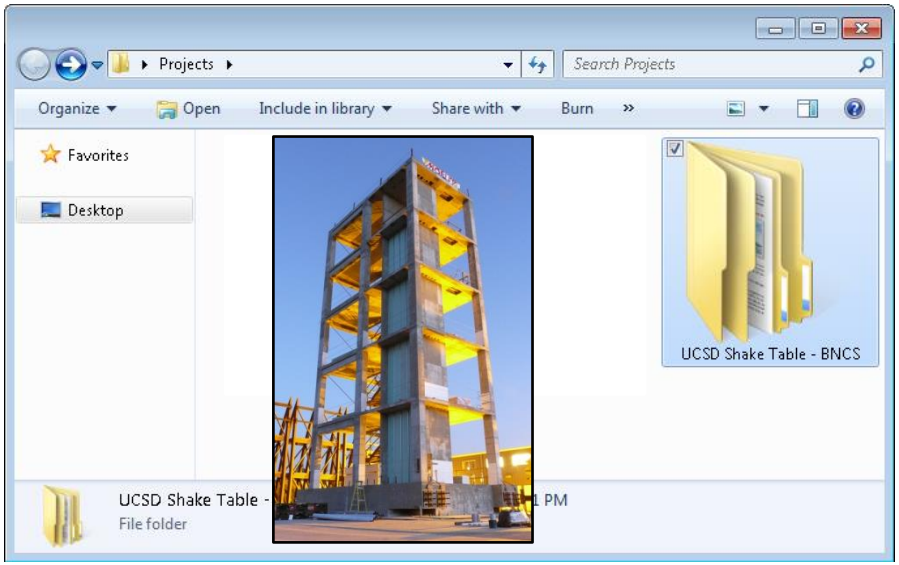
THANK YOU

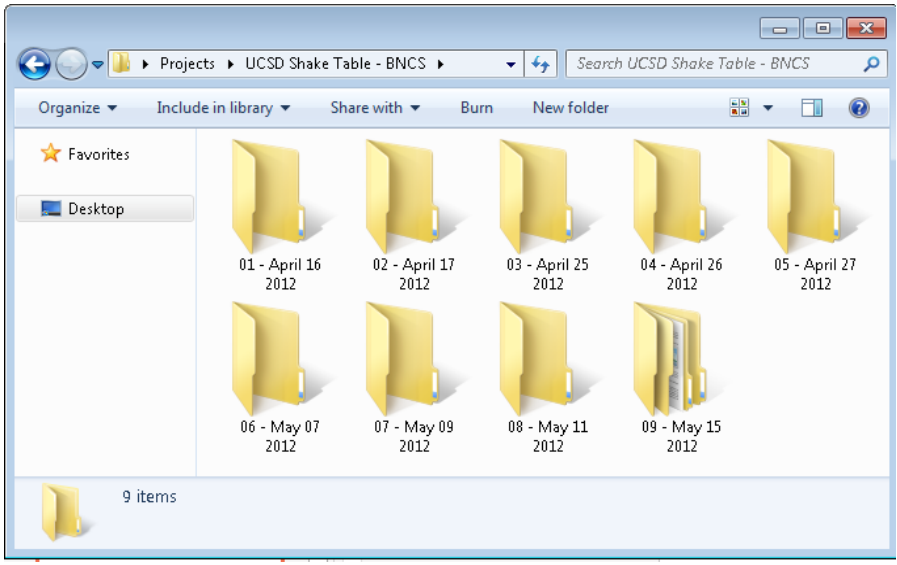
Rapid data visualization

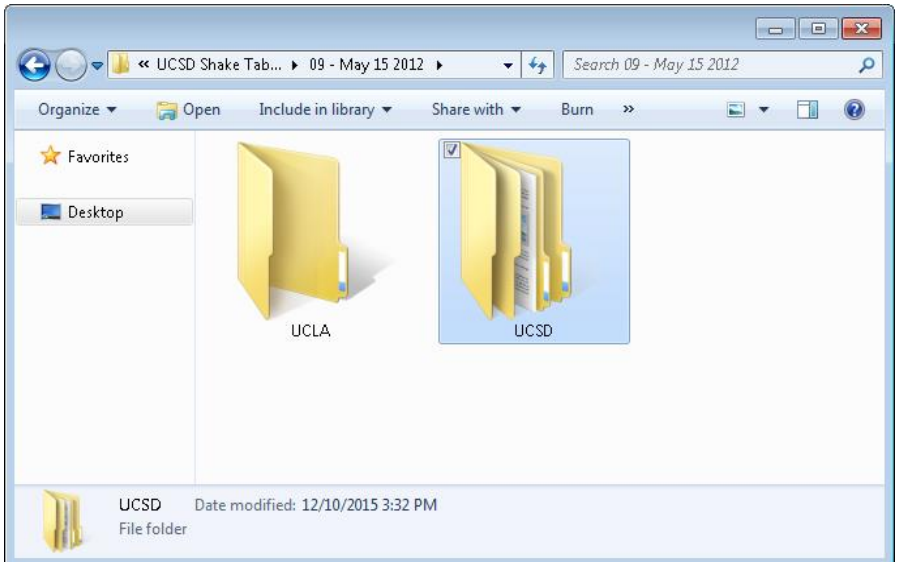
Example 1: BNCS project (2012)

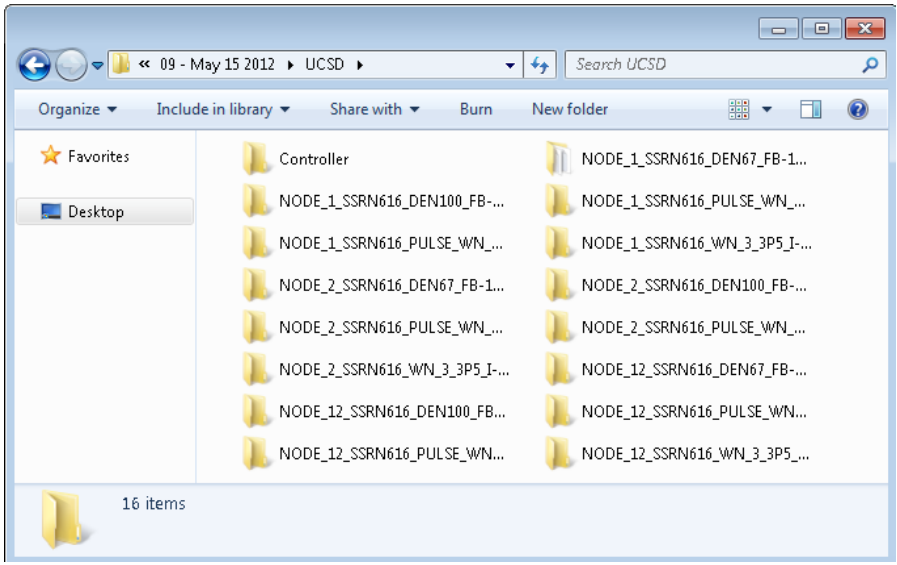


Rapid data visualization

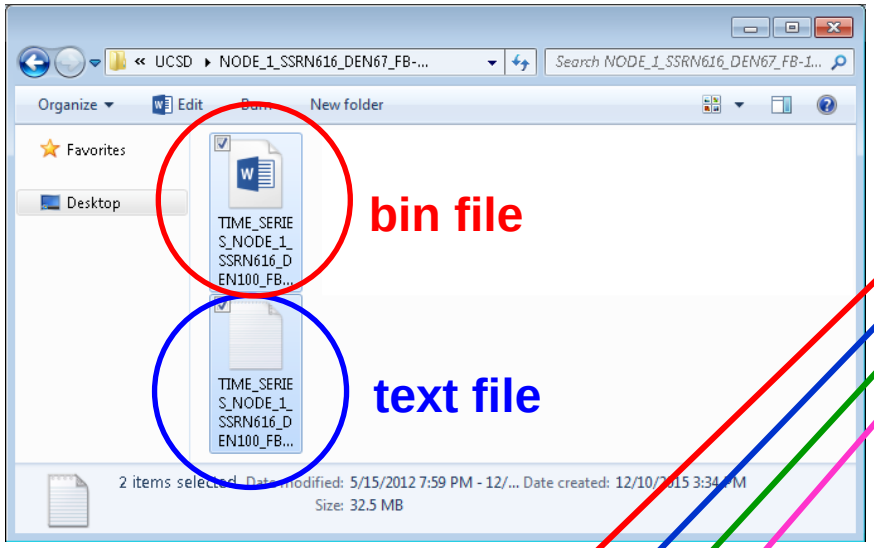








Rapid data visualization



bin file

text file

Δt

Channel #

Sensor name

units

Time histories

C:\Users\Owner\Desktop\Projects\UCSD Shake Table - BNCS\09 - May 15 2012\UCSD\NODE_1_SSRN...

File Edit Search View Encoding Language Settings Macro Run Plugins Window ?

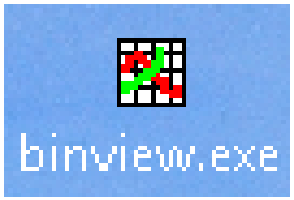
TIME_SERIES_NODE_1_SSRN616_DEN100_FB_18540415052012.txt

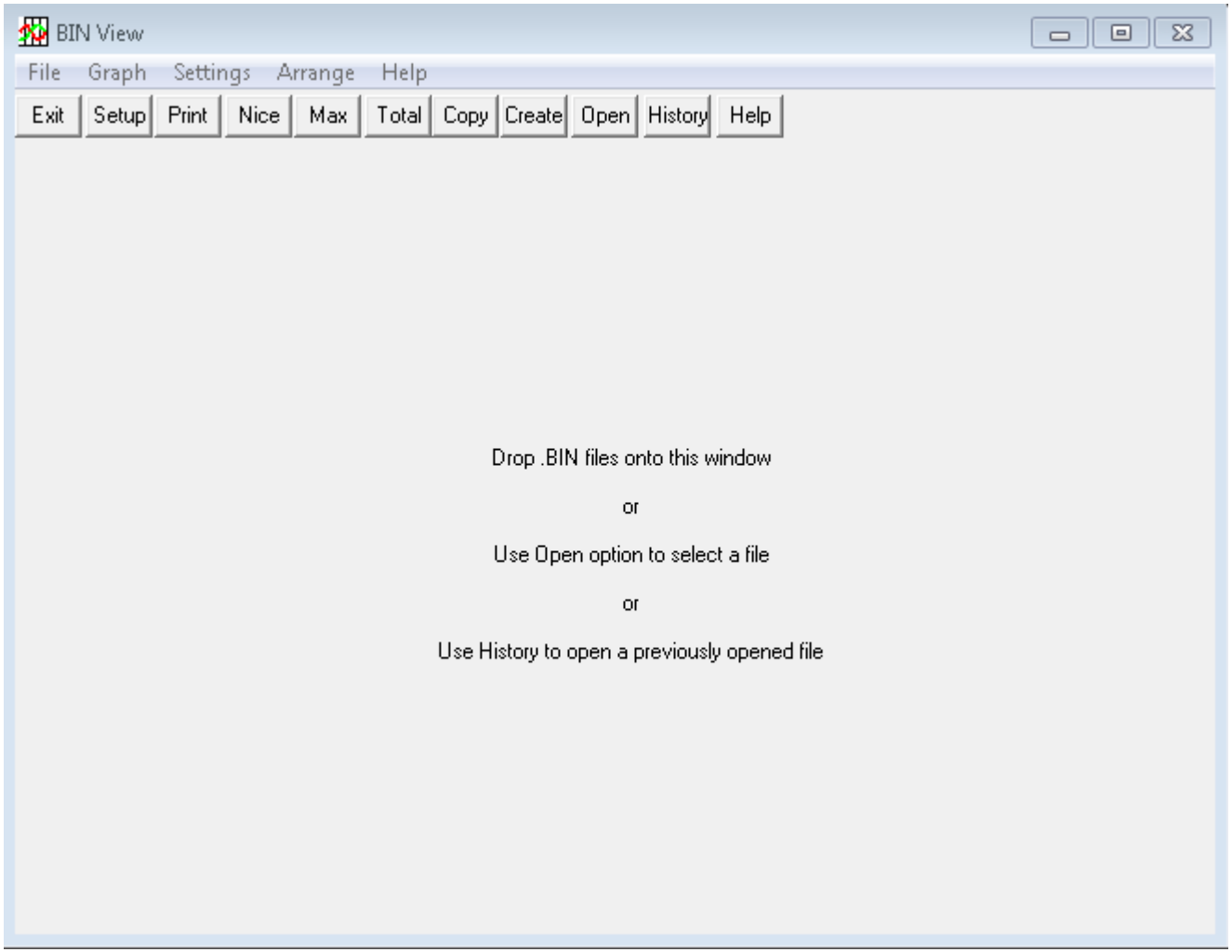
1	DELTA T			4.16666667E-3
2	ch1	ch2	ch3	ch4
3	AC323N	AC147E	AC112N	AC124U
4	g	g	g	g
5	0.291871	0.000610	-4.100921	0.015297
6	0.293031	0.000223	-4.100585	0.016112
7	0.292645	0.000997	-4.100585	0.017334
8	0.293418	0.000223	-4.101257	0.016112
9	0.292258	0.000997	-4.100585	0.015297
10	0.292258	0.002544	-4.101593	0.016926
11	0.293031	0.003704	-4.100921	0.016519
12	0.293031	0.002157	-4.100921	0.014889
13	0.291871	0.001770	-4.100921	0.015704
14	0.293031	0.000610	-4.101593	0.015704
15	0.293418	-0.000937	-4.101257	0.016112
16	0.293418	-0.002484	-4.101257	0.016112
17	0.293031	-0.001710	-4.100585	0.015704
18	0.292645	-0.000163	-4.101257	0.014482
19	0.292645	0.000223	-4.101257	0.015297
20	0.293418	0.003704	-4.100921	0.016926
21	0.292645	0.002157	-4.100921	0.016519
22	0.293031	0.002931	-4.100921	0.018149

length : 24090859 line: Ln : 1 Col : 1 Sel : 0 | 0 Dos\Windows UTF-8 w/o BOM INS

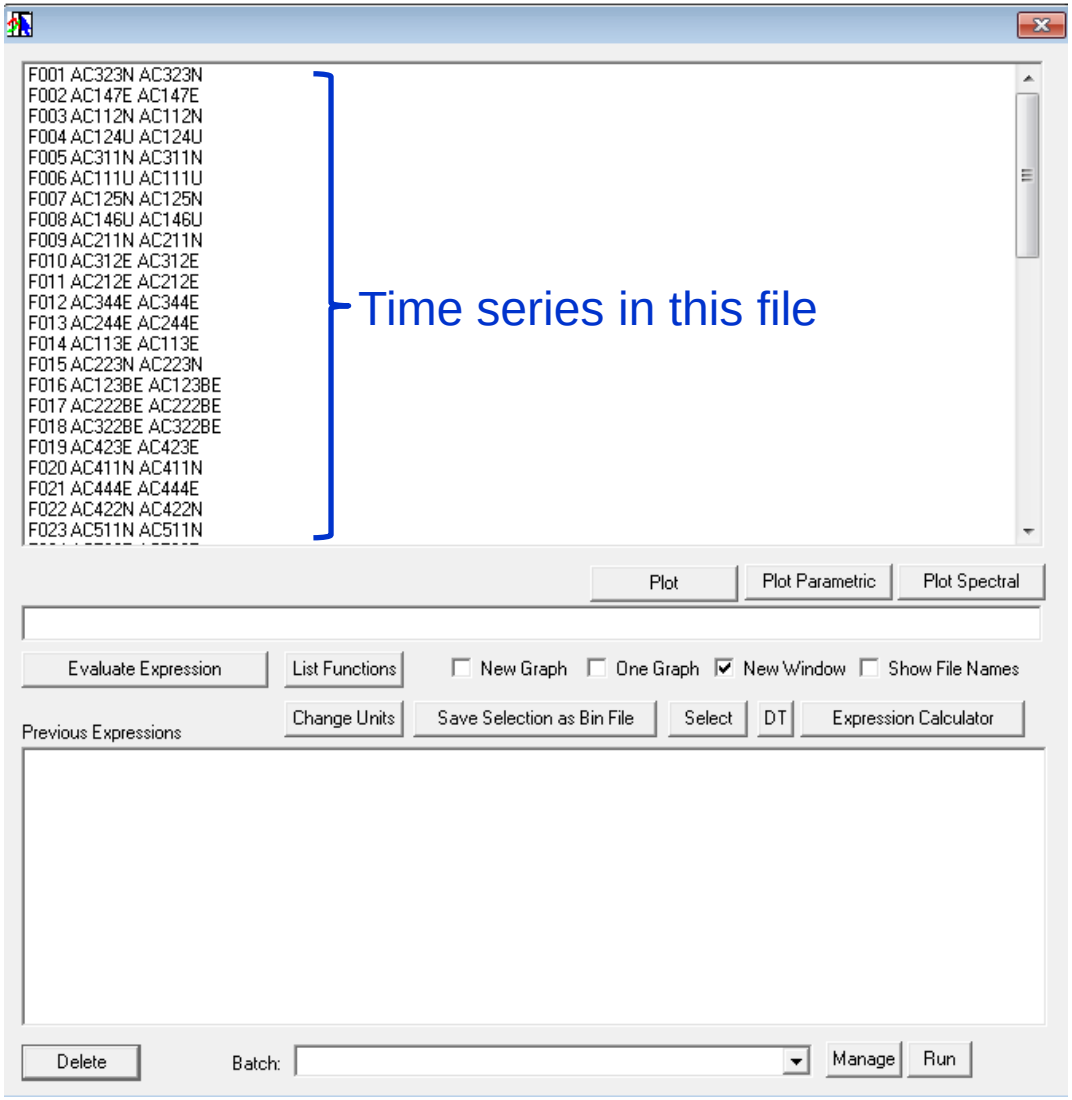
Rapid data visualization – Bin View

Bin view: Drag and drop binary files



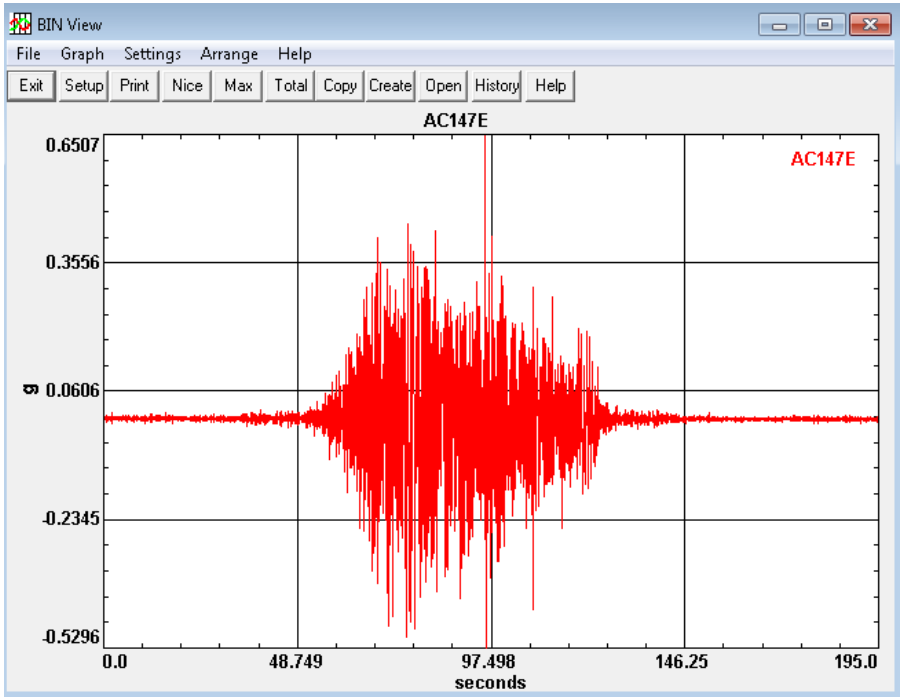


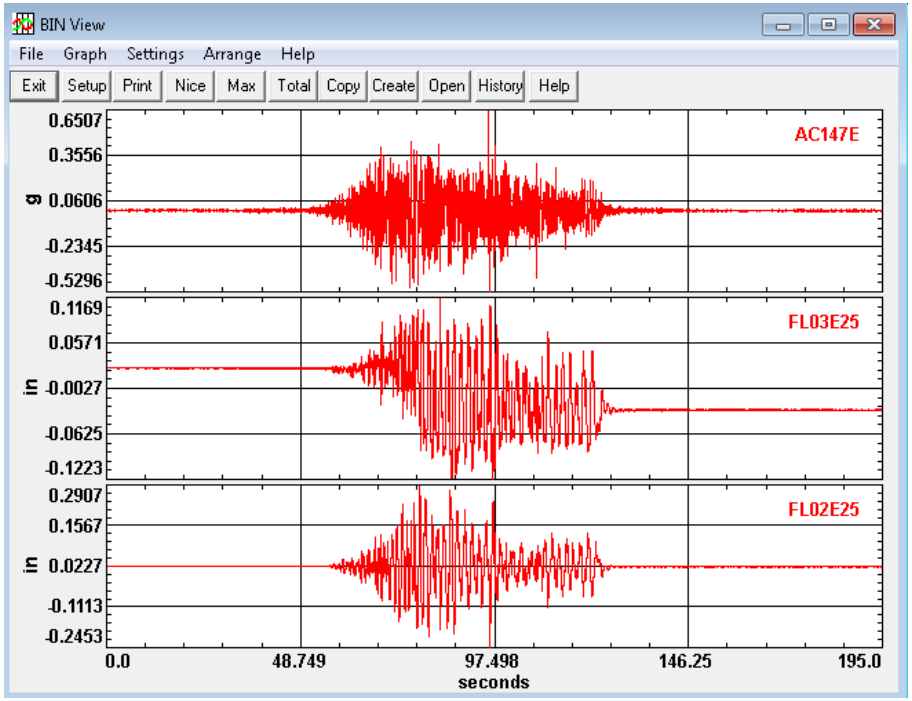
Rapid data visualization



Rapid data visualization

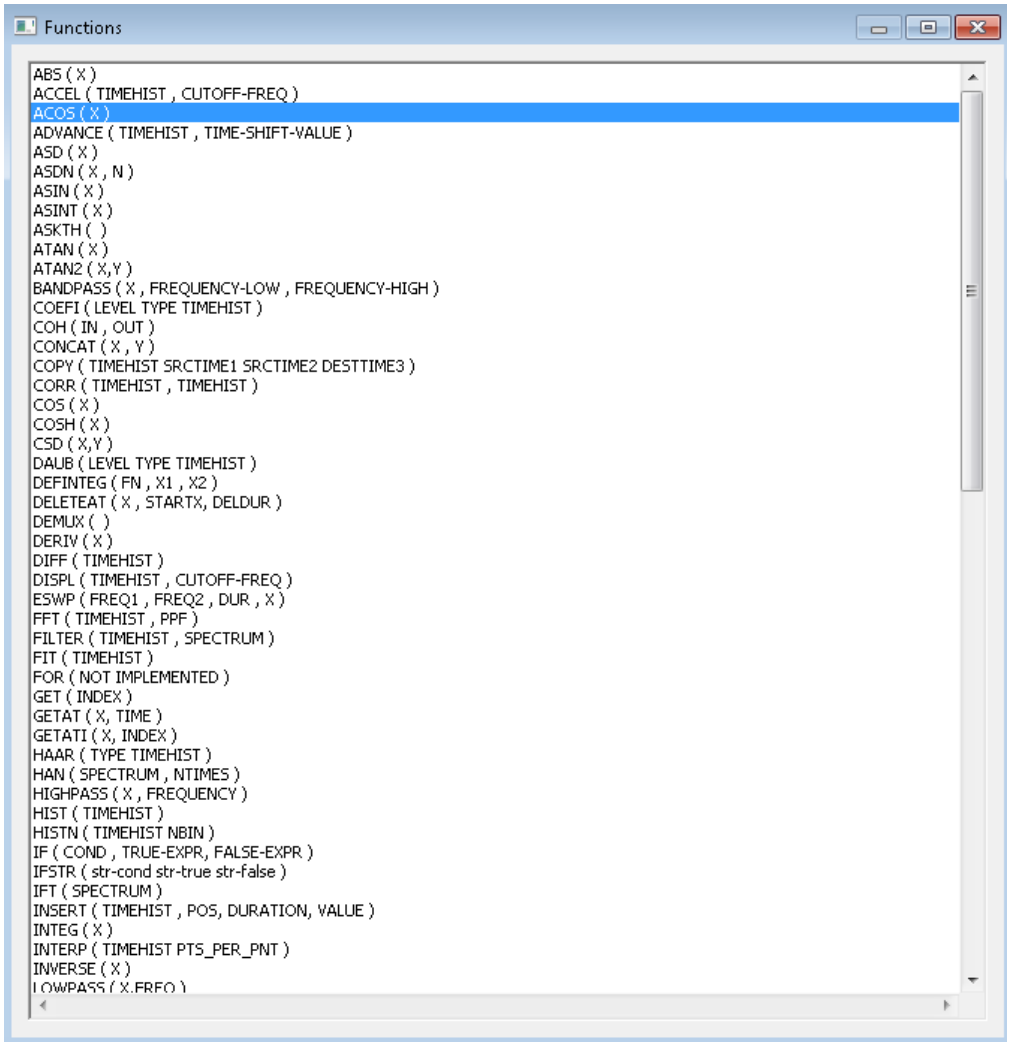
Select 1 or multiple channels and press plot:

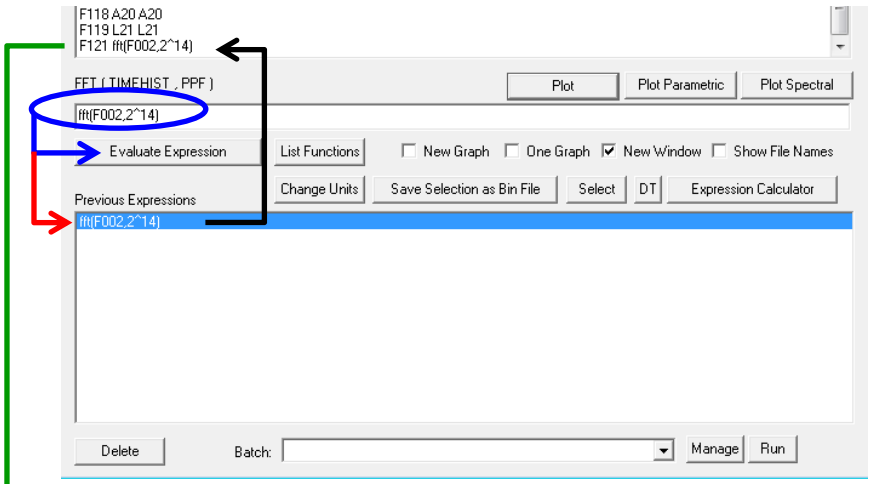


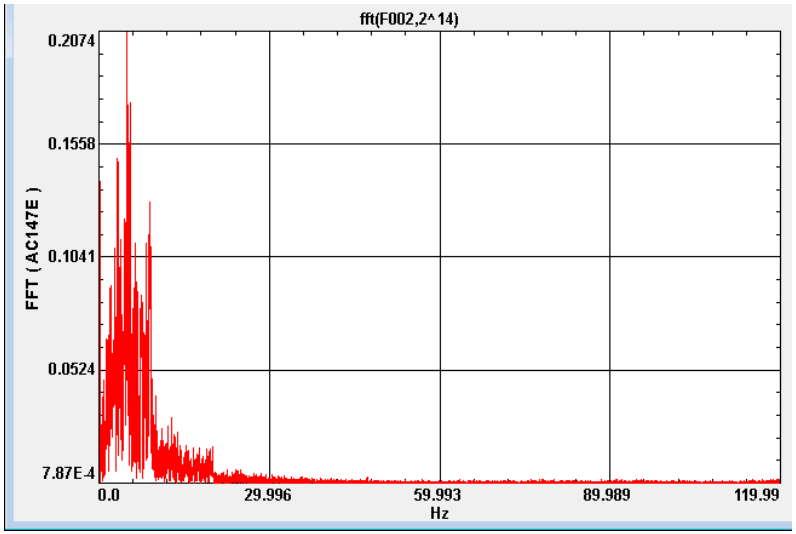


Rapid data visualization

Many built-in DSP tools: fft, filter, lowpass, baseline, resample, etc.







Rapid data visualization

Example 2: Bridge Pier (2010)

Rapid data visualization

Matlab: the structure of output files is always consistent

Editor - C:\Users\Owner\Google Drive\Publications\Journal\18-(RA-IP)Nonlinear ID bridge column\(0) Motions\RUN_ALL_SENSORS.m

File Edit Text Go Cell Tools Debug Desktop Window Help

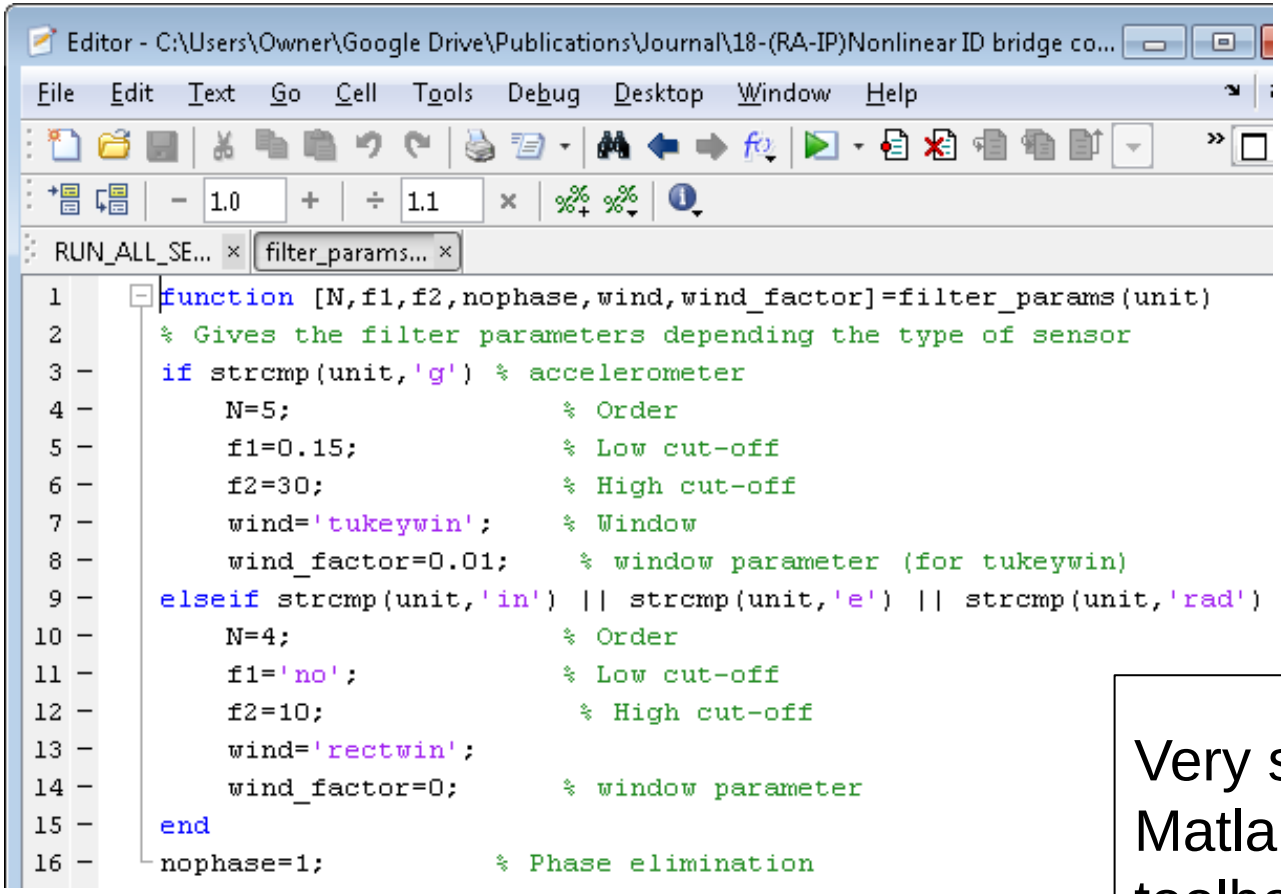
```
clear all; close all; clc;

motion={'EQ1','EQ2','EQ3','EQ4','EQ5','EQ6','EQ7','EQ8','EQ9','EQ10'};%{'EQ1','EQ2','EQ3','EQ4','EQ5','EQ6','EQ7
N_motions=length(motion);
Nodes={'1','2','4','5','7','8'};    % nodes required to load data
Fs=240;              % sampling rate
Fs_Control=256;      % sampling rate of control
offset='remove';     % 'remove' to remove offset in string/linear pot and strain gauge
imprime='yes';       % 'yes' to plot results
guarda='yes';        % 'yes' to save plot
format='-dpng';      % figure format
quali='-r150';       % figure quality

for uu=1:N_motions
    Control=importdata(['.\',motion{uu},'\Control.txt']);
    if strcmp(imprime,'yes')
        figure; plot([0:size(Control.data,1)-1]/Fs_Control,Control.data(:,1)); hold all;
        if strcmp(guarda,'yes')
            print(format,quali,[motion{uu},'_controller']);
        end
    end
    dif_nodes=unique(Nodes);
    if sum(strcmp('1',dif_nodes))==1, UCSD.Node1=importdata(['.\',motion{uu},'\Node1.txt']); end
    if sum(strcmp('2',dif_nodes))==1, UCSD.Node2=importdata(['.\',motion{uu},'\Node2.txt']); end
    if sum(strcmp('4',dif_nodes))==1, UCSD.Node4=importdata(['.\',motion{uu},'\Node4.txt']); end
    if sum(strcmp('5',dif_nodes))==1, UCSD.Node5=importdata(['.\',motion{uu},'\Node5.txt']); end
    if sum(strcmp('7',dif_nodes))==1, UCSD.Node7=importdata(['.\',motion{uu},'\Node7.txt']); end
    if sum(strcmp('8',dif_nodes))==1, UCSD.Node8=importdata(['.\',motion{uu},'\Node8.txt']); end
    UCSD_Names = fieldnames(UCSD);
    for ii=1:numel(UCSD_Names)
        UCSD.(UCSD_Names{ii}).leg=strread(UCSD.(UCSD_Names{ii}).textdata{3,1},'%s');
        UCSD.(UCSD_Names{ii}).unit=UCSD.(UCSD_Names{ii}).colheaders';
```

script Ln 1 Col 27 OVR

Load and plot all test data automatically

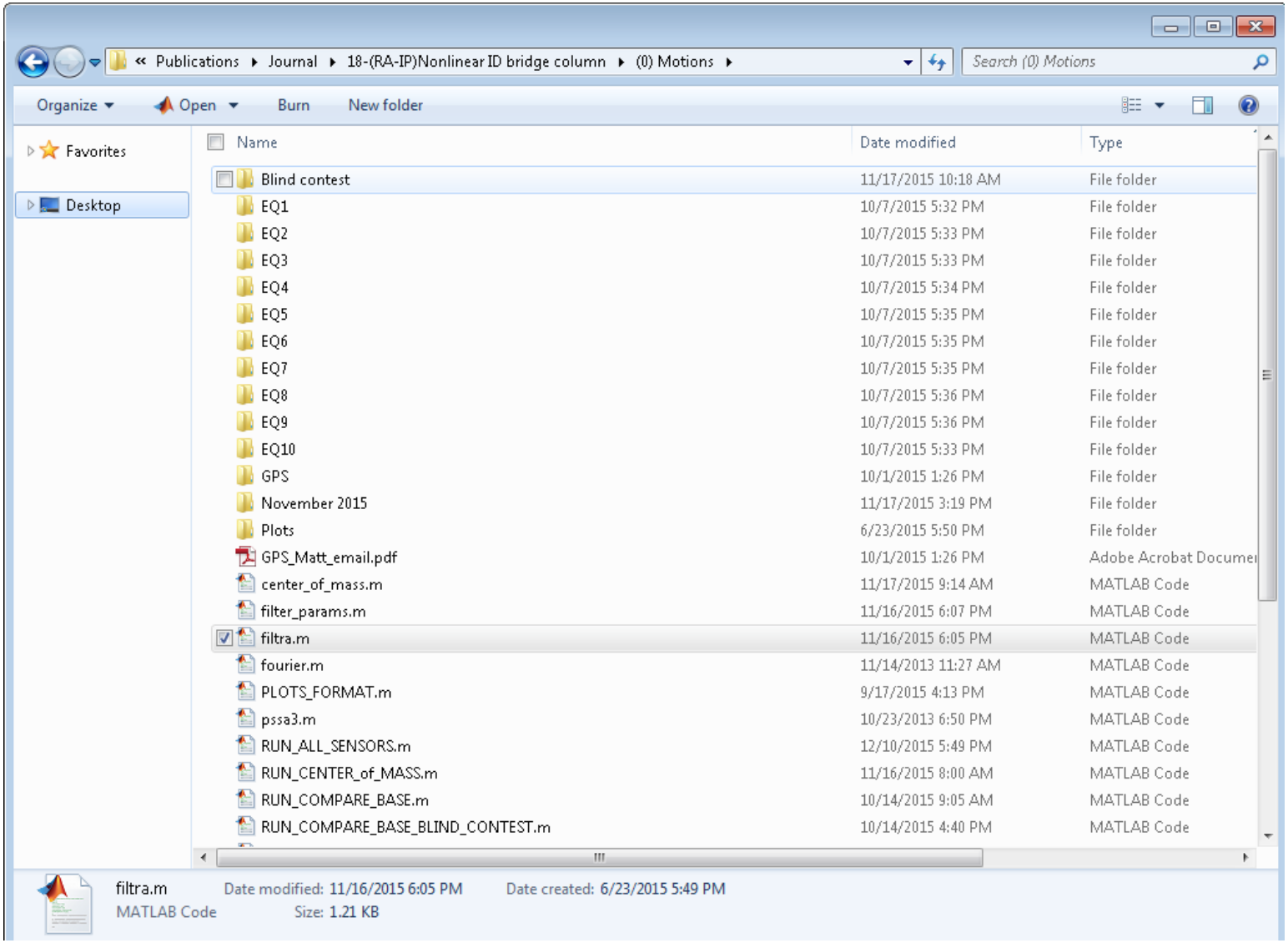
Very simple code ~ 50 lines

Rapid data visualization

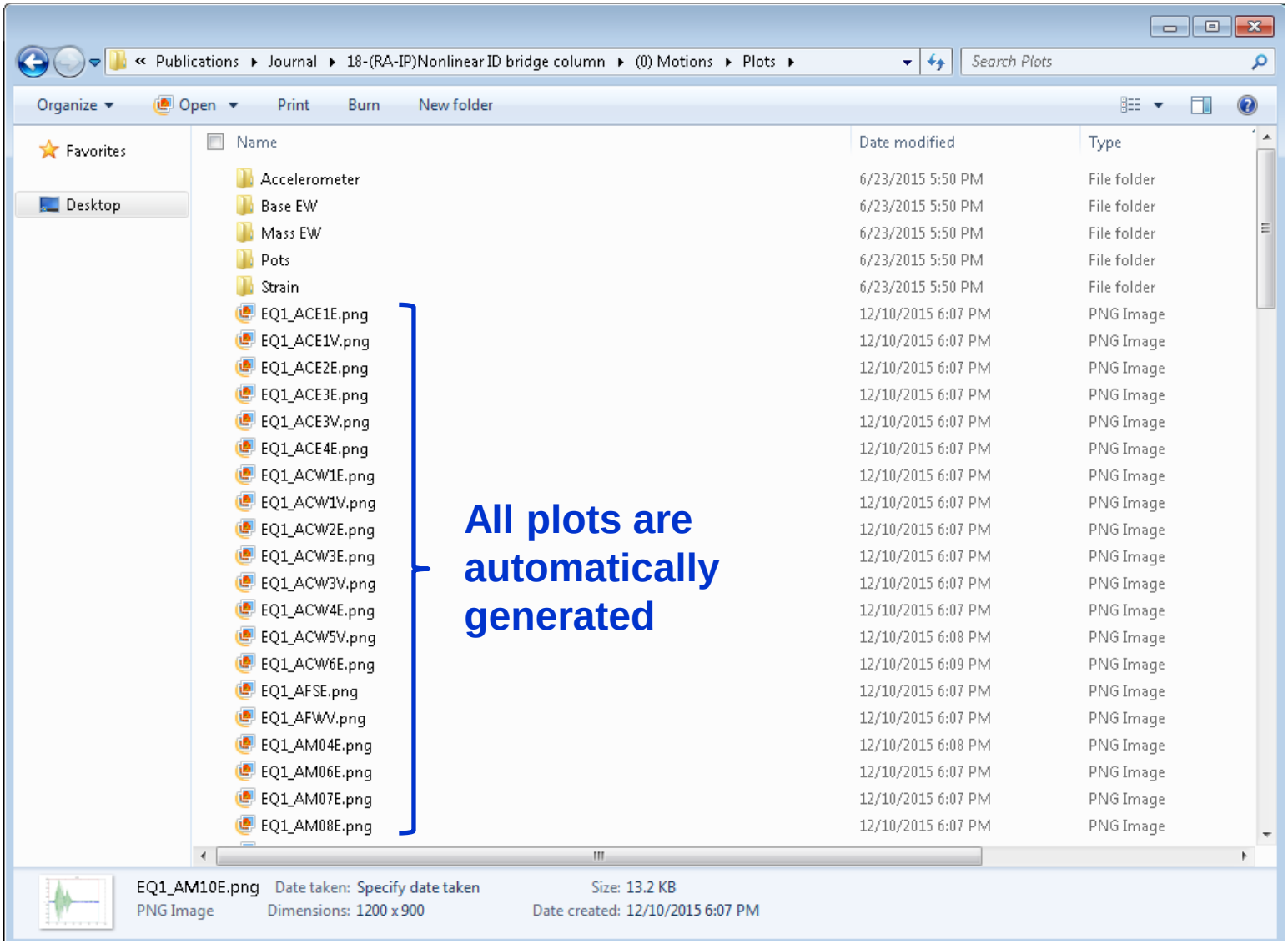


Very simple DSP using Matlab built-in codes and toolboxes

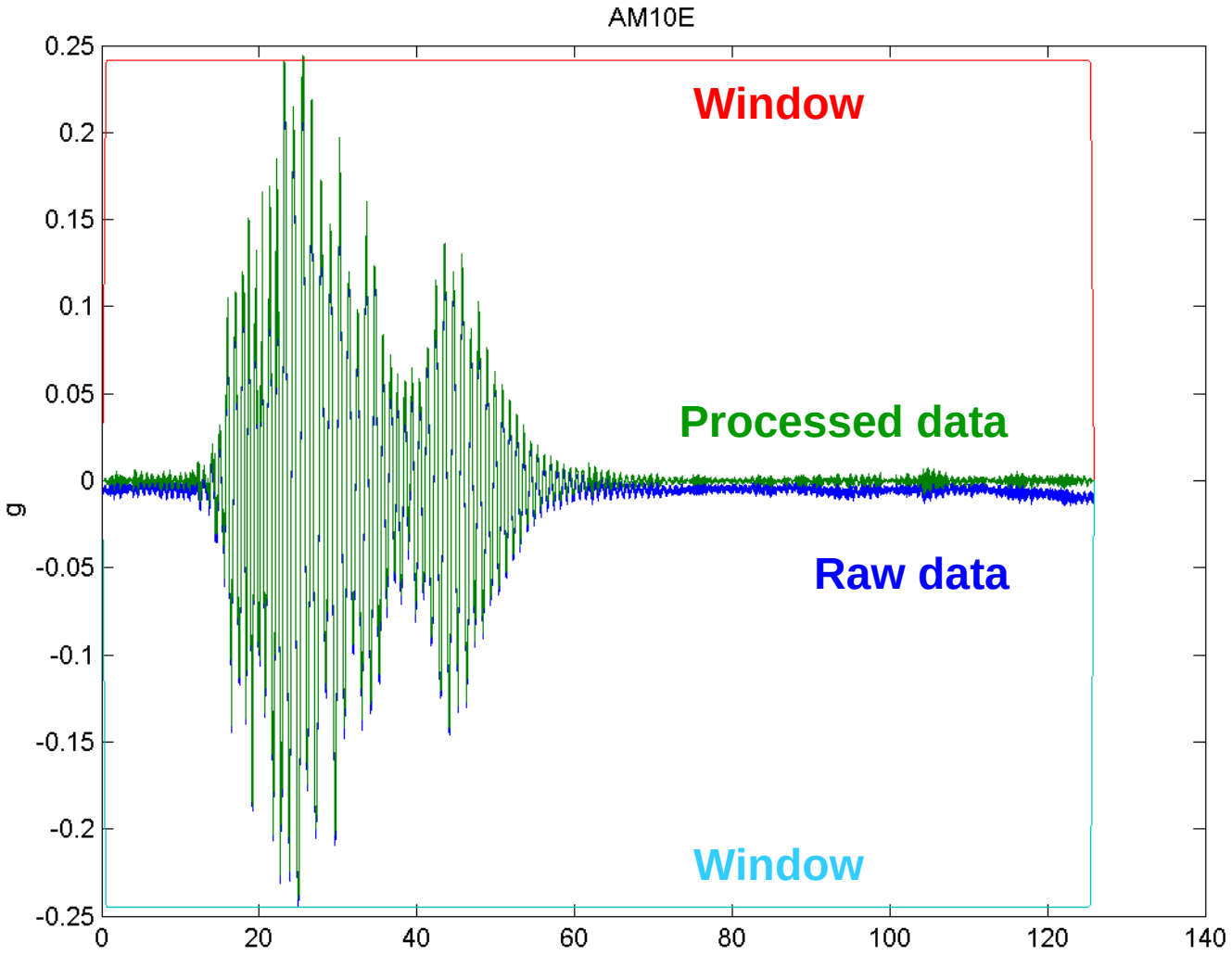
Rapid data visualization



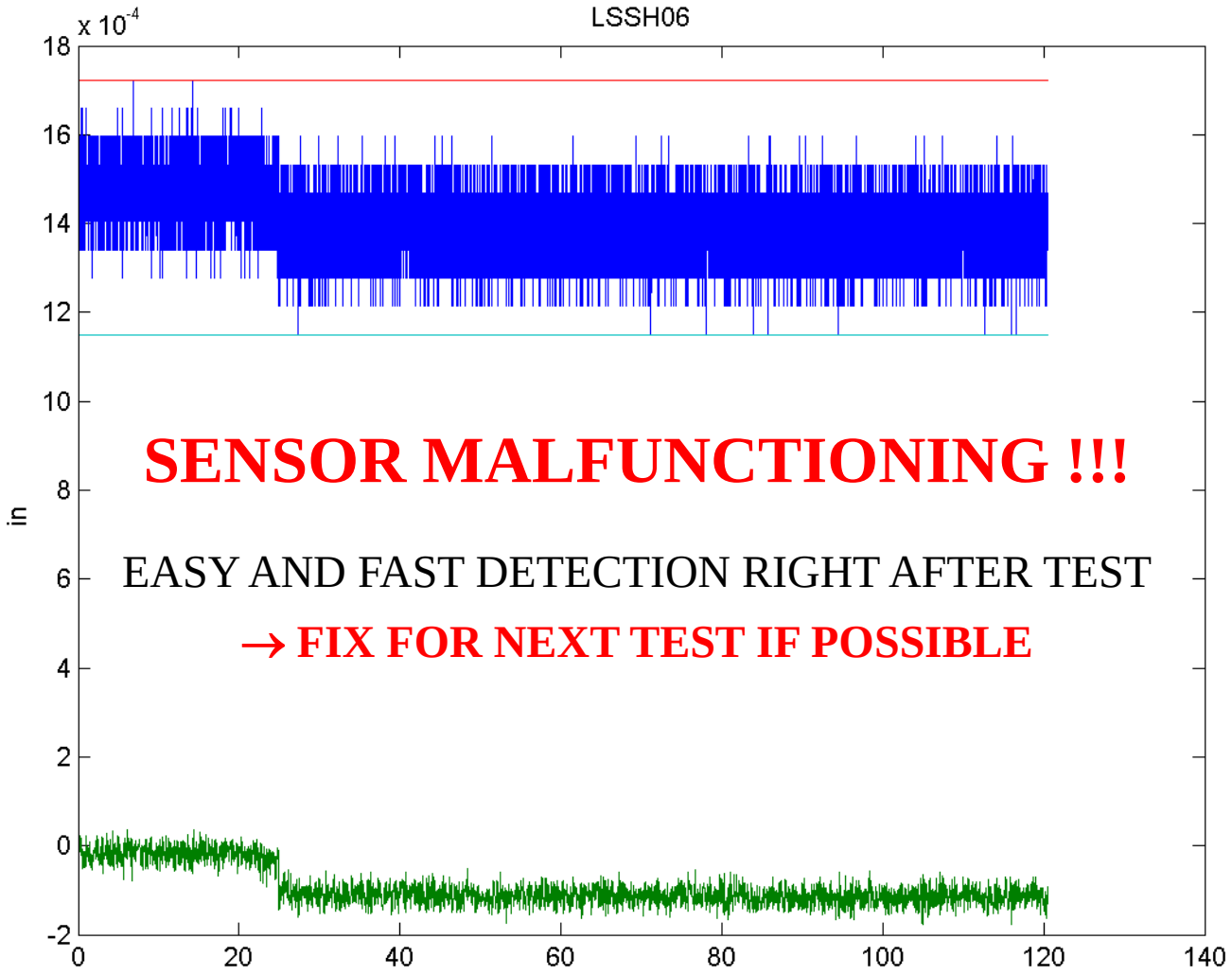
Rapid data visualization



Rapid data visualization

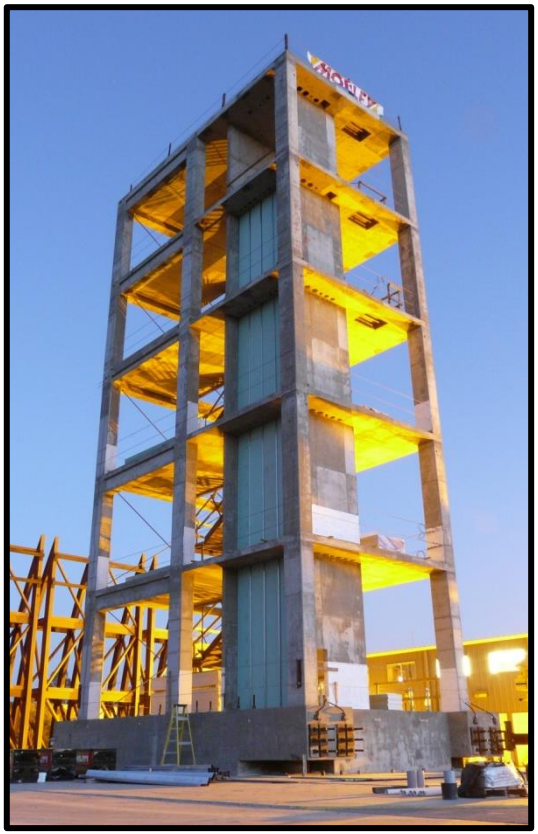


Rapid data visualization



Rapid analysis of data

Example 1: BNCS project (2012)



Rapid analysis of data

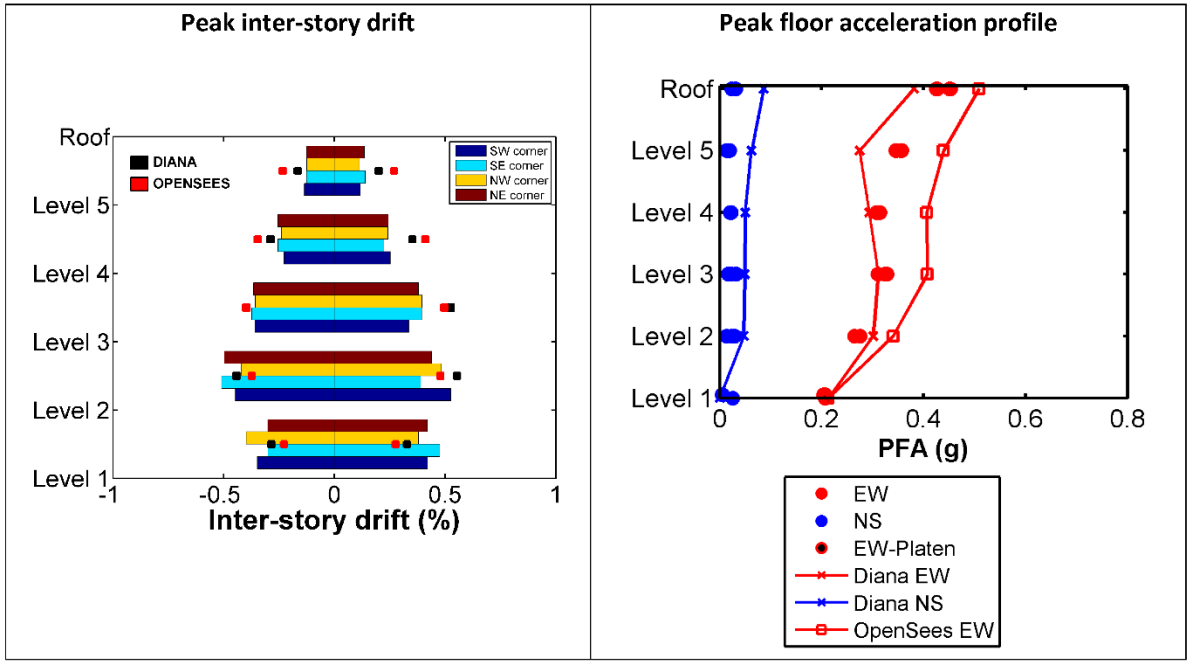
- A graduate student prepares a report as soon as the test data is obtained (same day of testing).
- The reports are emailed to the PI and co-PIs of the project the same day of testing.
- Comparison with pre-test simulations is included if possible.
- Computer codes (e.g., in Matlab) should be developed prior to the beginning of the tests.
- The information is very useful to check sensors, response of the specimen, unexpected behavior, agreement of experimental data with computer simulations, etc.

Rapid analysis of data

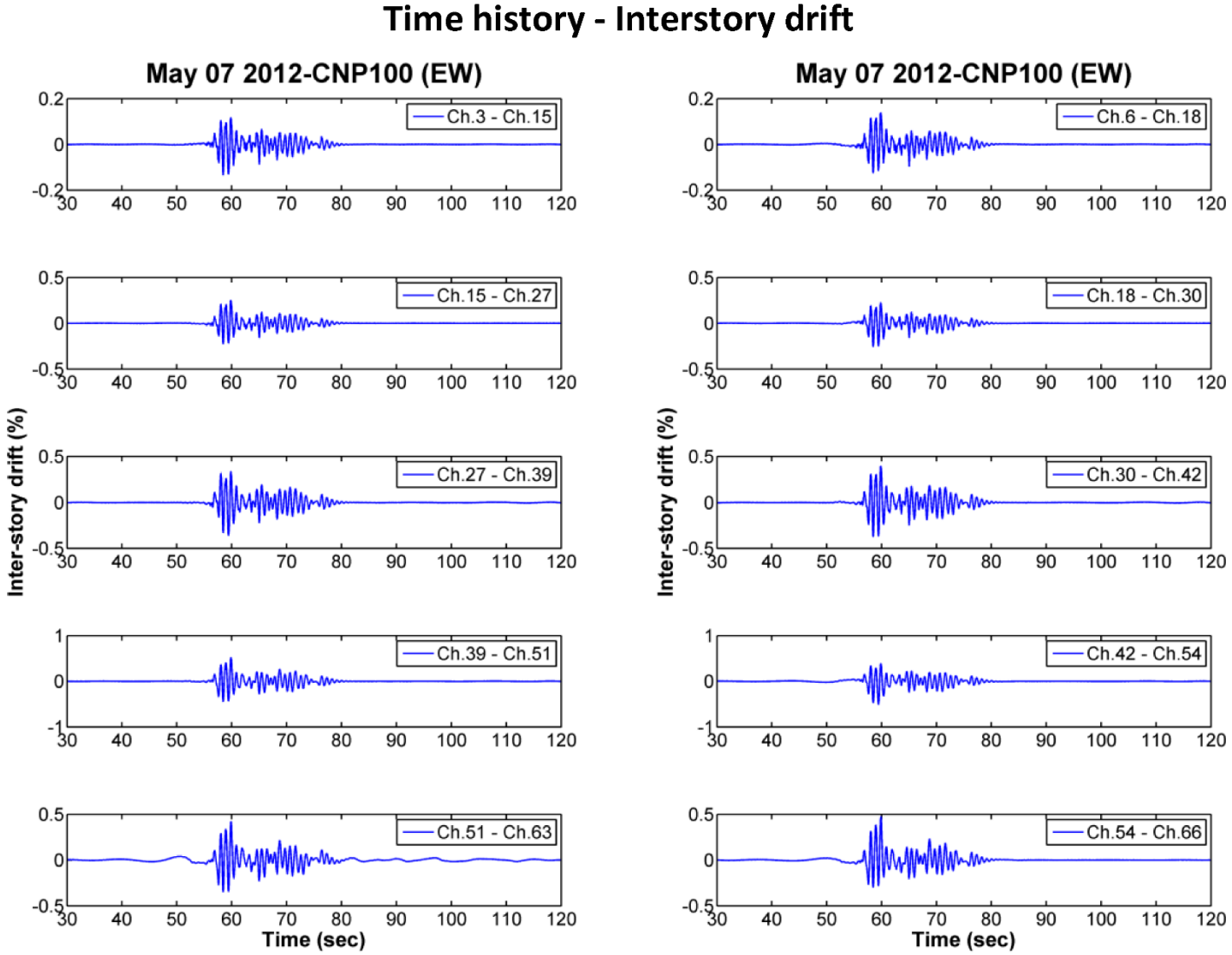
REPORT MAY 07, 2012

1. **Checking of sensors and signals:**
   a. UCLA:
      - All the channels in the systems UCLA2 recorded properly for all the input motions (WN1 and CNP100).
   b. UCSD:
      - Elide and Xiang are working on this.
2. Preliminary analysis of the structure and comparison with FE models:
   A bandpass (0.07-25 Hz) Butterwoth filter (order 4) was used to correct the raw data.

CNP100



Rapid analysis of data



Instrumentation and Data Acquisition

Thank you