IT Operations and Cyber Infrastructure

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Overview

- IT Infrastructure and Equipment
- Hardware/Software Capabilities
- User Training and Testing
- Cybersecurity and Risk Mitigation
IT Experiment Support
Start to Finish

1. Researchers and NHERI Lehigh team work together on training, development of experimental protocols, instrumentation, control and safety plans
2. Create project storage and collaboration space on DesignSafe-CI Data Depot
3. Design control configuration through numerical and hydraulics off simulations for validation
4. Configure data acquisition system for sensors
5. Configure video acquisition system for cameras
6. Configure data stream for local and remote data viewing
7. Initiate safety protocols and run experiment
8. Data is locally archived and synced with Project Warehouse
9. Research team processes data locally and stored in Data Depot at DesignSafe-CI into data model. Tools available to process data available locally and on DesignSafe-CI
IT Mission

- Design IT Architecture from the ground up
- Complete control of all IT aspects to facilitate all types of required simulation techniques

2004 ➔ Present
SCRAMNet GT

- Replaced EOL SCRAMNet+ equipment
- Increased throughput and reliability
- Expanded vendor compatibility
- Maintenance contract
RTMDdaq

- Pacific Instruments 6000 Data Acquisition System
  - 304 channels, 384 expandable
    - Voltage, Strain, Thermocouple
  - Variable sampling rates
    - 4 kHz for Real-time Testing
IT Infrastructure

Control Systems

Hydraulic Pumps & Accumulator System

RTCMDtele
Data Turbine
RTCMDsim
Simulation Coordinator
RTCMDxPC
Real-time Target
RTCMDxPC
Real-time Target
RTCMDdata
Data Archiver
RTCMDws
Website

RTMDctrl
Pulsar Servo Controller
RTMDctrl
Inertia Servo Controller
RTMDdaq
Data Acquisition

DCS
NI
DAQ

Web Cameras

Lehigh Firewall

Internet Level 3
Internet2

Lehigh HPC Resources
Globus Data Transfer Node

Border Router

10 Gbps
1 Gbps
10 Gbps

Cisco 1/10 Gbps Ethernet

PH5000

Instrumentation & Sensors

Damper

Hydraulic Actuators
RTMDctrl

• Servotest Pulsar Hub Control System
  • Configurable servo-control system for hydraulics actuator PID control
  • 2048Hz or higher control rate
  • Wide vendor support
  • Customizable interface
RTMDctrl

• Wineman INERTIA Control System
  • Unlimited multi-mode closed-loop control
  • Integrated test editor
  • Integrated with various NI modules
  • Integrated PID control loop tuning
  • Complete access to tuning system variables
  • Programmable control and DAQ rates
Simulation – RTMDsim/RTMDxPC

- Host-Target configuration
  - Real-time and custom applications
- Dell i7 Precision Workstation
  - High power workstation for execution and processing
- Speedgoat Targets (Simulink Real-time)
  - Dedicated Intel i7 4Ghz real-time systems
- Multiple Targets
  - Defined roles
  - Parallel processing for larger, more complex models
RTMDsim

- Workstation/Host
  - Mathworks suite
  - Coordinator of synchronized control and data acquisition
  - Hydraulics on/off testing – numerical simulation for safety, validation & training
- Process and analyze data
RTMDxPC

- Speedgoat systems, CPU performance up to 4 GHz
- Industrial quality design for robustness
- Multi-core support for parallel processing
- Daisy chaining
- Available modules for DAQ and control
- Simple interface with Simulink and S-Functions
- Quick prototype turnaround
Telepresence

• Data Turbine (RBNB) (dataturbine.org)
  • Aggregates data from SCRAMNet using RTMD tools to define channel list, sample rate and duration
  • Streaming of data and images locally and remotely
  • Additional storage archive of test data
RDV

- Real-Time Data Viewer (RDV)
  - Connect from anywhere on any system
  - Invaluable tool for visualizing Real-Time Hybrid Simulations
Video

• Video/Imaging systems
  • (24) Amcrest Bullet/PTZ IP Cameras (up to 8k)
  • (4) Sony SNC-EP550 HD (720p HD)
  • (9) GoPro Hero 3 Black camcorders (1080p60 HD)
  • (2) Sony SNC-RZ30N network cameras (SD Security)
  • Nikon D70 D-SLR camera
  • HD camcorders available upon request through Lehigh

• Blue Iris Servers
  • Portal for all users to access and control web cameras
  • Archived video available for previous experiments
RTMDdata

• Synology DS 1817
  • 8 hard drive slots, 96 TB capacity up to 216 TB
  • 10Gb Connection
• Dual-disk Redundancy
• Network Attached Storage
• Public and Private storage
Data Management Plan

- Local repository for data storage managed by NHERI Lehigh with offsite backup risk mitigation through DesignSafe-CI
- Unlimited Google Drive space through Lehigh University
- Locally stored data adheres to the Lehigh University records retention policy or extended by the ATLSS Center IT management
- Included under NHERI Lehigh data management umbrella:
  - Unprocessed and RAW data from experiments
  - Converted and derived data sets using computational software
  - Experimental photos and videos
  - Computational models and analytical data sets
  - Scripts and software developed for project tasks
- Local curation utilizing folder/file structure
  - Project/Date/Task Description/Data Set; format “testname_date”
- Automated Globus Project data upload
- DesignSafe-CI curation through Data Depot and Data Model
Software Capabilities

• Components for simulation coordination
  • MATLAB, Simulink (RT)
  • Lehigh HybridFEM through Matlab, Simulink
  • LabVIEW RT/VeriStand (Wineman Inertia)
  • OpenSEES via OpenFresco
Training: Documentation

- User’s Guide
- Repository of technical documents, demos and video tutorials
- Available to all users
Simulation Safety

- Command software limits
  - Bound and rate limits
- Controller software limits
  - System trip and shutdown
- Hardware displacement limit switches
- E-Stop buttons
Hybrid Simulation Components

- Simulation coordinator
- Integration algorithm
- Computational model of analytical substructure
- Kinematic error compensator
- Actuator delay compensator
- Experimental substructure
RTHS: Model Flow

\[
\begin{align*}
\text{Simulation coordinator} & \quad \leftrightarrow \quad \text{Integration Algorithm} \\
\mathbf{x}(i+1) & \quad \leftrightarrow \quad \mathbf{x}(i+1) \\
\mathbf{\dot{x}}(i+1) & \quad \leftrightarrow \quad \mathbf{\ddot{x}}(i+1) \\
\text{Position} & \quad \leftrightarrow \quad \text{Target} \\
\text{Experimental Component} & \quad \leftrightarrow \quad \text{Actuator Control} \\
\mathbf{x}(i)e & \quad \leftrightarrow \quad \mathbf{x}(i+1)e \\
\text{Simulation coordinator} & \quad \leftrightarrow \quad \text{Receive Component Responses} \\
T_i & \quad \leftrightarrow \quad T_{i+1} \\
\text{Computational Model} & \quad \leftrightarrow \quad \text{Integration Algorithm} \\
\text{State} & = f(\mathbf{x}(i+1)a) \quad \text{done} \\
[\text{state}] & \quad \text{memory}
\end{align*}
\]
RTHS: Multiple Targets

Ground motion

Update accelerations from equations of motion

Integration algorithm

Update displacements/velocities

Experimental substructure restoring forces

Analytical substructure restoring forces

Commands

SCRAMNet

Analytical substructure restoring forces

xPC1

xPC2
Example Projects and Demos
Thank you!