NHERI SimCenter Vision

“Transforming the nation’s ability to understand and mitigate adverse effects of natural hazards on the built environment through computational simulation”

Grounded in the present

Five year focus

Ten year vision
SimCenter Mission

Pivot to a comprehensive, open source, cloud-based, HPC framework or simulation “ecosystem” that:

✓ is modern, extensible, scalable, secure and robust,

✓ harnesses machine learning, artificial intelligence, expert systems, self-assembling knowledge bases to help model, validate and build trust in numerical simulations,

✓ quantifies the sensitivity of performance to various uncertainties,

✓ is performance oriented and data-driven, and

✓ characterizes performance appropriately for different stakeholders.
SimCenter Broader Goals

• Treats all natural hazards equally.
• Considers models at all scales.
• Remembers cities are not just structures, includes infrastructure, lifeline networks and social services.
• Integrates seamlessly with other NHERI components to ensure a functional and cohesive national infrastructure.
• Supports decision-making at all levels.
Capable Leadership Team

Steve Mahin
UC Berkeley

Ahsan Kareem
Notre Dame

Laura Lowes
Washington

Greg Deierlein
Stanford

Sanjay Govindjee
UC Berkeley

Camille Crittenden
UC Berkeley

Frank McKenna
UC Berkeley

Matt Schoettler
UC Berkeley

Plus nearly 25 experts in engineering, urban planning, social science and computer and information science
Tackling the “Grand” Challenges posed by a Nation at Risk from Natural Hazards

- Hurricanes
- Tornadoes
- Floods
- Tsunami
- Earthquake - High
- Earthquake - Moderate
Builds upon a solid performance-based, risk informed methodology.

Extension to multiple hazards, and portfolios of different kinds of structures and systems, and optimization of structural characteristics to improve performance.

\[ \lambda(DV > dv) = \int \int \int G(dv \mid dm) \, dG(dm \mid edp) \, dG(edp \mid im) \, d\lambda(im) \]
Our plan: Transitioning from PCs to the cloud

Current software is often good, but:
- Regular software updating needed
- Unable to scale to HPC,
- Difficult to interact with and move data from one app to another.

- Move to cloud-based HPC environment
- Provide integrated “plug and play” capability to link multiple software apps together into workflows
Application of Applications Framework
Application of Applications Framework

Xinzheng Lu @ Tsinghua University
Trustworthy Simulations

Concrete Column Blind Prediction Contest 2010

41 expert teams participated

PEER-NEES Blind Analysis Contest

38%

Full-scale 1D tests of circular column - Jose Restrepo, PI (PEER, Caltrans, UNR, FHWA, NEES@UCSD, NEEScomm & NSF)
Simplified PBE Work Flow

IM → EDP → DM → DV

Ground Motion Library
NGA
SCEC
Other

Tsunami Database
PEER
Other

Wind Database
TBD

Other Natural Hazards Database
TBD

Natural Hazards Database
Simplified PBE Work Flow

Simulation Software
- Analysis software supported by DesignSafe-ci
- OpenSees
- FEAP
- LS-Dyna
- Abacus
- Ansys
- OpenFoam
- Others

Extend or adapt to multiple hazards
Automated, data-driven modeling and analysis
Hybrid Simulation
Simplified PBEE Work Flow

Expand PBE to Generic Facilities & Multiple Hazards
- Buildings
- Industrial Facilities
- Lifelines
- Networks
- Services
- Wind
- Seismic
- Tsunami
- Other
Simplified PBE Work Flow

Characterizing effects of uncertainties in theoretical constructs, numerical models, procedures & parameters, analysis methods, etc.
Optimize design decisions to achieve EDP criteria, maximize return on investment, minimize repair costs or down times, etc.

Wang and Mahin, 2016
Enabling complex workflows

- Ground Motion Workflow
- Seismic Response Simulation Workflow
- Seismic Loss Simulation Workflow
- Tsunami/Coastal Inundation Generator Workflow
- Tsunami / Coastal Inundation Response Simulation Workflow
- Tsunami / Coastal Inundation Loss Simulation Workflow
- Wind Effects Workflow
- Wind Response Simulation Workflow
- Wind Loss Simulation Workflow
Enabling complex workflows

Scenario Manager

Ground Motion Workflow → Seismic Response Simulation Workflow → Seismic Loss Simulation Workflow

Tsunami / Coastal Inundation Generator Workflow → Tsunami / Coastal Inundation Response Simulation Workflow → Tsunami / Coastal Inundation Loss Simulation Workflow

Ground Motion Workflow → Seismic Response Simulation Workflow → Seismic Loss Simulation Workflow

Wind Effects Workflow → Wind Response Simulation Workflow → Wind Loss Simulation Workflow
If you can do this for one facility

X.Z. Lu

Portfolio and community simulation models

Lifeline, supply chain and service networks
Local and Regional Government Planning
Development, Policies & Programs

(Source: Bay Conservation and Development Commission, 2009)
SimCenter Framework for Building Workflow Applications

Each **component** is a **software application**: it does something and has clearly defined interfaces (input and output APIs).

We will use **Scientific Workflow Management Software** to schedule components & manage the passing of data between the components. The software we will use is **Pegasus**.

Our goal is to define the interfaces so existing and future applications of the users choice can be used.
Facilitating complex regional-scale workflows
High profile early deliverables

Time needed to get the framework “backend” developed

**Year 1 Highlights**

- **App 1**: Integrated performance-based engineering workflow application
- **App 2**: Integrated uncertainty quantification workflow
- Educational apps illustrating sensitivity of dynamic response to excitation and structure characteristics.
- Kick start education activities, including programming boot camp and (M)OOCs (modeling best practices)
- Development and assessment of framework building blocks (metadata, ontologies, APIs, wrappers, user interfaces, etc.)
To Achieve Our Broad Vision for the SimCenter

We need your advice, help and collaboration, so we can effectively address community needs.

Our framework is a skeleton, and needs users to provide it with the data necessary to make it useful.

We are happy to work with researchers and other NHERI Components in developing proposals to use our framework and exploit capabilities of HPC.
Thanks!

Questions?

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