

Introduction to SimCenter

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NSF award: CMMI 1612843

Outline

Introduction to SimCenter

Research Applications

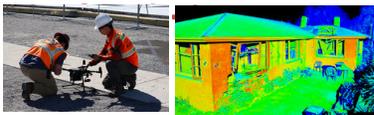
Education & Outreach

NSF NHERI (Natural Hazards Engineering Research Infrastructure)

NCO



Experimental



Rapid facility



SimCenter NHERI
Center for Computational Modeling and Simulation

Cloud-enabled research applications
Scalable to run on HPC with emphasis on UQ

Front-end

SimCenter Research Applications



We are a Virtual EF

Leadership Group



Sanjay Govindjee
UC Berkeley



Ahsan Kareem
Notre Dame



Laura Lowes
Washington



Greg Deierlein
Stanford



Satish Rao
UC Berkeley

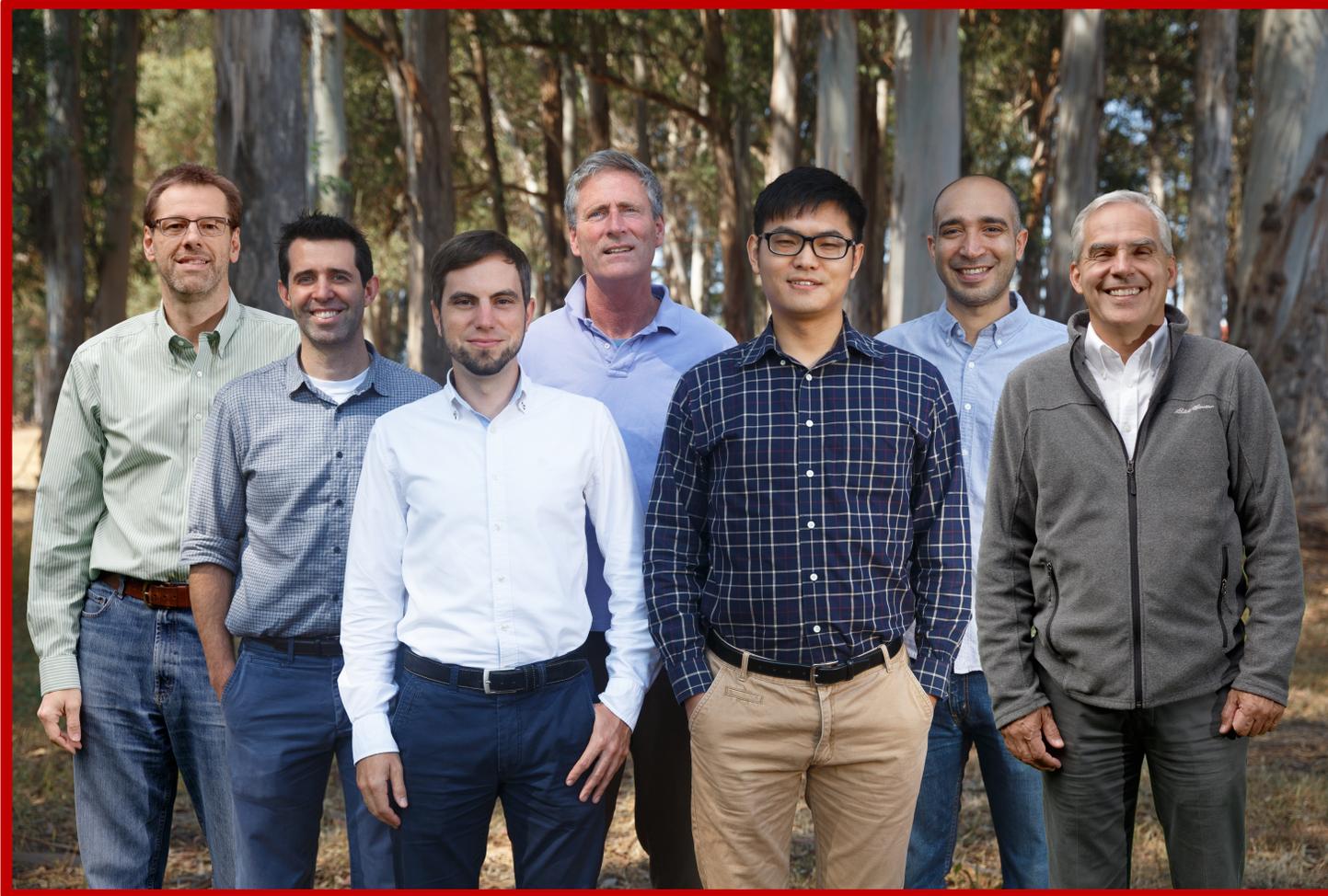


Frank McKenna
UC Berkeley



Matt Schoettler
UC Berkeley

Software Development Team



**Peter (UW), Michael, Adam (Stanford), Frank,
Charles, Wael, Pedro (UW)**



Qian



Ziad



**Jiawai
(ND)**



Barbara

Domain Experts

Additional experts in engineering, urban planning, social science, and computer and information science



Iris Tien



George Deodatis



Patrick Lynette



Alex Taflanidis



Jack Baker



Ann-Margret Esnard



Joel Conte



Vesna Terzic



Jonathan Bray



Tracy Kijewski-Correa



Michael Motley



Paul Waddell



Camille Crittenden



Filip Filippou



Ewa Deelman



Kincho Law



Ertugrul Taciroglu



Stella Yu



Eduardo Miranda



Andrew Kennedy

Mission

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

Grounded in the present

Five year focus

Ten year vision

Advanced Computational Simulation?



- 1) Applications that generate UQ in Response Quantities
- 2) Applications to perform Performance Based Engineering
- 3) Applications for Community Resiliency
- 4) Educational Applications

How Are We Making the Mission a Reality?

Software

Educational Activities

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SimCenter Software Goals

To produce Extensible Software Researchers
in NHE can use in their research

- Develop an **open-source computational framework** to support decision-making to enhance community resilience to natural hazards **in the face of uncertainty**;
- **Design a framework** that is sufficiently **flexible, extensible, and scalable** so that any component of it can be enhanced to improve the analysis and thereby better meet the needs of the community;
- **Seed the framework** with enough **data** and **interfaces to existing simulation tools** so that it can be employed in the near-term;
- **Release tools/applications built using this framework** that meets the computational needs of researchers in natural hazards engineering;
- **Provide an ecosystem** that fosters collaboration between scientists, engineers, urban planners, public officials, and others who seek to improve community resilience to natural hazards.

Some Released Software

UQ

FEM



EE

UQ

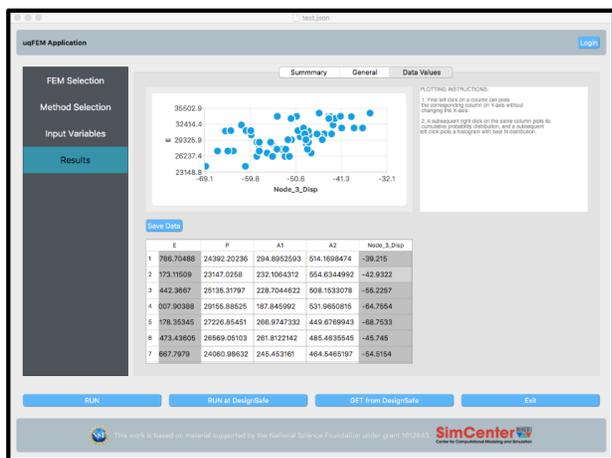


PBE





(to be renamed quoFEM)



Govindjee, Conte, Kennedy & Taflanidis
 Frank McKenna & Ziad Ghauch

Current Release V1.1 (Oct 2018)

- Correlation matrix for sampling methods
- Computation for Sobolev indices for sampling algorithms
- Specifying user-defined probability distribution functions for random variables (for sampling methods)
- Fitting of probability distribution functions for sampling results
- Conjugate gradient for calibration problems
- Pattern search for calibration problems

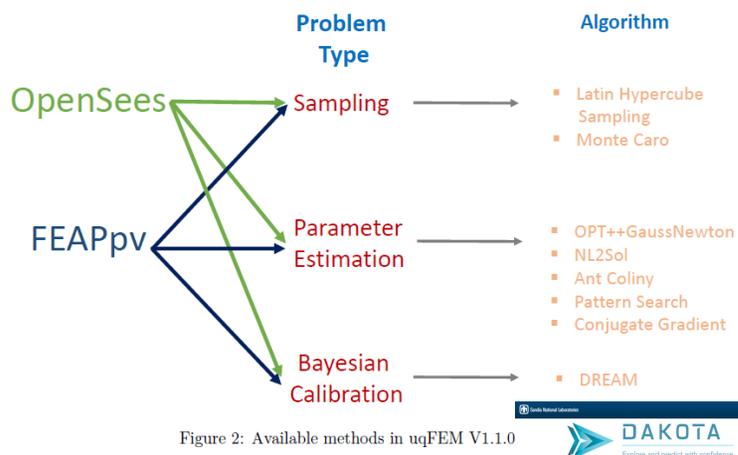


Figure 2: Available methods in uqFEM V1.1.0



Future Release V2.0 (Sept 2019)

- Summary Statistics
- Correlation Matrix Testing with multiple events options
- User Defined Distribution



Current Release V1.1 (March 2019)

- Loading:
 - PEER Motions
 - Site Response 2D/1D motion, Effective Stress
 - Stochastic Loading – Vlachos et al.
 - Site Hazard Analysis
- Shear Building Model & OpenSees Models
- Earthquake & User Defined EDP



Arduino, Baker, Bray, Conte, Deodatis,
Tacioglu & Taflanidis

Frank McKenna, Wael Elhaddad,
Charles Wang & Michael Gardner

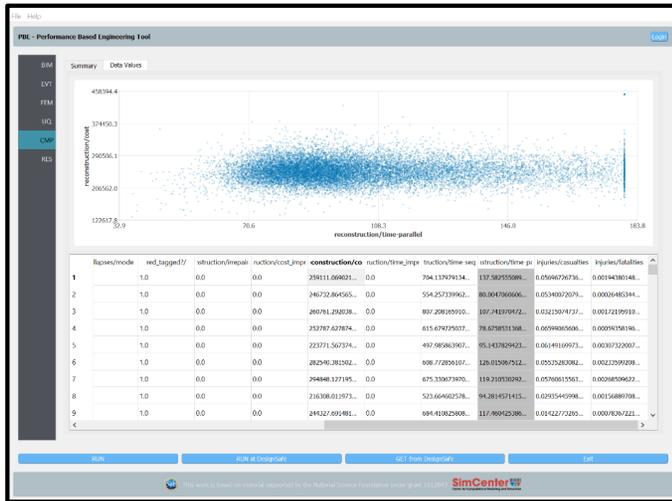
Future Releases

V1.2 (June 2019)

- Loading - Soil Column - 2d Motion, Effective Stress

V2.0 (Sept 2019)

- Loading:
 - Random Field Vertical
 - Stochastic Loading – Dobaghi
- Building:
 - Expert System for Walls, Moment Frames and Braces
 - Conditional Spectrum



Deierlein, Baker, Taflanidis & Terzic
 Frank McKenna & Adam Zsarnóczy

Current Release V1.1 (March 2019)

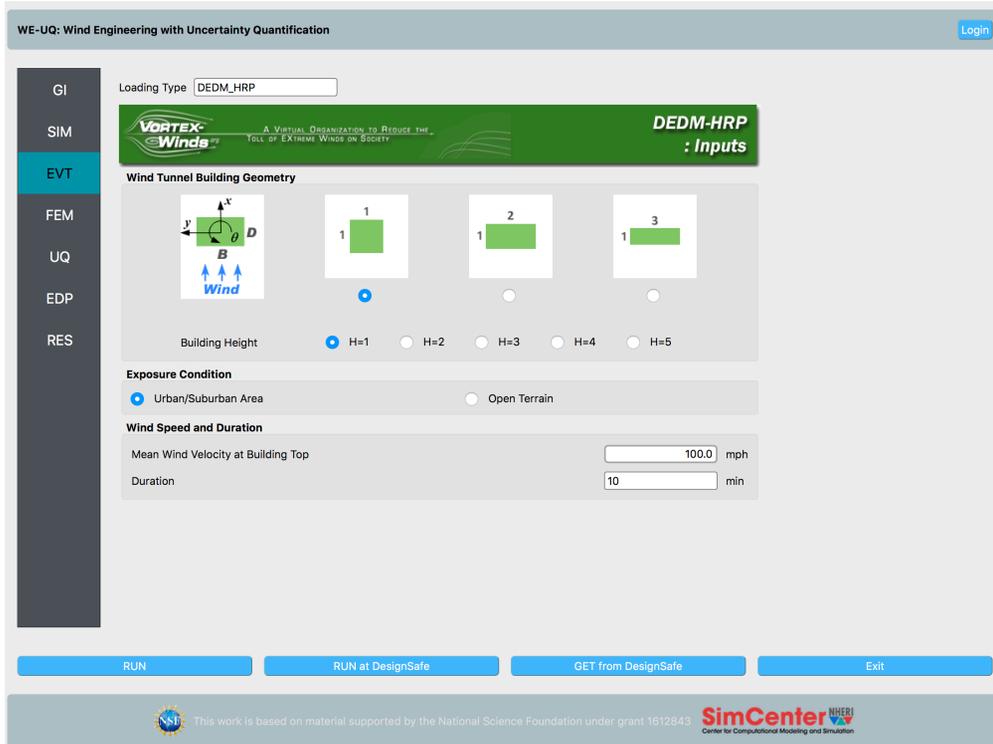
- Incorporates EE-UQ features for building system analyses
- Enabled component-group-based (FEMA P58-style) loss assessment for earthquake hazard.

Future Release V2.0 (Sept 2019)

- Extend to incorporate damage and loss functions for wind and storm surge (HAZUS).
- Enable response estimation without simulation (HAZUS-style simplified approach typically using a simple formula), Business interruption (HAZUS).
- More sophisticated injury characterization (HAZUS).
- Downtime (REDi)
- Alternative UQ propagation methods for combining collapse and damage

Major Upcoming Applications (within next year)





Initial Release V1.0 (June 2019)

- Wind Engineering Tool to consider UQ
 - Random Variables in all but CFD
 - Sampling Methods
- Loading
 - Stochastic loads.
 - Interface to Vortex Winds (HighRise).
 - CFD
 - User defined meshes.
 - Inflow for the initial conditions

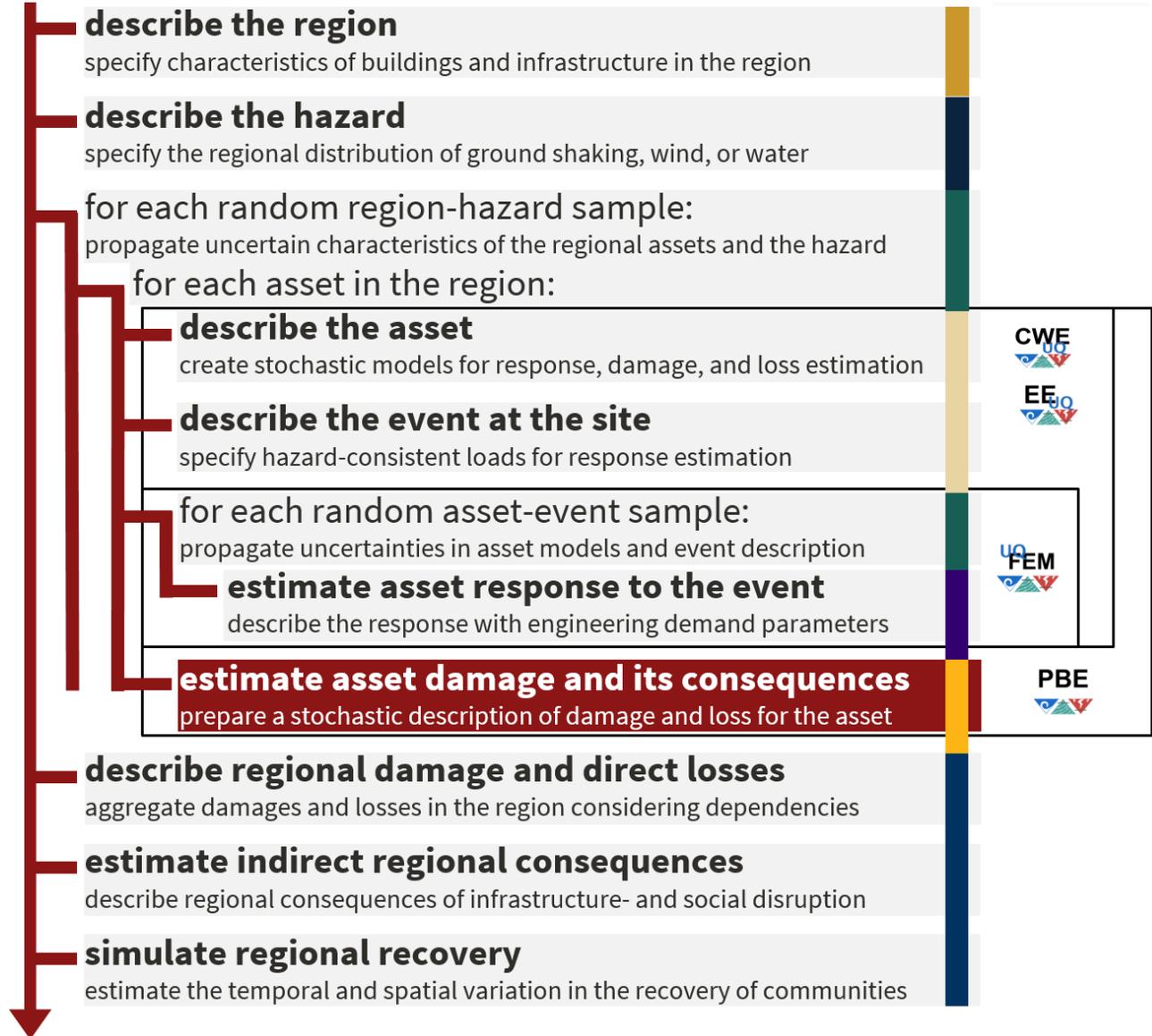
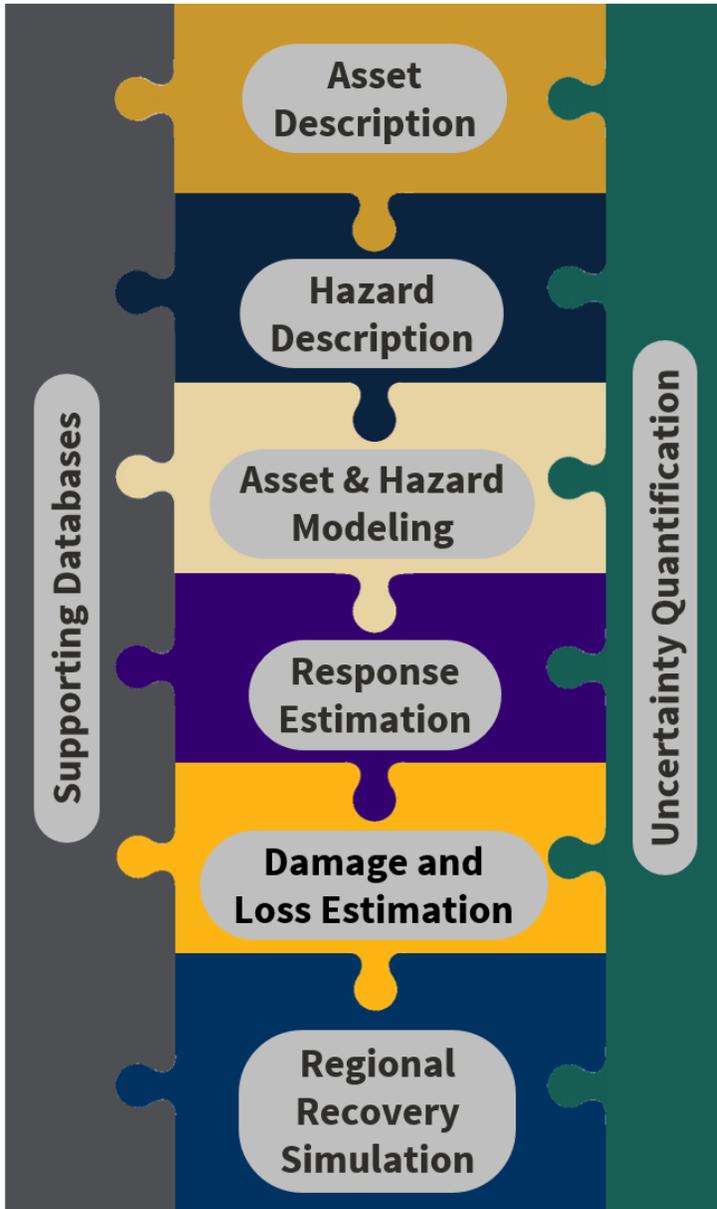
Release V1.1 (Sept 2019)

UQ for CFD & Basic Meshing

Kareem, Kennedy, Motley & Taflanidis

Frank McKenna, Peter Mackenzie-Helnwein,
Jiawei Wan, Wael Elhaddad, Charles Wang &
Michael Gardner

Resiliency Decision Tool



Regional Workflow for Hazard And Loss Estimation

rWHALE

Deierlein, Kareem, Conte, Deelman, Deodatis,
Kijewski-Correa, Taflanidis & Tien

Frank McKenna & Wael Elhaddad



Current Release V1.1 (Feb 2019)

- Regional earthquake workflow
- Various hazard representations

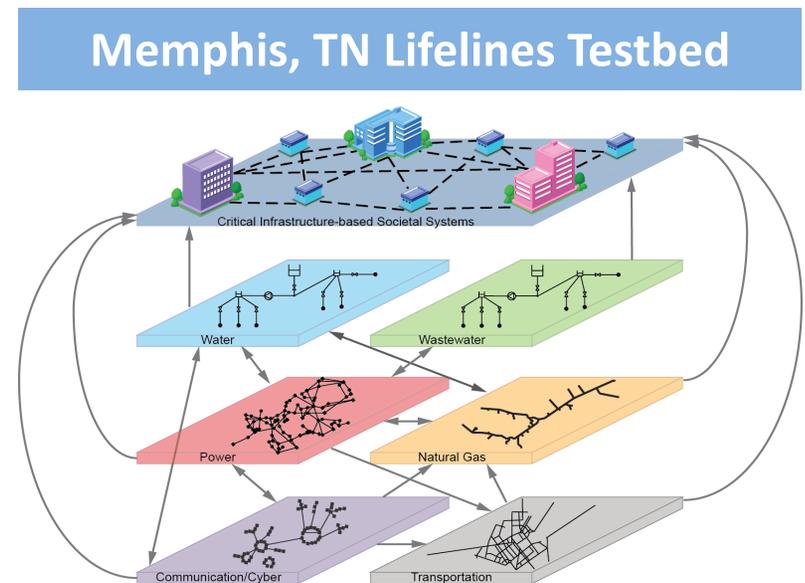
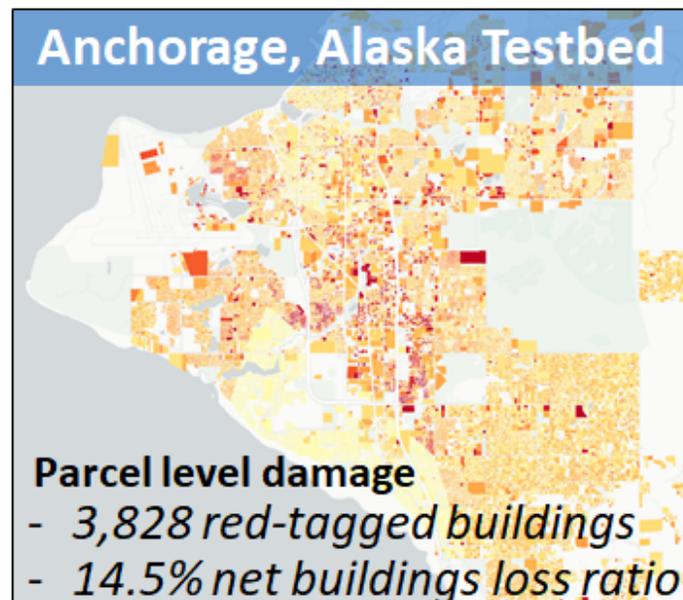
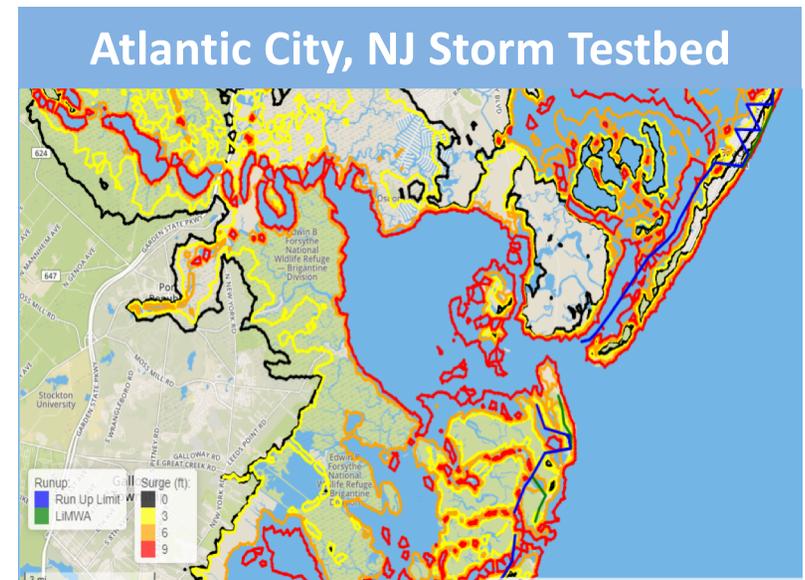
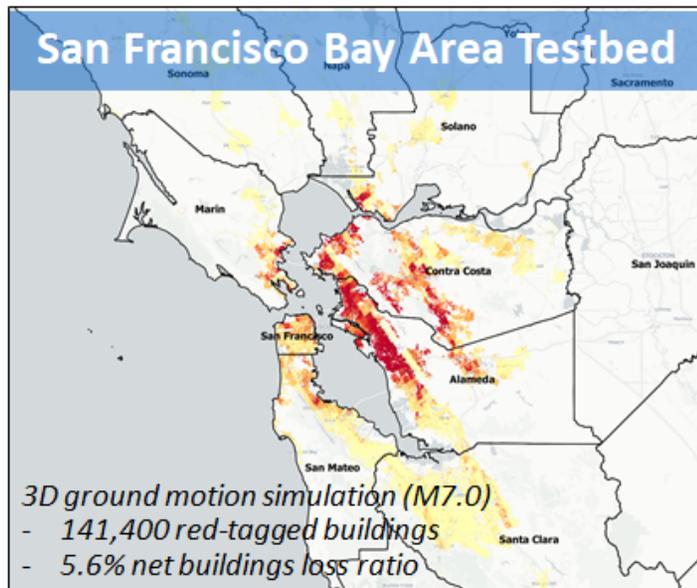


Future Release V2.0 (Sept 2019)

- Regional storm workflow
- Initial version to consider ASCE7 wind loading and HAZUS type damage and loss



Regional Workflow Testbeds to Verify rWhale



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Education & Outreach

SimCenter ECO Activities

- Training
 - Online Webinars
 - Workshops
 - Tool Training
 - Programming Bootcamp
 - NHERI Summer REU Program
 - State-of-the-Art Report
- Education
 - Educational App's
- Learn about the SimCenter
 - NHERI Summer Institute
 - Subscribe to SimCenter news and join Slack channels
<https://simcenter.designsafe-ci.org/join-community/>

Training Activities: Workshops

- SimCenter Tool Training Workshop (June 13-14 2019)
 - Hands-on software training and instruction in SimCenter Tools and their useful applications in natural hazards engineering (45 registered)
- Summer Programming Bootcamp (July 22-26, 2019)
 - Goal is to train NHERI researchers in the programming paradigms not covered in traditional civil engineering coursework, but required to advance NHE simulation capabilities (30 registered)



Educational Applications (Years 1&2)



Multiple Degrees of Freedom Application

Input Motion Earthquake Motion **Output** Displaced Shape

Input Motion: Scale Factor: 1 **Add**

Max Disp: 7.46 in
Fundamental Period: 2.09 sec

Analysis Duration: 31.2 sec

Building Properties

Number Floors: 5
Building Weight: 800 k
Building Height: 720 in
Story Stiffness: 31.54 k/in
Damping Ratio: 0.05 %
 Include PDelta

Weight	Height	K	Fy	b	zeta
1	100	144	31.54	1e+100	0.01
2	100	144	31.54	1e+100	0.01
3	100	144	31.54	1e+100	0.01
4	100	144	31.54	1e+100	0.01
5	100	144	31.54	1e+100	0.01

Current Time: 4.70 sec
Current Roof Disp: -0.12 in
pgm: 0.33g

Play **Stop** **Exit**

This work is based on material supported by the National Science Foundation under grant 1812843 **SimCenter** Center for Computational Modeling and Simulation



SimCenter Pile Group Tool

System Plot

Hints

- The Pile Group Tool uses metric units: meters, kilonewtons.
- Select piles or soil layers to display and/or change by clicking on the pile inside the System Plot.
- Go to Preferences to select which result plots are shown.

Ground water table
Depth below surface: 4.00 m

Soil Layers
Changing layer: #1 #2 #3

Layer Properties

Thickness: 3.00 m
dry unit weight: 18.00 kN/m³
saturated weight: 18.00 kN/m³
friction angle: 30.0 deg
Shear modulus: 200.0 MPa

System Plot
Groundwater Layer #1 Layer #2 Layer #3 Pile #1 Pile #2

Output
Displaced Shape
current = 12.03 in
Hysteretic Response
Axial Force Diagram
Moment Diagram
Applied Displacement History

Input
Experiment: TC873_WBX28.pgm **Add Experiment**

Element Section Material Connection
Element: 1
Section: Force-based Fiber
Material: 181.64 in
Connection: 100.50 in

Brace Length, L: 100.50 in
Number of Sub-Elements, ne: 4
Number of Integration Points, NIP: 5
Camber: 0.200 %
Sub-File Distribution: distributed
Integration Method: Gauss-Lobatto
Camber Shape: endcap perturbation

Output
Displaced Shape
current = 12.03 in
Hysteretic Response
Axial Force Diagram
Moment Diagram
Applied Displacement History

Experiment: -0.61 in -24.03 kips Simulation: -0.62 in -51.60 kips

Analyze **Round** **Reset** **Exit**

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Earthquake Versus Wind

Input Forces

Earthquake: Input Motion: Scale Factor: 1 **Add**

Wind: ASCE 7 Exposure Category: B Gust Wind Speed (mph): 97.3 seed: 100

Fundamental Period: 2.09 sec

Building Properties

Number Floors: 5
Building Weight: 500
Shape: Square
Height: 720 in Width: 720 in
Drag Coefficient: 1.3
Story Stiffness: 31.54
Damping Ratio: 0.05
 Include PDelta

Weight	Height	K	Fy	b	zeta
1	100	144	31.54	1e+100	0.05
2	100	144	31.54	1e+100	0.05
3	100	144	31.54	1e+100	0.05

Current Disp: -0.00 in Current Disp: -0.00 in
Max Disp: 7.46 in Max Disp: 5.06 in

Current Time: 0.00 sec

Run **Stop** **Exit**

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Braced Frame Modeling

Input
Experiment: TC873_WBX28.pgm **Add Experiment**

Element Section Material Connection
Element: 1
Section: Force-based Fiber
Material: 181.64 in
Connection: 100.50 in

Brace Length, L: 100.50 in
Number of Sub-Elements, ne: 4
Number of Integration Points, NIP: 5
Camber: 0.200 %
Sub-File Distribution: distributed
Integration Method: Gauss-Lobatto
Camber Shape: endcap perturbation

Output
Displaced Shape
current = 12.03 in
Hysteretic Response
Axial Force Diagram
Moment Diagram
Applied Displacement History

Experiment: -0.61 in -24.03 kips Simulation: -0.62 in -51.60 kips

Analyze **Round** **Reset** **Exit**

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How to Collaborate

- Use The tools and provide feedback
- If there are additional features that exist in existing software you would like to see added let us know
- If you want to as part of your research incorporate your work into our tools we can work with you (letters of collaboration, send students for a visit,....)
- Nominate / volunteer your graduate students and postdocs to participate in the early researcher webinar series..
- Few Spots in Summer Programming Bootcamp still open .. Send your student or come learn to program yourself!
- State-of-the-Art Report: Version 2.0 .. Don't agree or want to add to the existing state-of-the-art report get in touch.
- Follow us on [Twitter](#), [Facebook](#), and on our [website](#)
- Feedback is essential: email, tool surveys, tool slack channels

Some Noteworthy Metrics

- **5 Research Tools and 4 Educational Apps released.**
- ~750 downloads of our tools in the last seven months.
- 2 Testbeds released that demonstrate earthquake capabilities of rWHALE.
- 19 webinars hosted.
- More than 5,000 cumulative online views of our webinars.
- More than 1,000 downloads of our State-of-the-Art Report.
- Letter of Collaboration requests: >1 per month.
- 172 subscribers to our email newsletter (65% open rate).
- Twitter has 131 followers and had 9,600 impressions in the last 28 days.