



# Introduction to SimCenter

**Frank McKenna**  
University of California, Berkeley



NSF award: CMMI 1612843

# Outline

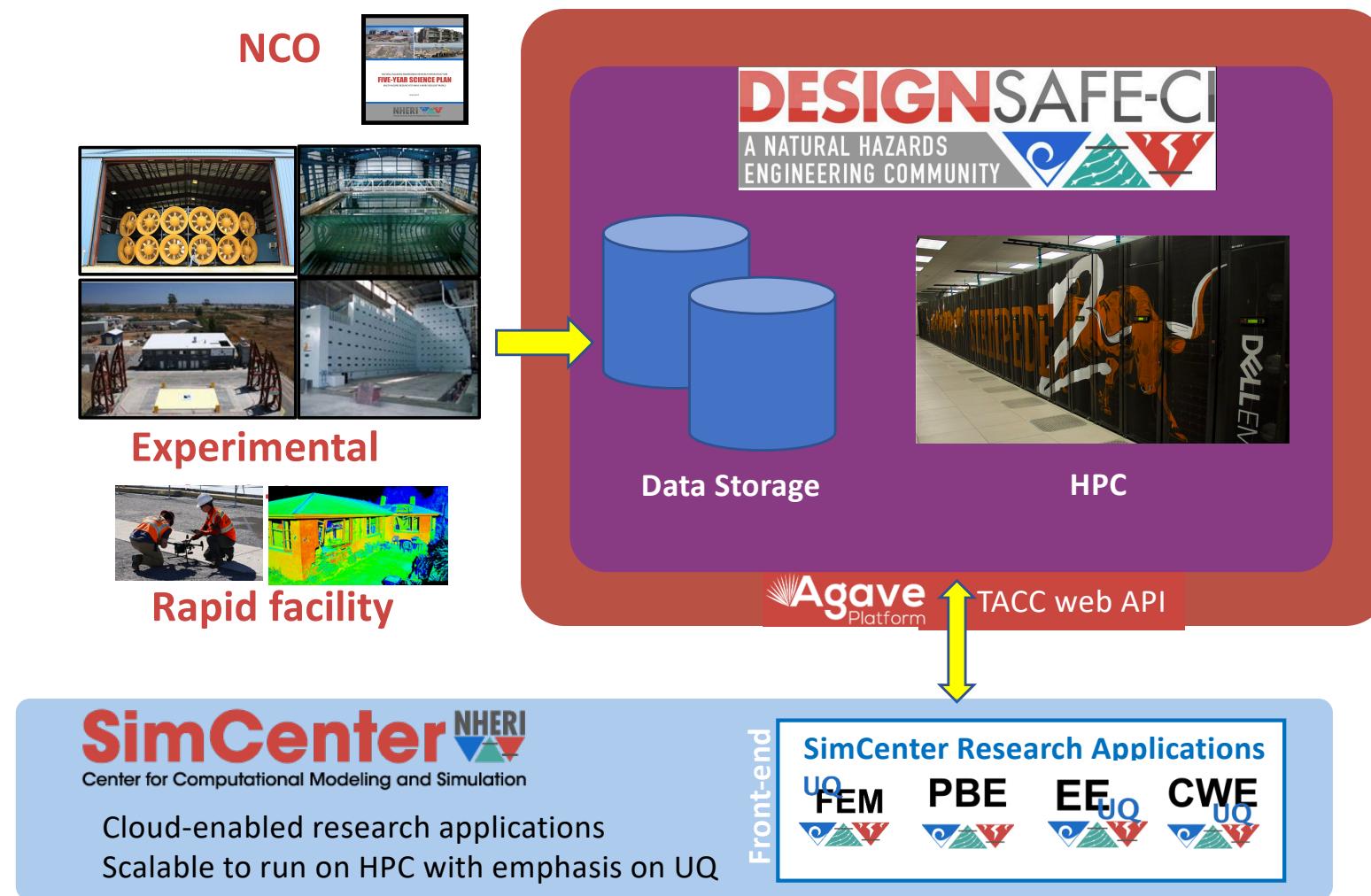
Introduction to SimCenter

Research Applications

Education & Outreach

# NSF NHERI

(Natural Hazards Engineering Research Infrastructure)



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

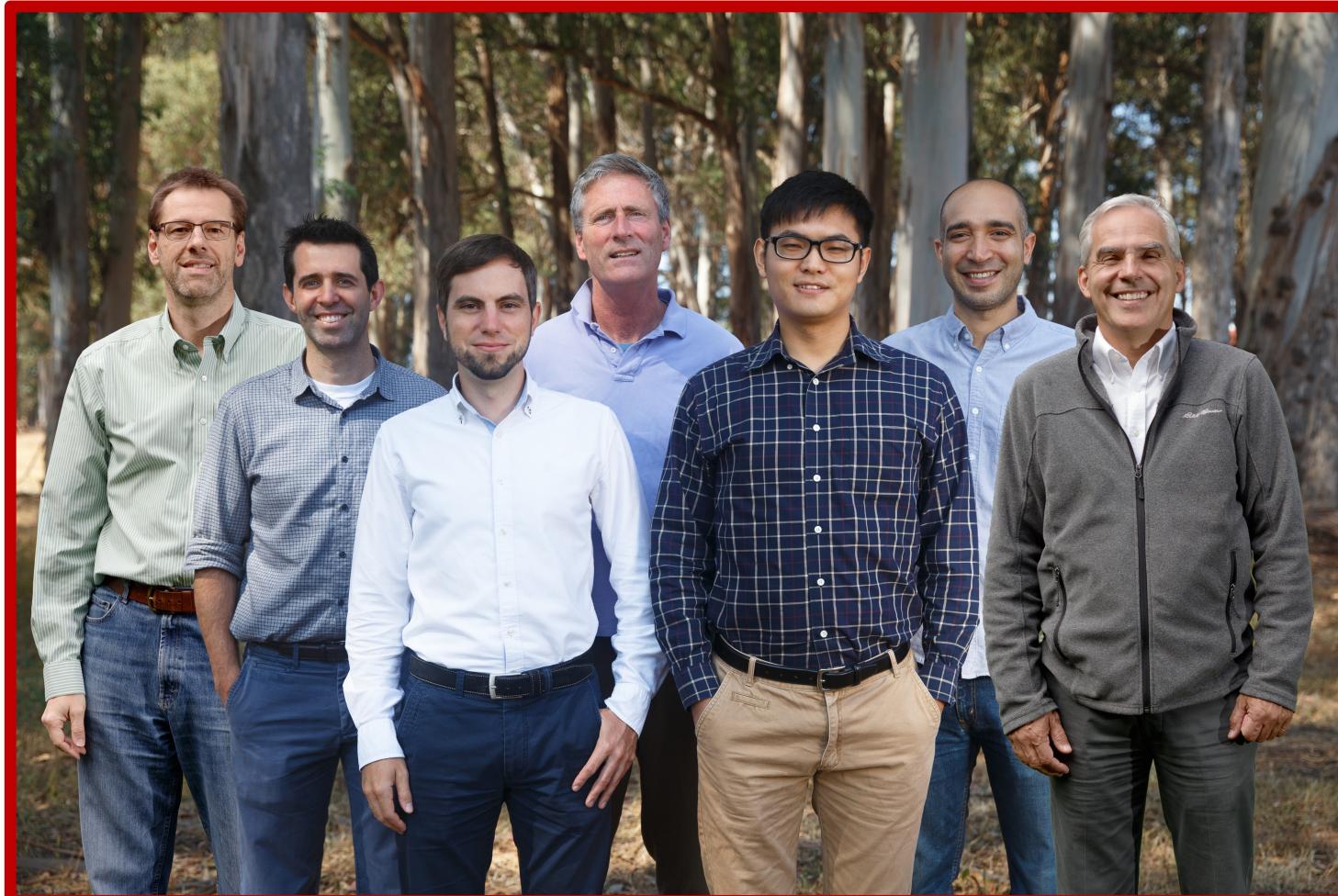


**Frank McKenna**  
UC Berkeley



**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

# Outline

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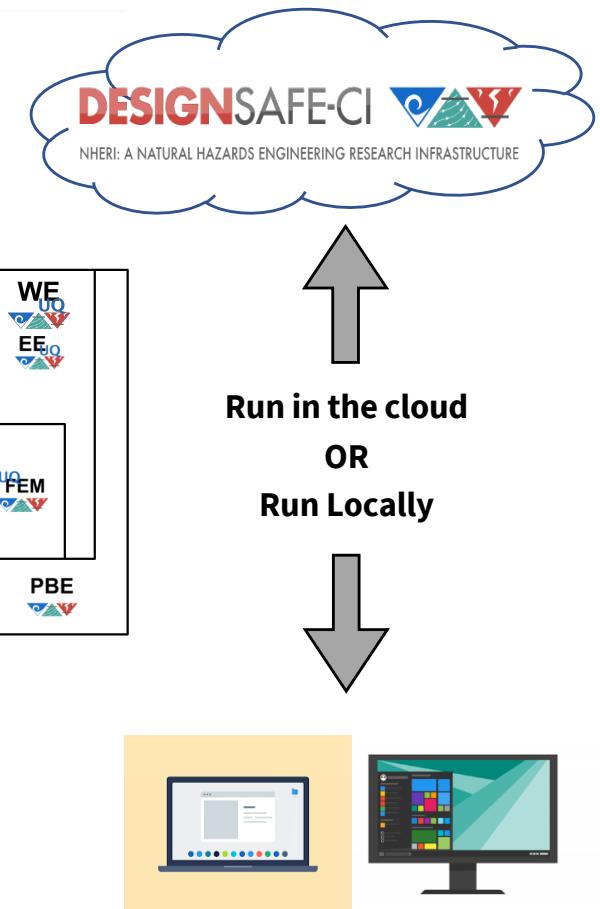
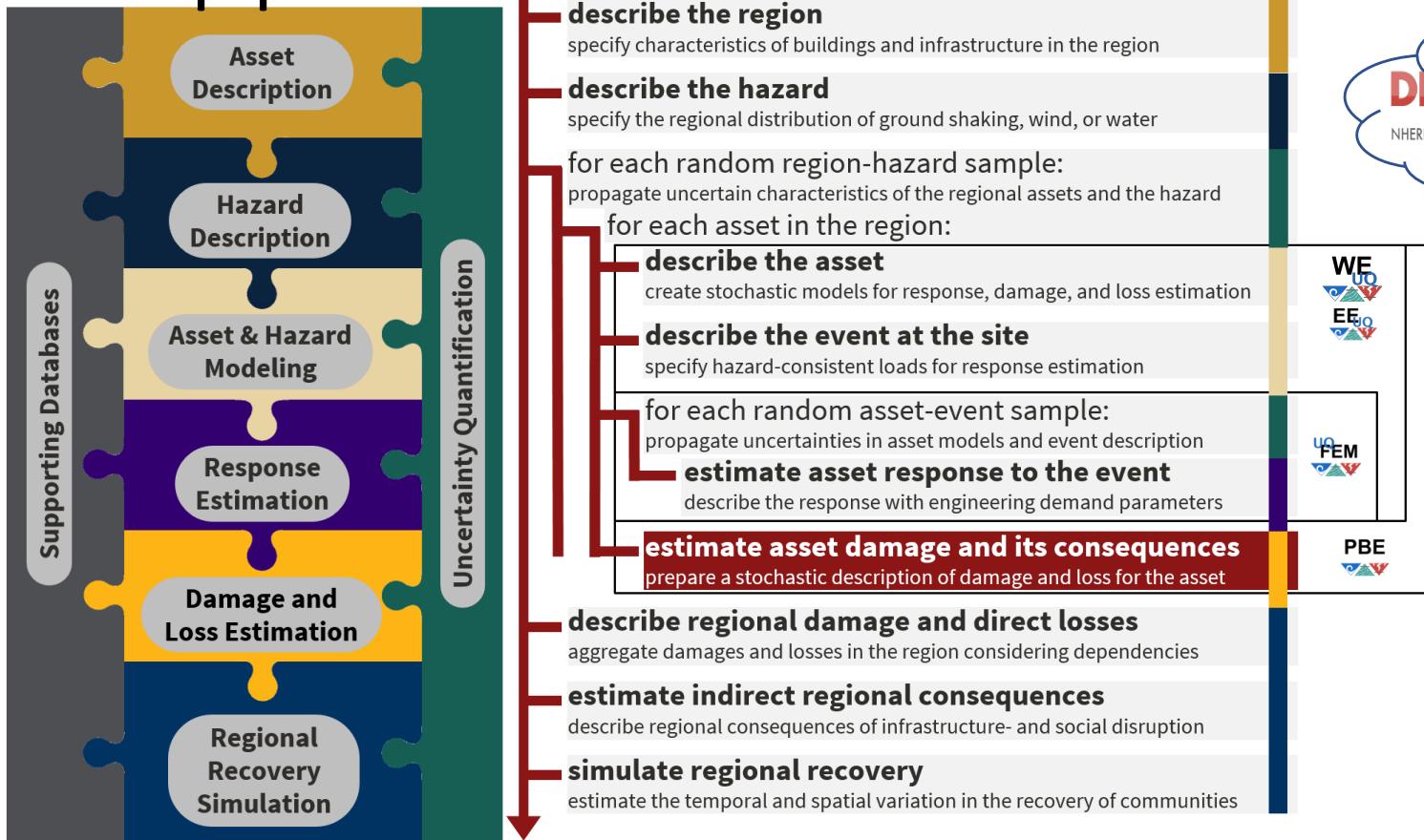
Education & Outreach

# SimCenter Mandate

To produce Extensible Software Researchers in Natural Hazards Engineering can use in their research

- Develop an **open-source computational framework** for **building workflow applications** 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.

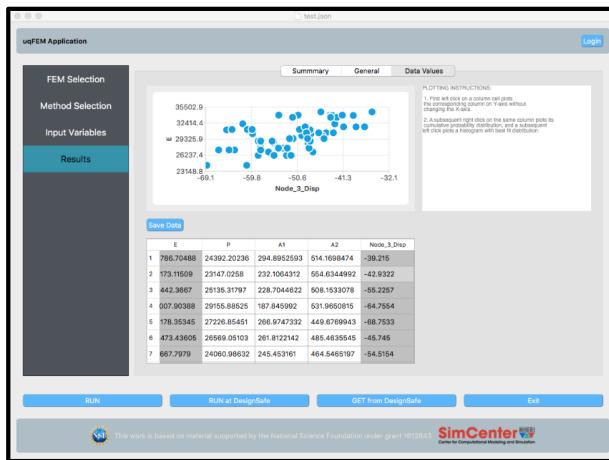
# Framework for Building Workflow Applications



# Some Released Software For Looking at Effect of Hazard At Individual Building Level



# (to be renamed quoFEM)



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

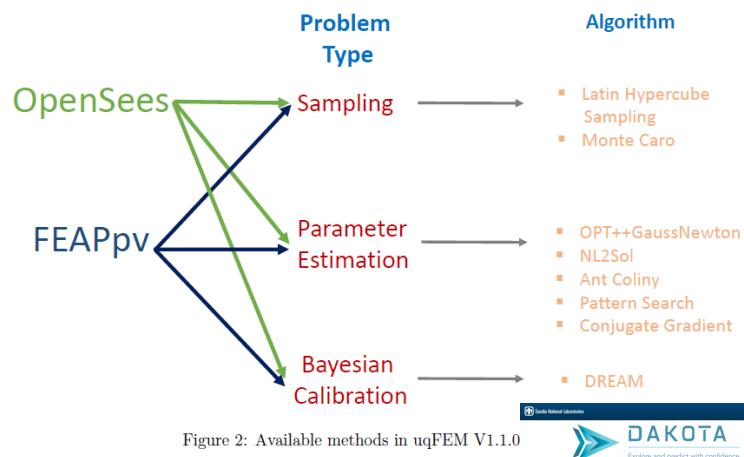


Figure 2: Available methods in uqFEM V1.1.0

## 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

## Future Release V2.0 (Sept 2019)

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



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

**Frank McKenna, Wael Elhaddad,  
Charles Wang & Michael Gardner**

## 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

## Future Releases

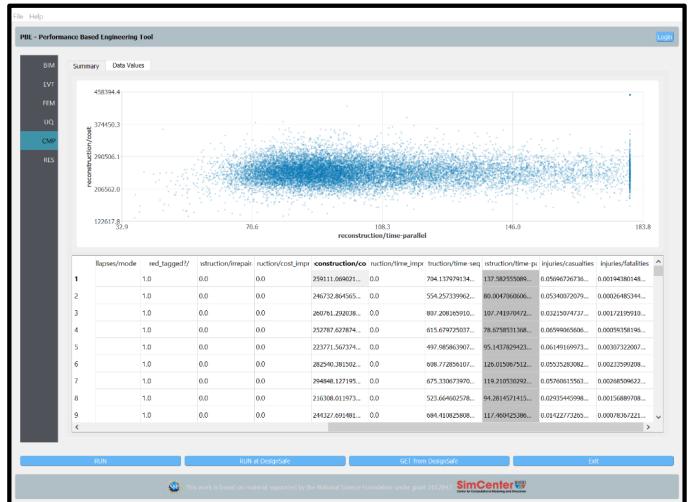
### V1.2 (June 2019)

- 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

# PBE



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

## 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



WE-UQ: Wind Engineering with Uncertainty Quantification

Login

GI  
SIM  
**EVT**  
FEM  
UQ  
EDP  
RES

Loading Type : DEDM\_HRP

**DEDM-HRP : Inputs**

Wind Tunnel Building Geometry



Building Height: H=1 (selected), H=2, H=3, H=4, H=5

Exposure Condition: Urban/Suburban Area (selected), Open Terrain

Wind Speed and Duration

Mean Wind Velocity at Building Top: 100.0 mph

Duration: 10 min

RUN RUN at DesignSafe GET from DesignSafe Exit

This work is based on material supported by the National Science Foundation under grant 1612843 SimCenter Center for Computational Modeling and Simulation

## 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

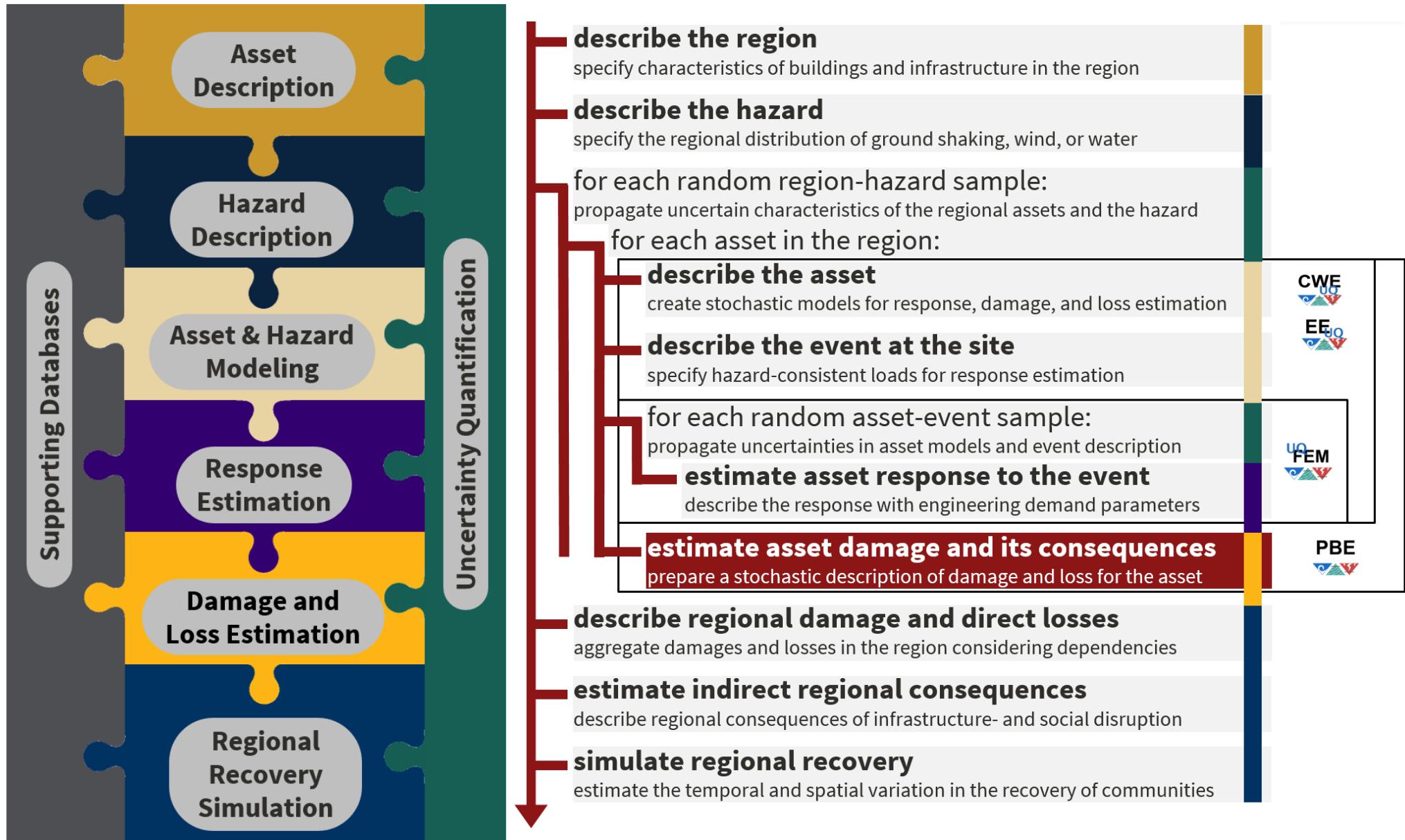
Kareem, Kennedy, Motley & Taflanidis  
Frank McKenna, Peter Mackenzie-Helnwein,  
Jiawei Wan, Wael Elhaddad, Charles Wang &  
Michael Gardner

# Major Upcoming Applications (within next year)

**RDT**



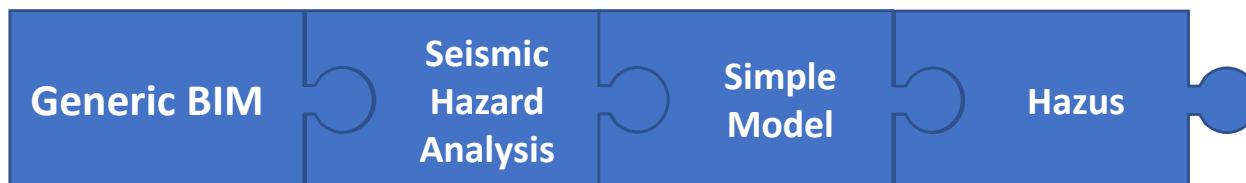
# Resiliency Decision Tool



# 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

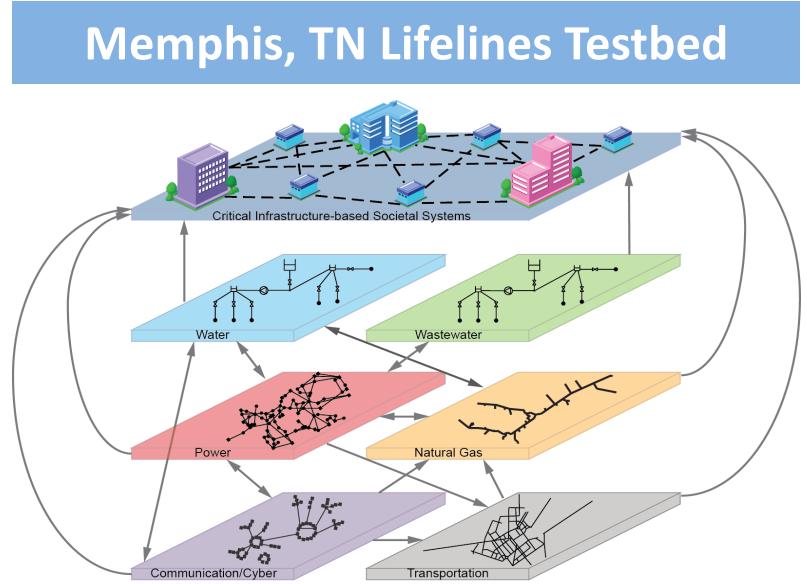
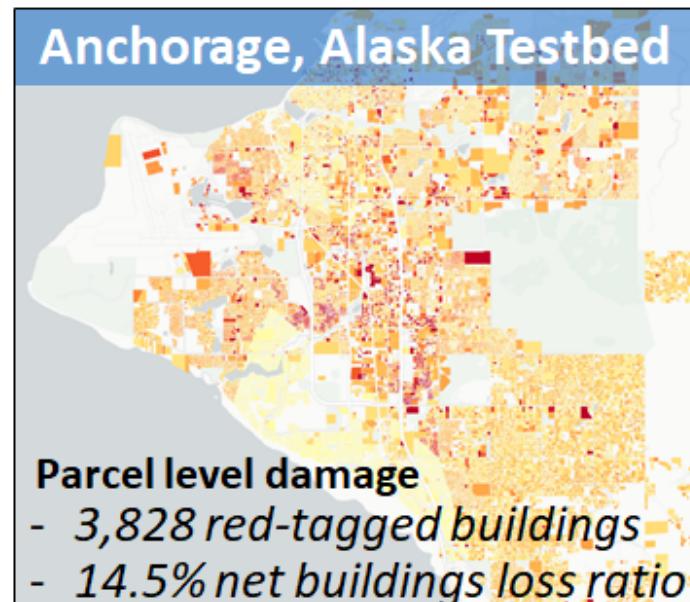
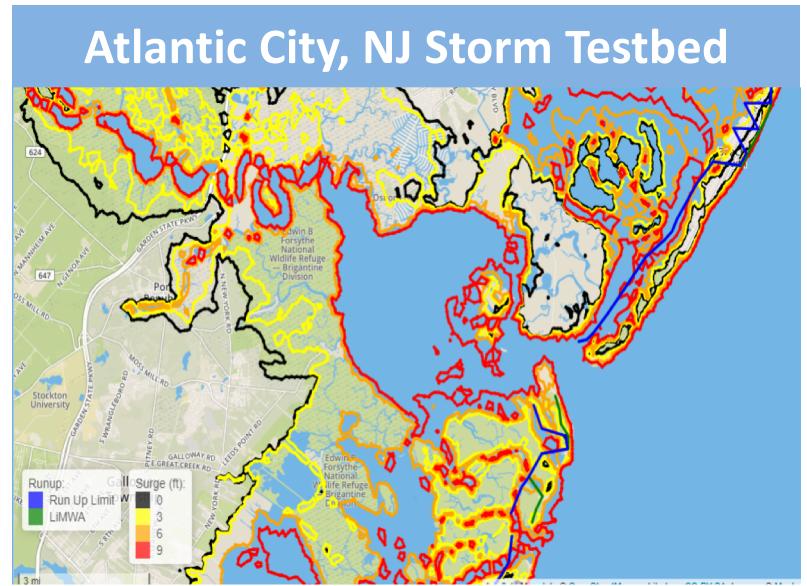
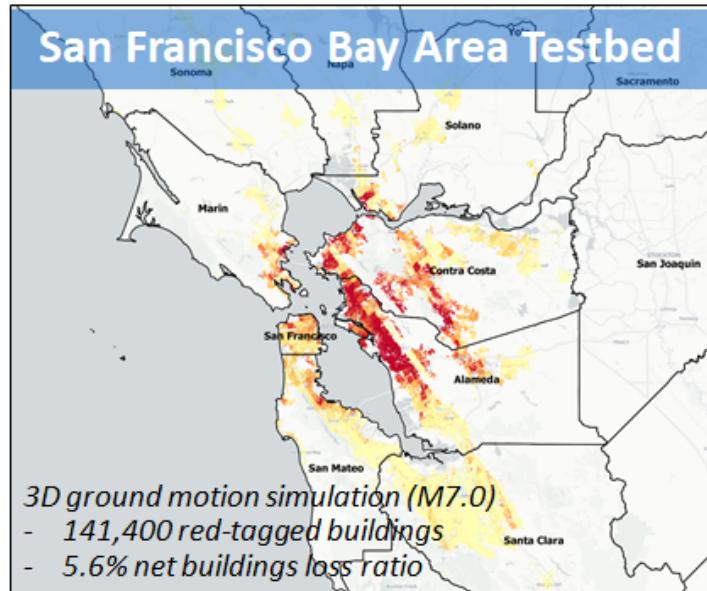


**Future Release V2.0 (Sept 2019)**

- 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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# SimCenter ECO Activities

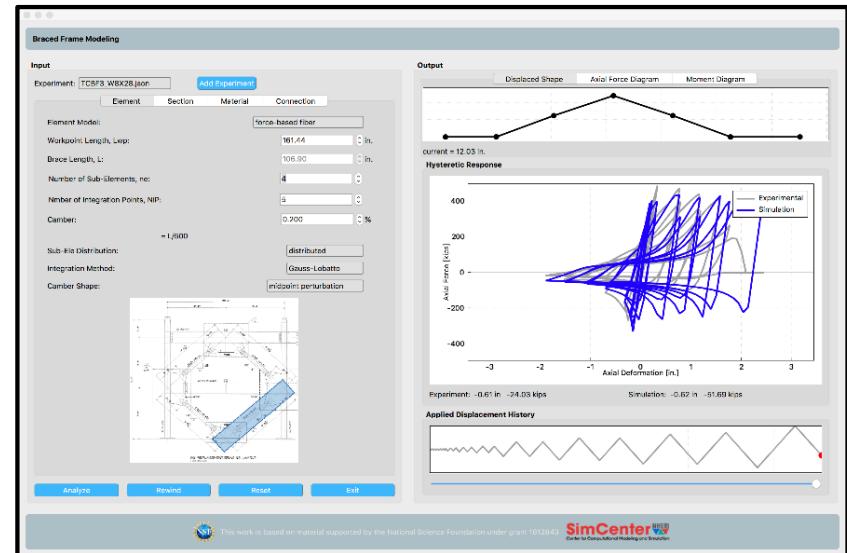
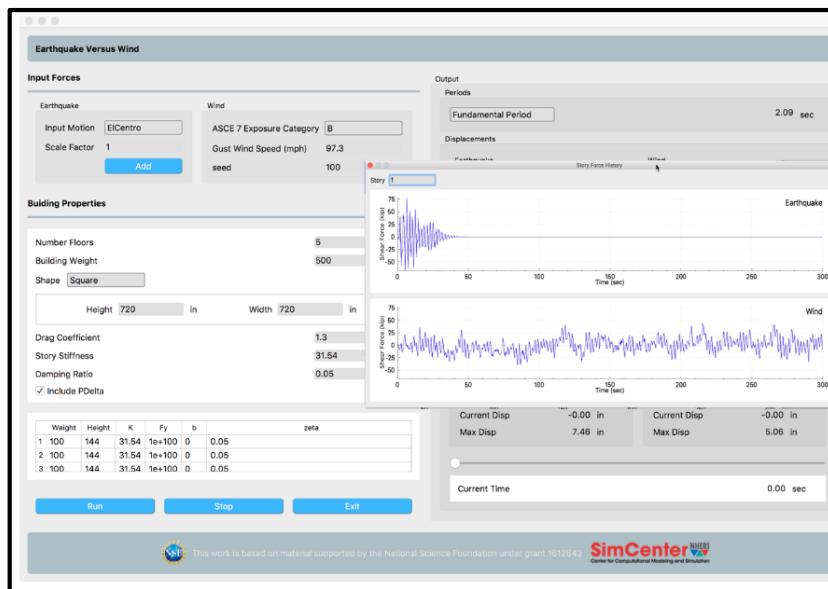
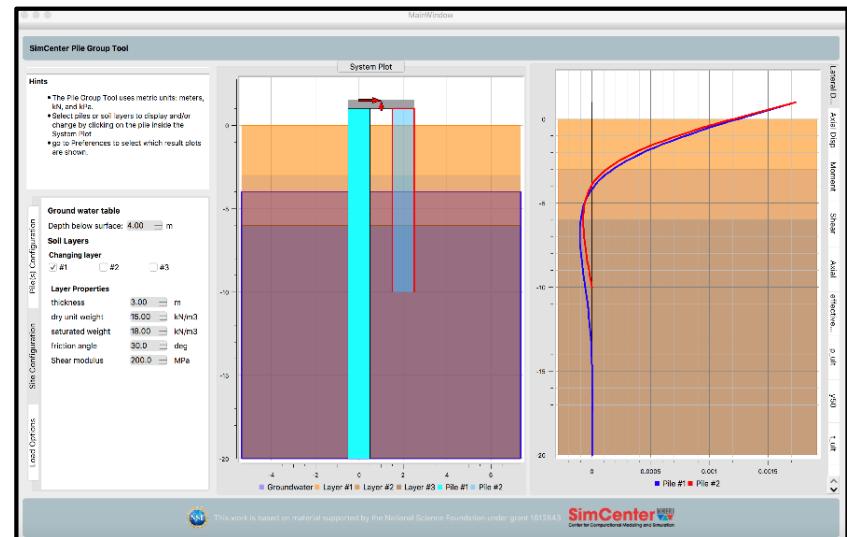
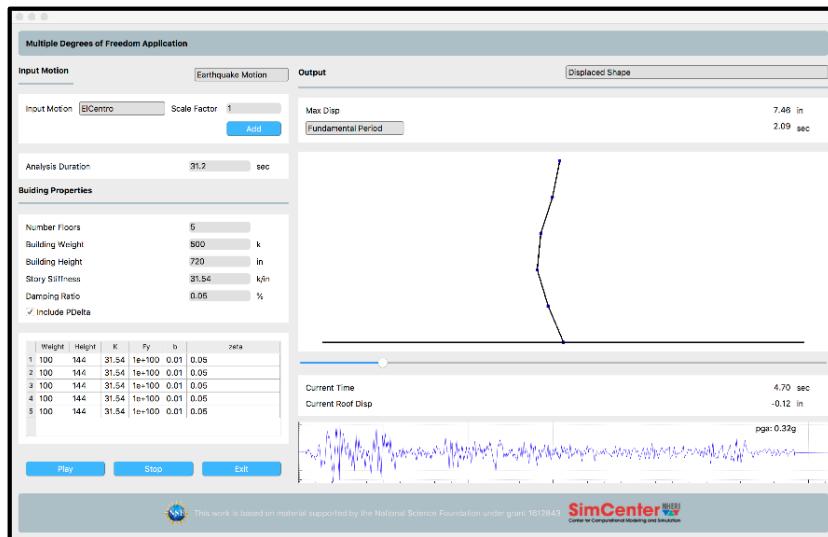
- Training
  - Online Webinars
  - Workshops
    - Tool Training
    - Programming Bootcamp
  - NHERI Summer REU Program
  - State-of-the-Art Report
- Education
  - Educational App's
- Learn about the SimCenter
  - NHERI Summer Institute
  - Subscribe to SimCenter news and join Slack channels  
<https://simcenter.designsafe-ci.org/join-community/>

# 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)



# 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.