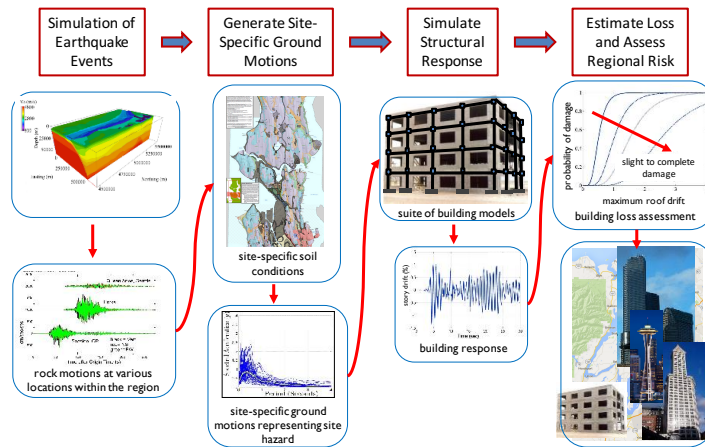


Breakout Goals and Format

- Overview of the Regional Testbed (w/Q&A)
 - concept and supporting software tools
 - testbed applications
- Discussion Points
 - testbed applications



Performance-Based Engineering



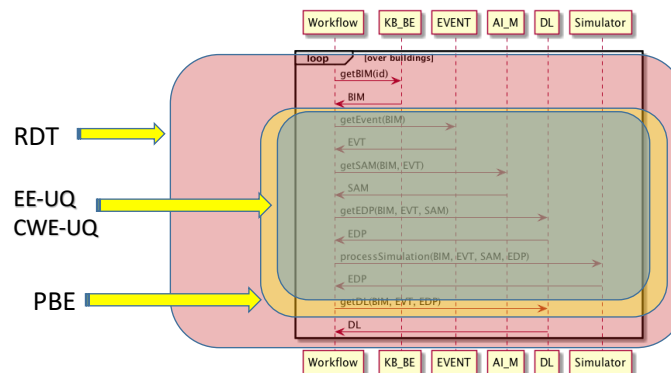
Software Components and Workflows for Regional PBE Simulations

Earth Scientists Str/Geo Engineers Loss & System Modelers Social Scientists

2

Real Importance of Testbed Workflows?

- They Test the Interfaces of Framework for the Different hazards
- They Provide Seed Data & Example Applications
- Demonstrate Flexibility & Extensibility of Framework
- Foster Collaboration
- Provide Code For Research Applications



3



Tool to Predict the Response of a Building to an Earthquake Event

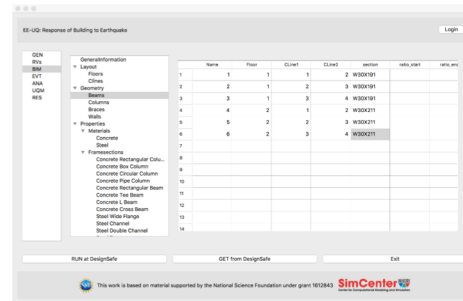
- User Inputs Building Information
- User Selects from different loading options & Inputs Parameters
- User Specifies RV distributions
- The tool when run will auto generate the analysis model, run a set of deterministic simulations on DesignSafe.
- User selects run & views different output results.

Release Dates:

- V1.0 (June 2018) Uniform Excitation + Moment Frame
- V2.0 (Sept 2018) Rock Outcrop motions
- V3.0 (2019) Soil Box around Building

Research Opportunities:

- Different applications for creating the finite element models and the hazard, applications for UQ including surrogate model generation.
- Data Sets for Model Calibration



PBE Tool to Predict the Damage & Loss to a Building given some Hazard Event



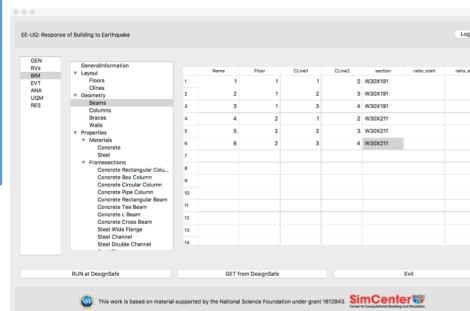
- User Inputs Building Information
 - Structural & Contents
- User Selects from different loading options & Inputs Parameters
- User Specifies RV distributions
- The tool when run will auto generate the analysis model, run a set of deterministic simulations and use Pact or equivalent to generate D&L all on DesignSafe
- User selects run & views different output results.

Release Dates:

- V1.0 (Sept 2018) Earthquake
- V2.0 (2020) Wind
- V3.0 (2021) Water

Research Opportunities:

- In addition to modeling & hazards, different applications for calculating damage & loss
- Validated data for different fragility and loss curves.





Tool to Evaluate Regional Resiliency

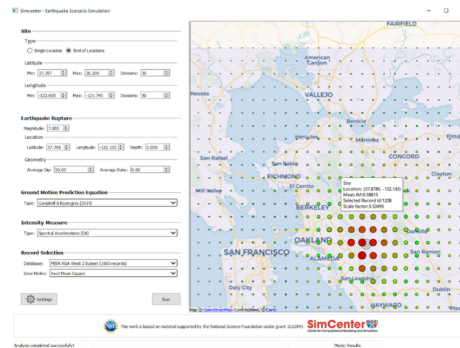
- User Interface allowing users to create a regional event simulation
- User Selects Region, Event, and different applications to use in the workflow.

Release Dates:

- V1.0 (2020) Earthquake
- V2.0 (2021) Wind
- V3.0 (2022) Water

Research Opportunities - Applications :

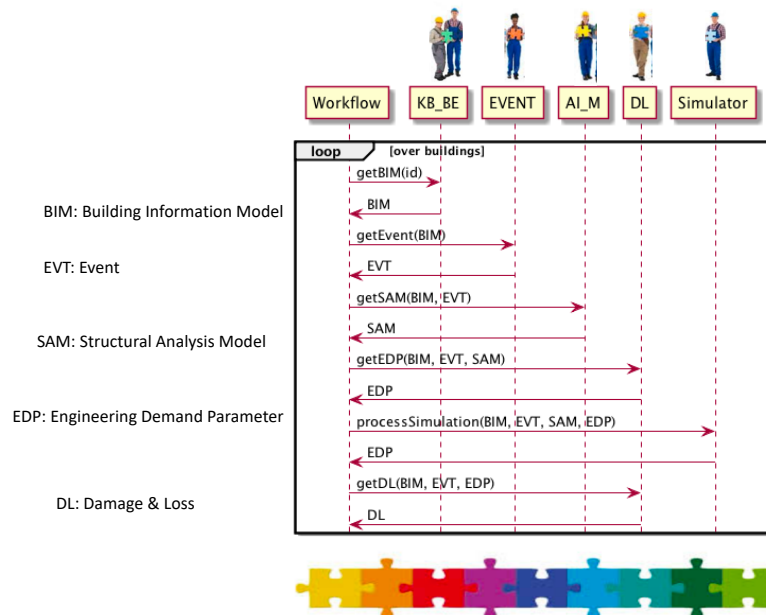
- Applications for multi-scale regional hazard,
- AI applications for generating building info from variety of data sources (e.g. google street view, GIS databases)
- Applications creating BIM models(e.g. provide canonical buildings from a database)
- Applications for D&L calculation,
- **Integration of Applications for Recovery after event**



Research Opportunities – Curated Databases :

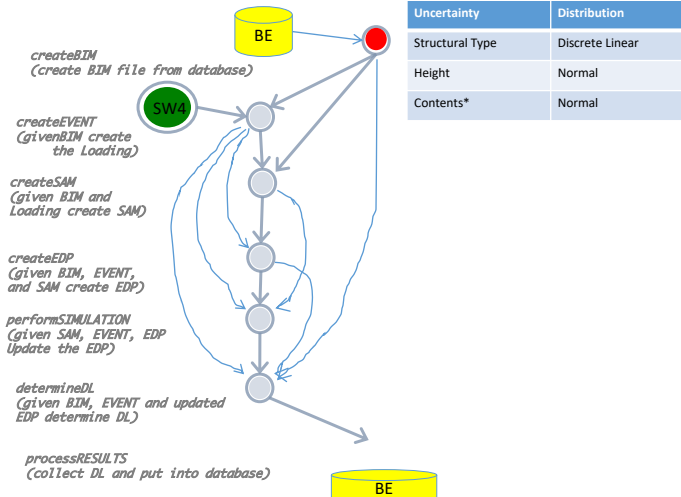
- Buildings
- Building Inventories
- Fragility and Loss Functions
- Functions for recovery

Sequence Diagram for Workflow:



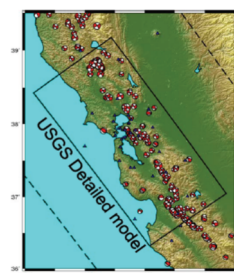
Data input and propagation in Workflow:

Uncertainties: createBIM

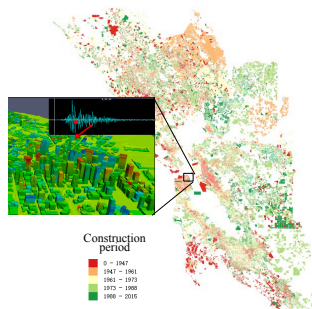


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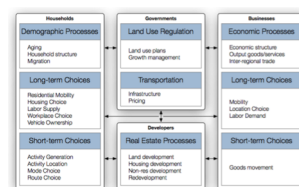
PBE Regional End-to-End Testbed



M7.0 Hayward Fault



1.8 million buildings in SF Bay Area



Policy/Planning decision support:
building losses & downtime in
2010 and 2040

Objective: develop and exercise a workflow to connect software models and systems on a challenging computational model that engages a broad cross-section of NEHRI community

Ground Motions: 3D simulation, GM's at 2km grid (Rodgers, Pitarka & Petersson)

Building Inventory: UrbanSim and DataSF Portal; geometry, age, occupancy

Building Analyses: OpenSees, simplified NL MDOF, FEMA P58 (w/Cheng & Lu, Tsinghua)

Visualization: UrbanSim and 3d Urban Polygon Modeling (Xiong et al., 2015)

Interpretation: UrbanSim; urban growth, damage/loss, displaced occupants/population



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J. Baker

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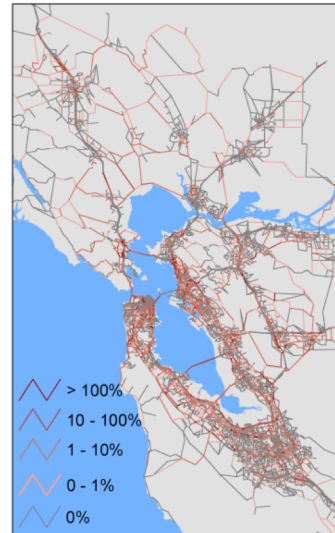
Impact on Regional Transportation Systems

We consider the network state one week after an earthquake

Transit model from the Metropolitan Transportation Commission

- Variable travel demand
- Population represented by agents with trip preferences
- **6+ hours to analyze network and behavior for one simulation**

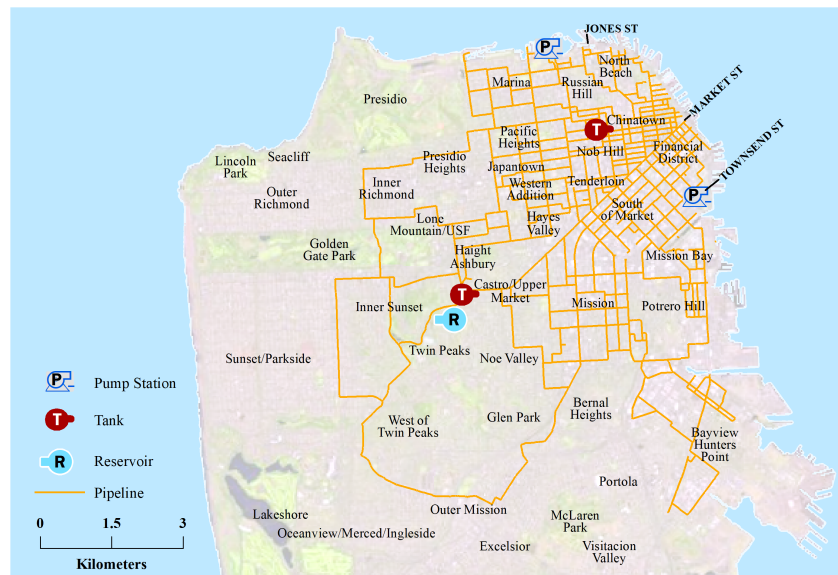
Travel time increase



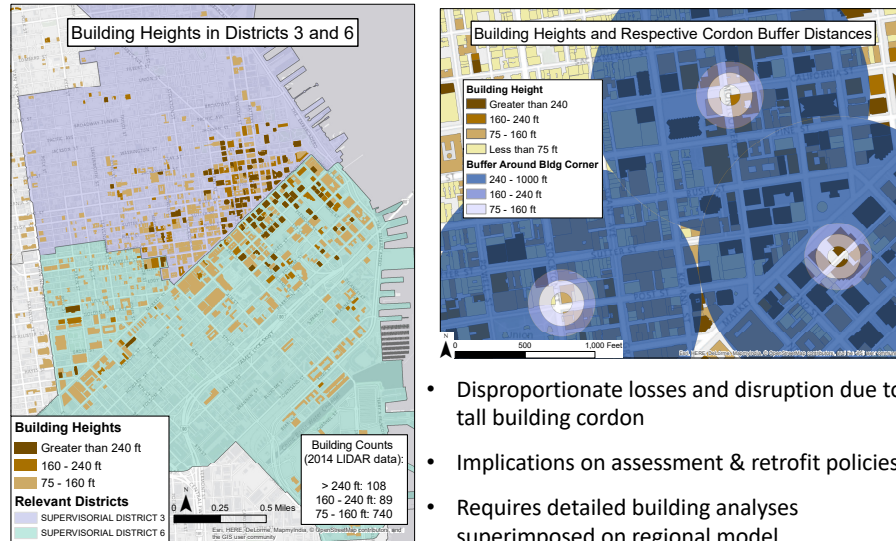
J. Baker

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Auxiliary Water Supply System (AWSS) of San Francisco



Tall Building – Downtown SF



- Disproportionate losses and disruption due to tall building cordon
- Implications on assessment & retrofit policies
- Requires detailed building analyses superimposed on regional model

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Desirable Attributes for a “Use Case”

1. Address an interesting and challenging problem!
2. Use a broad range of domain applications
 - hazard (OpenSHA, PEER NGA), scenario-based events (SCEC BBP)
 - structural analysis, soil-structure interaction, continuum FE, CFD (OpenSees, OpenFoam)
 - uncertainty quantification (Dakota)
 - loss assessment (PACT, OpenSLAT ... new OpenSource OOP Tool)
3. Enable coupling with other disciplines/groups in future
 - bridge network fragilities + freight traffic for post-disaster econ recovery
 - water storage & distribution fragilities + first responders
 - building fragilities + USGS ShakeMap for rapid post-event assessment
4. Engage a broad group of researchers
 - what proposals are being submitted to NSF?
5. Facilitate the development of inventories
 - Data harvesting
 - Knowledge bases and samples to train AI
 - Automated/semi-automated generation of models
 - User-built model repositories



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PBE Regional Systems – Illustrative Use Cases

- EQ Scenarios
 - Accessibility to Transportation
 - Retrofit Prioritization for SF Water System
 - Tall Building Impacts (red-tagging, cordoning, aftershocks)
 - Large buried water reservoirs
- Interdependent power, water, and gas networks
- Hurricane – winds/storm surge
 - Needs and risks for sheltering in place (schools/critical facilities)
 - Desired level of reliability under normal and stressed conditions
 - Identifying key vulnerabilities (where to harden)
 - Inform development of effective post-disaster recovery plans
 - Assess post-event demand/labor shortages for recovery
- Insurance – live catastrophe response/assessment and planning/prediction (OASIS framework)



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PBE Regional Systems – Future Plans

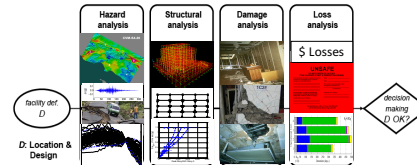
- **Year 1:**
 - Defined and implemented end-to-end simulation of SF Bay Area EQ scenario into UrbanSim (w/urban growth model)
- **Year 2:**
 - Complete/distribute end-to-end SF Bay Area EQ simulation, including UQ modeling of building response and losses
 - Researcher engagement (webinars, meetings, NHERI site visits)
 - Explore incorporation of transportation and water network into regional workflow to UrbanSim
 - Develop plan for wind/flood regional simulation



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PBE Tools and Workflows at Year 5

PBE Facility Assessment Tool

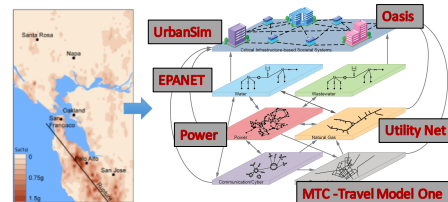


- General Functionality:
 - Earthquake, Storm Surge/Tsunami Inundation, Wind hazards
 - Extensible to other hazards
 - Facilitates mix/matching of modeling and UQ techniques
- OpenSource OOP Implementation
 - Engaged network of research users/developers/contributors
 - Integration with workflows for facility specific and regional assessment
- DesignSafe Data and Knowledge Base Integration
 - Research contributions through published/linked libraries with:
 - archetype buildings
 - validated fragility and loss functions
 - Improved consequence and recovery models
 - benchmarking results

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PBE Tools and Workflows at Year 5

PBE Regional Assessments



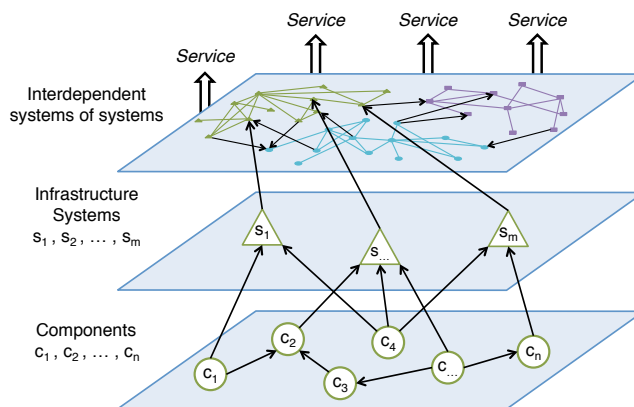
- Hazard Models/Data:
 - Earthquake, Storm Surge/Tsunami Inundation, Wind hazards
 - Empirical – to - Physics Based
 - Integration of multi-scale models
- GIS Inventory Databases:
 - Facilitate development and utilization of curated opensource building and infrastructure databases
 - Integration of physical assets with socio-economic and demographic features
- Knowledge Base and AI Integration:
 - Semi-automated development of inventory and facility assessment models
 - Cross validation of results across models and datasets

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PBE Tools and Workflows at Year 5

Provide a data and workflow architecture that facilitates:

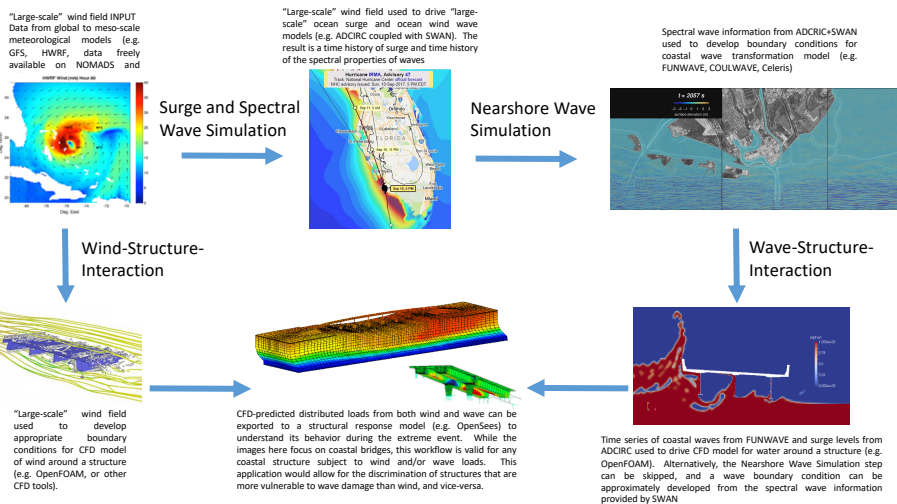
- Integration of individual systems → distributed networks
- Connections, interactions, and interdependencies between systems (Bayesian network models)



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PBE Tools and Workflows at Year 5

Hurricane Wind and Wave Loading on Coastal Infrastructure



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Regional PBE Testbeds

Bring up previous slides:

- a. What do you like?
- b. What is missing?
1. What other software can be used:
 - a. e.g. canonical set of buildings for different # stories
2. How to integrate with lifelines. Include bay area water network
3. What other testbed should we look at?
4. Identification of a new testbed hazard and city
5. Inclusion of lifelines in the bay area seismic simulation
6. User Preferences/Community Building and Information Sharing:
 - a. How could an accessible regional PBE testbed impact your research?
 - b. What would be the first investigation you would conduct using such a testbed?
 - c. What type of training activities do you feel would be most effective in building your capacity to access such a testbed? (e.g. webinars, online office hours, in person workshops, video documentation, written documentation)