SimCenter NHERI

Center for Computational Modeling and Simulation

Performance Based Engineering Application

https://simcenter.designsafe-ci.org/research-tools/pbe-application/

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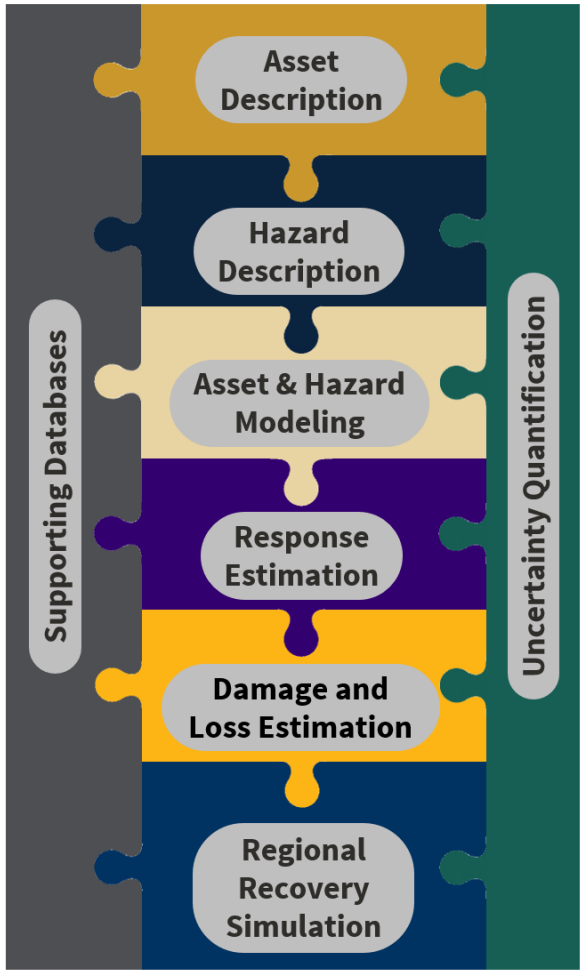
Outline

- **Introduction to the PBE Application and pelicun**
- Simple test examples
- Realistic example
- Limitations, expected new features

What is the PBE Application?

Application Framework



Regional Hazard Workflow

describe the region
specify characteristics of buildings and infrastructure in the region

describe the hazard
specify the regional distribution of ground shaking, wind, or water

for each random region-hazard sample:
propagate uncertain characteristics of the regional assets and the hazard

for each asset in the region:

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CWE
EE
FEM
PBE

Desktop Applications

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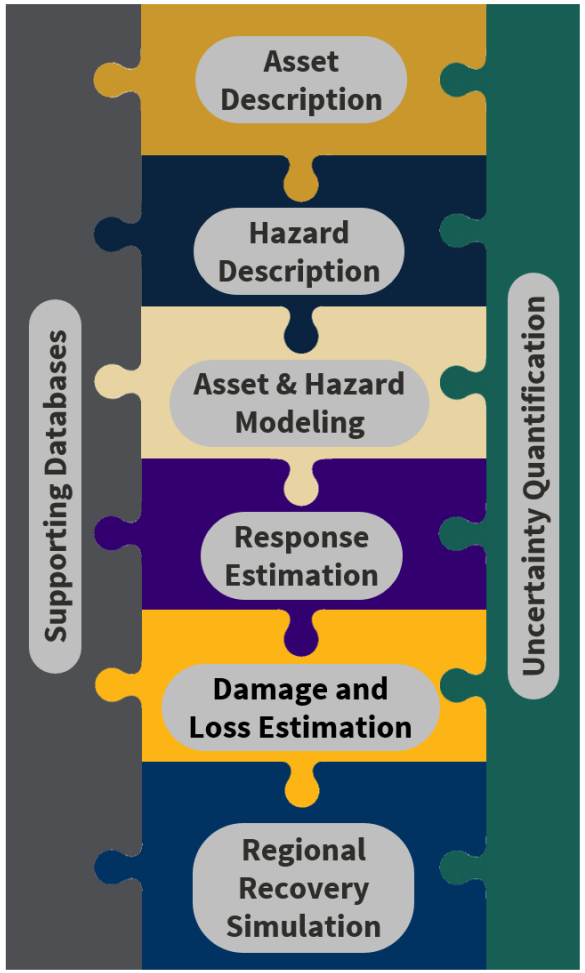

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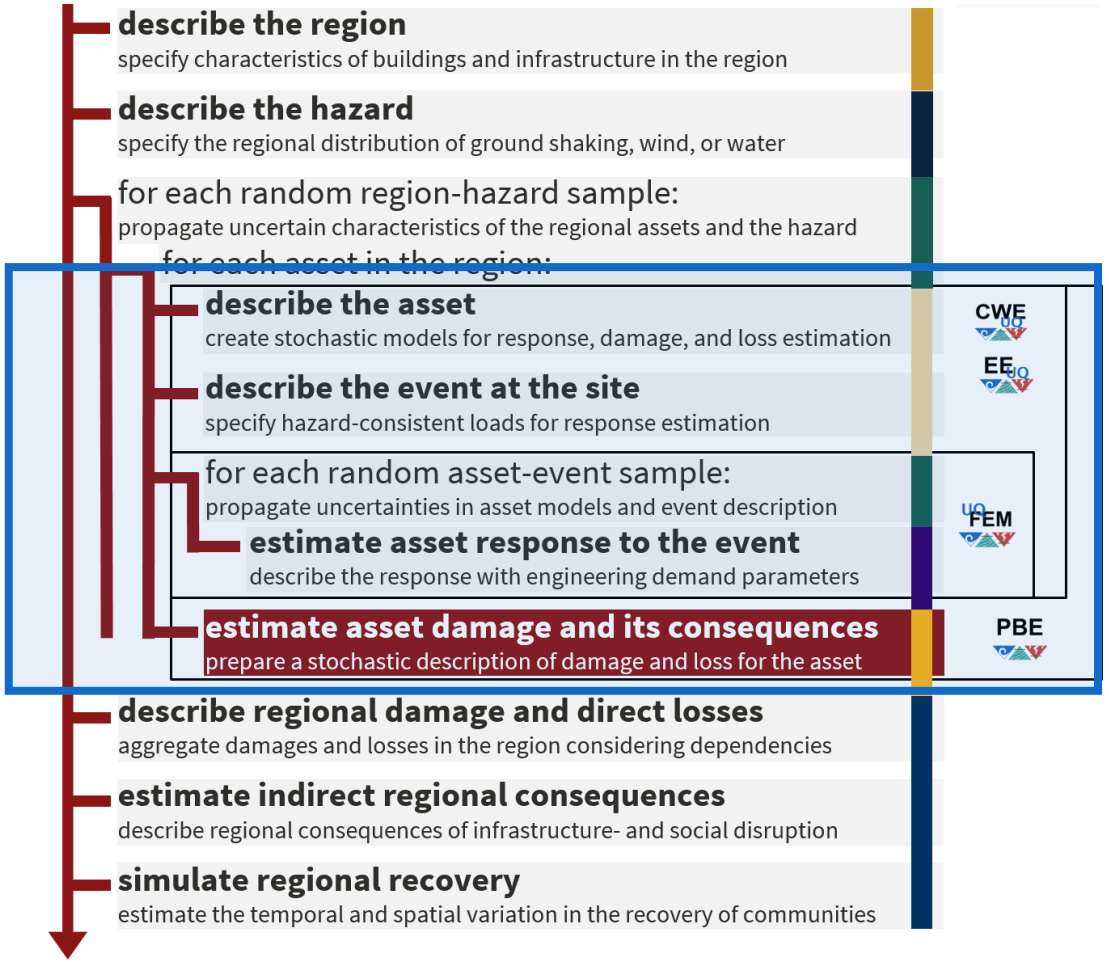

Desktop Applications

Performance Based Engineering Application

Frontend - Desktop Application

Provides a convenient user interface to use the loss assessment workflow for a single building.

Prepares an input file for the backend.

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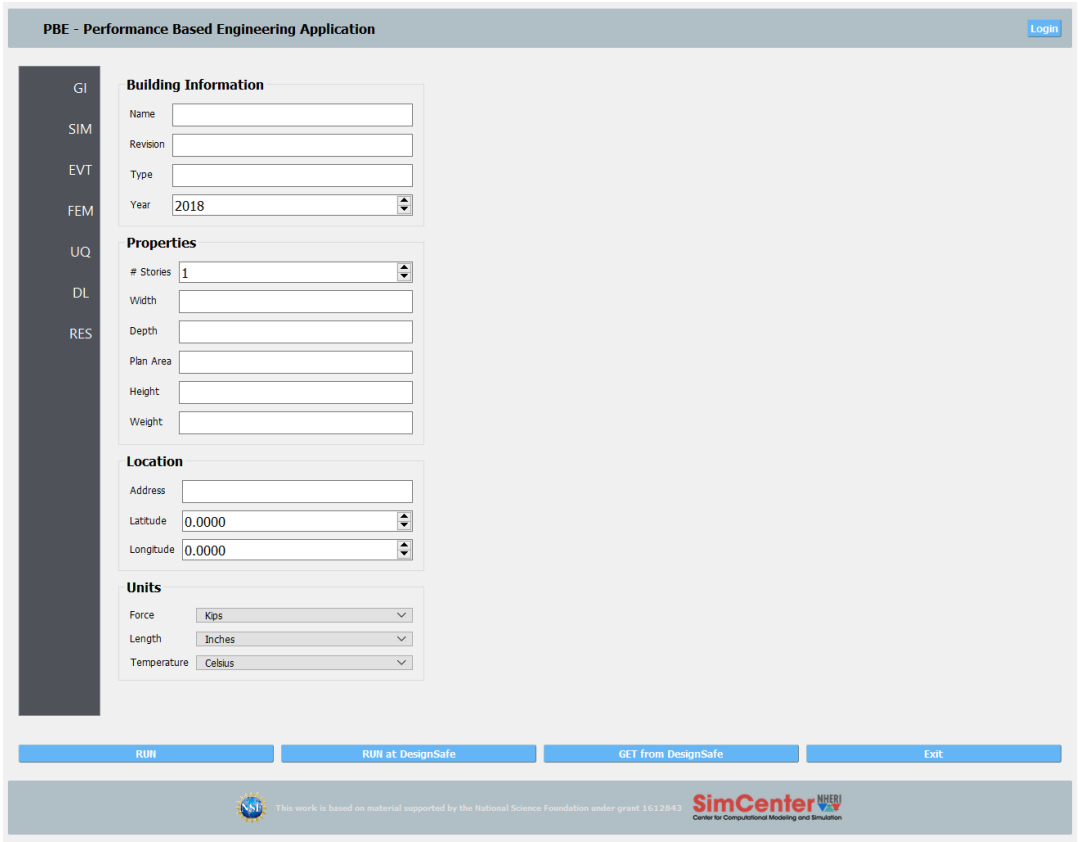

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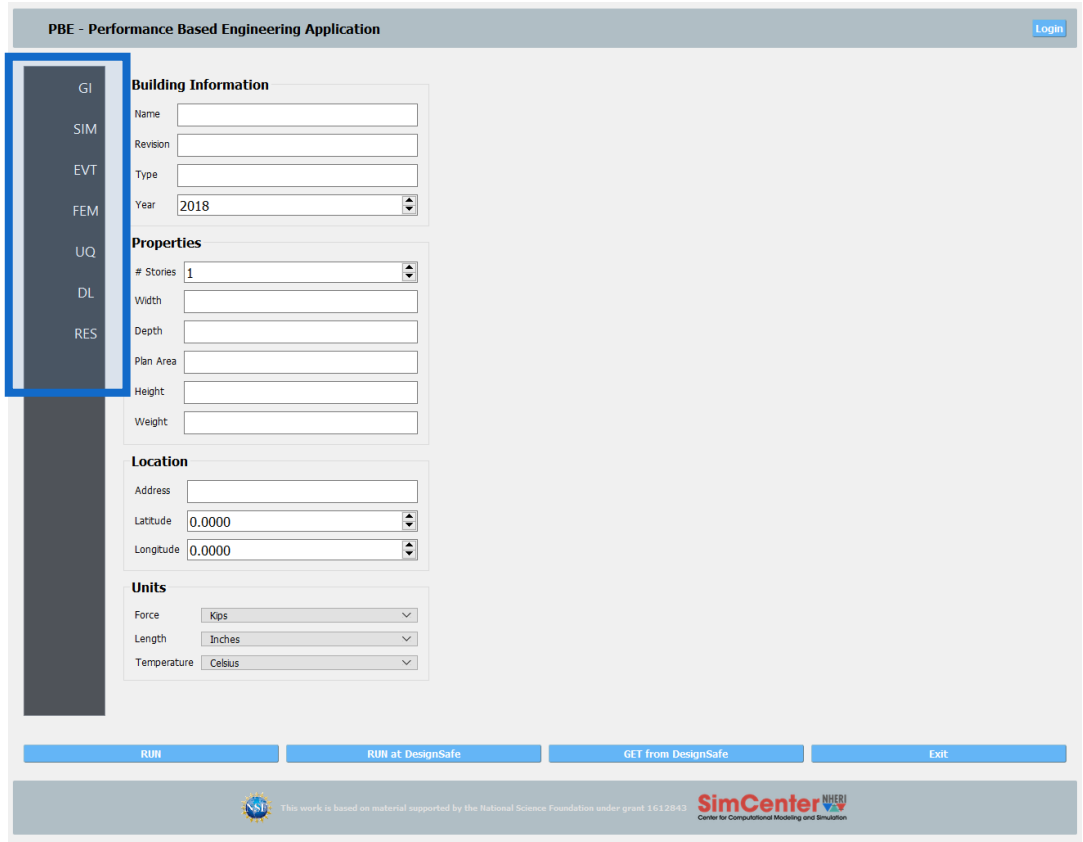

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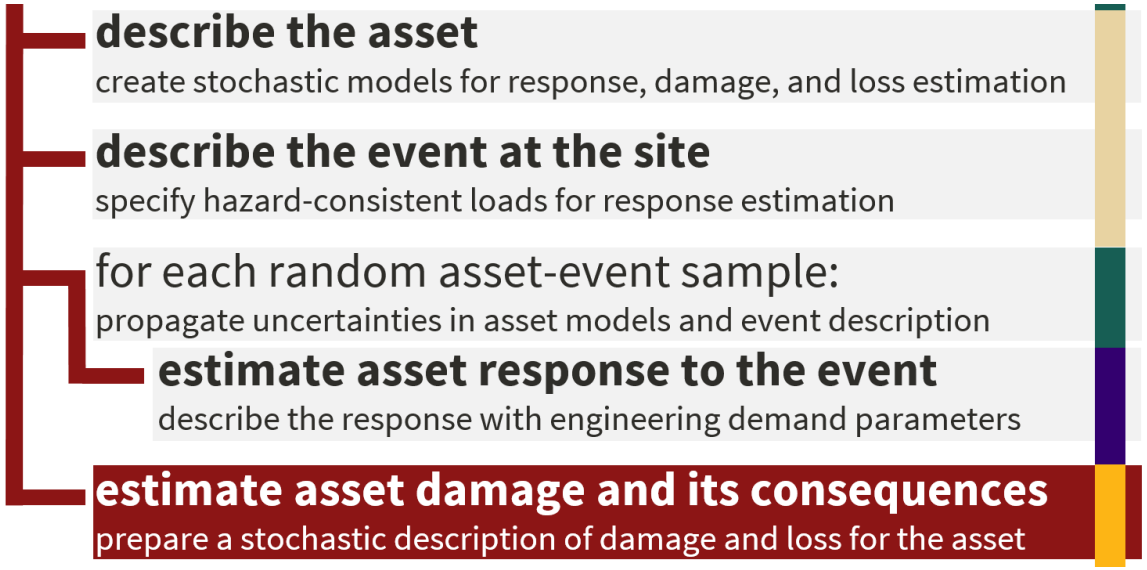


GI	**General Information**
SIM	**Simulation Model**
EVT	**Events = Ground Motions for now**
FEM	**FEM Analysis Options**
UQ	**Uncertainty Quantification**
DL	**Damage and Loss Model**
RES	**Results**

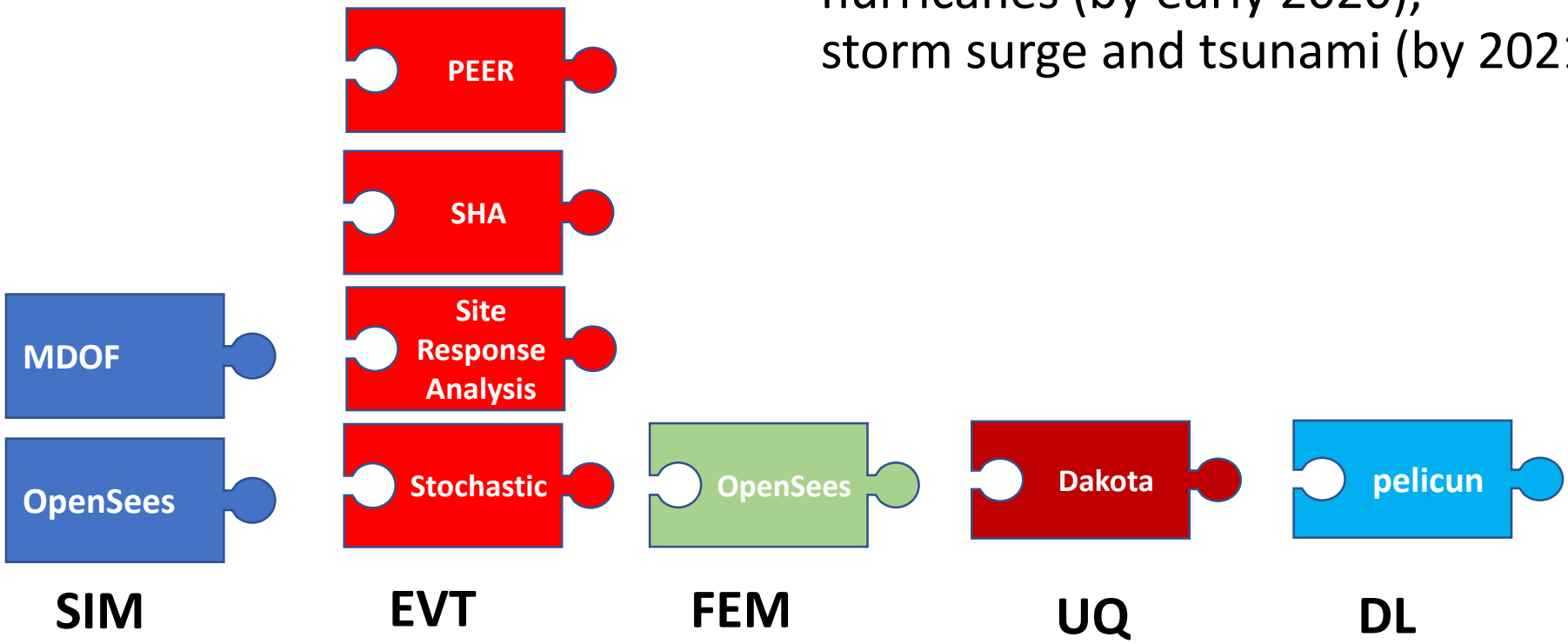
Performance Based Engineering Application

Backend – Workflow (i.e., Python script)

EE-UQ backend extended with loss assessment.

Damage and Loss assessment performed using **pelicun** (https://github.com/NHERI-SimCenter/pelicun)

Hazard-agnostic workflow designed for earthquakes (now),
hurricanes (by early 2020),
storm surge and tsunami (by 2021)



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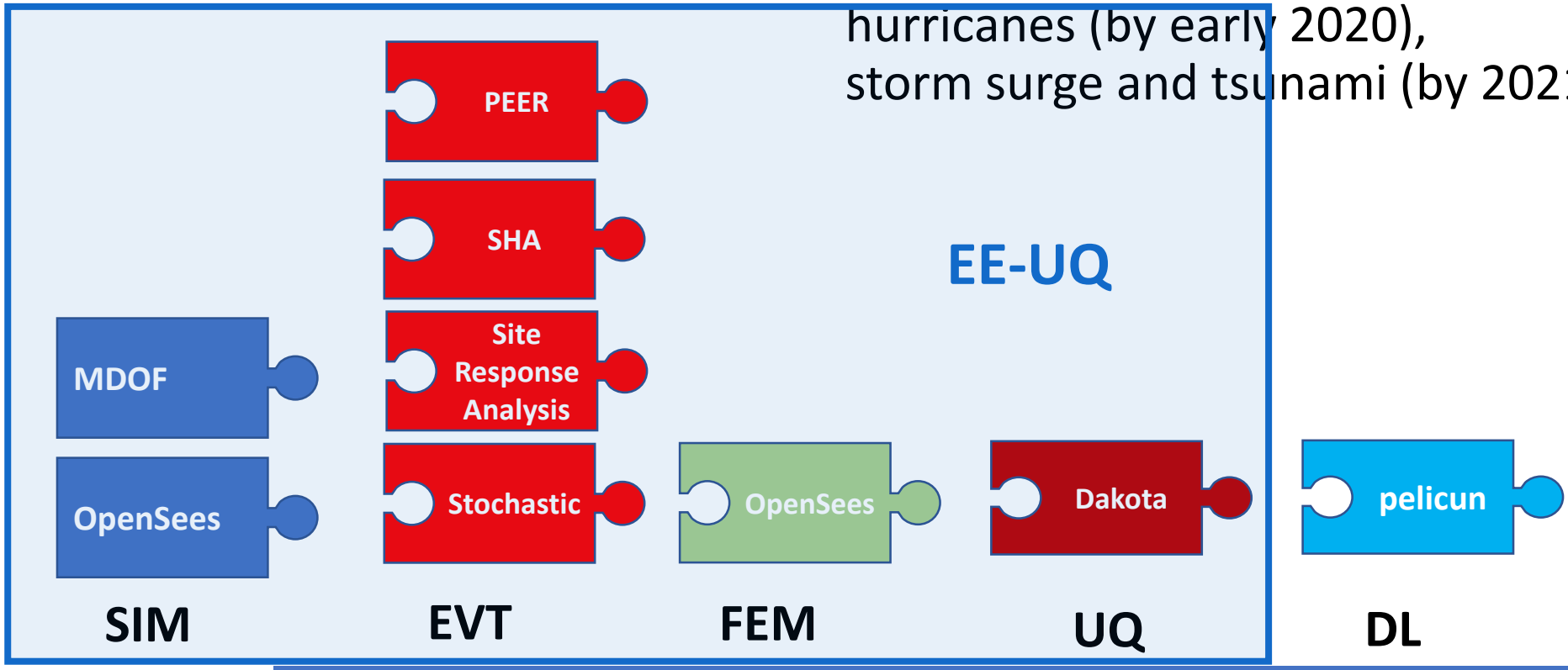

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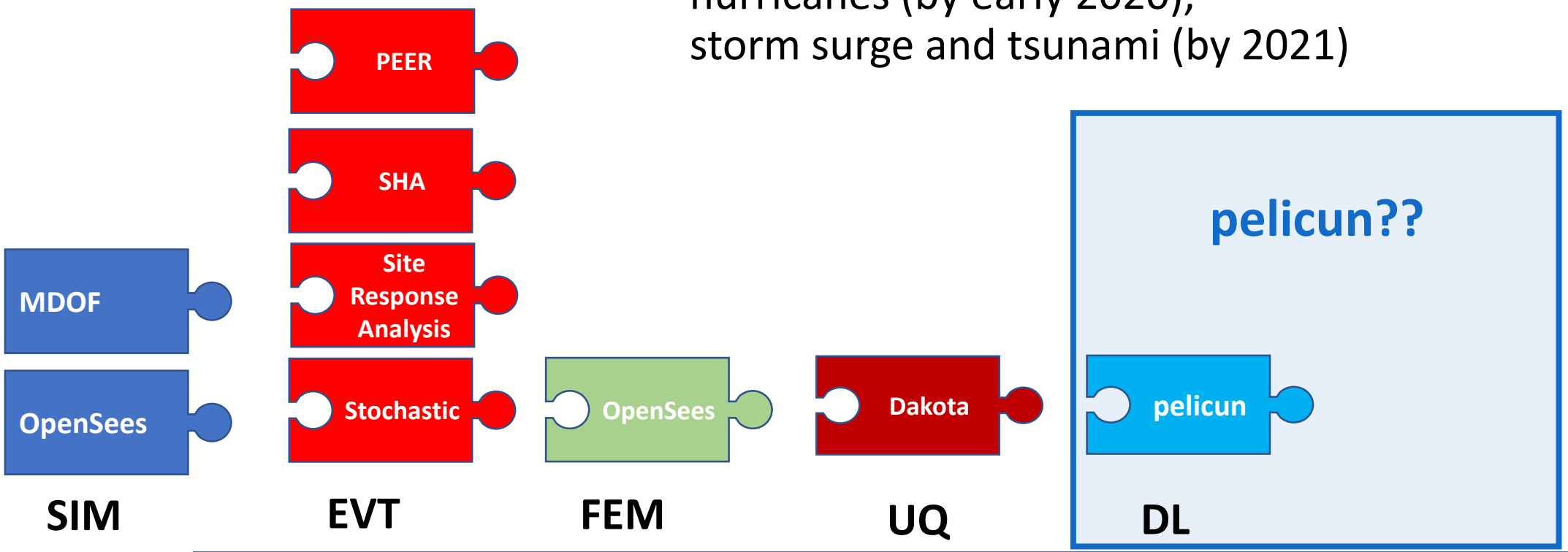

What is pelicun?

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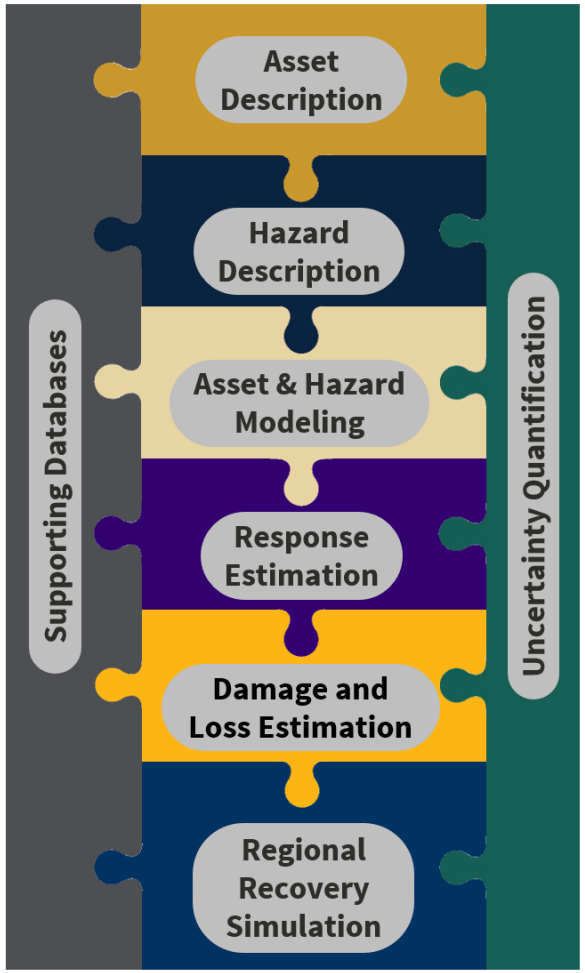

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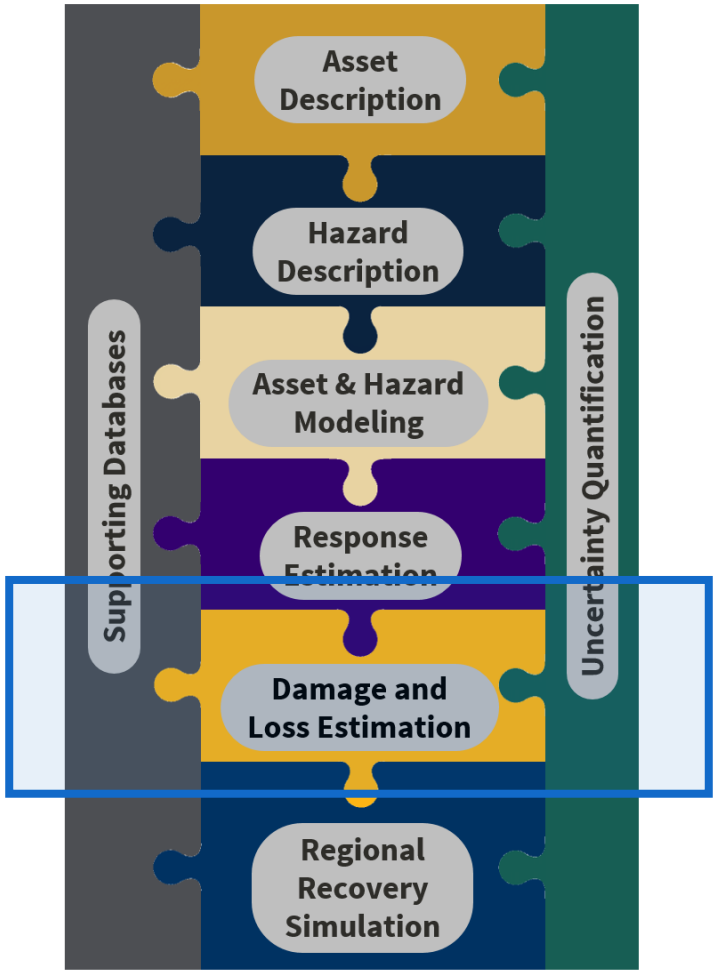

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What is pelicun?

pelicun is an acronym

Probabilistic Estimation of Losses, Injuries, and Community resilience Under Natural disasters

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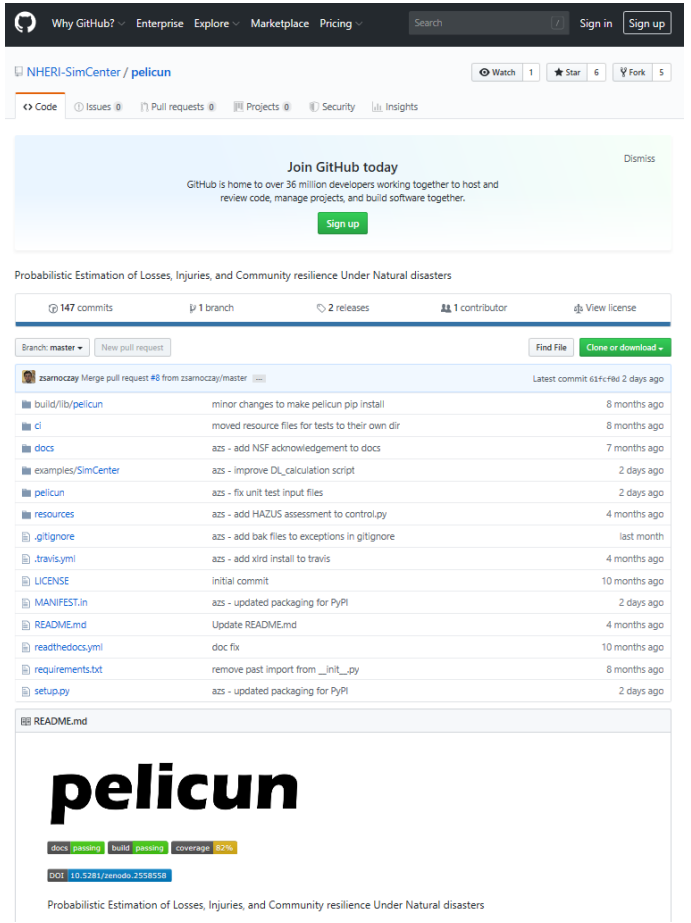
- not part of the PBE application, but used by its backend workflow



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pelicun is a Python package for damage and loss assessment

- not part of the PBE application, but used by its backend workflow
- uses a **generic, stochastic damage and loss model**
- FEMA P58 and HAZUS earthquake DL methods and fragility data are already available

HAZUS – based on component assemblies, lower fidelity, less input needed

FEMA P58 – based on individual components, lots of input data needed

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- verified by unit tests and continuous integration
- every function is documented, a getting started manual is coming by July
- already has active users -> help discover bugs and suggest new features
- calculations are preformed by C libraries -> fast and efficient

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- **free and open source**

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General Information

- stories and plan area are important for loss assessment
- pay attention to the units!
- other pieces of information are not used currently

Simulation Model

MDOF

- Uses a shear beam with a bilinear constitutive model. Good for frames, limited applicability for shear walls.
- Allows random variables for parameters.

OpenSees

- Tcl input files for now, but OpenSeesPy support coming in July
- Pay attention to proper definition of the column line!
- Random parameters need to be in the main file.
- EDPs only PID and PFA for now, user-defined EDPs coming by September

Events (ground motions)

Multiple PEER & Multiple Existing

- The difference is only in the data format (PEER and SimCenter)
- Names need to be unique!
- Multi-degree of freedom excitation has not been thoroughly tested
- Load directory allows you to load multiple motions and scale factors quickly

Hazard Based Event

- We need a ground motion database – working on an agreement with PEER

Site Response

- Multiple ground motion support coming in September

Stochastic

- Other models coming soon

Events (ground motions)

Scenario-based analysis is supported now,

time-based coming in September

FEM Analysis

- Pay attention to damping and tolerance!
- *npts* and *dt* parameters are available for the custom analysis script

Uncertainty Quantification

Method

- I recommend keeping it LHS
- keep in mind: samples = number of NLTH analyses
- also keep in mind**: response estimation and loss assessment are decoupled**

Random Variables

- Random vars from MDOF, OpenSees Tcl file, and Event settings should show up automatically
- Distributions need to be set up here
- Calibration of models can be done in uqFEM (quoFEM soon) before running PBE
- Constant distribution - does not work, don't use it (bug)
- Correlation matrix – be careful until the next major release

Damage and Loss assessment

Demonstrate features in the PBE App

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