Welcome to
First NHERI/E-Defense Joint Meeting

July 13 and 14, 2017

General Instruction

by

Masayoshi Nakashima
President of KRC
Professor Emeritus of Kyoto Univ.

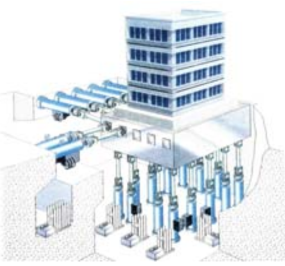
Serious Damage Disclosed in Urban Regions

1994 Northridge | **1995 Kobe**

Highways

Buildings

Construction of Large-Scale Experimental Facilities for Earthquake Engineering Research

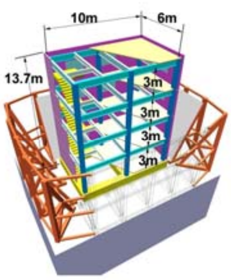


E-Defense
Ready in April, 2005

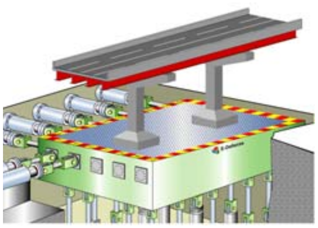
NEES
Ready in October, 2004

NEES/E-Defense First Phase 2005 to 2009

Phase I NEES/E-Defense Collaboration Major Focuses



Steel



Bridges

Planning Meetings

NEES/E-Defense Collaboration Memorandum of Understanding (MOU)

MEXT & NSF (National Science Foundation)：
Research Collaboration on Disaster Mitigation
NIED & NEES (J. Brown Jr. Network for Earthquake Engineering Simulation)：
Collaboration on Joint Research Using NEES/E-Defense

NIED-NEES, August 3, 2005

MEXT-NSF, Sept 13, 2005

A History of Planning Meetings

Planning Meetings

First	April, 6 to 8, 2004 at Kobe
Second	July 12 to 13, 2004 at Washington DC
Third	January 17, 2005 at E-Defense
Fourth	August 2 to 3, 2005 at E-Defense
Fifth	September 27 to 29, 2006 at E-Defense
Sixth	September 28 to 30, 2007 at E-Defense
(Workshop for Second Phase of NEES/E-Defense)	January 12 to 13, 2009 at Washington DC
Seventh	September 18 to 19, 2009 at E-Defense
Eighth	September 17 and 18, 2010 at E-Defense
Ninth	August 26 and 27, 2011 at E-Defense

Complete Collapse Test of Four-Story Steel Moment Frame

E-Defense Steel Collapse

Final Collapse in First Story

Final Collapse

Local Buckling at Column Base

Local buckling at First Story Column Top

Blind Analysis Competition

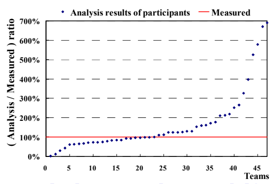
- Participants from all over the world.
- Application through website.
- Competition for accurate simulation of collapse test
- Category :

(1) 3D Analysis, Researcher
(2) 3D Analysis, Practicing Engineer
(3) 2D Analysis, Researcher
(4) 2D Analysis, Practicing Engineer

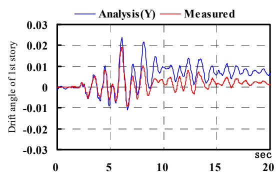
- Registration：115 teams （US:44, Japan:37, others:34）
- Final submission : 47 teams （Japan:17, US:15, others:15）

Please, predict my life!

Blind Analysis Competition – Examples (for JR Takatori 60%)

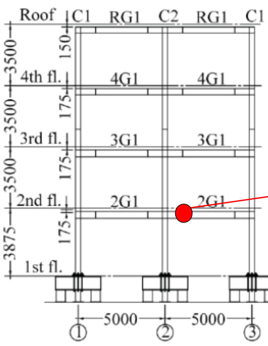


Statistics: Maximum drift angle of first story (Y-direction)

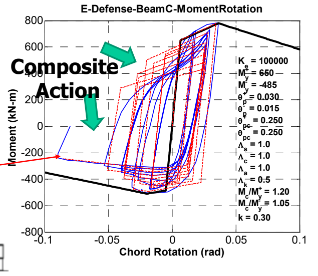


A good example: Time history of first story drift (Y-direction)

Calibration of Numerical Model: Beams

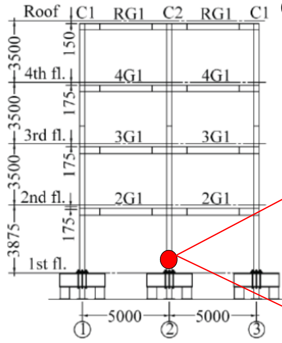


(Modified Ibarra-Krawinkler model, Lignos and Krawinkler 2009)

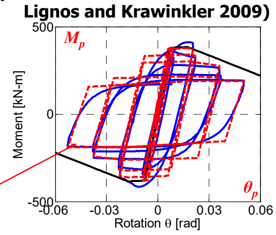


(Data from Pre-Test E-Defense Blind Competition: Composite Beam under cyclic loading

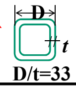
Calibration of Numerical Model: Columns



(Modified Ibarra-Krawinkler model Lignos and Krawinkler 2009)

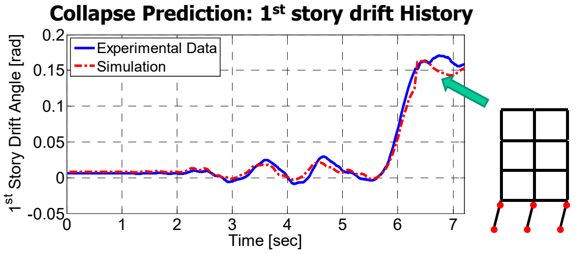


Data from Pre-Test E-Defense Blind Competition: HSS 300x300x9 tested in 45°



Numerical Prediction of First Story Collapse Mechanism

Collapse Prediction: 1st story drift History



1st story collapse mechanism

Full-Scale RC Bridge Pier Test

Specimen
Diameter = 1.8 m
Height = 7.5 m
Total Height = 12 m

C1: old practice, shear
C1: closer view

NEES Projects in Liaison with E-Defense

NEESWood: Development of a Performance-Based Seismic Design Philosophy for Mid-Rise Woodframe Construction
PI: John van de Lindt

Controlled Rocking of Steel-Framed Buildings with Replaceable Energy Dissipating Fuses
PI: Gregory Deierlein

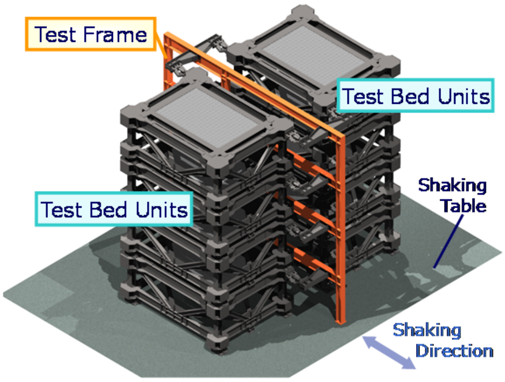
International Hybrid Simulation of Tomorrow's Braced Frame Systems
PI: Charles Roeder

TIPS - Tools to Facilitate Widespread Use of Isolation and Protective Systems
PI: Keri Ryan

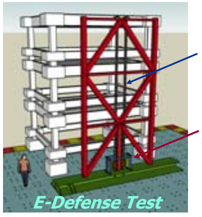
Simulation of the Seismic Performance of Nonstructural Systems
PI: Emmanuel Maragakis

NEESWood: Final Verification Test At E-Defense In July 2009


Versatile "TestBed" at E-Defense



NEESR: Controlled Rocking Frame System Lead by Greg Deierlein of Stanford Univ.



Active post-tensioning

Energy Dissipating Fuse

- Large-Scale Validation
  - fuse/rocking frame interaction
  - PT, fuses, and rocking details
- Proof-of-Concept
  - constructability
  - design criteria
- Performance Assessment
  - nonlinear computer simulation
  - life-cycle benefit cost analysis

Develop a new structural building system that employs *self-centering rocking* action and *replaceable** fuses to provide safe and cost effective earthquake resistance.

***Key Concept – design for repair**

Controlled Rocking Frame System – Final Verification Test at E-Defense in August 2009

NEES/E-Defense Second Phase Initially thought from 2010 to 2014

Due to budget restraint on both parties, as well as restructuring of respective organizations, it was implemented in a reduced scale and for the periods of 2010 to 2016.

Resolutions Adopted in First Joint Planning Meeting for Second Phase of NEES/E-Defense Collaborative Research Washington DC, USA January 11 to 12, 2009

Resilient City as a Common Meta-Theme

The three meta-themes discussed in the meeting, i.e., "Disaster Resilient Communities", "Preparing for the Big One", and "Low-Probability, High-Consequence Events" are linked in many ways. The fundamentals of the first meta-theme are the damage reduction and quick recovery. These require developments of new materials and technologies that would enhance the performance of various components that form the urban area. Methods to detect the damage quickly and systems that can be repaired (or re-built) with minimal interruption of life and business are also the important topics to consider. In the second meta-theme, developments of new materials and technologies are the key to the prevention of a downward spiral of deterioration. The third meta-theme has much in common with the preceding two in light of the specific scientific challenges to be pursued. Thus, it was agreed that the 'Resilient City' provided a mutually important goal upon which members of the US and Japanese earthquake engineering communities could work and that US-Japan collaboration would accelerate realization of this goal and leverage the resources available in both countries.

Seventh NEES/E-Defense Planning Meeting September 18 and 19, 2009

32 participants from the US
29 participants from Japan

Eighth NEES/E-Defense Planning Meeting
September 17 and 18, 2010

No meeting from August, 2011 to December, 2013

A Continuing Effort

Planning Meetings

First	April, 6 to 8, 2004 at Kobe
Second	July 12 to 13, 2004 at Washington DC
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Ninth	August 26 and 27, 2011 at E-Defense
Tenth	December 12 to 13, 2013 at DPRI, Kyoto

Collapse Test – December 11, 2013

Amplification of Original History

Average (110cm/s)	baseline
Large (180cm/s)	1.64 times
Very Large I (220cm/s)	2 times
Very Large II (250cm/s)	2.27 times
Very Large III (300cm/s)	2.73 times
Very Large IV (340cm/s)	3.1 times
(at the table capacity)	
Extreme I (380cm/s)	3.8 times
Extreme II (380cm/s)	3.8 times
Extreme III (380cm/s)	3.8 times

→ Collapse

Final Collapse Overview

Final Collapse Connection

Tenth NEES/E-Defense Planning Meeting
December 12 and 13, 2013
At DPRI, Kyoto University

63 participants from the US
52 participants from Japan

Eleventh Planning Meeting
US/Japan Collaboration
September 15 and 16 2015

Toward the Third Phase beyond 2017

Grand Vision for Future US/Japan Collaboration

(I) Immediate but most important:
Let us continue US/Japan meeting as US and Japan conduct by far the most innovative and significant research/practice in earthquake engineering.

(II) Next immediate and very feasible collaboration:
Sharing the big test data accumulated by E-Defense with the US community shall be promoted immediately as E-Defense has established "ASEBI" system that contains precious data of forty some large scale tests conducted at E-Defense since 2005.

(III) Medium term collaboration, i.e., grand issues to challenge together:
In the previous NEES/E-Defense "challenge" meeting (held in Washington DC in January 2009), the buzzwords of "Resilient City" and "Next Big One" were discussed. The spirits of those words appear still applicable in the contemporary US, Japan, and the rest of the world.

Preliminary Meeting to First Planning Meeting of New US/Japan Collaboration
July 13 and 14, 2017

Starter of Next Phase with New Organizations

Program (Tentative)

DAY 1 (Thursday, July 13)

First Session (chaired by Nakashima and Mahin) — Greetings

9:30 – 9:30	Welcome Remarks (NIED: Hayashi)
9:35 – 9:40	Greetings from Japan (MEXT: Tanaka) and USA (Ramirez)
9:45 – 10:00	Goal of meeting and general instructions (Mahin & Nakashima)

Second Session (chaired by Nishitani and Ramirez) — Japan - Tokyo Resilience Project

10:00 – 10:40	Engineering Challenges in Tokyo Metropolitan Resilience – Part 1
	Overview (Nishitani, 7 min + 3 min discussion)
	Wood (Nagae: 10 min + 5 min discussion)
	RC (Kusunoki: 10 min + 5 min discussion)
10:40 – 10:55	Break
10:55 – 11:40	Engineering Challenges in Tokyo Metropolitan Resilience – Part 2
	Steel + Protective Systems (Kurata: 10 min + 5 min discussion)
	Nonstructural Elements (Sato: 10 min + 5 min discussion)
	Monitoring and Assessment (Nishitani: 10 min + 5 min discussion)
11:40 – 12:00	Discussion on mechanisms of collaboration
12:00 – 13:00	Lunch

Third Session (chaired by Kajiwara and van de Lindt) — US - Updates

13:00 – 13:10	Introduction of Tokyo Metropolitan Resilience (Hirata)
13:10 – 13:20	Introduction of NEHRI and Possible Collaboration with Japan (Ramirez)
13:20 – 15:35	Wood (van de Lindt: 10 min + 5 min discussion)
	RC (Pujol: 10 min + 5 min discussion)
	Steel (Mosqueda: 10 min + 5 min discussion)
	Control (Dyke: 10 min +5 min discussion)
	Nonstructural Elements (Miranda: 10 min + 5 min discussion)
	Monitoring and Assessment (Caicedo: 10 min + 5 min discussion)
	Simulation (Lowes: 10 min + 5 min discussion)
	SimCenter (Mahin: 10 min + 5 min discussion)
	Data Exchange (Rathje: 10 min + 5 min discussion)
15:35 – 15:45	Break
15:45 – 16:10	General discussion and instructions for breakout sessions

Program (Tentative)

DAY 1 (Thursday, July 13)

Fourth Session (chair not assigned) — Group Meetings

16:10 – 18:10	First Round of Discussion for Scheme of US-Japan Collaboration
16:10 – 18:10	Separate Discussion for Mechanism of Collaboration
18:30 – 20:30	Dinner

DAY 2 (Friday, July 14)

Fifth Session (chair not assigned) — Group Meetings

9:00 –10:40	Second Round of Discussions for Scheme of US-Japan Collaboratior
Resolutions	
10:40 – 10:50	Break

Sixth Session (chaired by Kajiwara and Ramirez) — Resolutions

10:50 – 11:40	Presentations of Resolution Drafts and Adoption of Resolutions
11:40 – 12:00	Closing Sessions (MEXT, NIED, NEHRI, etc.)

Critical Issues to Keep in Mind

1) Most important - be aware that we forget everything (or too busy) once we leave the room after closure.
2) Be sure to prepare "resolutions" (no need to be voluminous) before closure.
3) Be sure to include in "resolutions" who to be responsible and to sign for NSF proposals featured with US/Japan.
4) Be sure to include in "resolutions" when and where we meet next.
5) Submit each ppt presentation in a pdf form, six slides per page, upon the end of his/her presentation. Our KRC member, Atsushi Morikawa, will ask for your pdf file.

First NHERI /E-Defense Joint Meeting
(aka Eleventh NEES – E-Defense Joint Meeting)

Introduction to the Tokyo Metropolitan Resilience Project

Director of the
Tokyo Metropolitan Resilience Project Research Center at NIED
Naoshi Hirata
（Professor of Seismology,
Earthquake Research Institute, the University of Tokyo）

Date : July 13, July 14, 2017
Location: Akasaka KI Building, Kobori Research Complex, KI Building
6-5-30, Akasaka, Minato-ku, Tokyo, Japan

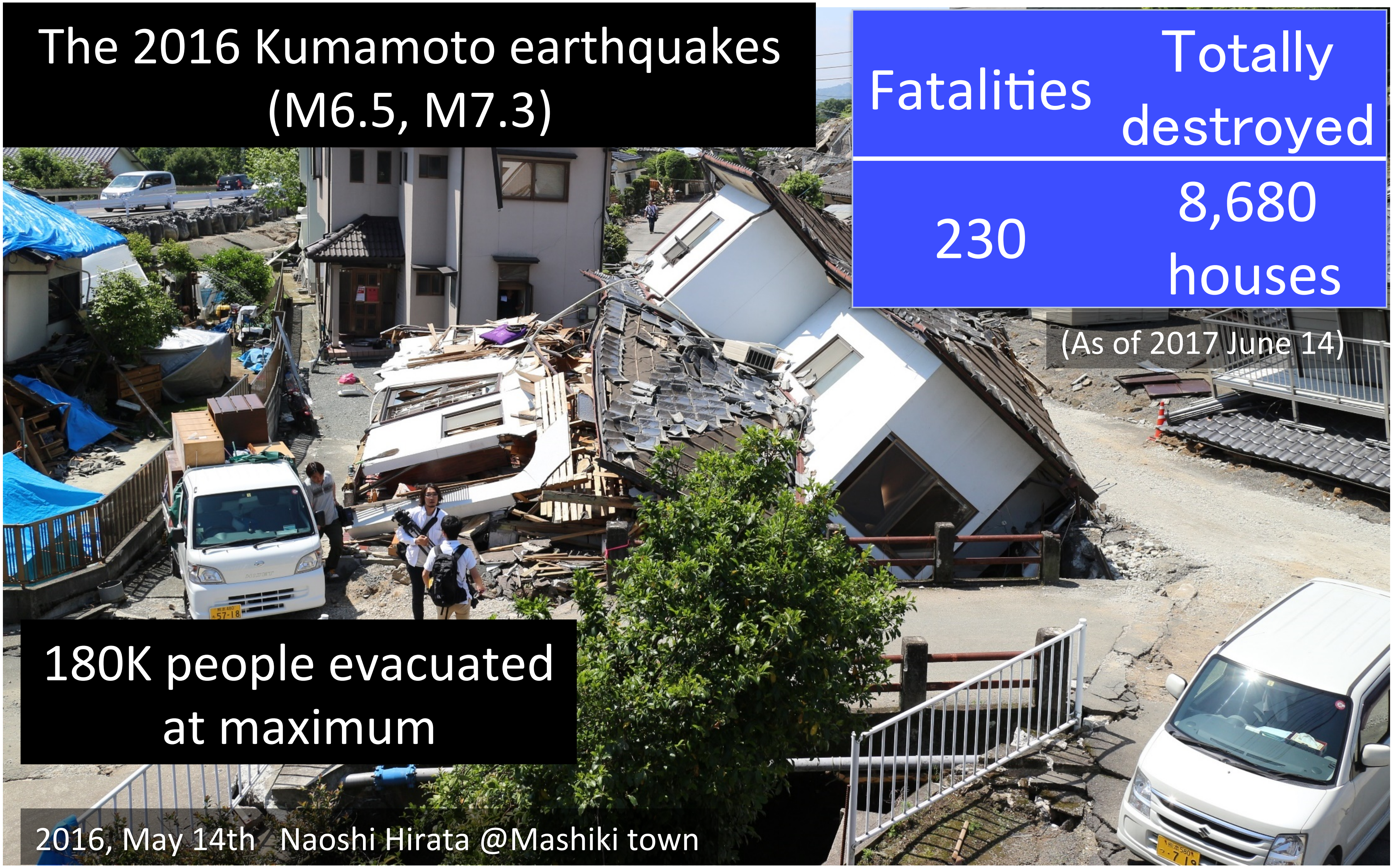
M7

The 2016 Kumamoto earthquakes (M6.5, M7.3)

Fatalities	Totally destroyed
230	8,680 houses

(As of 2017 June 14)

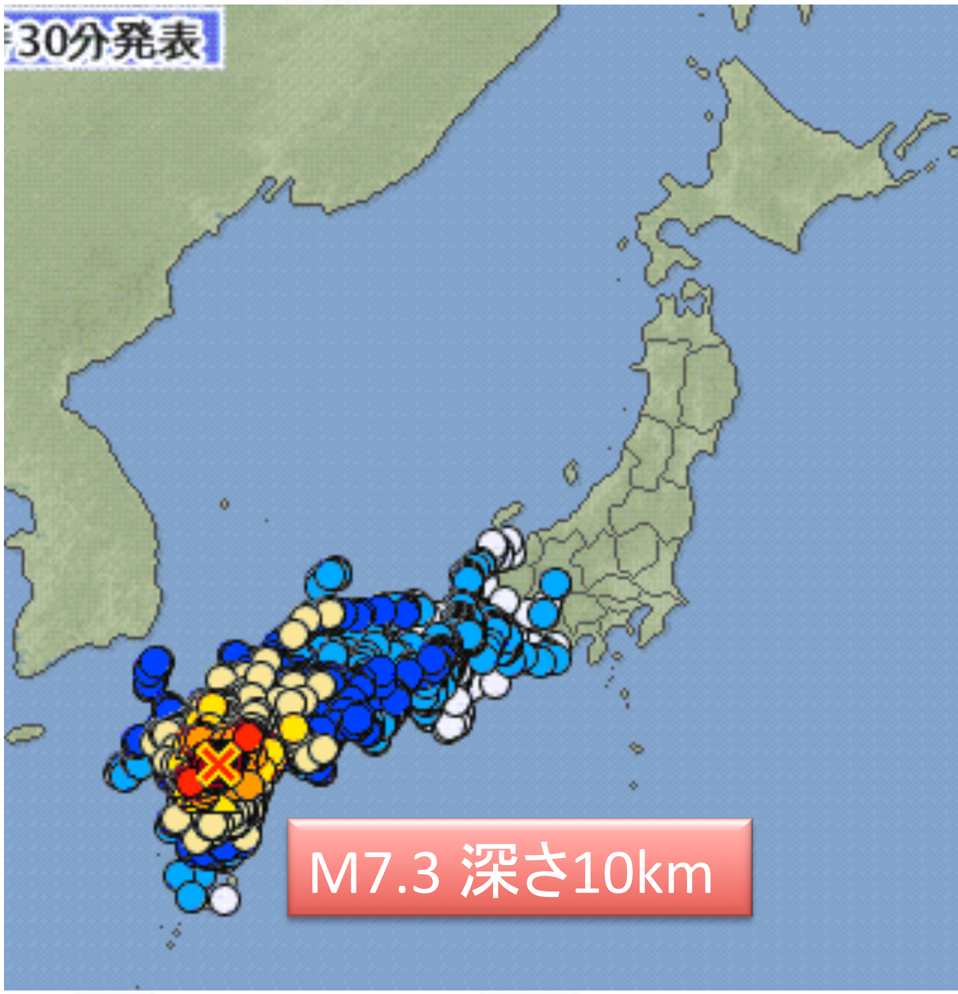
180K people evacuated at maximum



2016, May 14th Naoshi Hirata @Mashiki town

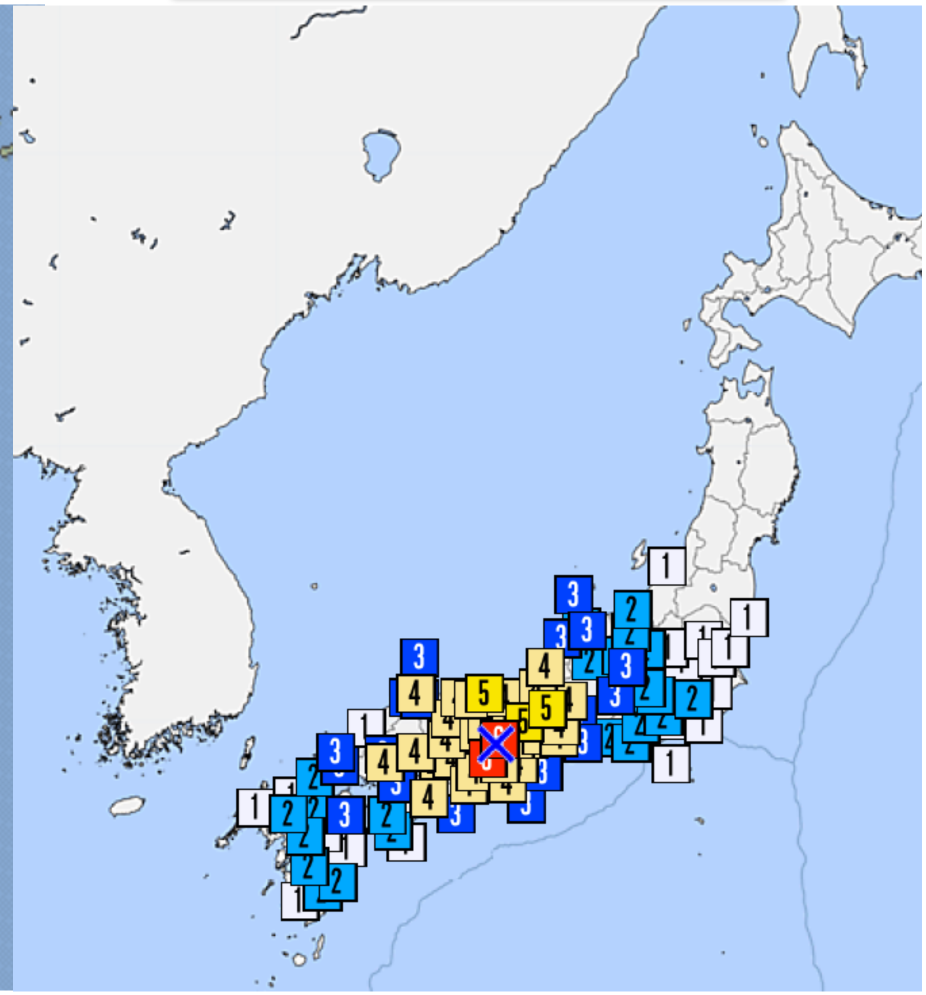
The 2016 Kumamoto Earthquake

2016/4/16 M7.3

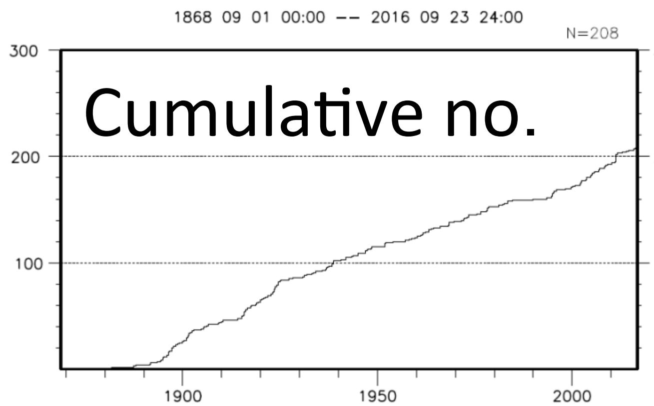


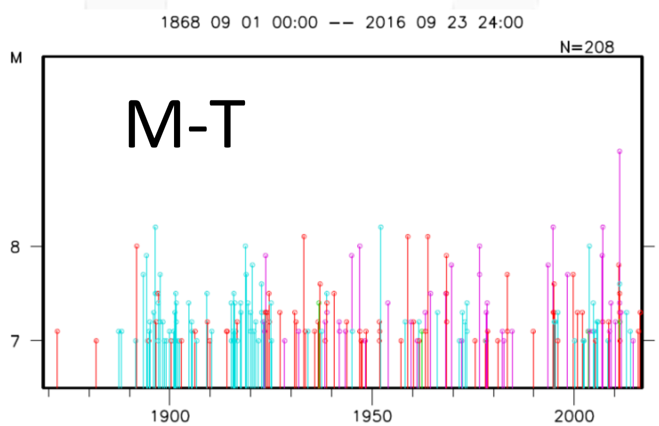
The 1995 Kobe earthquake

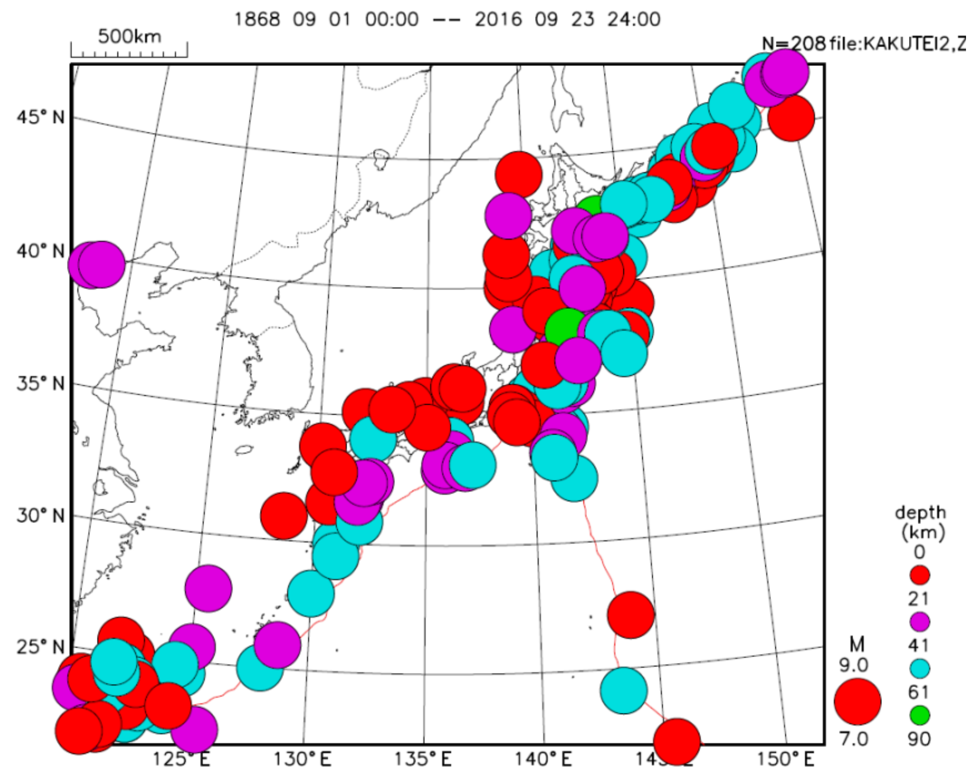
1995/1/17 M7.3



Earthquakes with M≧7 in 148 yrs. (1868-2016): 208 events







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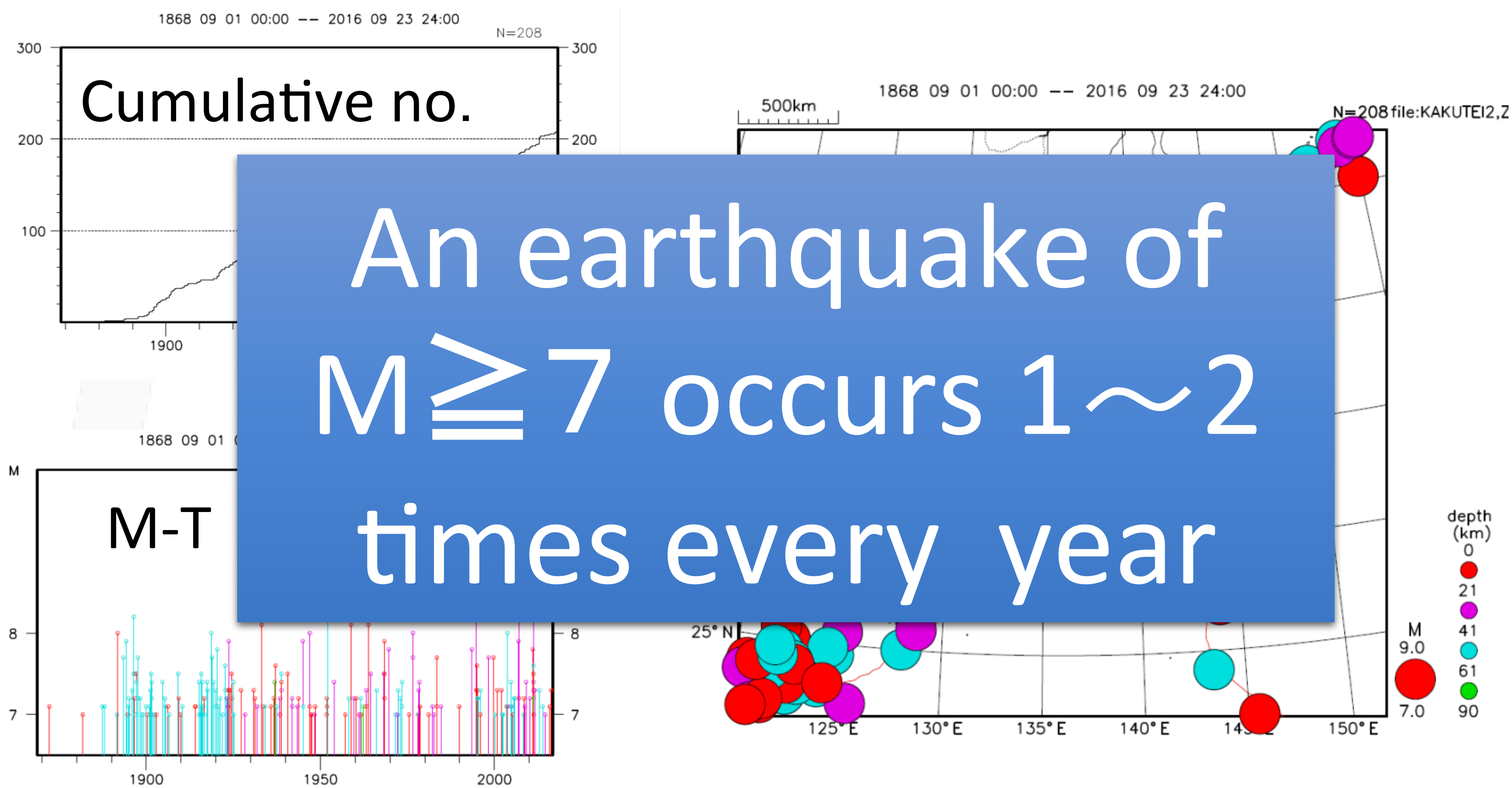
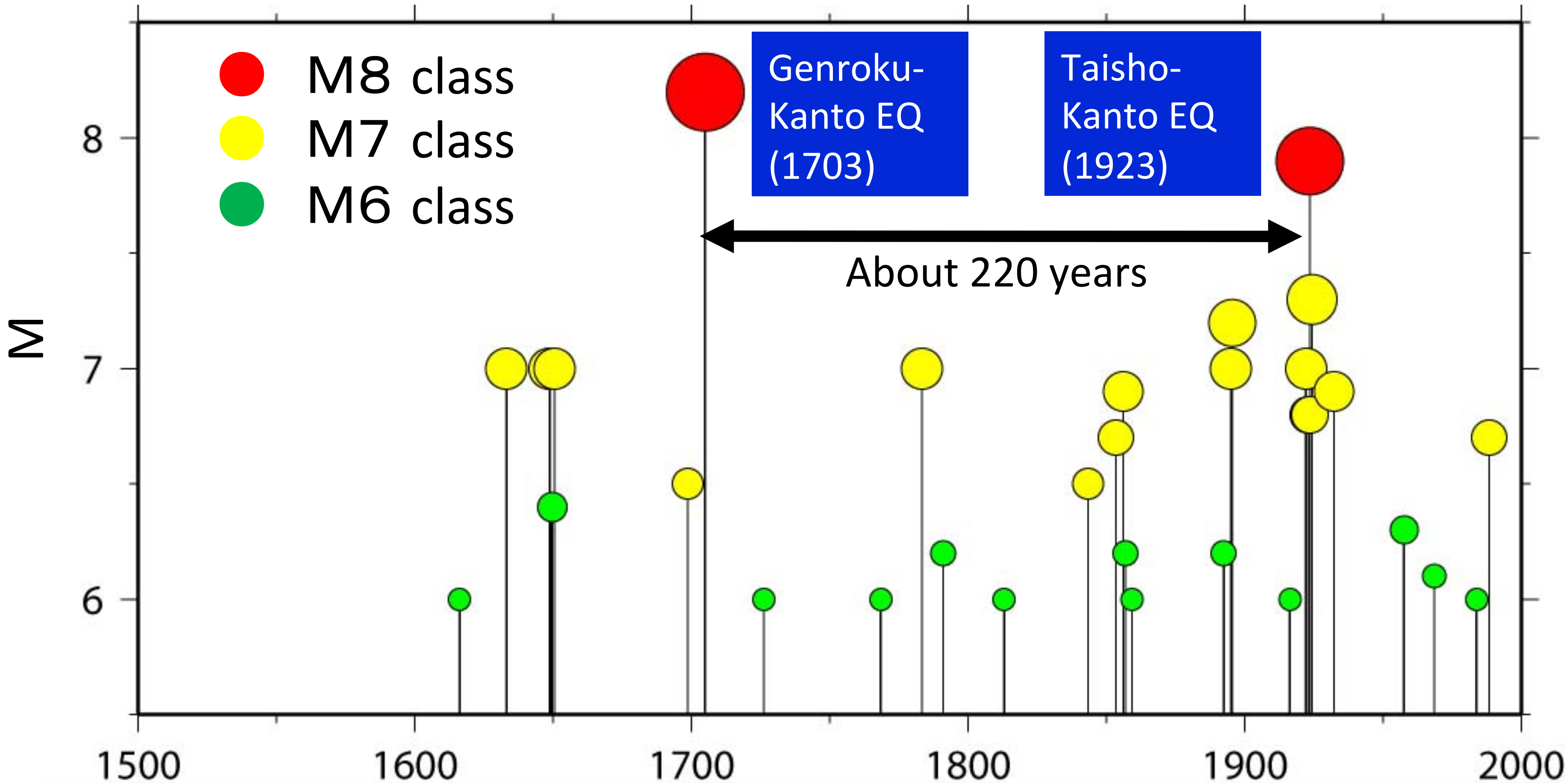


An earthquake of M≧7 occurs 1～2 times every year

Major Earthquakes in Kanto Region

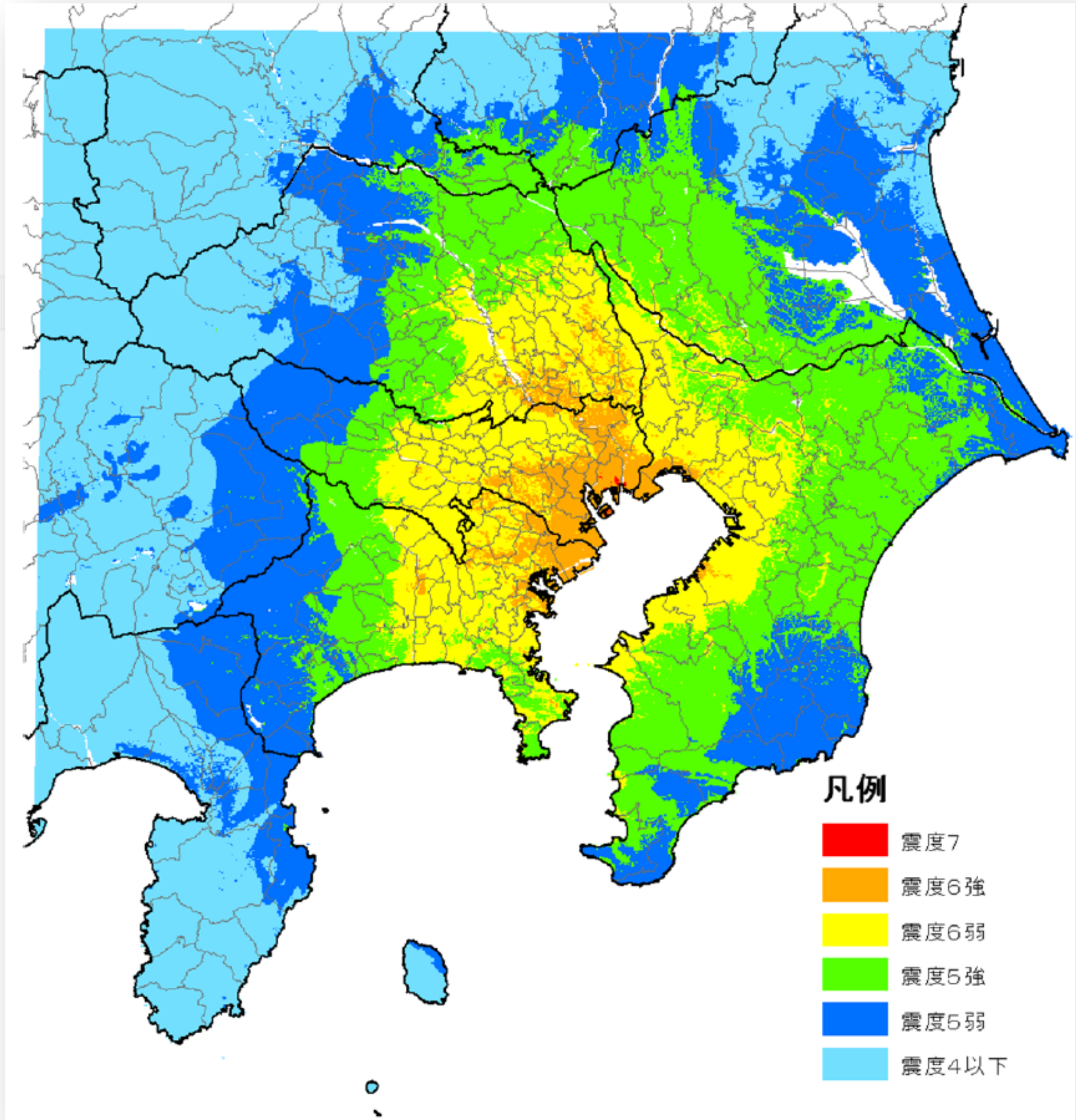


8 events from 1703 to 1923（220 yrs.）→ Average recurrence time : 27.3 yrs.

70% chance of occurrence of M7 earthquake in 30 yrs.

Impact of a M7-class event

Seismic intensity (Southern CBD earthquake)



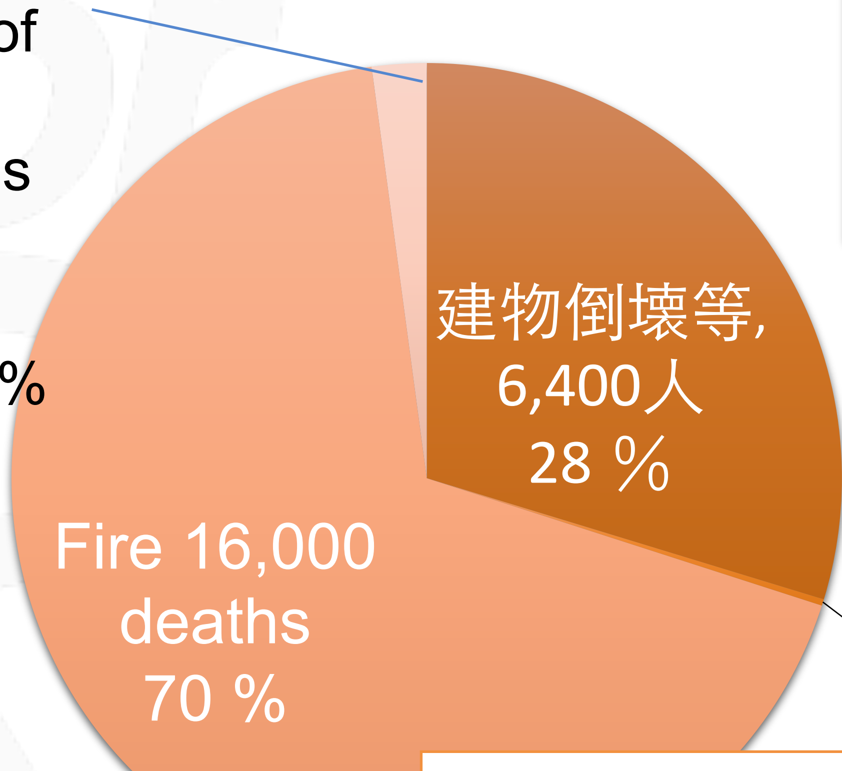
Area with 6- or larger covers 4,500 km^2 (30% of Tokyo, Kanagawa, Chiba, Saitama prefectures)

(2013: Cabinet Office Central Disaster Management Council)

Southern CBD earthquake

Cabinet Office
Central Disaster Management Council 2013

Number of fatalities/damage (winter/evening)



running about trying to escape

Completely destroyed/burned: 610,000 buildings

Evacuees : Max. 7.2 million 2 weeks after event

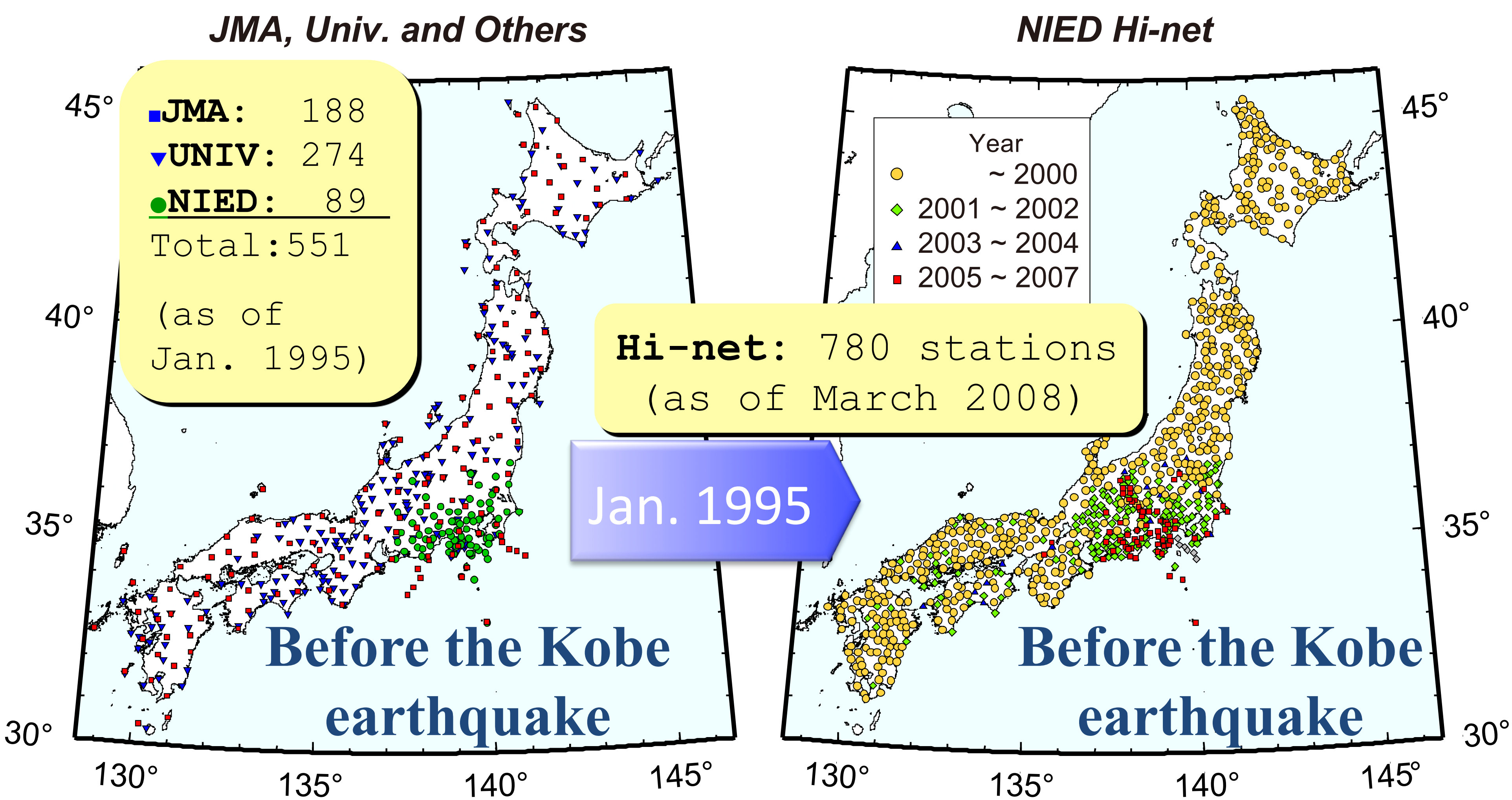
Fatalities 23,000

Casualties : max. approx. 123,000

Seismology

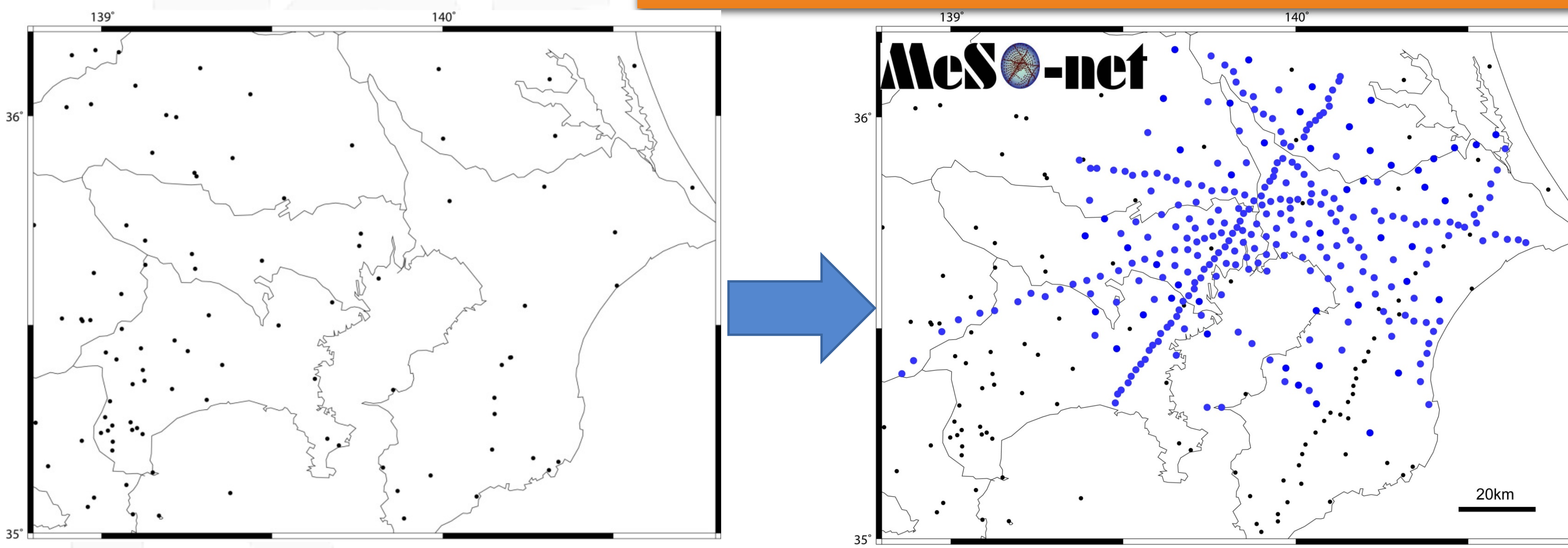
- understands earthquake generation mechanisms
- predicts strong ground motion

Progress of the seismic observation networks



MeSO-net: Metropolitan Seismic Observation network (2007-

Tokyo Metropotitran Project: Phase Ⅰ(2007－2012)
Phase Ⅱ(2012－2017)

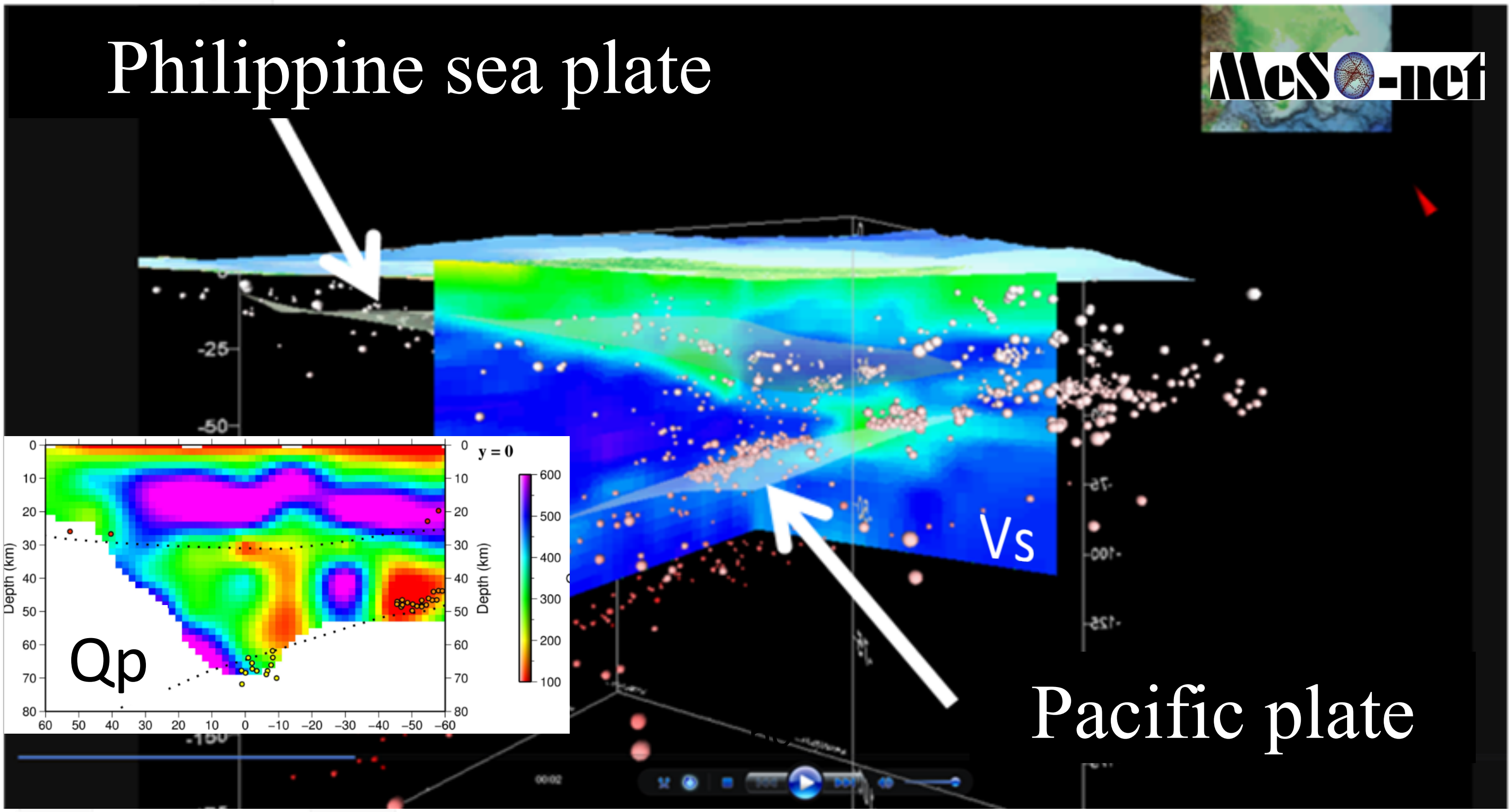


・Before MeSO-net

- ● 296 MeSO-net stations
- ▪ conventional stations

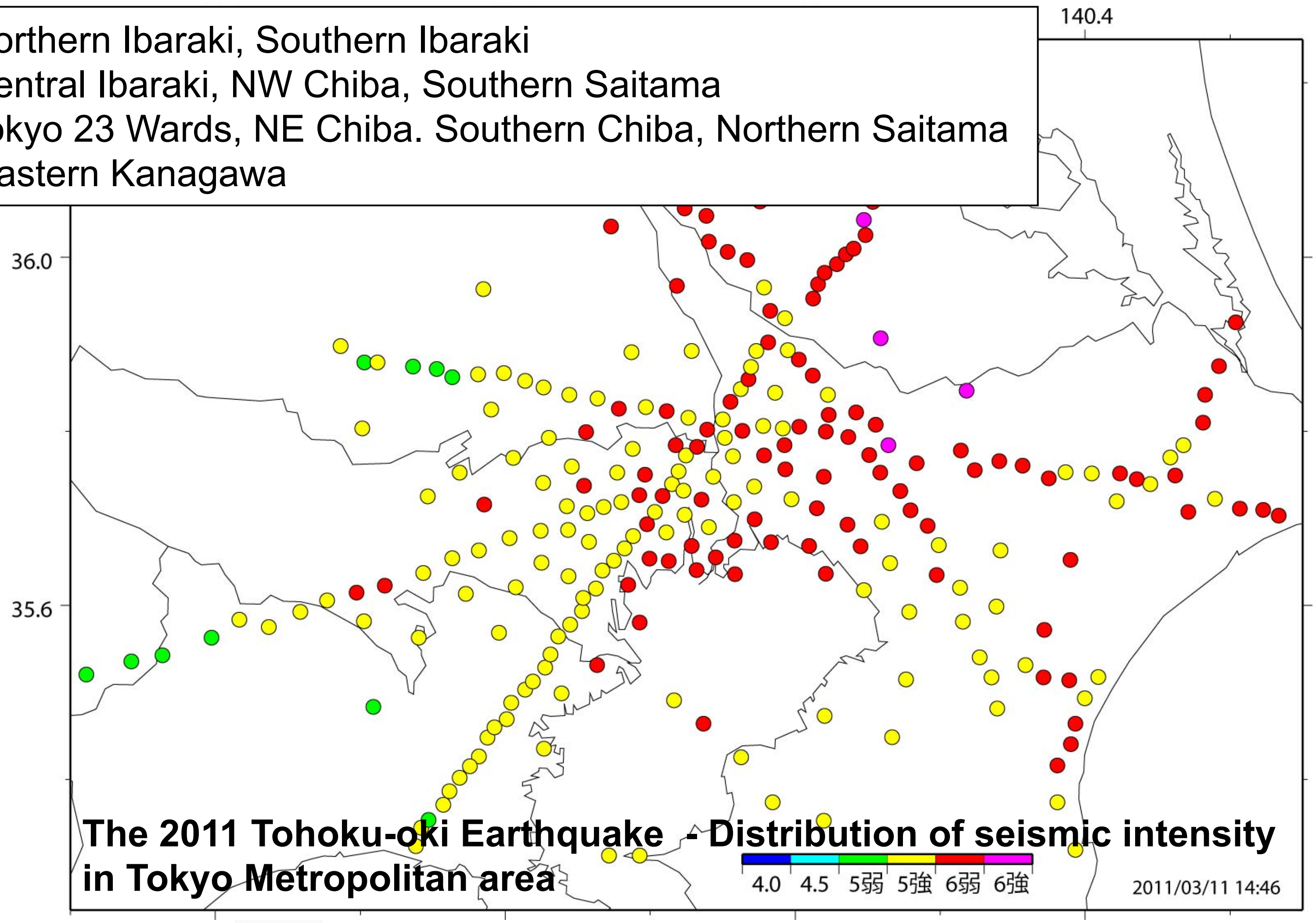
150TB continous seismic data

Subsurface structure beneath the greater Tokyo by MeSO-net



MeSO-net: Metropolitan Seismic Observation network (2007-

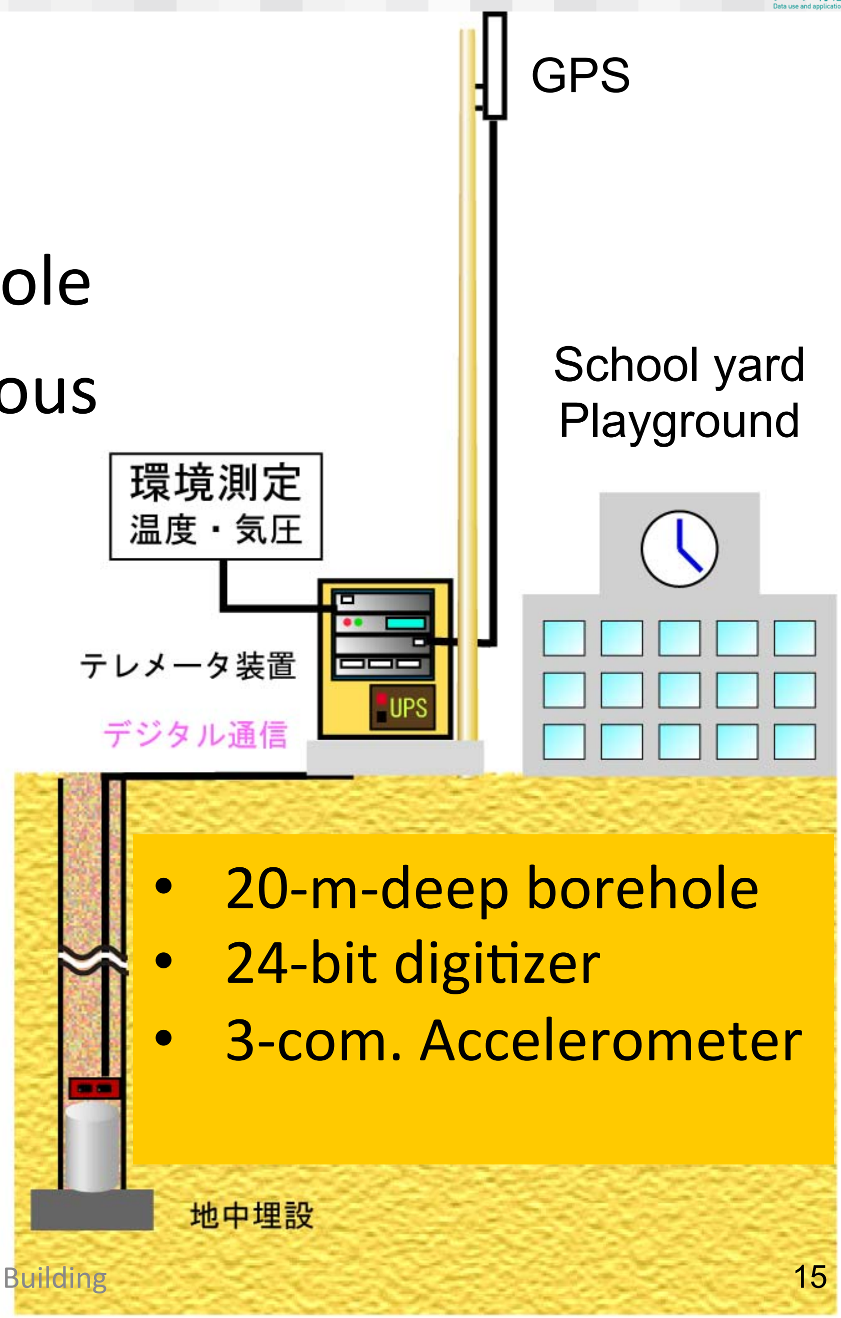
6+ Northern Ibaraki, Southern Ibaraki
6− Central Ibaraki, NW Chiba, Southern Saitama
5+ Tokyo 23 Wards, NE Chiba. Southern Chiba, Northern Saitama
Eastern Kanagawa



The 2011 Tohoku-oki Earthquake - Distribution of seismic intensity in Tokyo Metropolitan area

Installation

- Seismometer installed at the bottom of a 20m-deep borehole
- 200 Hz sampling and continuous transition/archive



Visiting Lecture

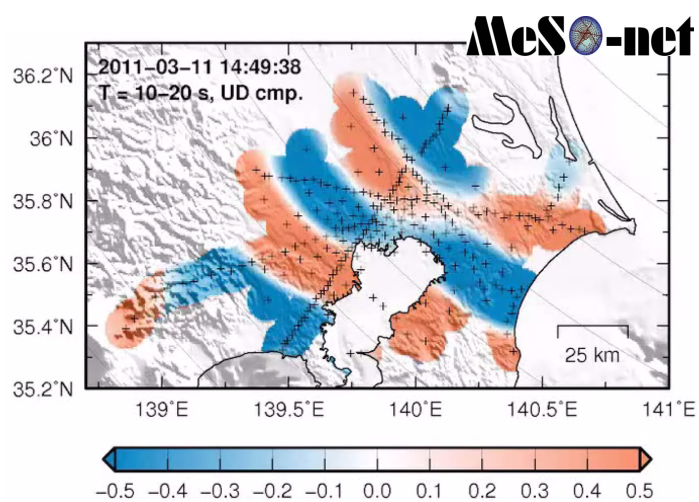
2008 March

New directions

- From underground to ground surface, buildings, and humans

Prediction of “shaking” for real time disaster prediction

Ground motion caused by the 2011 Tohoku-oki Earthquake captured by MeSO-net (wave field with 10-20 second period)

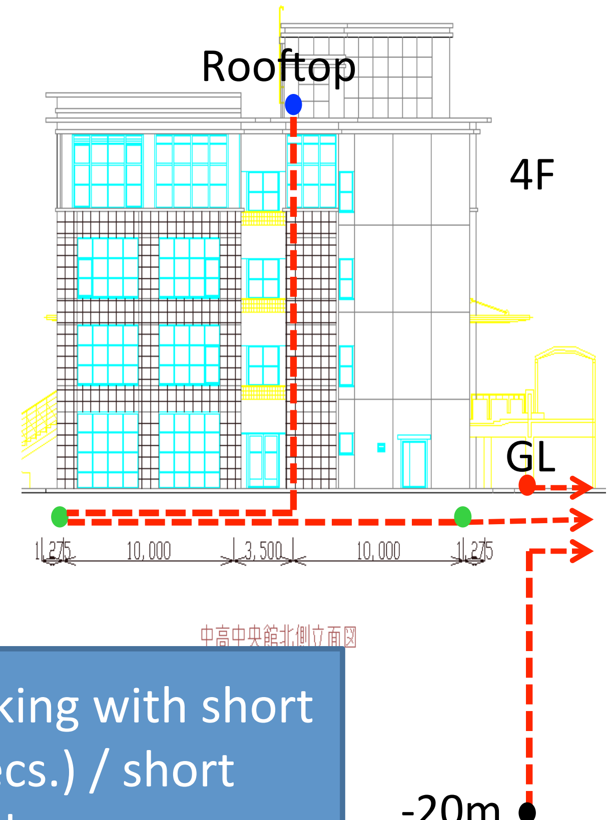


Acceleration amplitude (cm/s/s)

Motion 20m below ground level

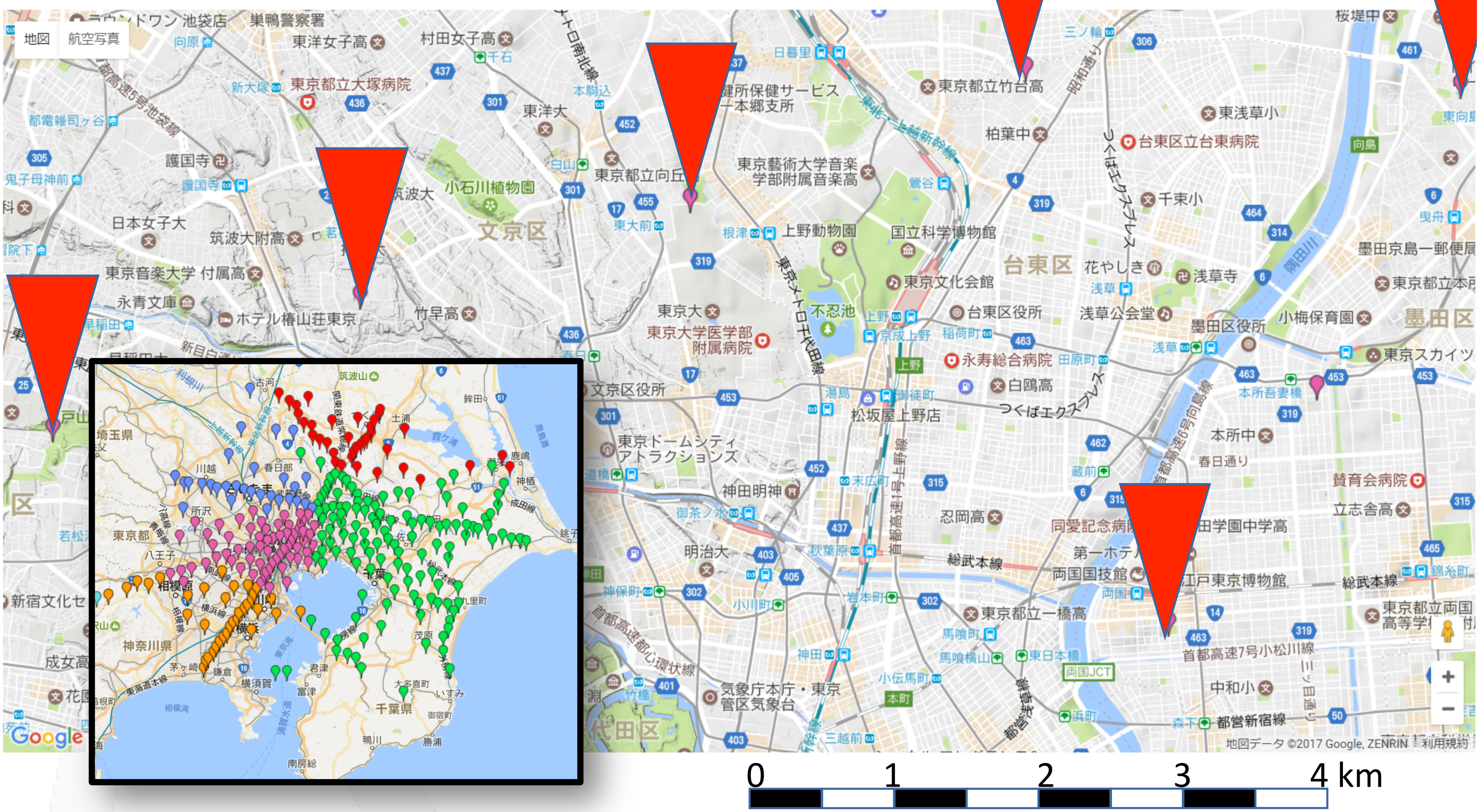
Immediate Management

① Shaking from under ground to buildings/ structures



② Estimation of shaking with short period (1-several secs.) / short wavelength

Not enough stations for disaster resilience



Enhancement of an area disaster resilience:

Data

Research

Collaboration

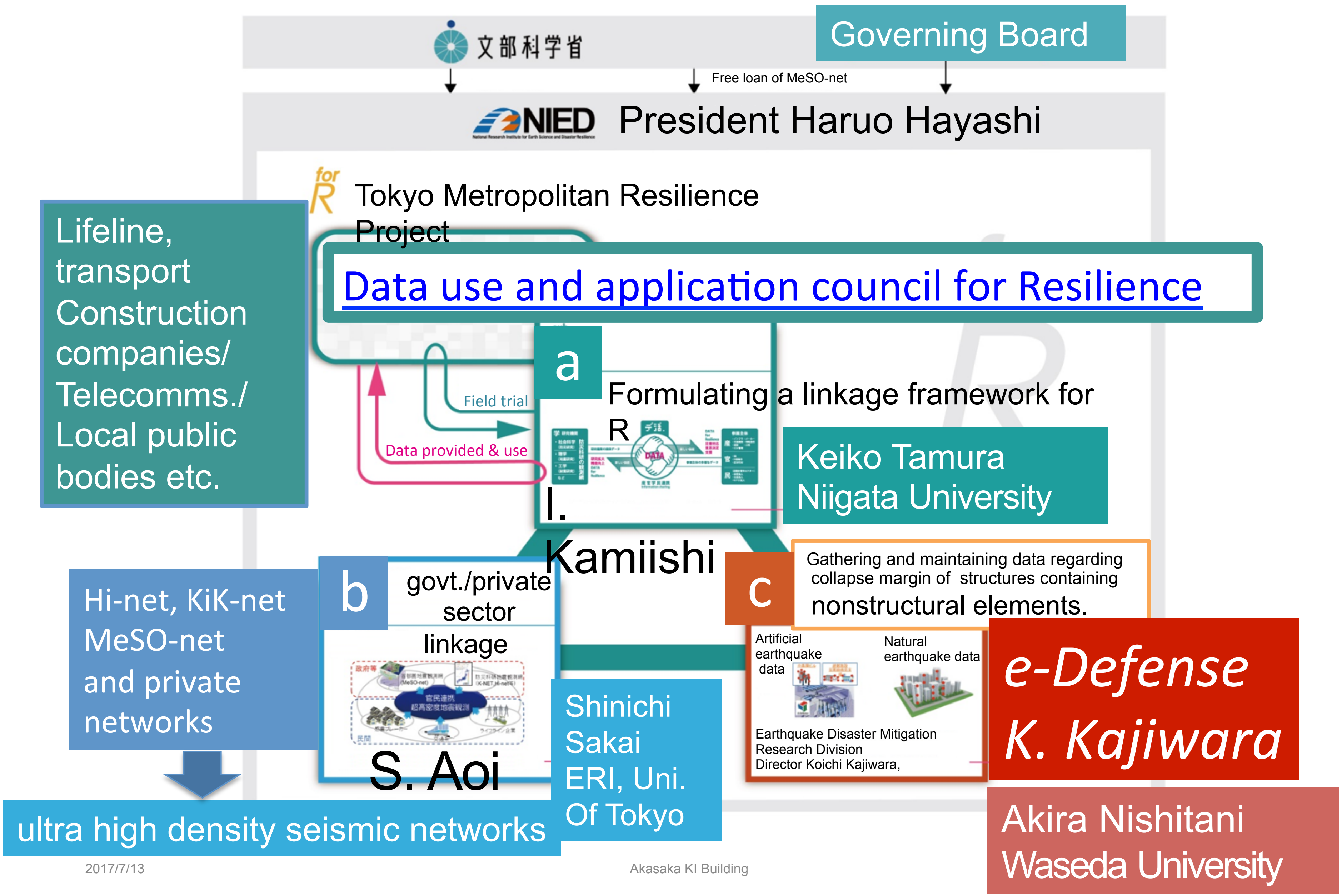
⋮

Somethings

Many things

} for Resilience

forR

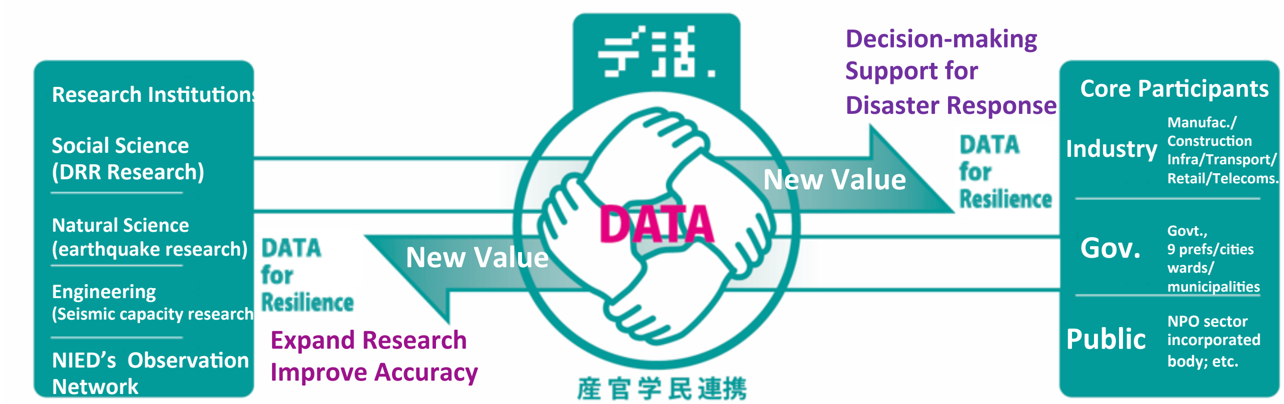

文部科学省
Governing Board
Free loan of MeSO-net
NIED President Haruo Hayashi
Tokyo Metropolitan Resilience Project
Data use and application council for Resilience
Lifeline, transport Construction companies/ Telecomms./ Local public bodies etc.
Field trial
Data provided & use
a
Formulating a linkage framework for R
I. Kamiishi
Keiko Tamura Niigata University
Hi-net, KiK-net MeSO-net and private networks
b
govt./private sector linkage
S. Aoi
Shinichi Sakai ERI, Uni. Of Tokyo
c
Gathering and maintaining data regarding collapse margin of structures containing nonstructural elements.
Artificial earthquake data
Natural earthquake data
Earthquake Disaster Mitigation Research Division Director Koichi Kajiwara,
e-Defense K. Kajiwara
Akira Nishitani Waseda University
ultra high density seismic networks

～Evolving CSR into CSV for Metropolitan Earthquake Risk～

デ活.

企業も強くなる
首都圏も強くなる
首都圏を中心としたレジリエンス総合力向上プロジェクト

[Data use and application council for Resilience]



Implementing a structure for usage and application of observation equipment/data possessed by corporations & organizations.

CSR: Corporate Social Responsibility ⇒ CSV: Creating Shared Value

Contribution to society = enhances economic value of one’s organization + enhances resilience capability of the area.

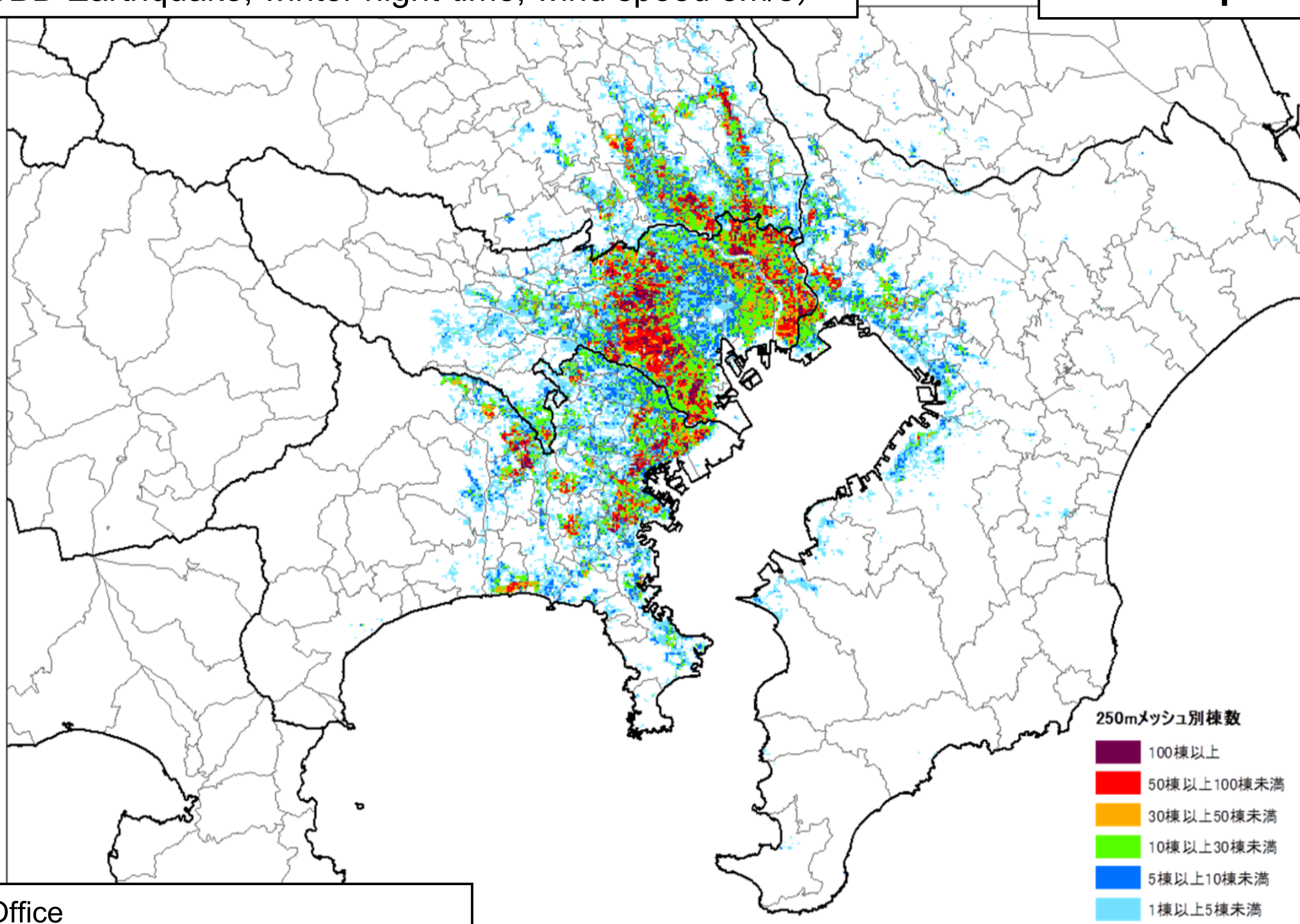
Summary

1. M7-class earthquake in Tokyo metropolitan area will likely inflict heavy damage.
2. Seismology knows the approximate generation mechanisms of a large earthquake and can predict strong ground motions under *many* assumptions.
3. New directions
   - From underground to ground surface, buildings, and humans
4. For the resilience capabilities of an area, data usage and application by corporations and organizations create new value in the field of disaster resilience

Number of buildings completely destroyed/completely burned

Tokyo Inland Earthquake

(Southern CBD Earthquake, winter night-time, wind speed 8m/s)



Cabinet Office
Central Disaster Management Council 2013

Project

Research Project for

Enhancement of Resilience for Tokyo Metropolitan Area

Supported by NIED & MEXT

Akira NISHITANI, Waseda U.

Research Project for

Tokyo Resilience Project

Supported by NIED & MEXT

Akira NISHITANI, Waseda U.


Tokyo Resilience Project
General Principal Investigator:
Naoshi HIRATA, U. of Tokyo/NIED
Subproject A
PI+Co-PI
Subproject B
PI+Co-PI
Subproject C
PI+Co-PI
Collection and Synthesis of Data
Regarding Structural/Non-structural Combined
Performance and Damage Evaluation
with E-defense shake table test experiments

Subproject C

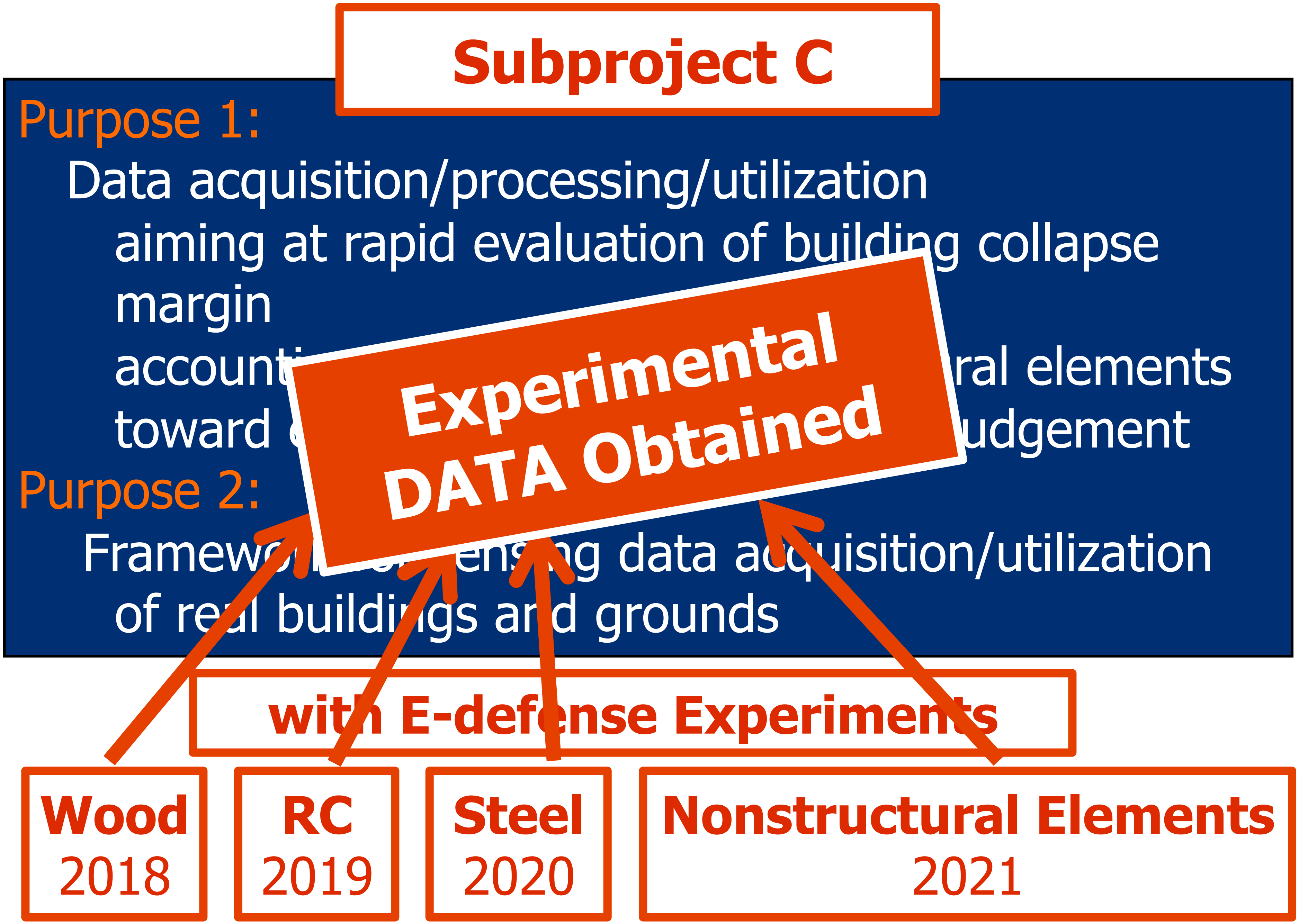
Purpose 1:

Data acquisition/processing/utilization
aiming at rapid evaluation of building collapse margin
accounting for structural/non-structural elements
toward effective business continuity judgement

Purpose 2:

Framework for sensing data acquisition/utilization
of real buildings and grounds

with E-defense Experiments



Subproject C
Purpose 1:
Data acquisition/processing/utilization
aiming at rapid evaluation of building collapse margin
accounti
ral elements
toward
udgement
Purpose 2:
Framewo
ens
g data acquisition/utilization
of real buildings and grounds
Experimental
DATA Obtained
with E-defense Experiments
Wood
2018
RC
2019
Steel
2020
Nonstructural Elements
2021

Tokyo Resilience Project

Subproject C

PI: Akira NISHITANI, *Waseda U.*
Co-PI: Koichi KAJIWARA, *NIED*

W **Team I: Leader** Takuya NAGAE, *Nagoya U.*

RC **Team II: Leader** Koichi KUSUNOKI, *U. of Tokyo*

S **Team III: Leader** Masahiro KURATA, *Kyoto U.*

NS **Team IV: Leaders**
Eiji SATO, *NIED* + Kazuhiro HAYASHI, *Toyohashi I. of Technology*

Leader for Team V: Akira NISHITANI, *Waseda U.*

Tokyo Resilience Project

Subproject (C)

PI: **Akira NISHITANI**, ***Waseda U.***
Co-PI: **Koichi KAJIWARA**, ***NIED***

Team I: Leader **T. NAGAE**, ***Na***

Wood, 2018

Team II: Leader **K. KUSUNOKI**, ***U.***

RC, 2019

Team III: Leader **M. KURATA**, ***I***

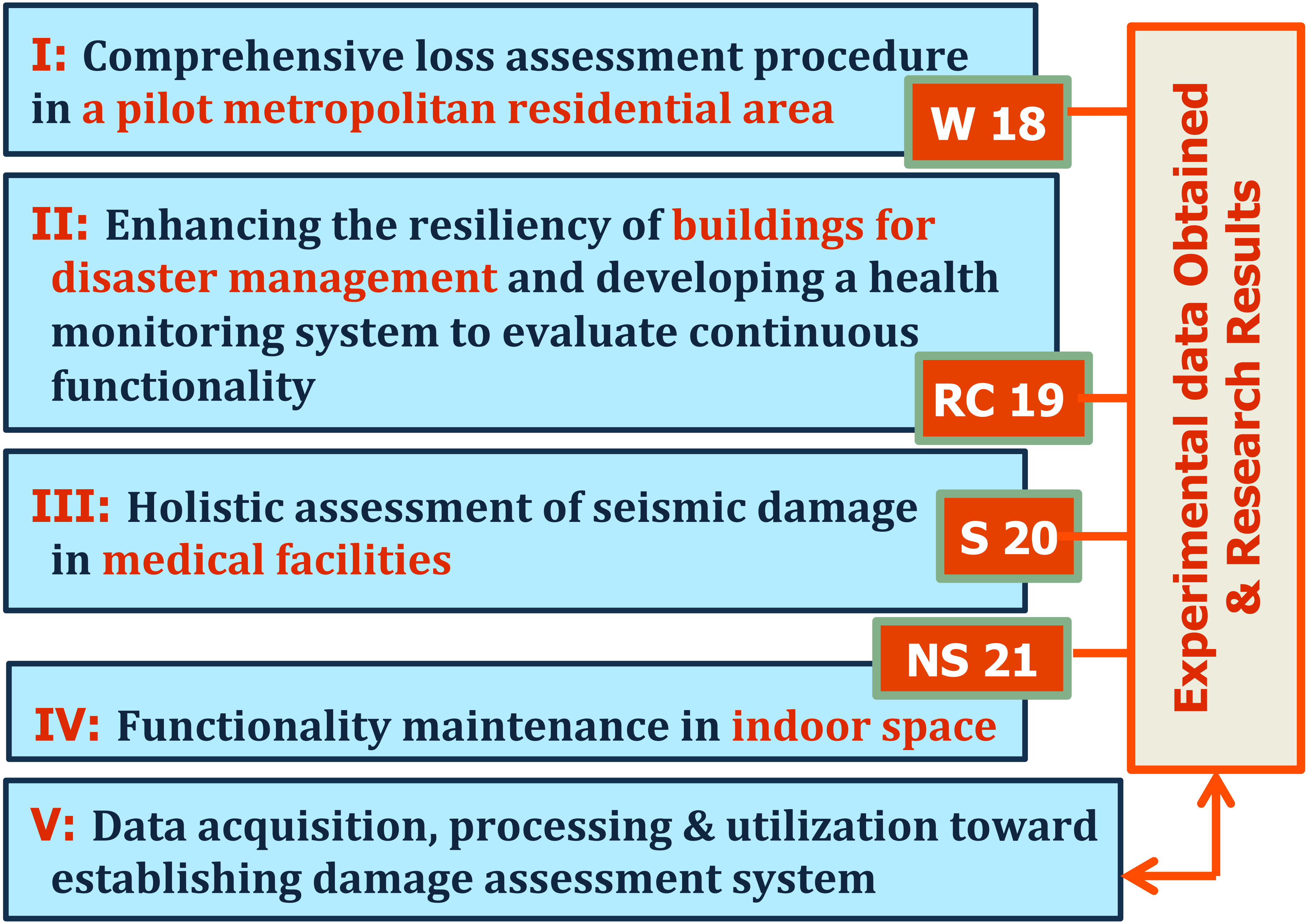
Steel, 2020

Team IV: Le

E. SATO, ***NIED*** **+ K. HAYASHI**, ***Toyoh***

Nonstructural Elements
2021

Leader for Team V: **A. NISHITANI**, ***Waseda U.***


I: Comprehensive loss assessment procedure in a pilot metropolitan residential area
W 18
II: Enhancing the resiliency of buildings for disaster management and developing a health monitoring system to evaluate continuous functionality
RC 19
III: Holistic assessment of seismic damage in medical facilities
S 20
NS 21
IV: Functionality maintenance in indoor space
V: Data acquisition, processing & utilization toward establishing damage assessment system
Experimental data Obtained & Research Results

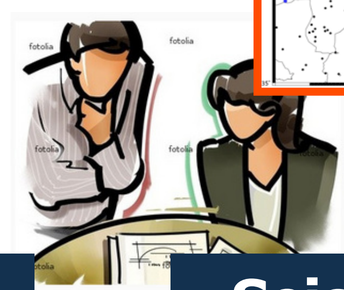
V: Data acquisition, processing & utilization toward the establishment of damage assessment system

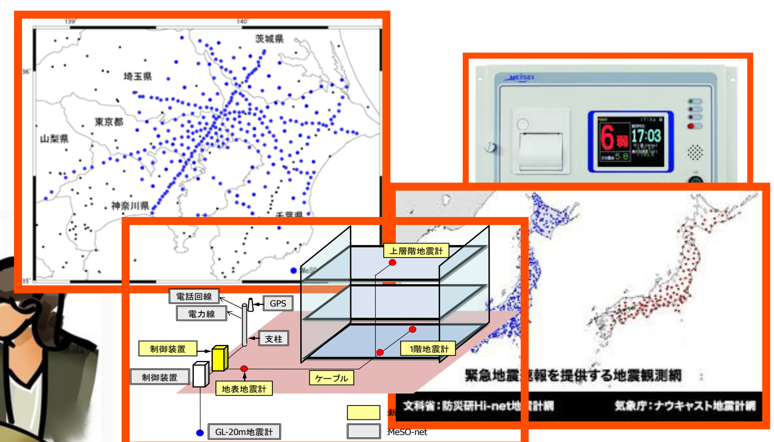
- **Team V takes the role of PI for all Teams I, II, III and IV.**
- **Data acquisition/processing of**

(i) E-defense experiments to be conducted by Teams I-IV;

(ii) E-defense tests previously-conducted;

(iii) seismographic network

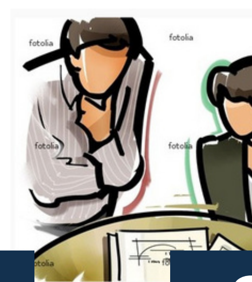


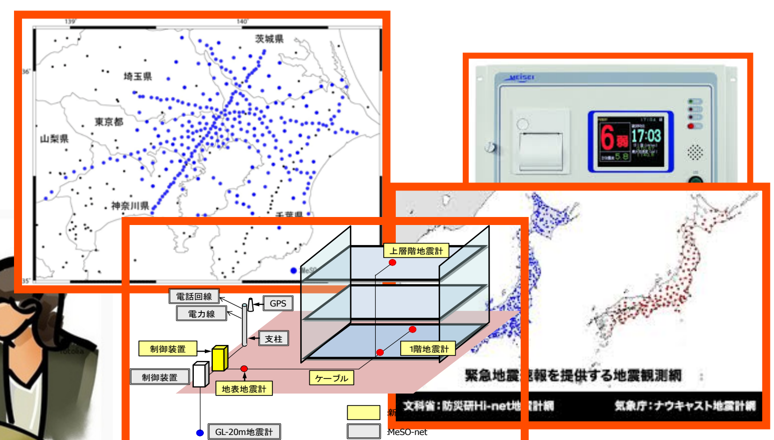


Experimental Data **Seismographic Network Data**

V: Data acquisition, processing & utilization toward the establishment of damage assessment system

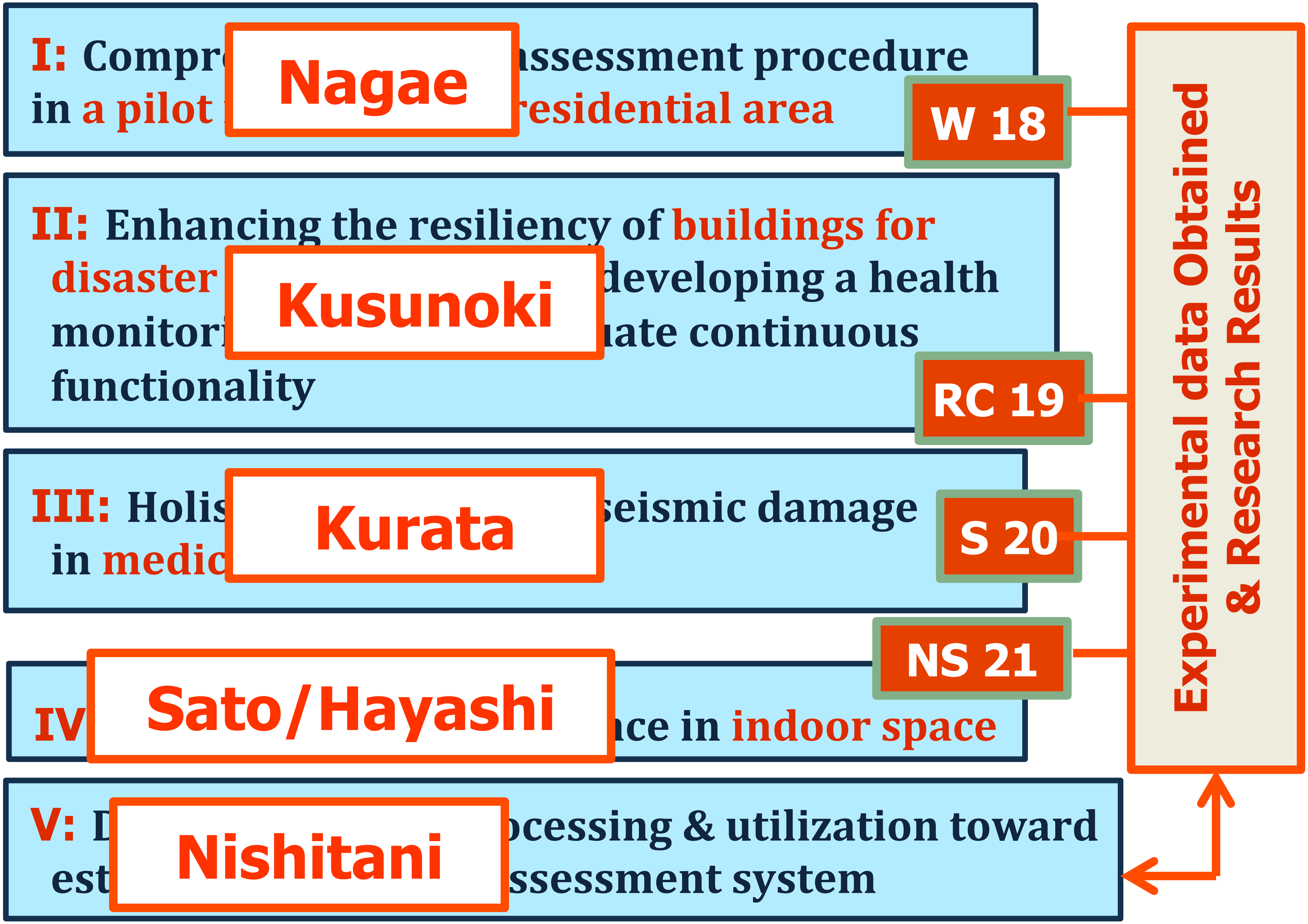
… and effective utilization of these processed data toward the establishment of seismic disaster prevention.





Experimental Data

Seismographic Network Data


I: Compr
assessment procedure
in a pilot
residential area
Nagae
W 18
II: Enhancing the resiliency of buildings for
disaster
developing a health
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RC 19
III: Holis
seismic damage
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Kurata
S 20
NS 21
IV
Sato/Hayashi
nce in indoor space
V: D
ocessing & utilization toward
est
ssessment system
Nishitani
Experimental data Obtained
& Research Results

Thanks for your attention.

2017/07/13 US-Japan workshop

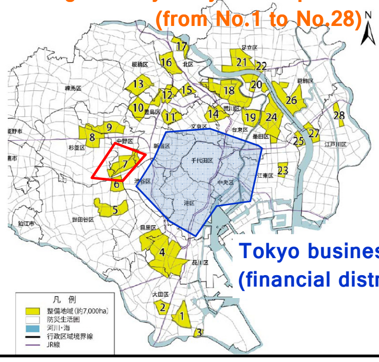
(2018) E-Defense Test Plan

Takuya Nagae

2006-2014 E-Defense
2014-2017 Nagoya University

Theme **I:** Comprehensive loss assessment procedure in a pilot metropolitan residential area

Densely populated wooden house areas are designated by Tokyo Metropolitan Government (from No.1 to No.28)



Theme **I:** Comprehensive loss assessment procedure in a pilot metropolitan residential area

View from the 45th floor of the main office building of Tokyo Metropolitan Government

Wooden houses spread west of the Tokyo Metropolitan Government building

---

Theme **I:** Comprehensive loss assessment procedure in a pilot metropolitan residential area

Wooden houses spread west of Tokyo Metropolitan Government office

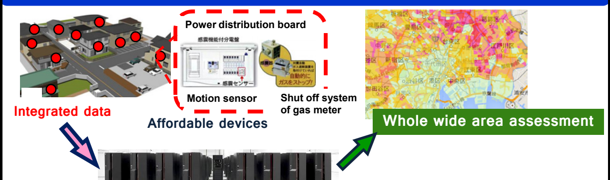
The 2018 test is focusing on the damage of this type of areas

Theme **I:** Comprehensive loss assessment procedure in a pilot metropolitan residential area

A strong mission from MEXT

- **Identification** of the significantly damaged locations
- **Rapid assessment** for the total seismic damage
- **Efficient control** of the ambulance service and rescue actions etc.

To make a test podium on the shaking table of E-Defense



TEST → Development of computational evaluation systems

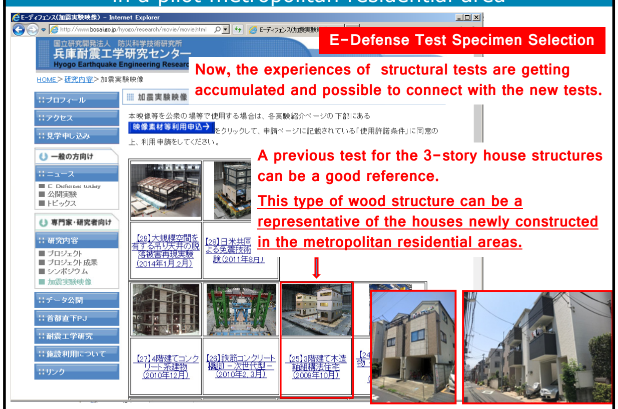
Theme **I:** Comprehensive loss assessment procedure in a pilot metropolitan residential area

E-Defense Test Specimen Selection

Now, the experiences of structural tests are getting accumulated and possible to connect with the new tests.

A previous test for the 3-story house structures can be a good reference.

This type of wood structure can be a representative of the houses newly constructed in the metropolitan residential areas.

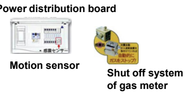


Theme I: Comprehensive loss assessment procedure in a pilot metropolitan residential area

The previous tests → Fixed Base Structure
A normal direction…
(Parameter → Amount of wall, connection detail etc.)

1923

This time, the utility functions related to occurrence of loss as well as fire will be incorporated → Sensor verification



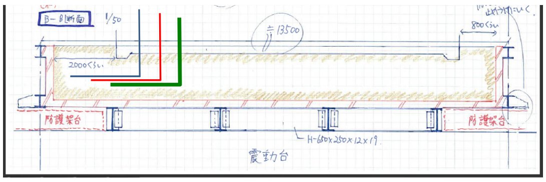
An extracted house system will be produced as systematically as possible.

A complex system

Theme I: Comprehensive loss assessment procedure in a pilot metropolitan residential area

Realistic boundary condition makes a story

Soil structure combined actions may cause failures of electricity, gas and water systems.



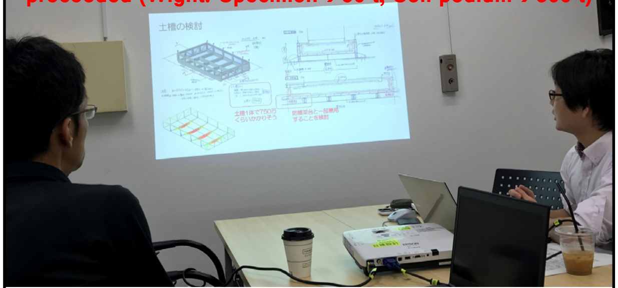
Theme I: Comprehensive loss assessment procedure in a pilot metropolitan residential area

EXAMPLE (Kumamoto Mashiki observations, 2016)

This type of Residential buildings showed failures of pipes due to soil structure combined actions

Theme I: Comprehensive loss assessment procedure in a pilot metropolitan residential area

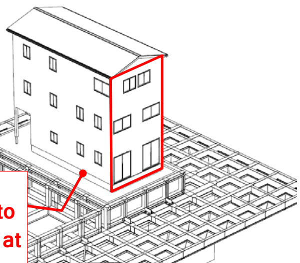
The numerical analysis for the test system is carefully proceeded (Wight: Specimen→50 t, Soil podium→500 t)



The test method for
Soil Structure Combined Action Test

Theme I: Comprehensive loss assessment procedure in a pilot metropolitan residential area

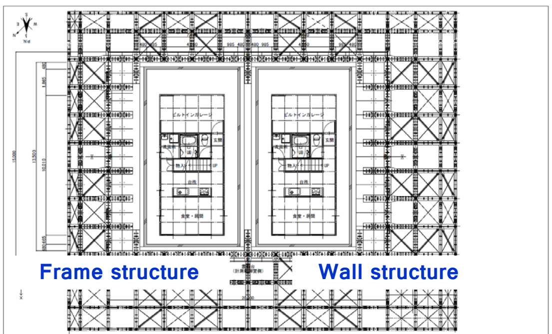
Aspect ratio
→ 2
Upper frame weight
→ 27 t
Concrete slab weight
→ 28 t



Simple moment balance:
Decompression due to rocking motion starts at the lateral force of 1 g

EXAMPLE
Soil structure combined action
v.s.
Damage assessment issue of utilities

Theme I: Comprehensive loss assessment procedure in a pilot metropolitan residential area



Plan of twin specimens

Theme I: Comprehensive loss assessment procedure in a pilot metropolitan residential area

Summary (The 2018 December test for densely populated urban area)

Typical 3-story wooden houses (current design base) will be set on their soil podiums.

The system includes underground pipes of gas, water and sewer. Electricity is planned, too.

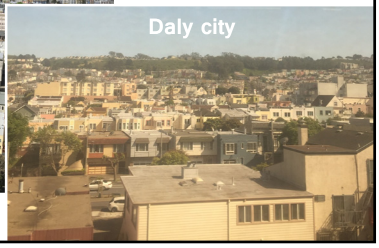
One is frame structure, the other is wall structure.

The loss assessment and structural performance assessment will be the target.

Theme I: Comprehensive loss assessment procedure in a pilot metropolitan residential area

The first stage → Preparation for the test podium

Thank you for your attention.



Theme I: Comprehensive loss assessment procedure in a pilot metropolitan residential area

- Design practitioner (experiences of 4 base isolation hospitals)
- Researcher (foundation and soil)
- Gas company(Nagoya Univ. project section)
- Electricity company(Nagoya Univ. project section)
- House makers(affordable repairing method)
- Structural engineers(response assessment)
- Insurance company(loss assessment)
- Consultants(hazard analysis)

→ Interaction with social science matters

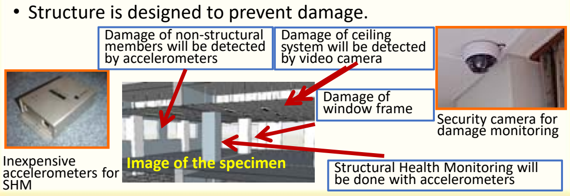
II: Enhancing the resiliency of buildings for disaster management and developing a health monitoring system to evaluate continuous functionality

Koichi Kusunoki
Earthquake Research Institute,
The University of Tokyo

"U" City Hall Under demolishment

II: Outline of the sub-group

- Develop a system to evaluate the functionality of "center for disaster management" such as city hall soon after an earthquake.
- The functionality is evaluated based on not only structural health monitoring but also health monitoring of non-structural elements such as ceiling system and finishing.
- Structure is designed to prevent damage.



Member list

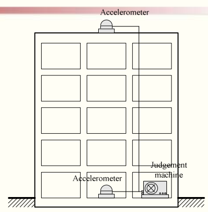
- Koichi Kusunoki (ERI)
- Hideo Katsumata (Obayashi)
- Kenji Yonezawa (Obayashi)
- Taka-aki Okubo (Hiroshima U)
- Tsuyoshi Seike (U of Tokyo)
- Yasushi Sanada (Osaka U)
- Tomohisa Mukai (BRI)
- Yo Hibino (Hiroshima U)
- Atsushi Teramoto (Hiroshima U)
- Kazuhiro Hayashi (Toyohashi IT)
- Satoshi Fukai (NIKKEN)
- Kiyomune Hirai (NEC)
- Hikaru Yamamoto (NEC)
- Masayuki Araki (ALabo)
- Izumi Nakamura(NIED)
- Taizo Matsumori (NIED)

Research items

1. Develop a monitoring method to classify damage level of structure with recorded accelerations.
2. Develop a monitoring method to detect damage of non-structural members with video camera such as ceiling system.
3. Integrate two monitoring methods and develop a system to evaluate the continuous functionality
4. Develop a new detailing of spandrel walls to control damage.
5. Conduct an E-Defense test to confirm the system

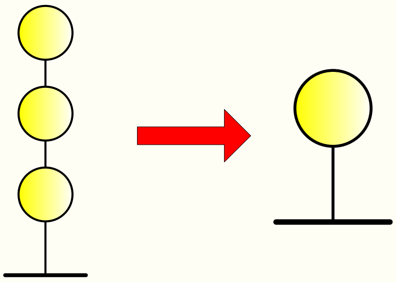
Simplified SHM W/ PBD

- At MOST one sensor for each floor
- Apply the Performance-based design procedure (Capacity spectrum method)
- Compare performance curve to demand curve
- Both curves are calculated only from the measured acceleration

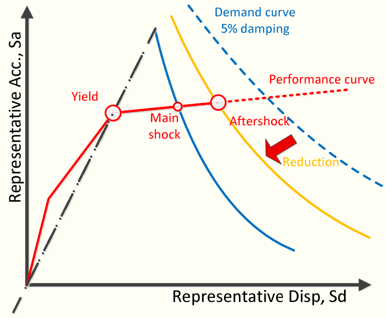


ITK sensor

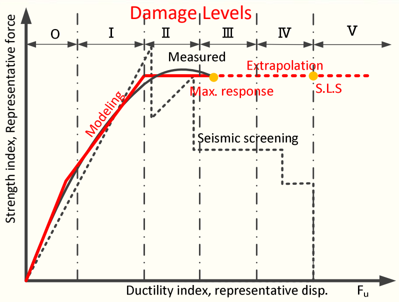
Simplify down to SDoF



Capacity Spectrum Method

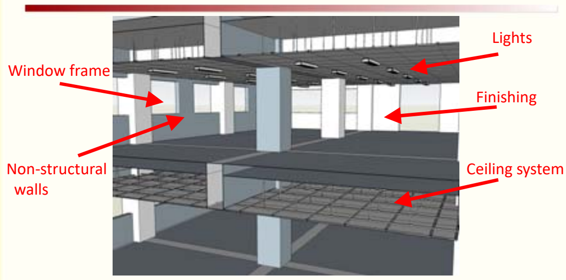


Damage classification



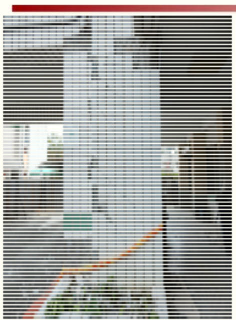
- Classify the damage level from 0 (None) to V (Collapse)

From "real scale" to "real building"



- Specimen will have non-structural members, too

Health Monitoring for Non-structural members

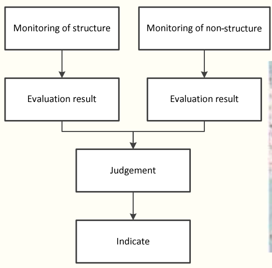



Security camera will be used to take pictures for judgement

Finishing tiles

Ceiling system

Integration

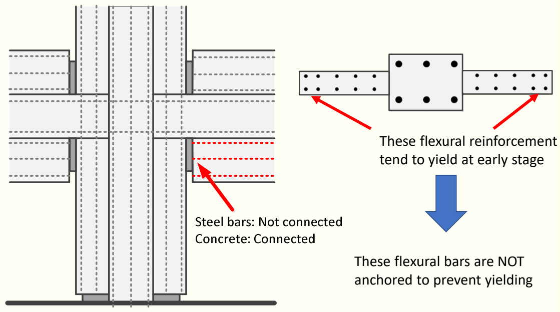


Design criteria of center for disaster management

- Structure has functionality even after severer earthquake.
  - The structure should carry the base shear coefficient of 0.55 at the story deflection angle of 1/300 or less.
  - The structure should have the base shear coefficient of 0.30 as bare frame.
- Non-structural elements should be designed according to the guidelines, too.

Kusunoki Laboratory
Earthquake Research Institute, the University of Tokyo

New details at the end of the walls



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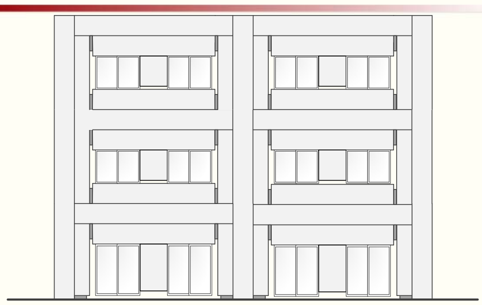
Earthquake Research Institute, the University of Tokyo

E-Defense test



2×1 span 3-story R/C specimen in full scale

Kusunoki Laboratory
Earthquake Research Institute, the University of Tokyo

Schedule

- Y2017 & Y2018
  - Member tests of R/C beams and columns with walls
  - Development of monitoring system for both structure and non-structural members
- Y2019
  - E-Defense Test
- Y2020
  - Further study of E-Defense test results
- Y2021
  - Trial production of the system

Kusunoki Laboratory
Earthquake Research Institute, the University of Tokyo

Thank you for your kind attention…

Kusunoki Laboratory
Earthquake Research Institute, the University of Tokyo

US-Japan Workshop, July 13 - 14, 2017

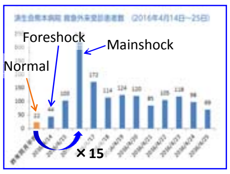
Holistic Assessment of Seismic Damage in Medical Facilities (Steel & Protective Systems)

Presenter: Masahiro Kurata (Kyoto University)

京都大学 KYOTO UNIVERSITY　DPRI-KU　KYUSHU　京都工芸繊維大学 KYOTO INSTITUTE OF TECHNOLOGY　TAKENAKA　Kyoto University Hospital　NIED

Resilience of Medical Service in Large EQs

Increase of Medical Demand



Kumamoto EQ., 2016/4/14-25

Reduction in Medical Function


Damage of Dialyzer Machine Room

- "Cliff edge" in medical system?
- Kanagawa pref. (next to Tokyo) predicts a failure of medical system even with moderate earthquake scenario

Sources: http://www.sk-kumamoto.jp/, http://www.jinnouchi.or.jp/

2

Hospital Evacuation

Suspension of medical service
- Damage to structural and non-structural components
- Damage to infrastructure and equipment


Dispatch of ambulances, defense force, and DMAT from the western Japan

Relocation of inpatients to other hospitals and homes

Source：Kurata

Worsen condition of patients	Degrade regional medical services	Deteriorate hospital management

3

Survey in Kumamoto: Hospital Evacuation

Multidisciplinary survey
- Structural engineering
- Medical doctors (DMAT)
- Medical information
- Clinical engineers
- Facility staff

4

Non-structural damage

5

Primary Reason of Evacuation

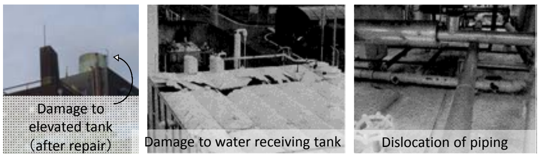
- Concerns on seismic resistance of buildings
- Water shortage due to building infrastructure damage
- Regional water shortage

Table. Primary Reason of Evacuation

Hospital	A	B	C	D	E	F	G	H	I	J
Seismic resistance	●	●	●	●	●	-	-	-	-	-
Water (building)	-	●	●	-	●	●	-	-	●	-
Water (regional)	-	-	-	-	-	●	●	●	●	-

6

Impact of Water Shortage



Why water supply is so much concern?

1. Medical service operation, e.g. dialyzing
2. Sanitation, Prevention of Infection

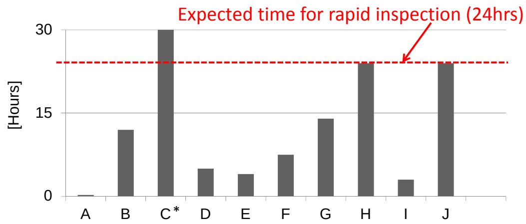
（Sources：Jinnouchi Hospital webpage and Kumamoto City Hospital Report）

7

(3) Holistic Assessment of Seismic Damage in Medical Facilities

10

Time required for Decision-Making



C*：Temporal evacuation 5 min. after mainshock

- Very quick decision was required to hospital owners / managers
- No room to wait for rapid inspection results.

8

Evaluation of special equipment and functionality loss in disaster-base facilities

Project Objectives:

- Methods to quantitatively evaluate functionality loss after extreme EQs will be proposed.
- A framework to avoid unnecessary disorder, and support safe and efficient decision-making by hospital managers on continuous use of facilities will be developed.
- Methods to identify the post-earthquake medical functionality using advanced sensing technologies will be explored.

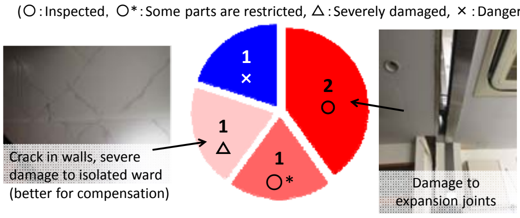
PI: Masahiro Kurata (Kyoto University)
Co-PI: Yosuke Kawamata (NIED)

Difficulty in Decision-making

- Decision-maker：Hospital managers or medical doctors
- Available information: Visual inspection by hospital staff

Post-earthquake diagnosis results

（○：Inspected, ○*：Some parts are restricted, △：Severely damaged, ×：Danger）

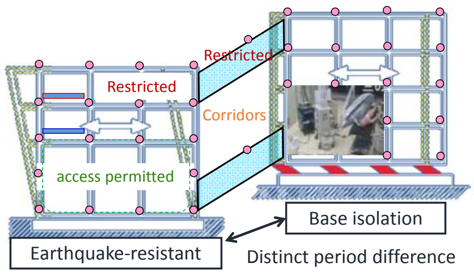


Diagnosis results provided by Hosps. tells that 4 out of 5 evacuated because of building damage could use actually.

9

Overview of E-Defense Test

- Medical Building Complex: base-isolated building with critical facilities, earthquake-resistant building, and connecting corridor of two buildings.



12

Working Group

A) E-Defense Test Plan:
Akazawa (Chair, Takenaka), Kawamata (NIED), Kurata (Kyoto U.), Saburi (Takanaka)

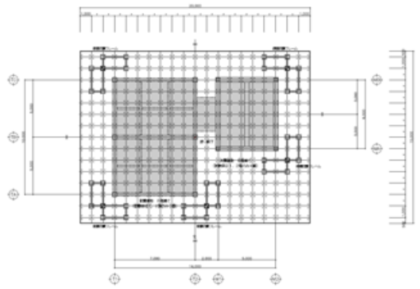
B) Medical Function Evaluation / BCP:
Otsuru (Chair, Kyoto U. Hospital), Kurata, Kawamata

C) Frame Design and Collapse Margin Assessment:
Kurata (Chair), Akazawa, Saburi, Matsuo (Kyushu U.)
Industrial collaborators (2)

D) Non-Structural / Equipment Design and Damage Assessment
Kanao (Chair, Kyoto Tech.), Akazawa, Kurata, Fujita (Kyoto U.), Kawamata
Industrial partners (6)

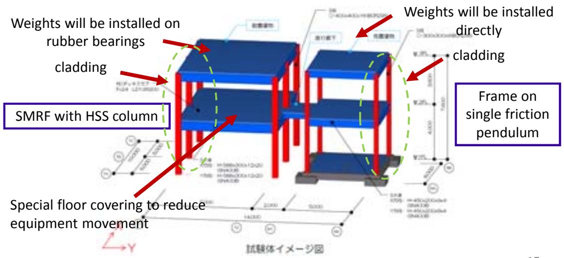
Specimen Idea (Frame WG)

- 1 by 2 spans steel moment resisting frame (5 m x 7 m grid)
- 1 by 1 span base-isolated steel frame (5 x 6 m grid)
- 2 m corridor connecting two frames



Specimen under Design (Frame WG)

- SMRF: 2-3 stories + weights for two stories (3,500 kN total)
- BI: 2-3 stories + weights for two stories (4,000 kN total)
- Corridor: expansion joints for base-isolation



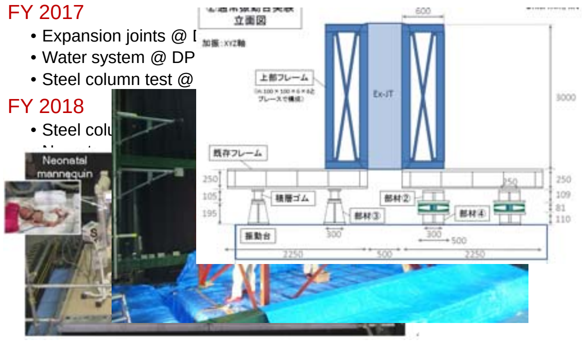
Damage Scenario

- Ground motions: ones corresponding to assumed hazard level (50/50, 10/50, 2/50, etc.), representative ones each for the periods of SMRF and BIF
- SMRF: test to collapse
- BIF: slight damage
- Non-structural components and equipment: failure of water supply system, etc. (no budget to buy thus tough negotiation with corporate partners are expected..)

Component-level Tests (Frame, Non-S WG)

FY 2017
- Expansion joints @ [
- Water system @ DP
- Steel column test @

FY 2018
- Steel colu



Assessment (Frame, Non-S WG)

- Floor level assessment for off-limits area
- Local damage evaluation of steel frames
- Damage evaluation of nonstructural components / medical equipment using advanced sensing
- Sensors and algorithms: Under discussion
- Corporate Partners: Kyocera Communications (ultra low power wireless sensing), Tokkyo kiki (non-structural), and more

Field Drill (BCP WG)

- Preparation of rapid inspection map and guideline
- Invitation to hospital managers, DMAT, hospital staffs, etc.
- Drill with Hospital BCP, hospital evacuation guideline: complete rapid inspection within 3 hours (BCP of Kyoto U.)

BCP of Kyoto U.

19

Possible Mechanisms of Collaboration

- Verification of performance-based design
  - Implementation on low-to-mid rise steel buildings
  - US method, JASCA method
- Payload tests
  - Sensing (anything idea is welcomed)
  - Non-structural components and equipment (reserved space / floor for US-Japan payloads)
  - Components and follow-up tests in US facilities
- Blind analysis contests (tighten scheduling…)
  - Joint organization that takes care of worldwide competition
  - Publication of summary
- Open data
  - Joint publication of data paper (Structure, Non-structural components, equipment, etc.)
- Creation of future “Grand Challenge” research topics
  - Boundaries between structural and non-structural components
  - Review on design of non-structural components associated with protective systems

20

Items to be Determined

- Mutual interests
  - Steel
  - Protective Systems
  - Non-structural
  - Boundaries
- Funding mechanism
- Scheduling
- Size of collaboration (# of teams from US side)
- Setup of US-Japan joint task team
  - Post-doctoral level secretary position (tough load on blind analysis, payload test, etc.)
  - Involvement of young researchers and PhD students
- Funding for human exchange
  - JSPS post-doctoral / researcher invitation
  - NSF-EAPSI summer program
  - DPRI oversees joint research program

21

Thank you for your attention.

22

NIED

E-Defense

Theme Ⅳ

Function Maintenance in Indoor Space

NIED: EIJI SATO

2017/7/13

1

Indoor damages in 2016 Kumamoto EQ

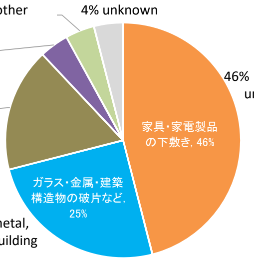
Indoor damage by 2016 Kumamoto earthquake

2

Background

Human damage against earthquake

The injury in 1995 Kobe earthquake



引用：「阪神淡路大震災による建造物の損壊と負傷に関する実態調査」調査結果

3

Objective

In earthquakes, it is important to reduce structural damages. However, **indoor damages** usually occur during lower level earthquakes then the structural damages, and **indoor damages** are more significant than the structural damages in many cases. And **the indoor damages have various influences on people**.

Mitigation of the indoor damages is important too.

In order to ensure the indoor space against earthquakes, detailed behaviors of various non-structural elements, furniture and so on need to be grasped. In addition, **appropriate approaches to assess the indoor damages** and **mitigation methods of the indoor damage** will be examined by performing E-Defense shaking table tests.

4

Implementation items

1）Establishment and standardization of the verification system of the function maintenance
- Establishment of the verification system on the excitation tests (on the same condition and repetition)
- Making of guideline of the verification technique (anywhere and the same condition)

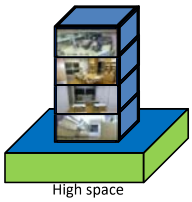
2）Examination of the assessment method for indoor damages
- Construction of system to detect the indoor damages.
- Estimation of the indoor damage levels (Safety, Warning or Danger etc.) from data measured by the damage detection system

3）Proposal of the damage reduction method for the function maintenance
- Development of new methods or improvement of existing methods to protect the indoor space against EQ
- Examination of the system for early restoration

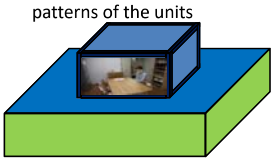
5

Verification system of the function maintenance

Basic concepts
- ✓ Specimens for shaking table test are assembled of units
- ✓ Indoor space and function can be modeled in the units
- ✓ The units can be reused for similar experiments in future
- ✓ There are various combination patterns of the units



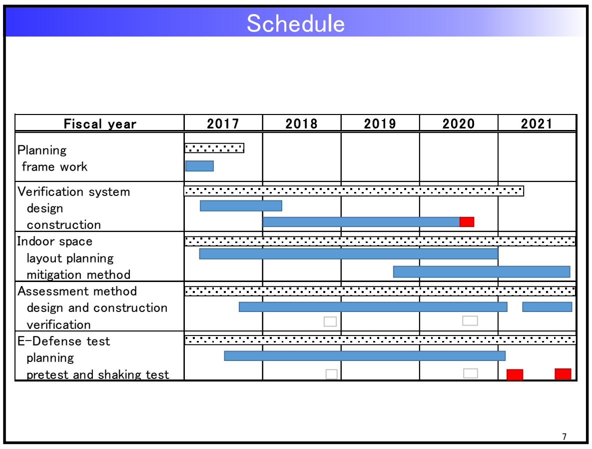
High space (Vertical combination)



Single unit

Large space (Horizontal combination)

6


Schedule
Fiscal year
2017
2018
2019
2020
2021
Planning
frame work
Verification system
design
construction
Indoor space
layout planning
mitigation method
Assessment method
design and construction
verification
E-Defense test
planning
pretest and shaking test
7


Thank you
8

Introduction of NEHRI and Possible Research Collaboration with Japan

First NHERI NIED/E-Defense Joint Meeting

Julio Ramirez, Director NHERI
Network Coordination Office
Purdue University
CMMI-1612144I

Kajima Corporation
Kobori Research Complex
Tokyo, Japan
July 13, 2017

Natural Hazards Engineering Research Infrastructure (NHERI)

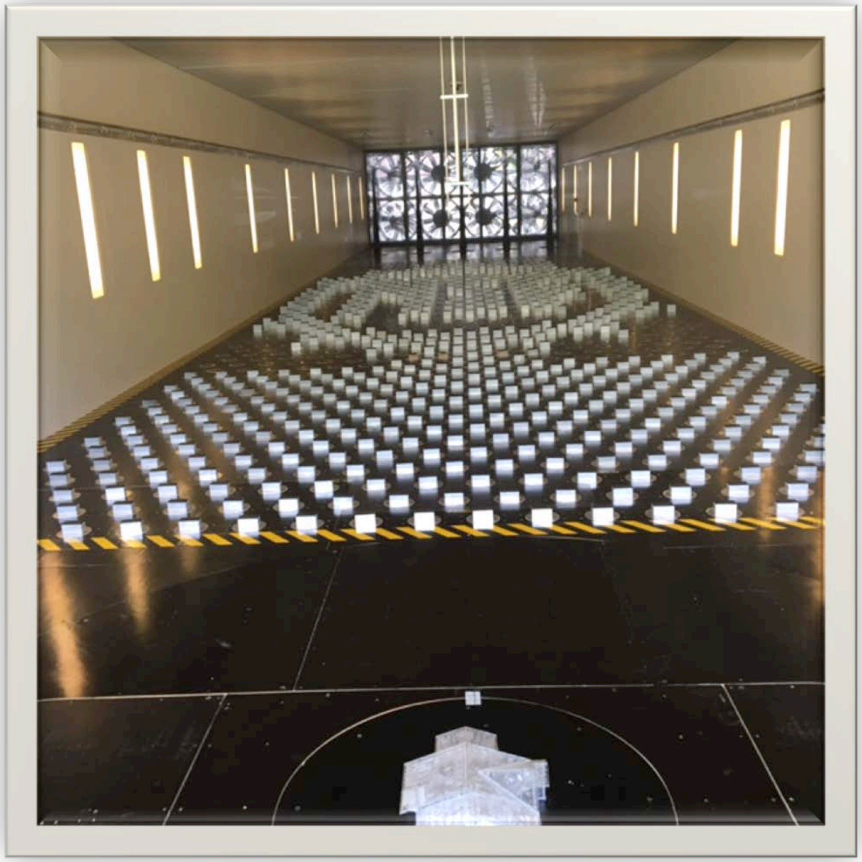
NHERI Access and Funding

- Access through NCO Centralized Facility Scheduling of user time (NSF-Supported and non-NSF-supported) at each Experimental Facility, including the RAPID.
- Funding:
  - NSF CMMI and other directorates
    - September 15, 2017
    - January 24, 2018
  - Other Federal and State Agencies and Industry

Research Team at OSU Facility – Dan Cox, OSU PI

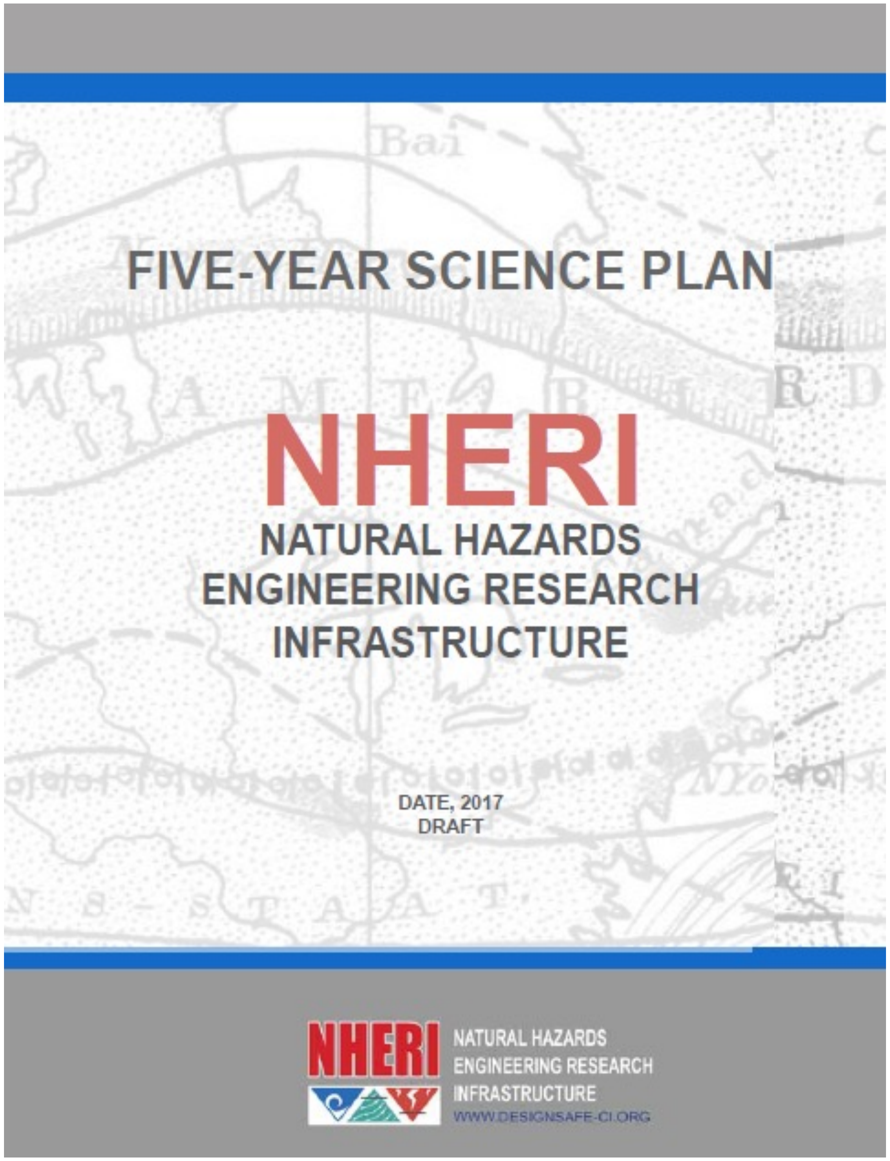
NCO Strategic Goals

- Community Leadership
    - ➢ Science Plan
    - ➢ Partnerships
- Enable Research Through Coordination of NHERI Facilities
- Education and Community Outreach
    - ➢ NHERI REU and Summer Institute
    - ➢ Broad dissemination of NHERI Impact



NHERI at University of Florida Boundary Layer Tunnel with roughness elements

NHERI Science Plan



Developed by Science Plan Task Group:

- Academia
- Early Career Professional
- Lifeline Infrastructure
- NHERI Investigators
- Practitioners
- Social Scientist

NHERI and NIED/E-Defense Research Collaboration

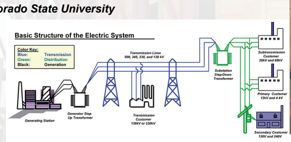
Elements:

- Access to Facilities
  - Testing Techniques
  - Condition Assessment
  - Post-disaster data collection
- Research Coordination Program
- Data Exchanges
- Educational and Outreach Activities

At E-Defense, shake table tests were performed on a 5-story full scale steel moment frame building isolated with triple pendulum bearings. The isolation system consisted of 9 bearings, one beneath each column of the building.

Testing of Full-Scale Wood Buildings in the Pursuit of Urban Seismic Resilience: Some Suggestions for Possible Collaboration

John W. van de Lindt
George T. Abell Distinguished Professor in Infrastructure
Co-Director, NIST Center for Risk-Based Community Resilience Planning
Colorado State University



NHERI/E-Defense Pre-Planning Meeting; Tokyo, July 13-14, 2017

Some Research Initiatives for Community Resilience (Eng.)

National Science Foundation

(2014) Resilient and Sustainable Buildings (RSB)
(2015) Natural Hazards Engineering Research Infrastructure (NHERI)
(2015) Engineering for Natural Hazards (ENH) program
(2015) Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP)

National Institute of Standards and Technology

(2015) Center for Risk-based Community Resilience Planning, Colorado State Univ.

Department of Homeland Security

(2015) Coastal Resilience Center, U. North Carolina
(2015) Critical Infrastructure Resilience Institute, UIUC
(Ongoing) Argonne National Labs

US Army Corps. of Engineers

(2014) North Atlantic Coast Comprehensive Study

NEHRP's Vision: "A nation that is earthquake-resilient in public safety, economic strength, and national security"

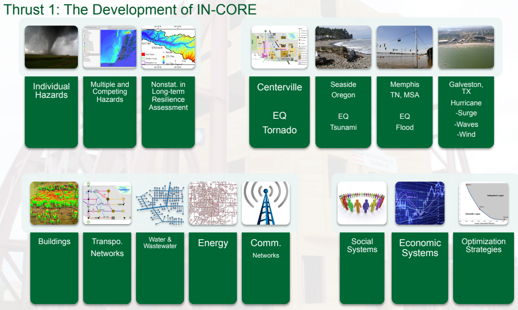
The ability of a community to prepare for and adapt to changing conditions and to withstand and recover from disruptions to its physical and non-physical infrastructure.

Presidential Policy Directive 21

NIST Center of Excellence for Risk-Based Community Resilience Planning

The NIST Center for Risk-Based Community Resilience Planning

Thrust 1: The Development of IN-CORE



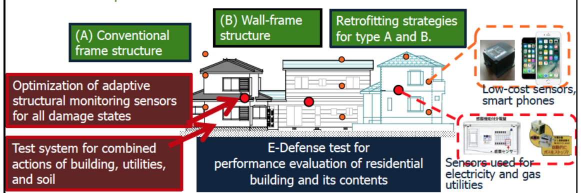
Preventing a hazard from becoming a disaster

- Recent disasters have revealed shortcomings in building practices that focus on performance of individual facilities.
- Financial limits on public investments in infrastructure renewal
- Presidential Policy Directive 21 (PPD-21): Critical infrastructure security and resilience

U.S. Wood Building Testing

- Design Code: CUREE-Caltech Woodframe Project (UC-Berkeley; UCSD; et al)
- PBSD: NEESWood: Development of a Performance-Based Seismic Design Philosophy for Midrise Woodframe Buildings (Buffalo; E-Defense, 2009)
- Retrofit: NEES-Soft: Seismic Risk Reduction for Soft-Story Woodframe Buildings (Buffalo, 2013; UC San Diego 2013)
- NHERI Tallwood: Testing and Modeling in Support of Resilience-Based Seismic Design for Tall Wood Buildings (UCSD, 2017; Lehigh 2018; UCSD 2020)
- CEA Cripple Wall Project (UC Berkeley & UCSD, 2017-2018)
- Numerous CLT projects ongoing ……

Resilience



Ref: Materials provided to U.S. pre-planning team

Some thoughts for NSF ENH Proposals or EArly-concept Grants for Exploratory Research (EAGER) for U.S. researchers:

#1: U.S. researchers would need to move quickly to obtain funds from ENH (US$1.5M is approximate max.)

#2: Type B wall-frame structure wood buildings are the most likely to be of interest for collaboration

#3: Several full-scale woodframe building tests within NHERI available for collaboration from Japanese researchers

Thank you.

Professor John W. van de Lindt
jwv@engr.colostate.edu

Acknowledgements

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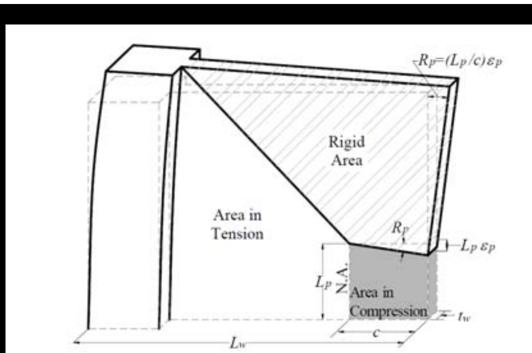
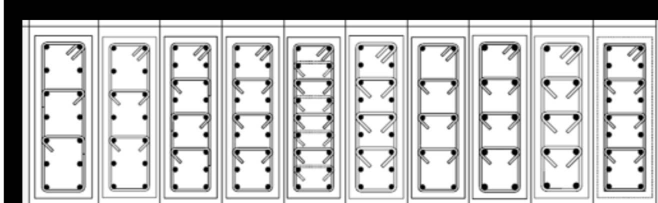
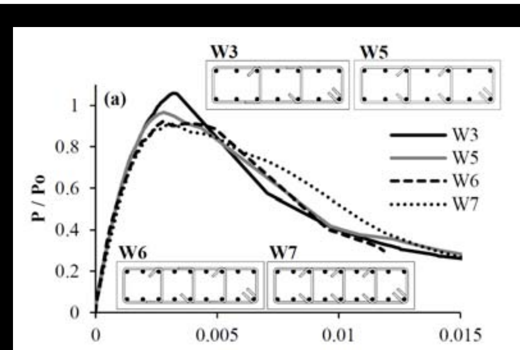
The Center for Risk-Based Community Resilience Planning is a NIST-funded Center of Excellence; the Center is funded through a cooperative agreement between the U.S. National Institute of Standards and Technology and Colorado State University (NIST Financial Assistance Award Number: 70NANB15H044). The views expressed are those of the author(s), and may not represent the official position of the National Institute of Standards and Technology or the US Department of Commerce.

US-JAPAN COLLABORATION
RC

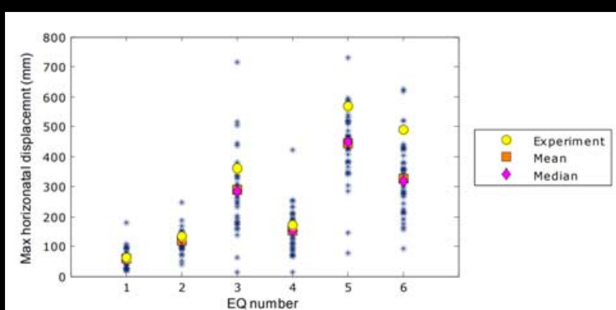
Rectangular Walls







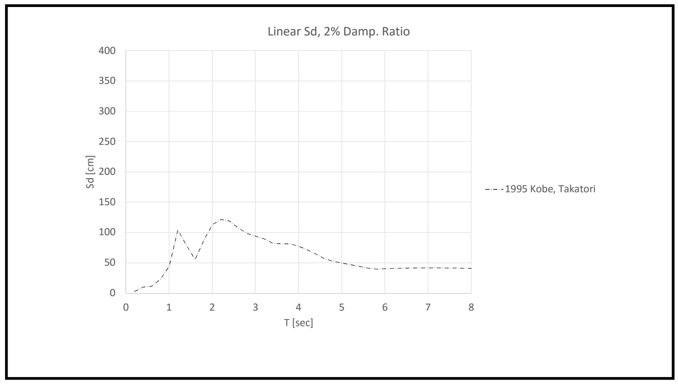
Systematic Vetting of Analysis Procedures / Software

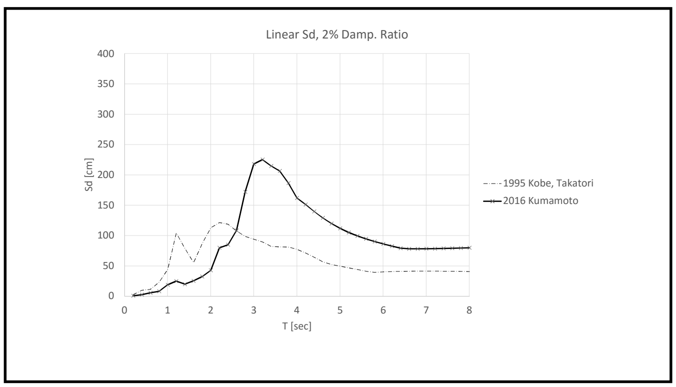


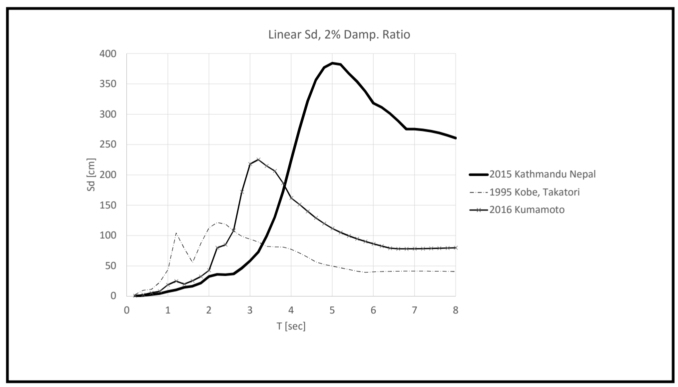
Common Database of Dynamic and Static Experiments / Instrumented Buildings

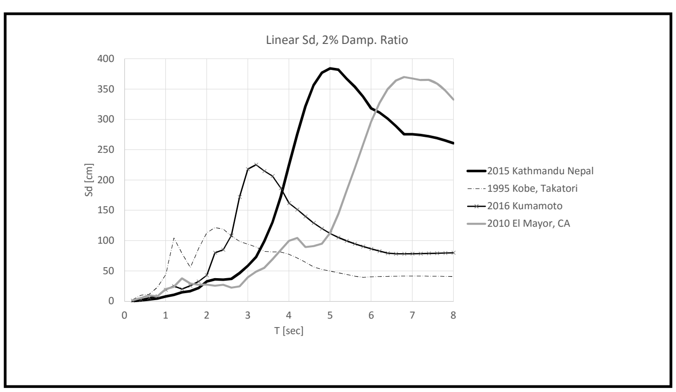
Automated Inspection Based on Images

Large Displacement Demands for Long-Period Structures









Japan/U.S. Planning Meeting for Collaborative Research:
First NHERI/E-Defense Joint Meeting

Advanced Steel Structures

Presented by
Gilberto Mosqueda (University of California, San Diego)
Co-Chair:
Masahiro Kurata (Kyoto University)

Japan/U.S. Opportunities for Collaboration

- **Upcoming test on steel hospital buildings**
- **Synergies between experimental resources such as E-Defense and NHERI facilities**
- **Use of existing data from past experiments to further advanced understanding of structural response**
- **Exchange of ideas and discussion of current/future research needs**
- **Take advantage of intellectual resources on both sides**

Identified Priority Research Topics in Steel Structures (Past Meetings)

- Reliable Simulation of the Seismic Response of Steel Structures through Collapse under 3-D Loading
- Resilient Steel Rocking Systems for Damage-free Performance
- Assessment of Complex Inelastic Response Mechanisms and Mitigation of Non-ductile Limit States
- Utilization of Available Experimental Data to Further Efforts towards Accurate Modeling of Structural Systems under Earthquake Loads

Reliable Simulation of Steel Structures

Opportunities for collaboration and data use

1) Testing of Steel Hospital Building at E-Defense
   a. Verification of simulation capabilities under multiple components of excitation
   b. Evaluation of performance assessment methods for complete building systems
   c. Comparison of fixed-based and seismically isolated configurations

2) Supplemental studies on component and subassembly behavior using hybrid simulation
   a. Columns under combined loading, including large axial loads
   b. Beam connections and base plate behavior
   c. Expand to other building configurations (tall buildings)

3) Detailed FEM modeling of steel structural components and system through for collapse

Assessment and Retrofit of Structures

1) Assessment of current evaluation strategies to quantify performance of complete system through collapse
   a. Consideration of structural and nonstructural systems
   b. Large-scale verification of retrofit strategies
   c. Advanced high performance solutions for immediate occupancy

2) Understanding global behavior governed by low ductility limit states in older structures
   a. Modeling of fracture and failure hierarchy
   b. Development of soft stories
   c. Effects of reserve capacity – backup strength

Response Control for Improved Functionality

1) Integration of response modification devices with structural and nonstructural system design
   a. Consideration of nonstructural response

2) Development of new strategies for response modification (materials, configurations, devices)

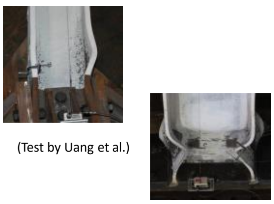
3) Recent focus on rocking systems that target immediate occupancy and damage-free performance

4) Application to existing and new construction
   a. Spine systems
   b. Self-centering systems

Current Research on Steel Moment Frames

Investigators: C.M. Uang (UCSD), S. El-Tawil, J. McCormick (U Michigan)

- **Behavior of deep columns under combined axial and lateral loads**
  - Testing under multiple components of excitation using SRMD at UC San Diego
  - Detailed finite element models that capture complex behavior



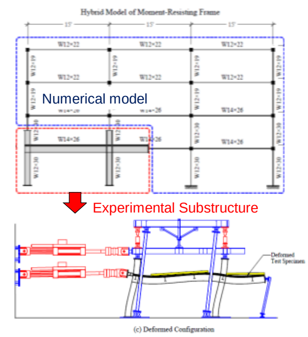
(Test by Uang et al.)

(Forgarty et al. 2015)

Hybrid Simulation of Steel Moment Frames to Collapse

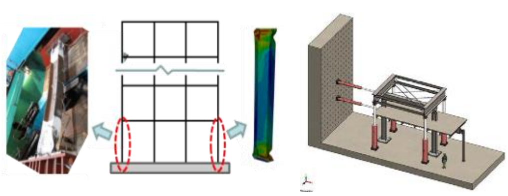
Develop and apply hybrid simulation for cost-effective large scale system level testing of structural systems to collapse.

- Include complex nonlinear numerical (OpenSEES/OpenFresco)
- Substructuring strategies to simplify actuator boundary conditions
- Applications to large scale experimental substructures



Hybrid Simulation of Steel Moment Frames

- **Hybrid simulation for system level behavior**
  - **Experimental substructures consisting of components and subassemblies**
  - **Numerical substructures including detailed FEM models**
  - **Expand to larger and more complex prototype structures such as tall buildings at scales that exceed shake table capabilities**

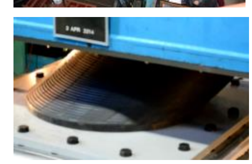


Hybrid Testing with Full Scale Seismic Isolation Bearing

Investigators: S. Mahin, A. Schellenberg, M Schoettler (UCB), G. Mosqueda, A. Sarebanha (UCSD)

Evaluate the behavior of full size bearing under realistic load combinations

- Subject full scale bearings to realist loads using hybrid testing with SRMD facility at UCSD
  - Developed hybrid testing capabilities for SRMD using ScramNet interface
- Apply 3-D ground motions to subject bearing to combined axial and shear loads
- Capture interaction between structure and bearing under large earthquakes



Research Opportunities for US-Japan Collaboration in Steel Structures

- **System level tests for verification of structural behavior using shaking tables**
  - Understanding local progression of damage to global failure mechanisms
  - System level verification of new design methodologies and retrofit strategies
  - Advancement of analytical modeling capabilities to simulate complex deterioration mechanisms and global system response
- **Characterize behavior of large scale steel structures under large deformations using university research labs in both countries**
  - Large scale testing of components under combined loading
  - Hybrid simulation on select substructures to complement/vary parameters investigated on shake table.
  - Use component data to further develop of simulation capabilities

Thank You

Discussion?

E-defense-NHERI Planning Meeting

SHIRLEY J. DYKE, PURDUE UNIVERSITY

JULY 13-14, 2017

Opportunities

LEVERAGE THE TESTS, DATA AND OBSERVATIONS

EXTEND RESULTS BY INVESTIGATING UNCERTAINTIES & BUILDING ROBUSTNESS

IDENTIFY THE MOST VULNERABLE STRUCTURES/SUBSYSTEMS NEEDING INTERVENTIONS

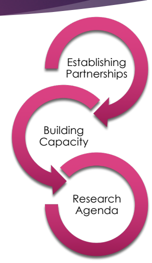
USE NHERI FACILITIES

Opportunities

A Research Coordination Network (RCN):

Multi-hazard Engineering Collaboratory in Hybrid Simulation

This research coordination network aims to facilitate the scientific advances needed to establish the theory of and expand the capacity for hybrid simulation as it applies to multi-hazard engineering.



Possible Research Topics

- Establishing Hybrid Simulations to Focus on Particular Regions-of-Interest
- Realistic Uncertainties & Building in Robustness
- Vulnerability needing Interventions: Retrofits and Control
- Extracting Information and Updating Damage State

How do we?

Leverage the tests, data & observations

MAJOR ADVANTAGE:

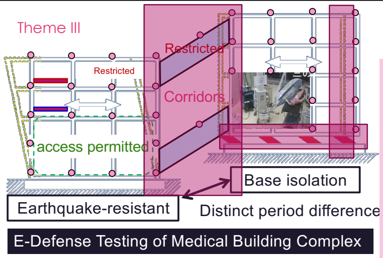
"REAL" BUILDINGS WITH CONTENTS, WALLS, CEILINGS, UTILITIES, ETC

SMALL DISADVANTAGE:

ONLY **ONE** CAN BE TESTED

Topic #1: Hybrid Simulation

- Each of the E-defense tests planned focuses on one structural configuration
- Extract the realistic features of the test, and vary the system by exploiting hybrid simulation to study:
  - Interactions present (at the boundaries)
  - Damage / collapse
  - Robustness
  - Algorithms being developed
- Study many configurations quickly with less cost, using RTHS
- Q: How to first demonstrate the validity of the hybrid simulation?



STEPS:
1. Work together to include sensors (payload) to build confidence.
2. Using US facilities, follow up with component tests or content tests using RTHS / HS
3. Examine questions, such as the interfaces between the structural and non-structural components.

Specific #1: Building Capacity for RTHS/HS Testbeds

How do we?

Extend results by investigating uncertainties & building robustness

MAJOR ADVANTAGE (SAME):

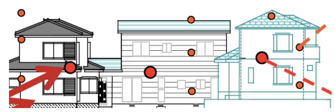
"REAL" BUILDINGS WITH CONTENTS, WALLS, CEILINGS, UTILITIES, ETC

SMALL DISADVANTAGE:

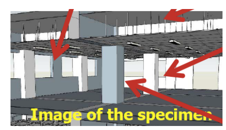
ONLY ONE CAN BE TESTED

Topic #2: Uncertainties & Robustness

- Each of the E-defense tests planned considers full scale structures with real sensors (low cost, phones, accelerometers, wireless, cameras, etc)
- Wireless sensors, for instance, may experience packet loss due to interference in real structures with real contents
- Cameras experience vibration which introduces error
- Real test data can be used to characterize these effects for use in emulation



THEME I
LOW COST
SHUTOFF SENSORS,
CELL PHONES



THEME II
ACCELEROMETERS
CAMERAS

Specific #2: Realistic Sensing Device Emulators

How do we?

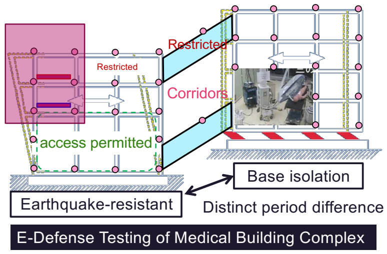
Improve our most vulnerable structures/ subsystems

HIGH PRIORITY VULNERABILITIES

CONSIDER RETROFITS & CONTROL SYSTEMS

Topic #3: Interventions/Control

- Observations from each of the tests, including structures, nonstructural components, utilities, (and sensors) help identify most critical vulnerabilities
- To avoid a loss of functionality, look at the problem from a system level
- Alleviate critical vulnerabilities to help provide continuous functionality through the use of control or other retrofit methods



THEME III
Different floor systems are considered for contents.

Perhaps other interventions for contents may be investigated.

Adding control, damping, isolation.

Specific #3: Observations > Vulnerabilities > Interventions

How do we?

Use data during an event to extract information

DAMAGE / CONDITION UPDATING

Topic #4: RT Damage / Scenario Updating

- Intensity estimation is proposed (theme I)
- Comprehensive damage assessment is proposed (theme II, III)
- Methods to evaluate loss of functionality are proposed (theme III)
- Can extend this to use the data collected, incorporate model updating and (real time) fragility updating (Payload)

SUPPORT THROUGH NHERI

- Establishing Hybrid Simulations to Focus on Particular Regions-of-Interest
  - RTHS TESTBEDS (UCSD & LEHIGH)
- Realistic Uncertainties & Building in Robustness
  - EMULATORS (SIM & CI)
- Vulnerability needing Interventions: Retrofits and Control
  - OBSERVATIONS > VULNERABILITIES > INTERVENTIONS (ALL)
- Extracting Information and Updating Damage State
  - DATA TO KNOWLEDGE (CI & SIM)

NHERI / E-Defense Collaborative Earthquake Engineering Research Program

Invitational
Pre-Planning Meeting

July 13-14, 2017
Tokyo, Japan

E. Miranda

NHERI / E-Defense Collaborative
Earthquake Engineering Research Program

Nonstructural Components

PROF. EDUARDO MIRANDA

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Nonstructural Components

For many years not enough attention has been paid to nonstructural components. Therefore, their earthquake resistant design is not as advanced as that of structures.

But we know they are very important due to three main reasons:

1. **Their damage may lead to injuries and possible casualties (even if the structure has a relatively good behavior);**
2. **Their damage can lead to partial or total loss of use/functionality;**
3. **Their damage is a major source of economic losses;**

Possible injuries and casualties to occupants

Destroyed storage racks
February 22, 2011 M_w 6.3 Christchurch, NZ Earthquake

Destroyed storage racks at warehouse. Photo / Michael Rowe

Possible injuries and casualties to occupants

Interior Damage
February 22, 2011 M_w 6.3 Christchurch, NZ Earthquake

(Photo courtesy of Prof. K. Elwood, UBC now at U. of Auckland, NZ)

Possible injuries and casualties to occupants

Nonstructural Damage, Pediatrics Floors, IESS Hospital, Manta
April 16, 2016 M_w 7.8 Manabi, Ecuador Earthquake

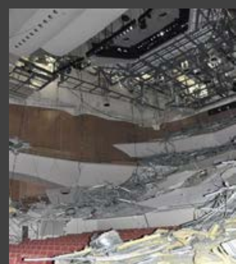
(Photo E. Miranda)

Possible injuries and casualties to occupants

Massive Ceiling Damage

March 11, 2011 M_w 9.0 Tohuko, Japan Earthquake

Kawasaki Concert Hall – Before EQ



Kawasaki Concert Hall – After EQ
(unoccupied at time of earthquake)
Ref: http://sankei.jp.msn.com

Building/Facility Downtime

Airport terminal at Santiago, Chile which was shut down mainly due to nonstructural damage

February 27, 2010 M_w 8.8 Maule, Chile Earthquake

Photo by G. Mosqueda

Photo by G. Pekcan

Many suspended air handling units like this fell to the ground

Building/Facility Downtime

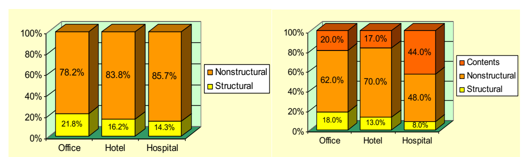
Airport terminal at Santiago, Chile which was shut down mainly due to nonstructural damage

February 27, 2010 M_w 8.8 Maule, Chile Earthquake

Photo E. Miranda

Why Nonstructural Components are a Major Source of Economic Losses ?

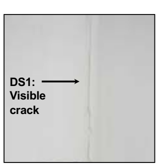
1. They typically represent most of the economic investment in buildings and therefore of the value at risk;



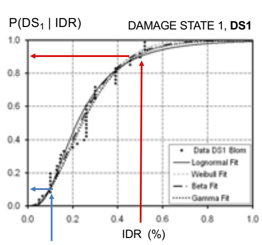
(After Taghavi and Miranda,2003)

Why Nonstructural Components are a Major Source of Economic Losses ?

2. Their damage is often triggered at levels of response much smaller than those necessary to initiate structural damage;



DS1: Can be repaired by patching, re-taping, sanding and re-painting the gypsum wallboards



(After Miranda and Araya, 2011)

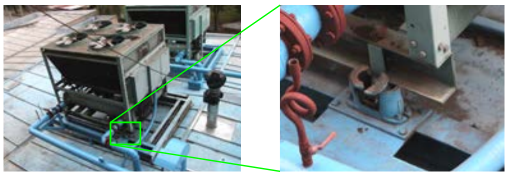
Many of today's hardware and attachments do not behave adequately

Photo E. Miranda, 2010 Chile EQ

Photo E. Miranda, 2010 Chile EQ

Many of today's attachments do not behave adequately

Source: http://rsv.com



(Photo E. Miranda, Chile EQ 2010) (Photo E. Miranda, Chile EQ 2010)

Examples of Recent Nonstructural Testing in the U.S.

(After M. Magarakis et al, 2012)

(After M.A. Phipps, 2015)

(After T. Hutchinson et al. 2013)

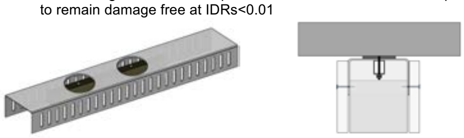
(After T. Hutchinson et al. 2013)

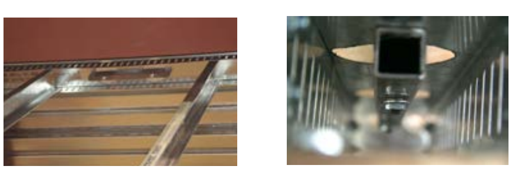
Examples of Shake Table Testing at E-Defense

Six brief examples of possible US-Japan cooperation

1. Development and Testing of New Generation of Nonstructural Components

Example: New Sliding/frictional developed at Stanford that allows interior partitions to remain damage free at IDRs<0.01

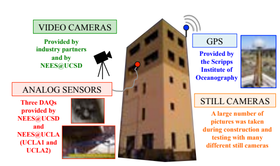




(After Araya and Miranda, 2012)

2. Instrumentation for Improving our Understading of Seismic Demands and Fragility of Nonstructural Components

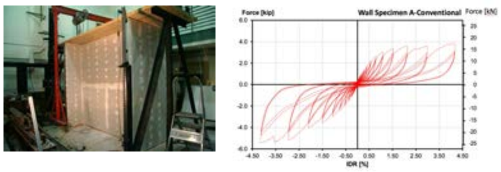
(After E. Miranda)



(After T. Hutchinson et al. 2013)

(After T. Hutchinson et al. 2013)

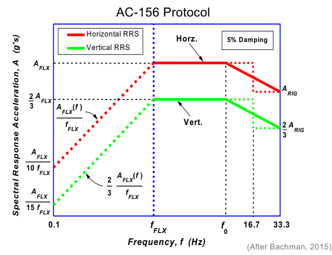
3. Development of Detailed Analytical Models for Improved Understanding of the Seismic Response of Nonstructural Components



4. Evaluation and Development of Loading Protocols for Testing of Acceleration-Sensitive Nonstructural Components

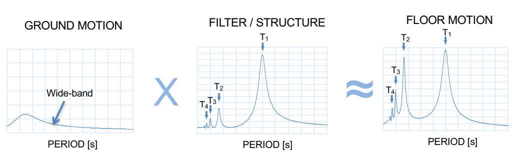
Example: In the U.S. many nonstructural components are being tested using dynamic loading protocols that have little to do with the characteristics of floor motions recorded in instrumented buildings during earthquakes.

AC-156 Protocol

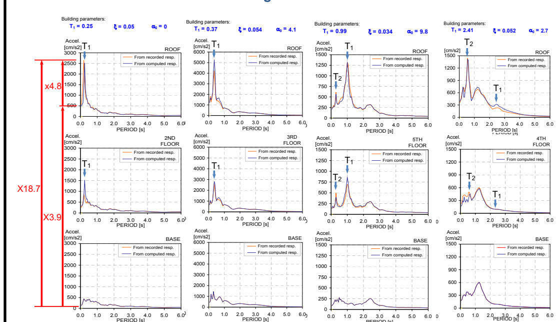


(After Bachman, 2015)

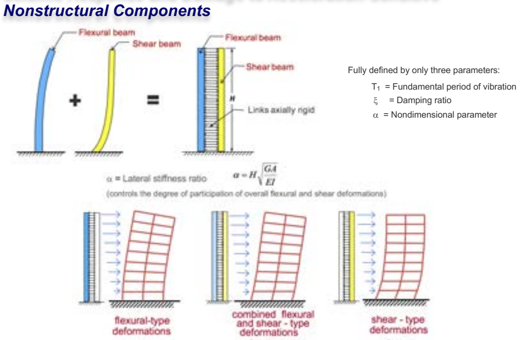
Narrow-Band Floor Motions in Buildings



A Few Examples of Narrow-Band Floor Motions Recorded in Instrumented Buildings



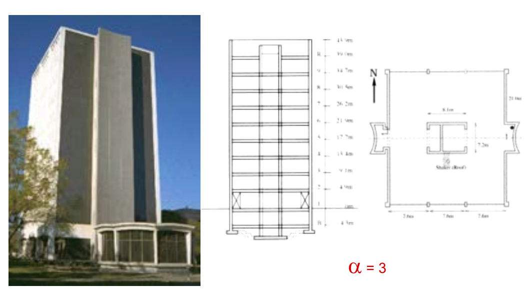
5. Rapid Estimation of Acceleration Demands in Buildings for Estimating Seismic Response and Damage to Acceleration-Sensitive Nonstructural Components

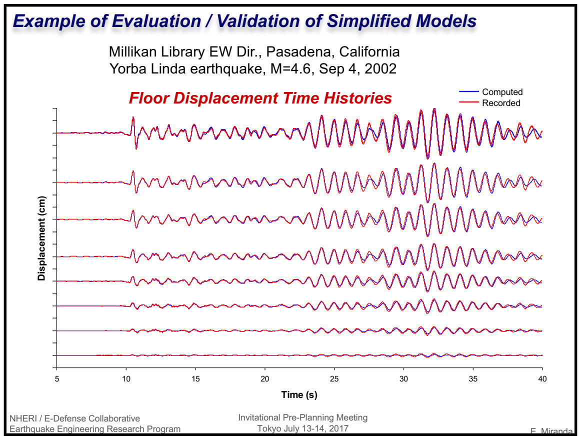


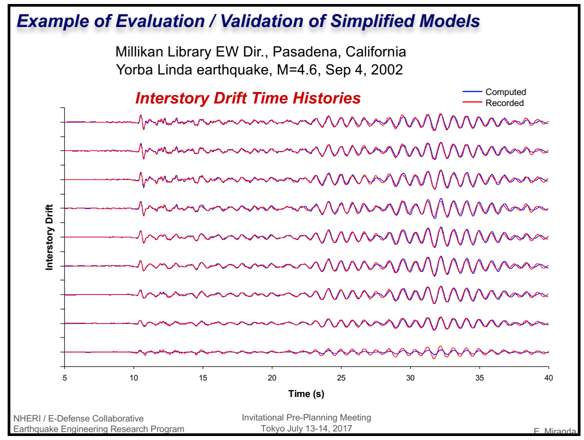
Example of Evaluation / Validation of Simplified Models

Millikan Library, Caltech campus, Pasadena, California

Yorba Linda earthquake, M=4.6, Sep 4, 2002




Example of Evaluation / Validation of Simplified Models
Millikan Library EW Dir., Pasadena, California
Yorba Linda earthquake, M=4.6, Sep 4, 2002
Floor Displacement Time Histories
Computed
Recorded
Displacement (cm)
Time (s)
NHERI / E-Defense Collaborative
Earthquake Engineering Research Program
Invitational Pre-Planning Meeting
Tokyo July 13-14, 2017


Example of Evaluation / Validation of Simplified Models
Millikan Library EW Dir., Pasadena, California
Yorba Linda earthquake, M=4.6, Sep 4, 2002
Interstory Drift Time Histories
Computed
Recorded
Interstory Drift
Time (s)
NHERI / E-Defense Collaborative
Earthquake Engineering Research Program
Invitational Pre-Planning Meeting
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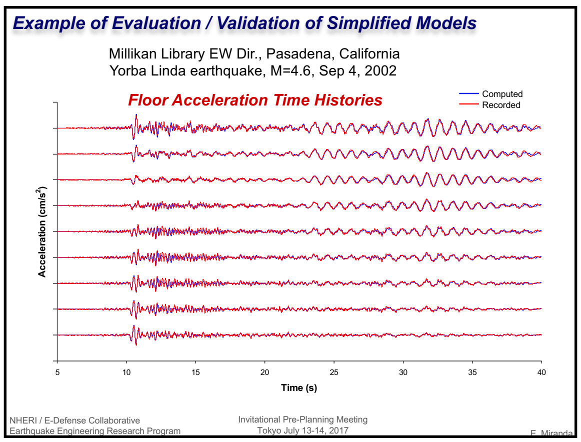
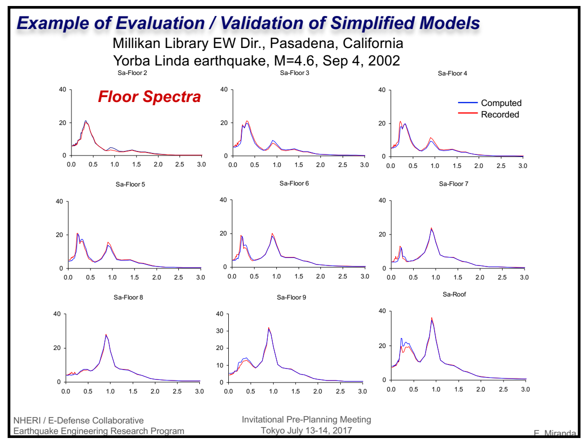

Example of Evaluation / Validation of Simplified Models
Millikan Library EW Dir., Pasadena, California
Yorba Linda earthquake, M=4.6, Sep 4, 2002
Floor Acceleration Time Histories
Computed
Recorded
Acceleration (cm/s²)
Time (s)
NHERI / E-Defense Collaborative
Earthquake Engineering Research Program
Invitational Pre-Planning Meeting
Tokyo July 13-14, 2017


Example of Evaluation / Validation of Simplified Models
Millikan Library EW Dir., Pasadena, California
Yorba Linda earthquake, M=4.6, Sep 4, 2002
Floor Spectra
Computed
Recorded
NHERI / E-Defense Collaborative
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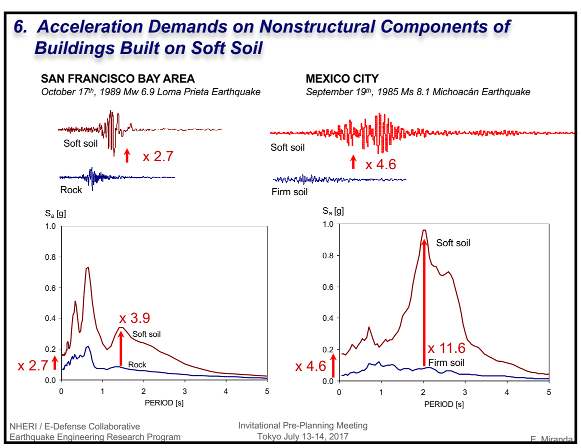
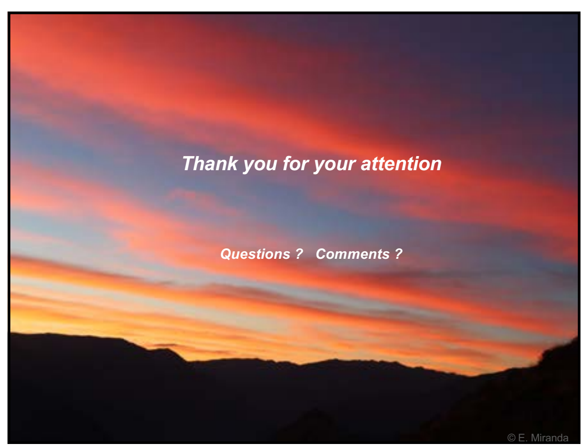

6. Acceleration Demands on Nonstructural Components of Buildings Built on Soft Soil
SAN FRANCISCO BAY AREA
October 17th, 1989 Mw 6.9 Loma Prieta Earthquake
MEXICO CITY
September 19th, 1985 Ms 8.1 Michoacán Earthquake
Soft soil
x 2.7
Rock
Soft soil
x 4.6
Firm soil
x 3.9
Soft soil
Rock
x 2.7
Soft soil
x 11.6
Firm soil
x 4.6
PERIOD [s]
NHERI / E-Defense Collaborative
Earthquake Engineering Research Program
Invitational Pre-Planning Meeting
Tokyo July 13-14, 2017

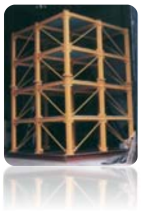

Thank you for your attention
Questions ? Comments ?
© E. Miranda

First NHERI / E-Defense Joint Meeting

Structural Health Monitoring

JUAN M. CAICEDO
UNIVERSITY OF SOUTH CAROLINA

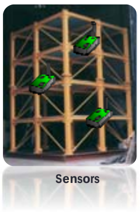
Structural Health Monitoring



The structure currently has the following performance:

- Fully operational: 50%
- Operational: 80%
- Life Safe: 95%
- No Collapse: 99%

Structural Health Monitoring

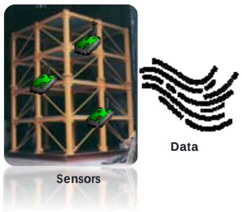


Sensors:

Research questions:

- Sensor placement (Effect of spatial density)
- What is the performance of sensors not widely used in SHM with earthquake engineering applications
  - Computer vision (i.e. digital image correlation)
  - Acoustic Emission
- What is the reliability of sensors?

Structural Health Monitoring

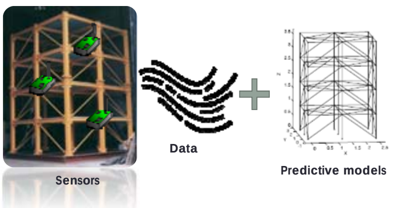


Data:

Research questions:

- What is the quality of the data?
- How to handle large datasets in almost real time?
- What information can be concluded from this data?

Structural Health Monitoring

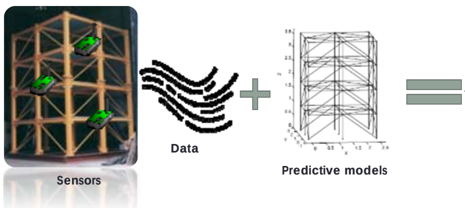


Inform models:

Research questions:

- Predictive capabilities of models?
- How to use diverse data to update models?
- How to reduce the computational time needed for updating and prediction?
- How to include engineering judgment and inspection information?

Structural Health Monitoring



- Fully operational: 50%
- Operational: 80%
- Life Safe: 95%
- No Collapse: 99%

Structural Health Monitoring

- Estimating uncertainty of estimations is needed in SHM
- Some of these research questions can include testing at NHERI facilities and validated with full scale testing at E-defense.
- Data **and algorithm** sharing is key.
- E-defense testing provides a fantastic opportunity to heavily instrument buildings.

DESIGNSAFE-CI
A NATURAL HAZARDS ENGINEERING COMMUNITY

A Cyberinfrastructure for the Natural Hazards Community

Prof. Ellen M. Rathje

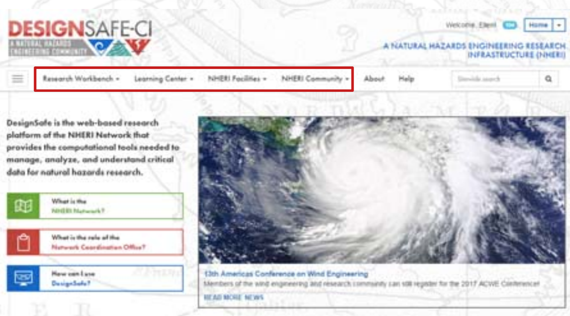
Warren S. Bellows Centennial Professor
Dept. of Civil, Arch., and Env. Engineering
University of Texas at Austin

What is DesignSafe?

- A web-based research platform that provides computational tools to manage, analyze, and understand critical data for natural hazards research

DesignSafe Vision

- A CI that is an integral part of research discovery
  - Support end-to-end research workflows and the full research lifecycle, including data sharing/publishing
  - Cloud-based tools that support the analysis, visualization, and integration of diverse data types
- Amplify and link the capabilities of the NHERI partners and natural hazards researchers around the globe



DesignSafe Components

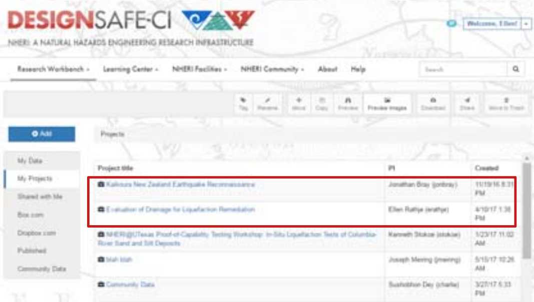
- Research Workbench
  - Data Depot
  - Discovery Workspace
  - Reconnaissance Portal
- Learning Center
  - Training resources and student engagement
- NHERI Facilities
  - Access to information about all NHERI facilities
- NHERI Community
  - News and online Slack community

Data Depot Features

- Different areas:
  - My Data (Private)
  - My Projects (Semi-Private, Collaborative)
  - Published (Publicly accessible, curated)
  - Community Data (Publicly accessible, uncurated)
- Upload files/folders via computer, cloud service providers, or bulk transfer
- Manage, preview files within Data Depot
- Data curation and publishing

DesignSafe Data Depot

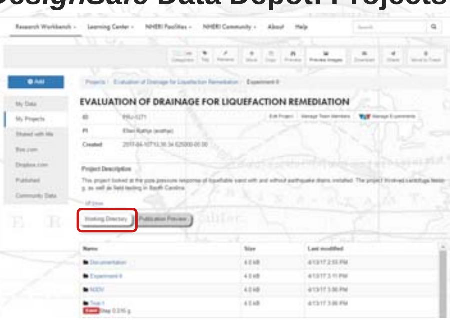
DesignSafe Data Depot: Projects



Data Management Philosophy

- ***Vision:*** Allow users to easily store, share, document, and publish the data associated with their research, supporting the full data lifecycle
  - Focus on achieving community's research goals
  - Flexible data model that supports how researchers organize their data
  - User-defined categories: Model Config, Sensor Info, Event, Report
  - Progressive curation integrated with research process

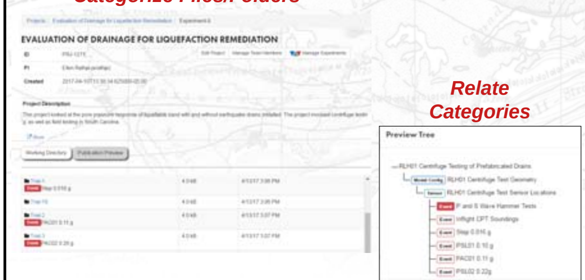
DesignSafe Data Depot: Projects



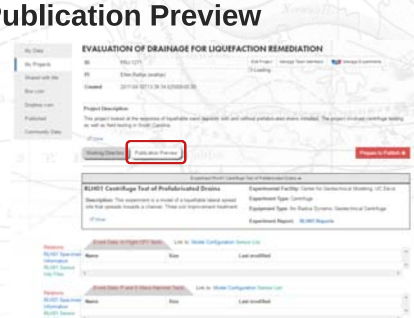
Data Curation

Categorize Files/Folders

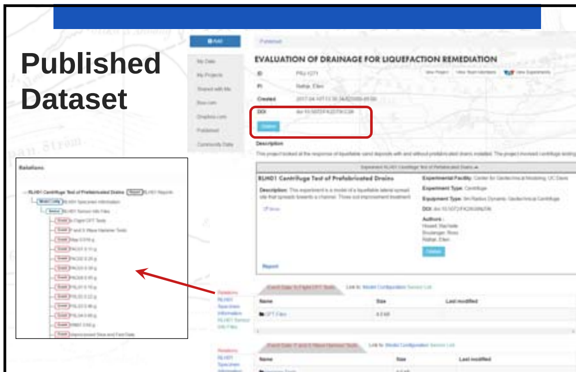
Relate Categories



Publication Preview



Published Dataset



Accelerating Research: Data Re-Use

- ***Formal publishing*** of well-documented/valuable data sets for re-use must be recognized by academic community as scholarly work
- Include data processing scripts, visualizations, etc.
- Data needs a permanent, digital location (DOI) similar to journal article, not just a URL
  - List curated data sets on your CV
- Data marketing via Data Papers (e.g., EERI Earthquake Spectra), Data Journals, etc.
- Formally cite data using DOI, citation language from Datacite.org

REUSE REDUCE RECYCLE

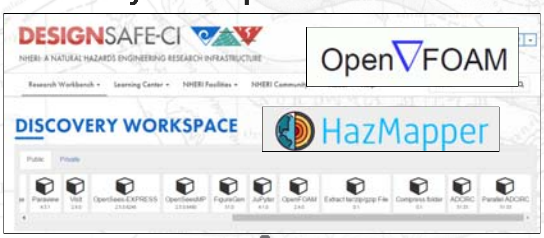
NEES/E-Defense Past Collaborations

- 7 Previous NEES/E-Defense Joint Projects
- Data published through NEEShub

Project 75 (PI Deierlein)	Project 895 (PI van de Lindt)
Project 254 (PI Mahin)	Project 1005 (PI Wallace)
Project 361 (PI Boulanger)	Project 1168 (PI Lemnitzer)
Project 571 (PI Ryan)	

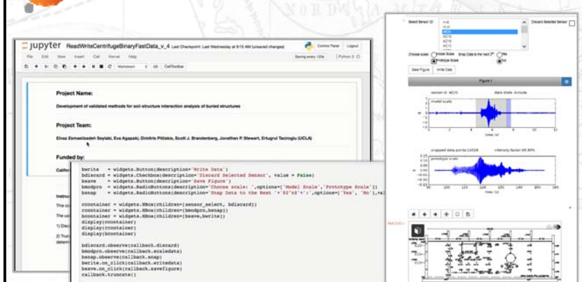
- Data currently available in DesignSafe Data Depot
  - Search "E-Defense" within Data Depot

Discovery Workspace Tools



OpenSees jupyter MATLAB LS Dyna

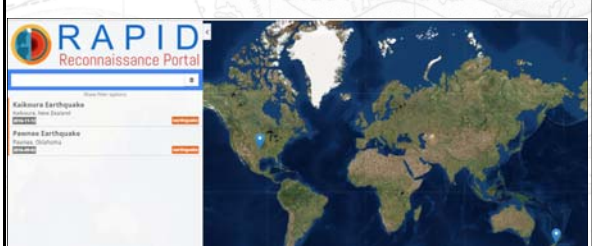
Interface with Experimental Data



From Prof. S. Brandenberg, UCLA

Reconnaissance Portal

Identifying Archived Datasets from Recon Events

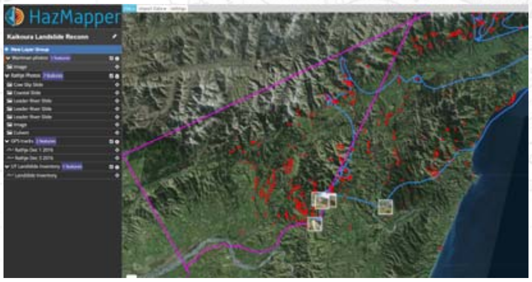


Reconnaissance Portal

Identifying Archived Datasets from Recon Events

HazMapper App

Interactive Map Viewer of Event Data



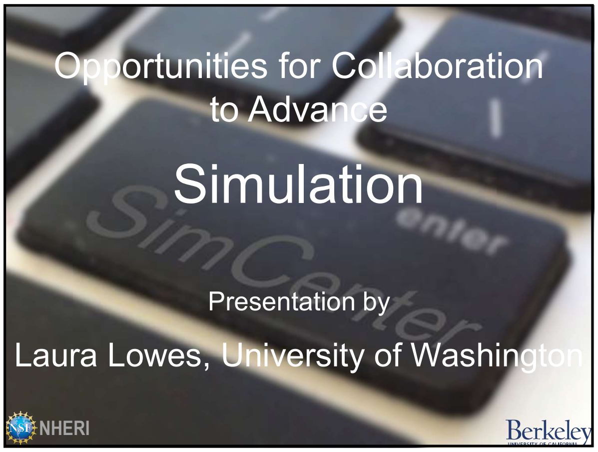
DesignSafe: Open for Business

www.designsafe-ci.org

- Capabilities available to the global natural hazards research community—account registration is free
- Training webinars
  - Overview webinars, as well as detailed training on Jupyter, etc.
  - Archived training webinars available at https://www.designsafe-ci.org/learning-center

Please share your feedback, ideas, experiences!

Ellen Rathje e.rathje@mail.utexas.edu



Opportunities for Collaboration via Simulation

1. State-of-the-art simulation to support design of the test program (specimen, instrumentation …)
2. Blind prediction studies to quantify model uncertainty.
3. Use of experimental data to evaluate, validate and advance ***response*** and ***damage prediction*** models.
4. Use of test data and simulation results to investigate regional resilience.

NHERI SimCenter

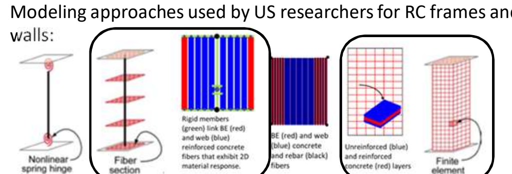
1. Collaboration to use state-of-the-art simulation to support test program design

- State-of-the-art simulation methods provide an opportunity for improving test program design.
- Collaboration on the simulation effort improves results and quantifies uncertainty.
- Examples of state-of-the-art simulation to support test specimen design follow

NHERI SimCenter

II: "Center for Disaster Management": RC system with damage-control spandrel walls

Modeling approaches used by US researchers for RC frames and walls:

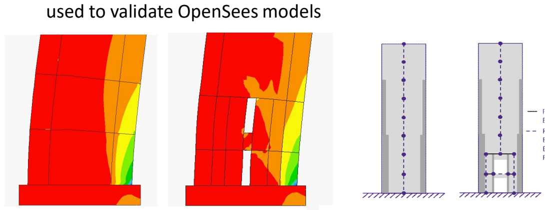


Modeling approaches documented in

- NSF-funded SAVI Wall Institute (PI Wallace): papers in development compare models for concrete walls.
- NIST GCR 17-917-46v2: *Guidelines for Nonlinear Structural Analysis for Design of Buildings –Reinforced Concrete Frames*
- NIST GCT 17-917-45: *Recommended Modeling Parameters and Acceptance Criteria for Nonlinear Analysis in Support of Seismic Evaluation, Retrofit, and Design*

II: "Center for Disaster Management": RC system with damage-control spandrel walls

- Nonlinear continuum analysis to investigate spandrel details and OpenSees analyses to simulate system response for design of E-Defense specimens:
- Images below show nonlinear continuum analysis (ATENA) used to validate OpenSees models



Minimum principal stress, which indicates failure due to concrete crushing & bar buckling

OpenSees line-element models used for dynamic analysis to assess collapse risk

II: "Center for Disaster Management": RC system with damage-control spandrel walls

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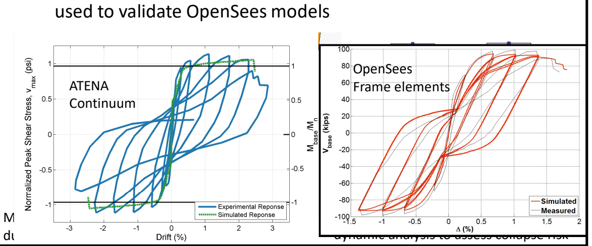
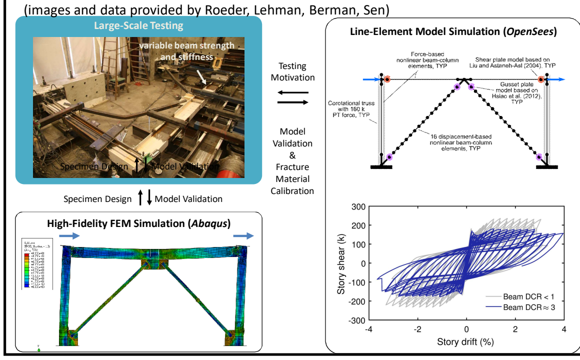
- Images below show nonlinear continuum analysis (ATENA) used to validate OpenSees models

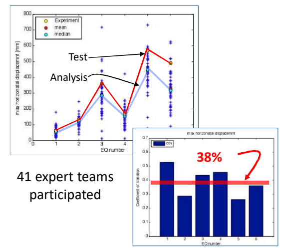


III: "Damage Assessment in Medical Facilities": Steel Earthquake-Resistant Fixed-Base Structure

Simulation-based design of a chevron concentrically braced frame test specimen (images and data provided by Roeder, Lehman, Berman, Sen)



2. Blind Prediction Studies



41 expert teams participated

PEER-NEES Blind Analysis Contest

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

Concrete Column Blind Prediction Contest 2010

2. Blind Prediction Study Using E-Defense Test Data & NHERI Resources

- Traditionally blind-prediction studies quantified uncertainty in primary response variables using data from multiple research groups
- E-Defense tests and NHERI resources offer new opportunities:
  - Quantification of uncertainty in
    - response quantities (acceleration, drift, etc.) as well as
    - damage (type, severity and location)
  - Quantification of uncertainty due to
    - modeling technique (hinge vs beam-column vs continuum element model vs ….)
    - model parameters (hinge length, material model, ….)
    - fragility function vs mechanistic damage prediction
  - Quantification of impact of uncertainty propagation from model parameters to response prediction to damage prediction.
- NHERI resources for collaborative teams
  - DesignSafe: software packages for simulating structural response, CPU time, data storage,
  - SimCenter & DesignSafe: Semi-automated uncertainty propagation via Dakota,
  - DesignSafe: structure for tracking providence of data, sharing data with specific groups, publishing data,

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3. Post-test Model Evaluation and Improvement

- E-Defense tests and NHERI resources offer some new opportunities within this context:
  - DesignSafe collaborative environment
  - Dakota analyses provide understanding of model and parameter combinations that provide most accurate simulation of response.

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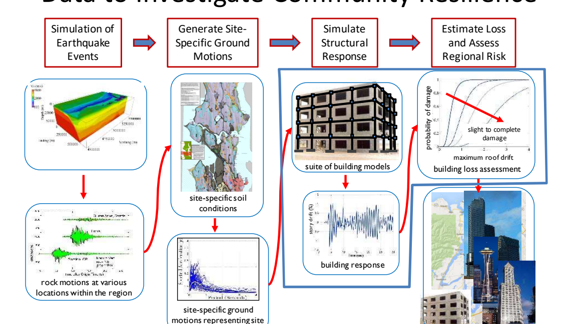
4. Software Framework to Use E-Defense Data to Investigate Community Resilience



Opportunities for Collaboration: What NHERI and US Researchers can do

1. NHERI can facilitate collaboration between US and Japanese researchers to use simulation to design test specimens, instrumentation layout, etc.
2. NHERI DesignSafe and SimCenter can collaborate to support blind prediction contests.
3. NHERI SimCenter and DesignSafe can provide software tools to facilitate use of shake table data for improving response and damage-prediction models.
4. NHERI SimCenter software products will provide a framework for using E-Defense data and Japanese research products to investigate and improve community resilience.

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NHERI RAPID Facility

Award No: CMMI 1611820

The RAPID facilty will provide *instrumentation* and *services* to enable the next generation of reconnaissance-based natural hazards research

Presentation by Laura Lowes, Professor, University of Washington and NHERI RAPID Project "Senior Personnel"

Opportunities for Collaboration: Image data collection

> SfM (structure from motion) creates 3D "structures" from high-resolution 2D image sequences

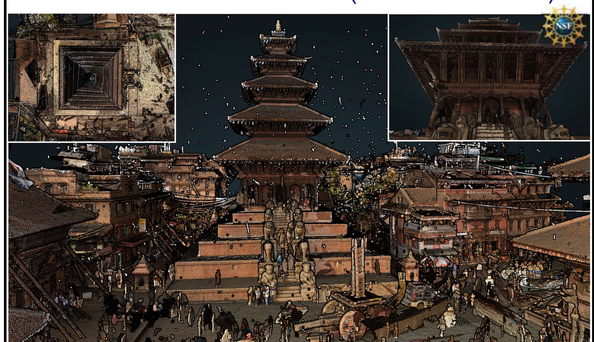
Data from the 2015 Ghorka Nepal Earthquake
Nyatapola Temple, Bhaktapur, Nepal (2015)

- Offers potential for rapid data collection.
- Images can be captured using ground- and drone-based cameras.
- 3D "structures" can be manually interrogated to extract measurements of residual drift and extent of damage (expect mm resolution)
- Current research addresses automated assessment of damage

Using 3D Reconstructions from SfM: Virtual Reality *CAVE* Demonstration

Port Hills, Christchurch, New Zealand (2014)

Sharing Using 3D Reconstructions from SfM: Online web access to data (Potree & Entwine)



Nyatapola Temple, Bhaktapur, Nepal (2015)

Opportunities for Collaboration: SfM and Terrestrial LiDAR

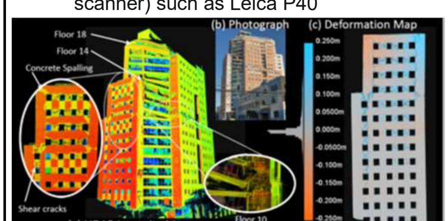
> SfM and terrestrial LiDAR data will be used to assess performance of Cross-Laminated Timber (CLT) Rocking Wall building currently being tested on NHERI Shake Table at UC San Diego

Wood building with two pairs of two-story rocking walls

Base of one pair of CLT rocking walls

Opportunities for Collaboration: Terrestrial LiDAR scanning

> Terrestrial laser scanning (i.e. LiDAR using ground-based scanner) such as Leica P40



Data from the 2010 Maule earthquake collected using Riegl VZ-400 scanner (Olsen et al., 2012). Image (c) shows out of plane displacement due to rotation at 10th story computed using LiDAR data.

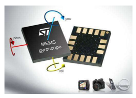
As with SfM:

- Offers potential for rapid data collection.
- LiDAR data can be used to *manually* identify and quantify damage.
- Current research addresses automated damage detection and quantification.

Opportunities for Collaboration: Strong Motion Instrumentation

> RAPID facility will include of accelerometers and tiltmeters for field deployment.

Kinemetrics Accelerometers



MEMS (digikey.com)

Tiltmeter

Proposed Collaboration

> NHERI RAPID facility deploys facility instrumentation to collect data characterizing structural response and performance of E-Defense tests.

> NHERI RAPID facility and E-Defense team collaborate to evaluate and use data.

NHERI Center for Computational Modeling and Simulation of the Effects of Natural Hazards on the Built Environment

Opportunities for US-Japan Collaboration

Stephen Mahin, Director, SimCenter

NHERI

Berkeley
UNIVERSITY OF CALIFORNIA

Leadership Group

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

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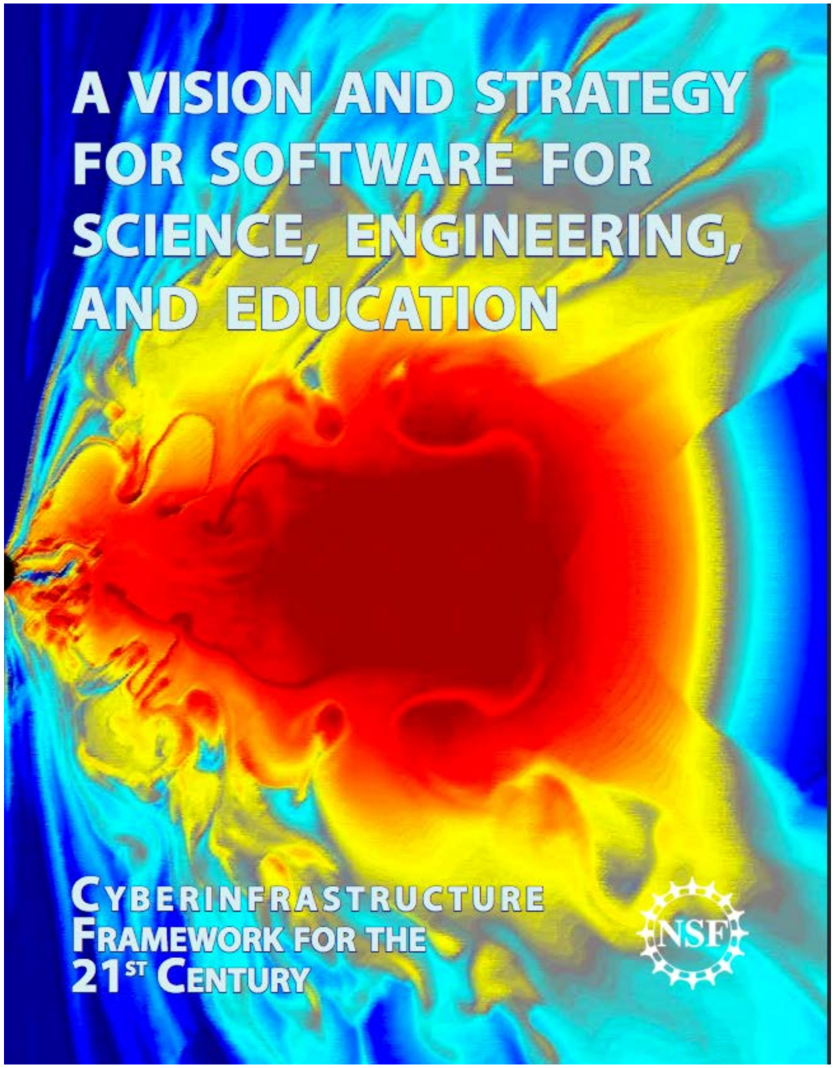

Enable transformative, interdisciplinary, collaborative, science and engineering research and education through the use of advanced software and service

Software Elements: small groups create and deploy robust software elements that advance significant areas of science and engineering.

Grand Challenges: Large multi-disciplinary, multi-institutional groups tackle complex engineering problems involving interdependent systems.

Software Frameworks: large, interdisciplinary teams develop and help apply sustainable community software frameworks serving diverse communities.

Reuse mechanisms: Incentivizing individuals and communities to use and build on existing infrastructure frameworks to advance science and engineering.

Enable transformative, interdisciplinary, collaborative, science and engineering research and … n through the use of … d service

… groups create and … lements that … s of science and

… multi-disciplinary, … ckle complex … ving

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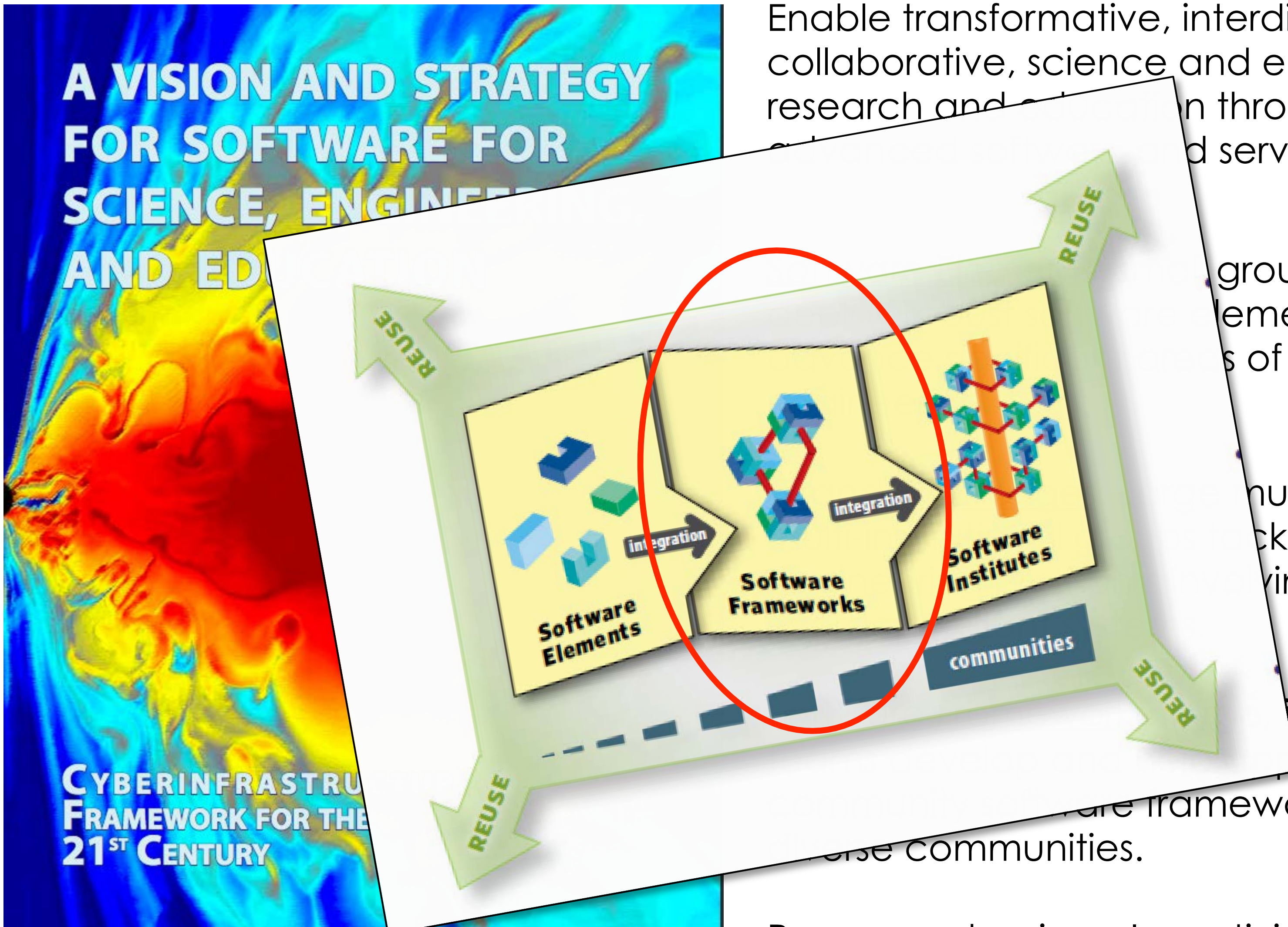

<u>Reuse mechanisms</u>: Incentivizing individuals and communities to use and build on existing infrastructure frameworks to advance science and engineering.

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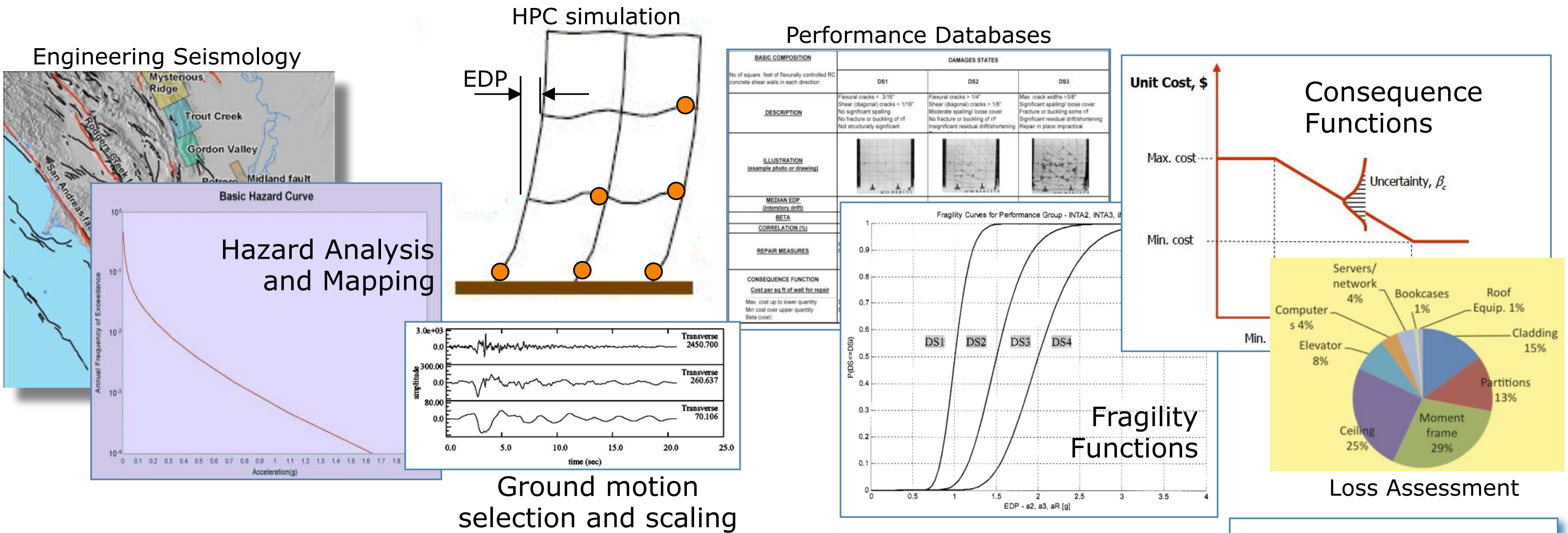
Some Possible Areas for Collaboration

- **Analysis software support** for design teams
- Community development of **improved modeling and simulation tools**
  - Data driven modeling (lab, simulation and field information)
  - Use of machine learning and AI to improve / automate modeling and parameter selection
  - Incorporating uncertainty characterization / quantification
- Support for understanding/enhancing **urban resilience**
  - Extending and refining Performance Based Engineering
  - Optimization for performance and cost metrics
  - City-scale modeling
  - Infrastructure and service networks
  - Resilience decision support tools

Our DNA
Probabilistic PBE methodologies



Seismic Hazard Analysis	→	Response Analysis	→	Damage Analysis	→	Loss Analysis
$\lambda(im)$		$G(edp \mid im)$		$G(dm \mid edp)$		$G(dv \mid dm)$
IM: intensity measure		**EDP**: Engineering Demand Parameter		**DM**: Damage Measure		**DV**: Decision Variable

$$\lambda(DV > dv) = \int_{im}\int_{dm}\int_{edp} G(dv \mid dm)\, dG(dm \mid edp)\, dG(edp \mid im) \left| d\lambda(im) \right|$$

Probabilistic Assessment of:
- ✓ Cost of repair and loss of function
- ✓ Downtime
- ✓ Casualties
- ✓ *Embodied energy*

Our plan:
Personal computer class software

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

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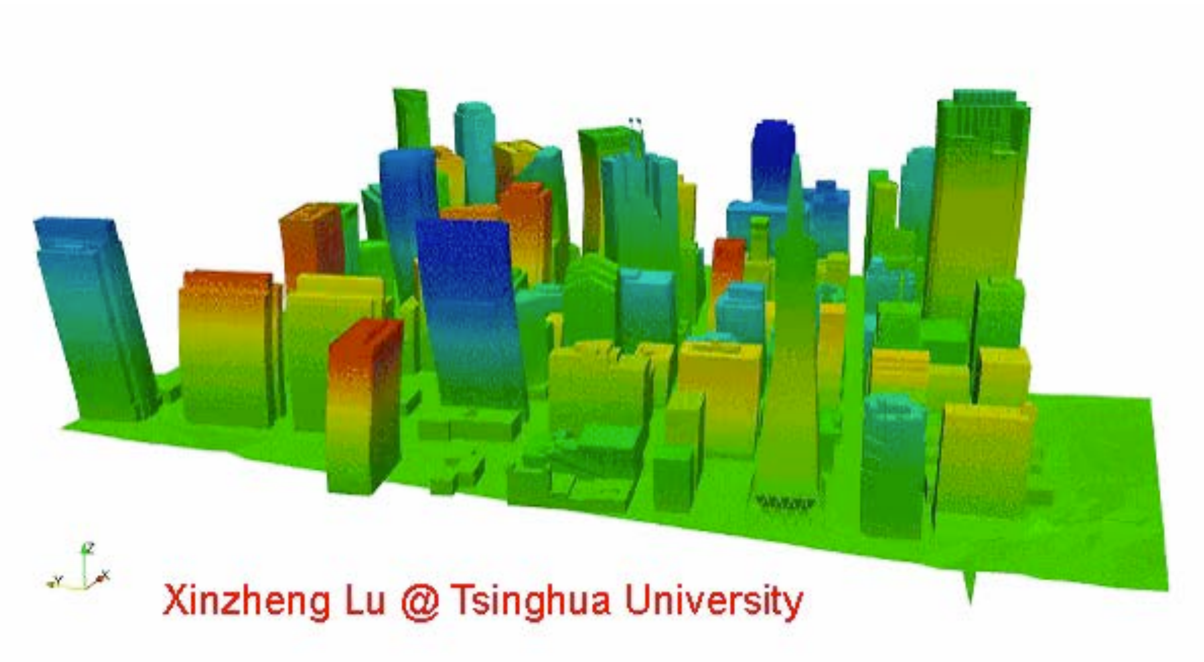
Application of Applications Framework



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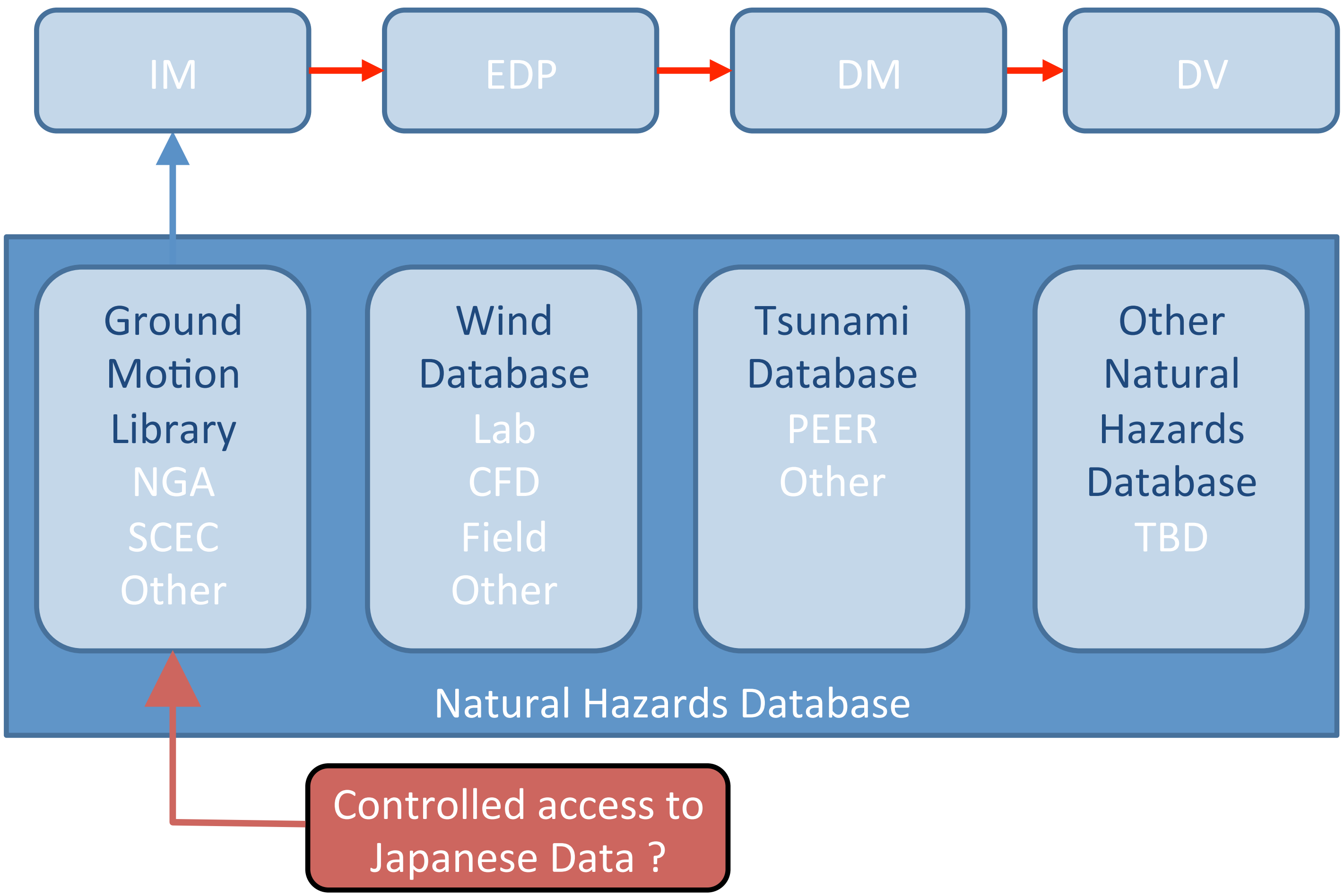
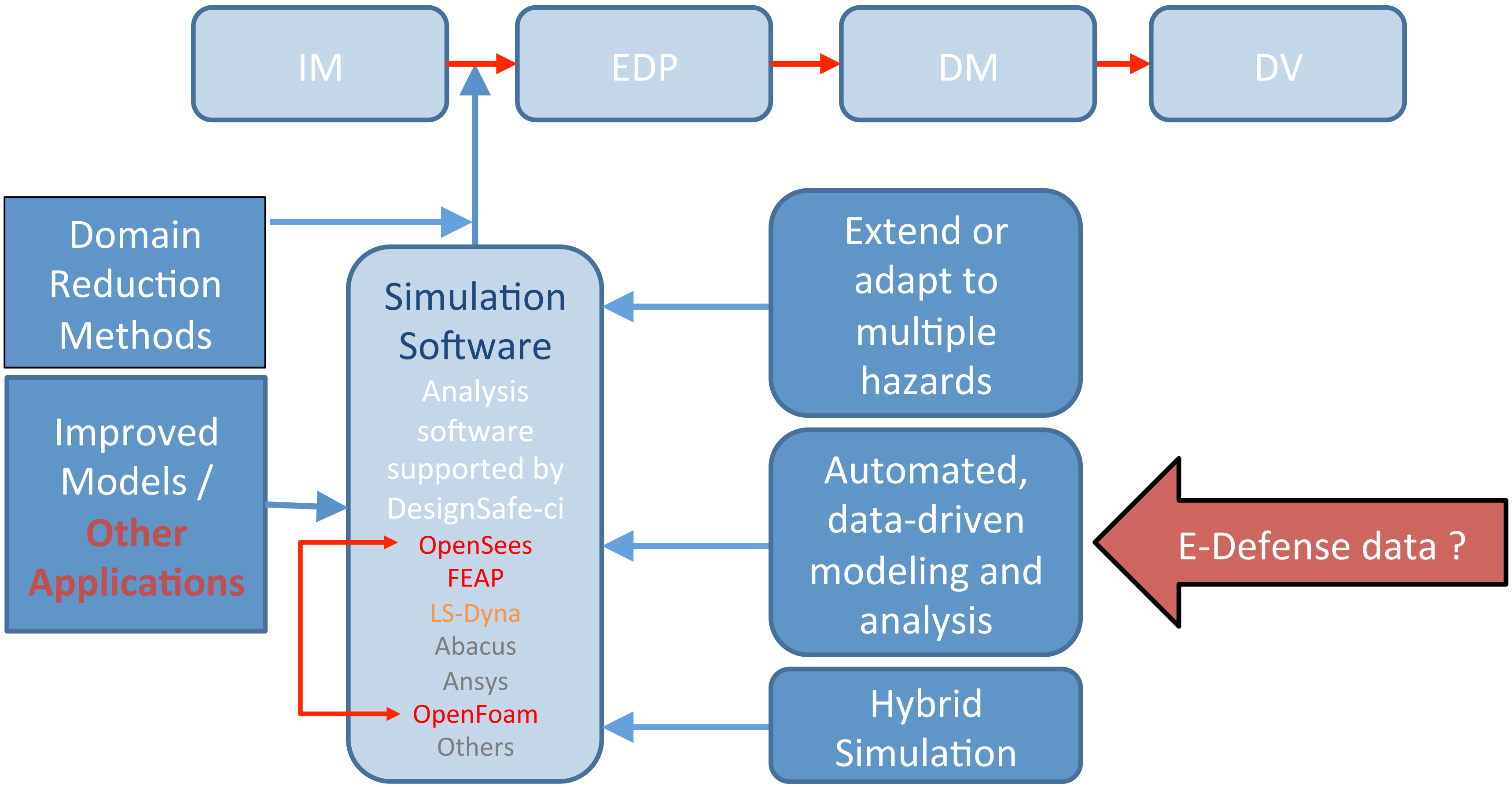
Simplified PBE Work Flow



Simplified PBE Work Flow



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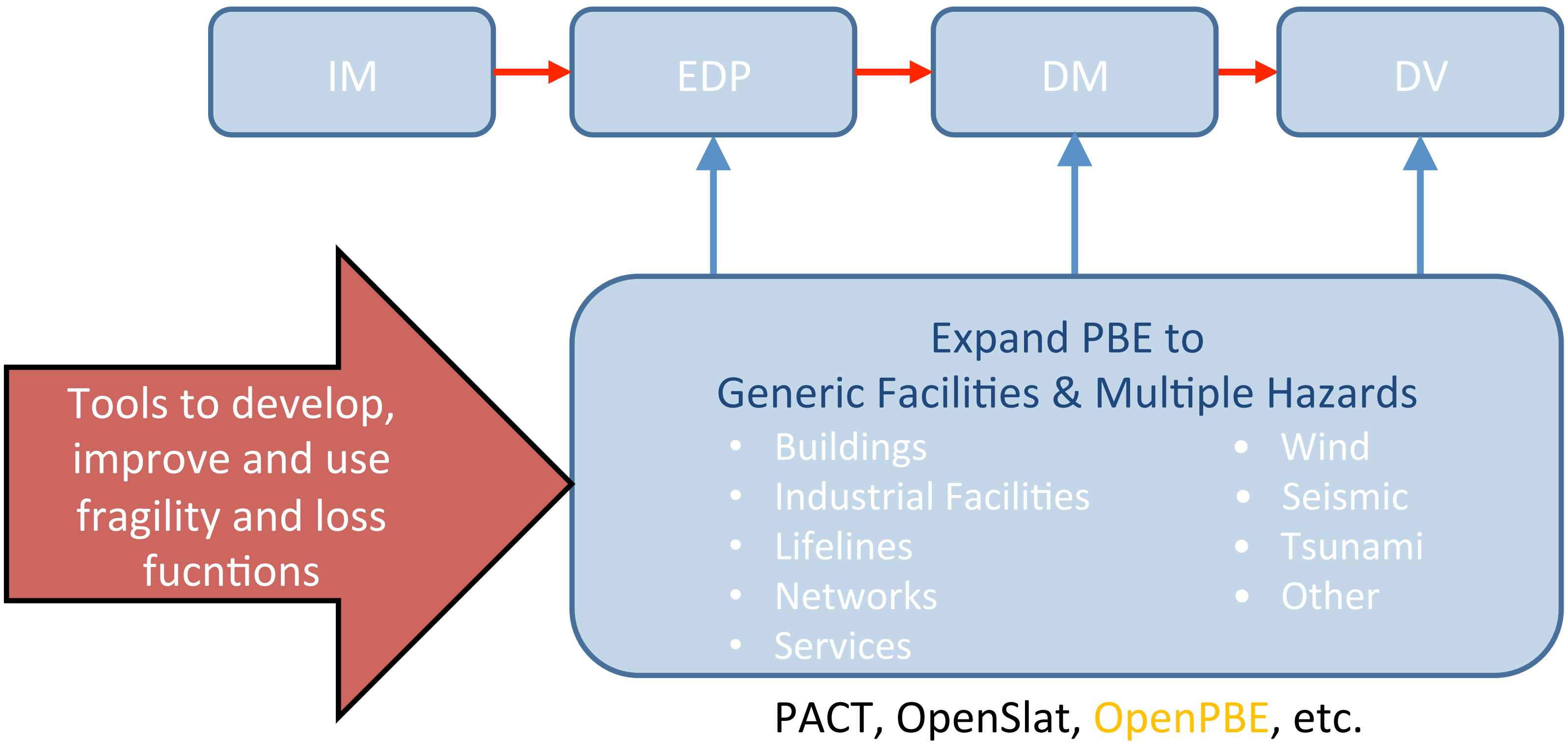
Simplified PBE Work Flow



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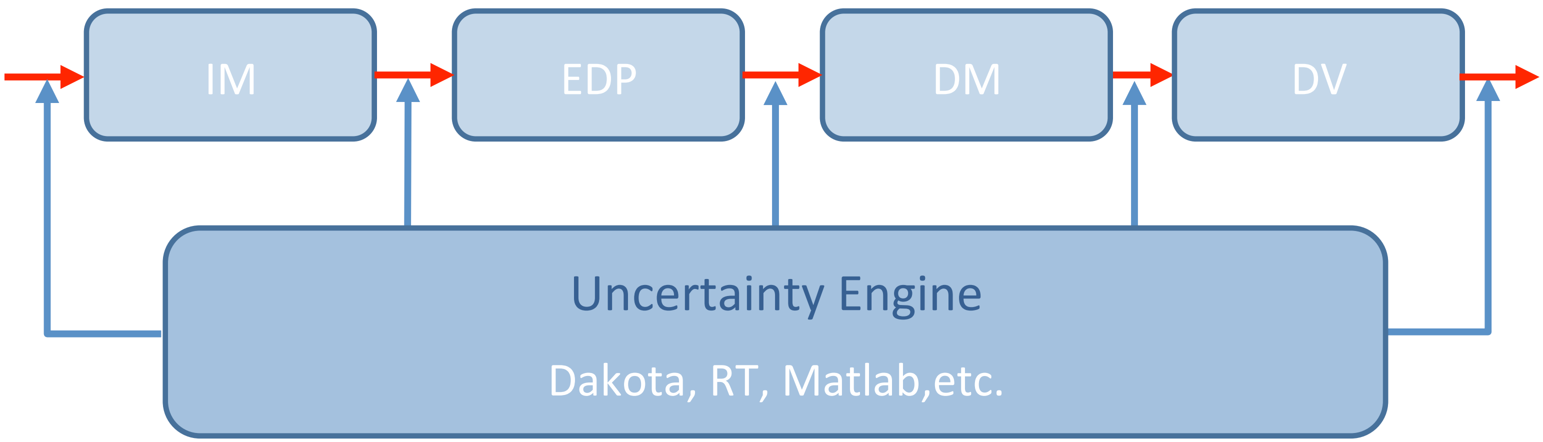
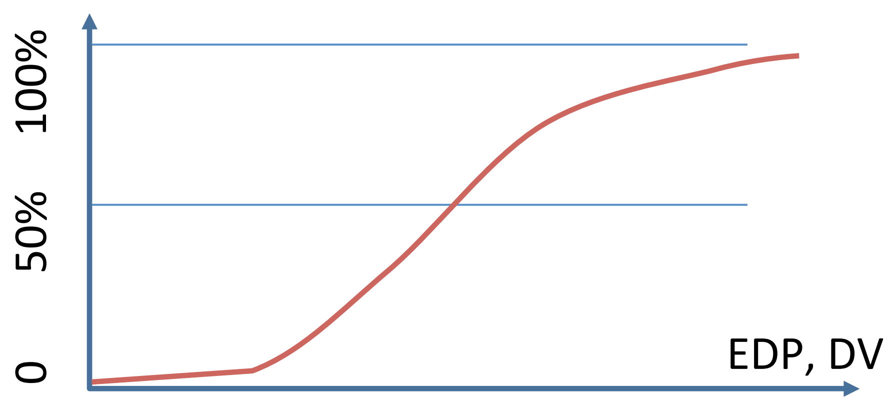
Simplified PBE Work Flow



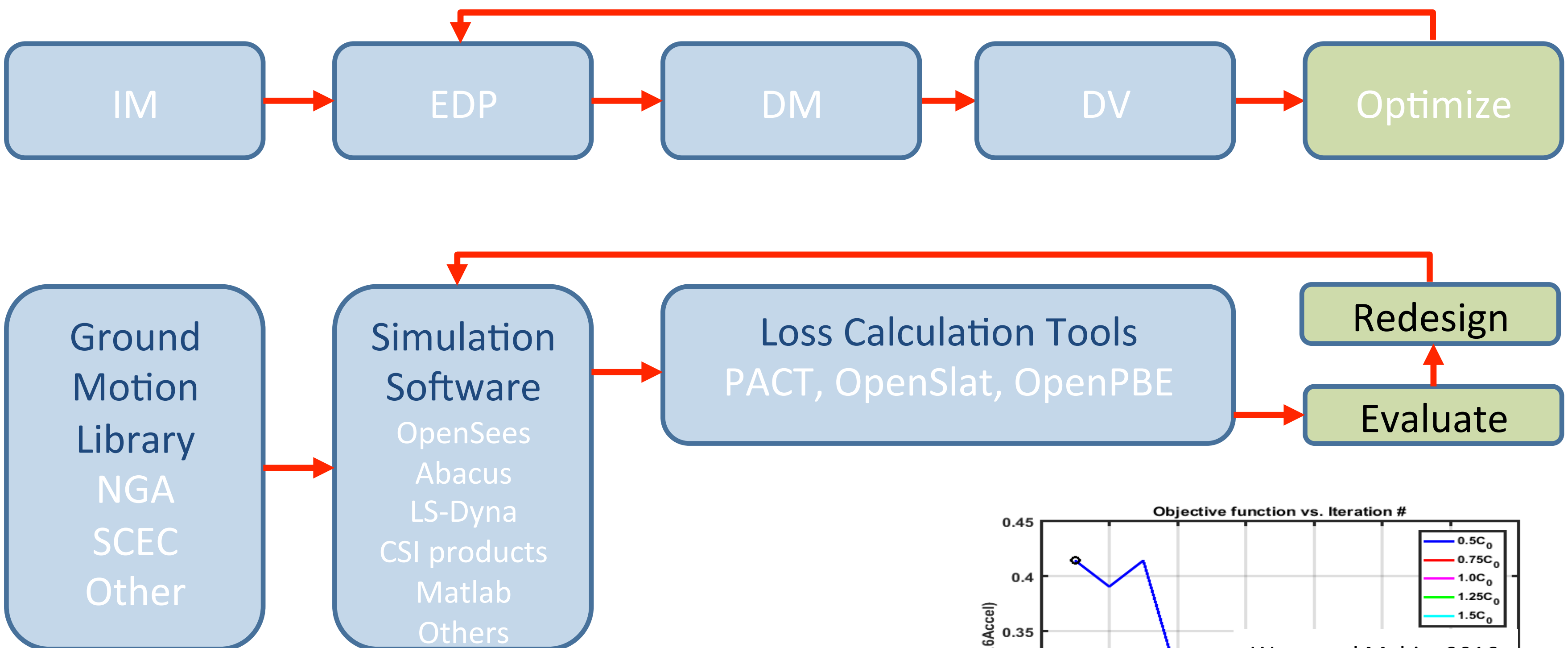
Characterizing effects of uncertainties in theoretical constructs, numerical models, procedures & parameters, analysis methods, etc.

Support for Blind and Insightful Analysis Contests

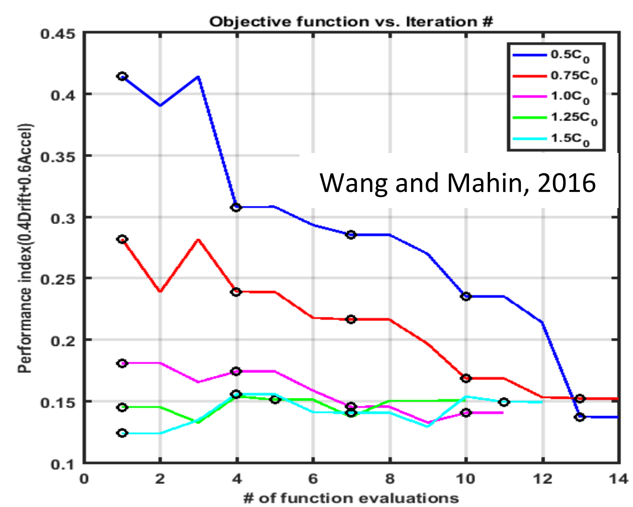


Uncertainty quantification

Simplified PBE Work Flow



Optimize design decisions to achieve EDP criteria, maximize return on investment, minimize repair costs or down times, etc.



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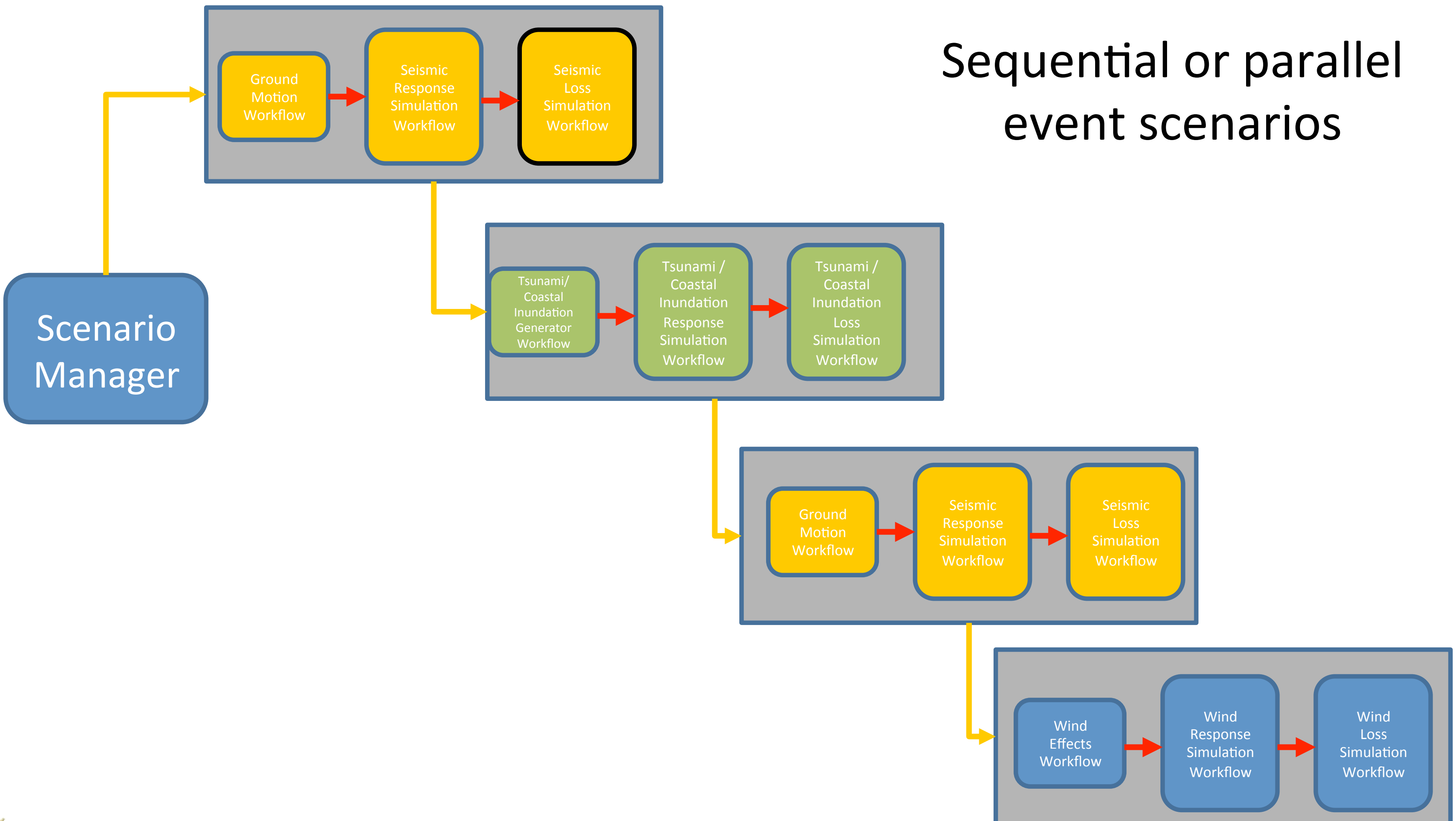
Enabling complex workflows



Sequential or parallel event scenarios

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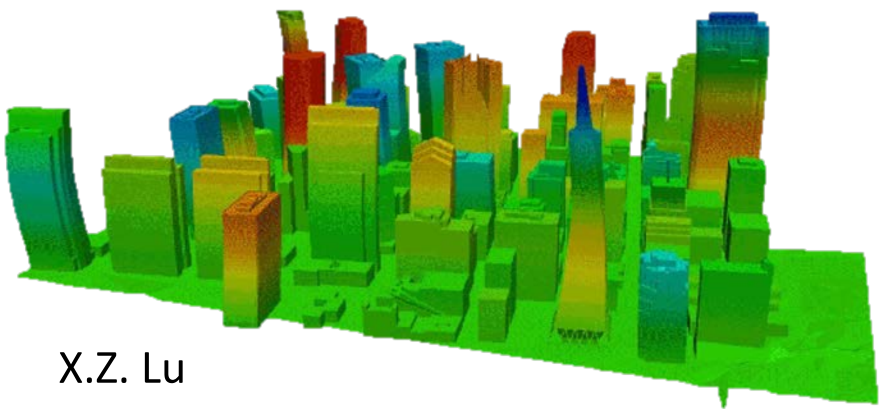
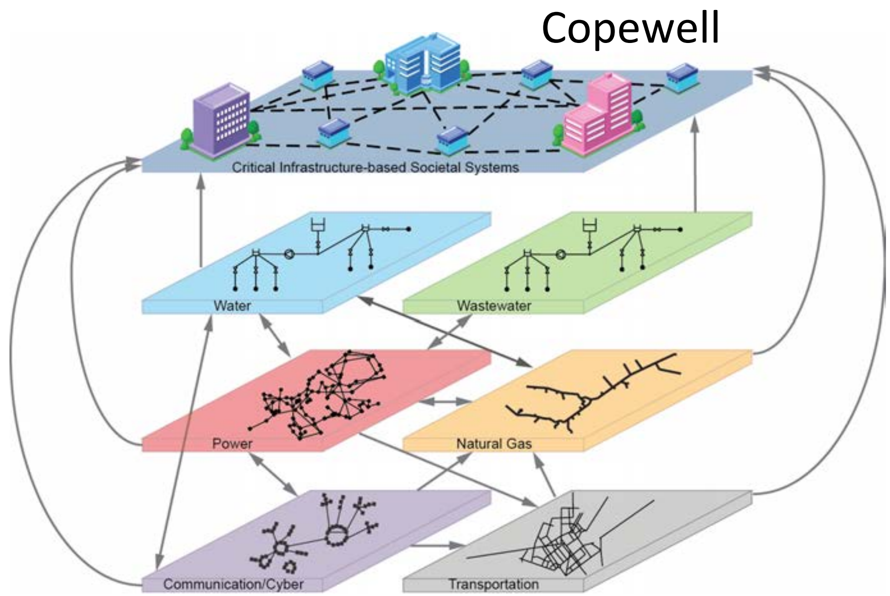
If you can do this for one facility



Portfolio and community simulation models



Lifeline, supply chain and service networks

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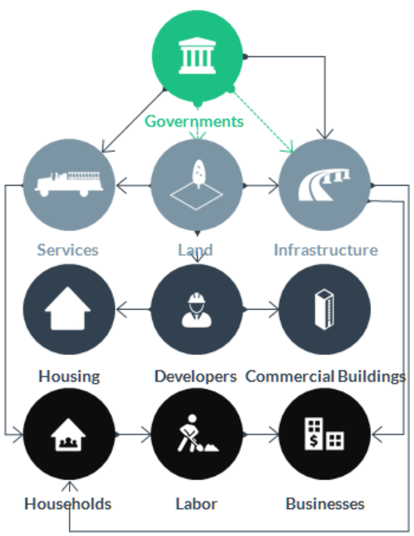
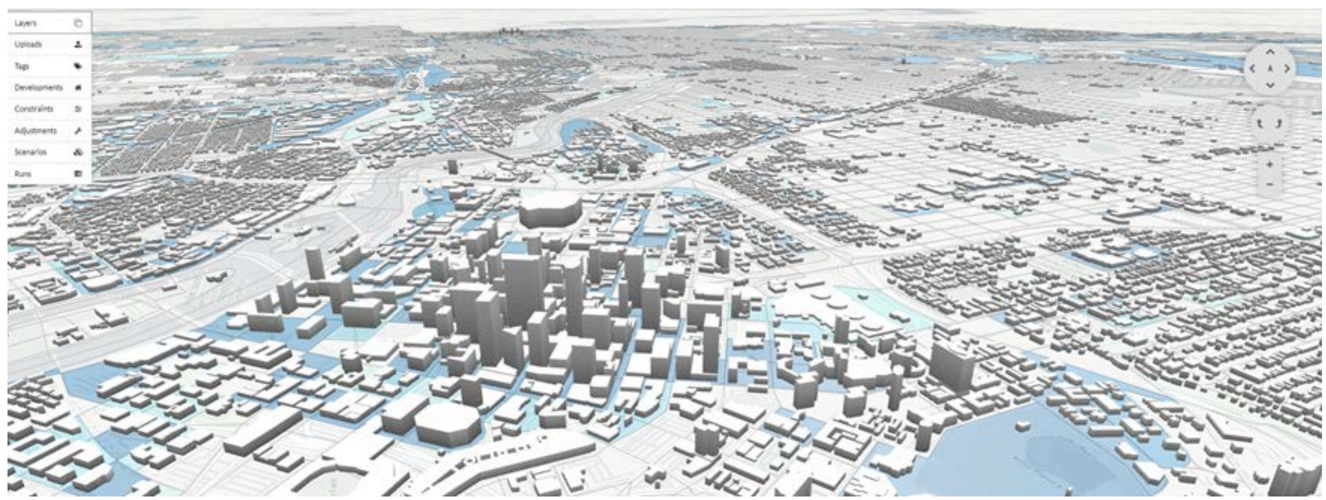
Integrated Tools to Develop and Evaluate Community Sustainability Plans

UrbanSim:

A simulation platform for supporting planning and analysis of urban development, incorporating the interactions between land use, transportation, the economy, and the environment.





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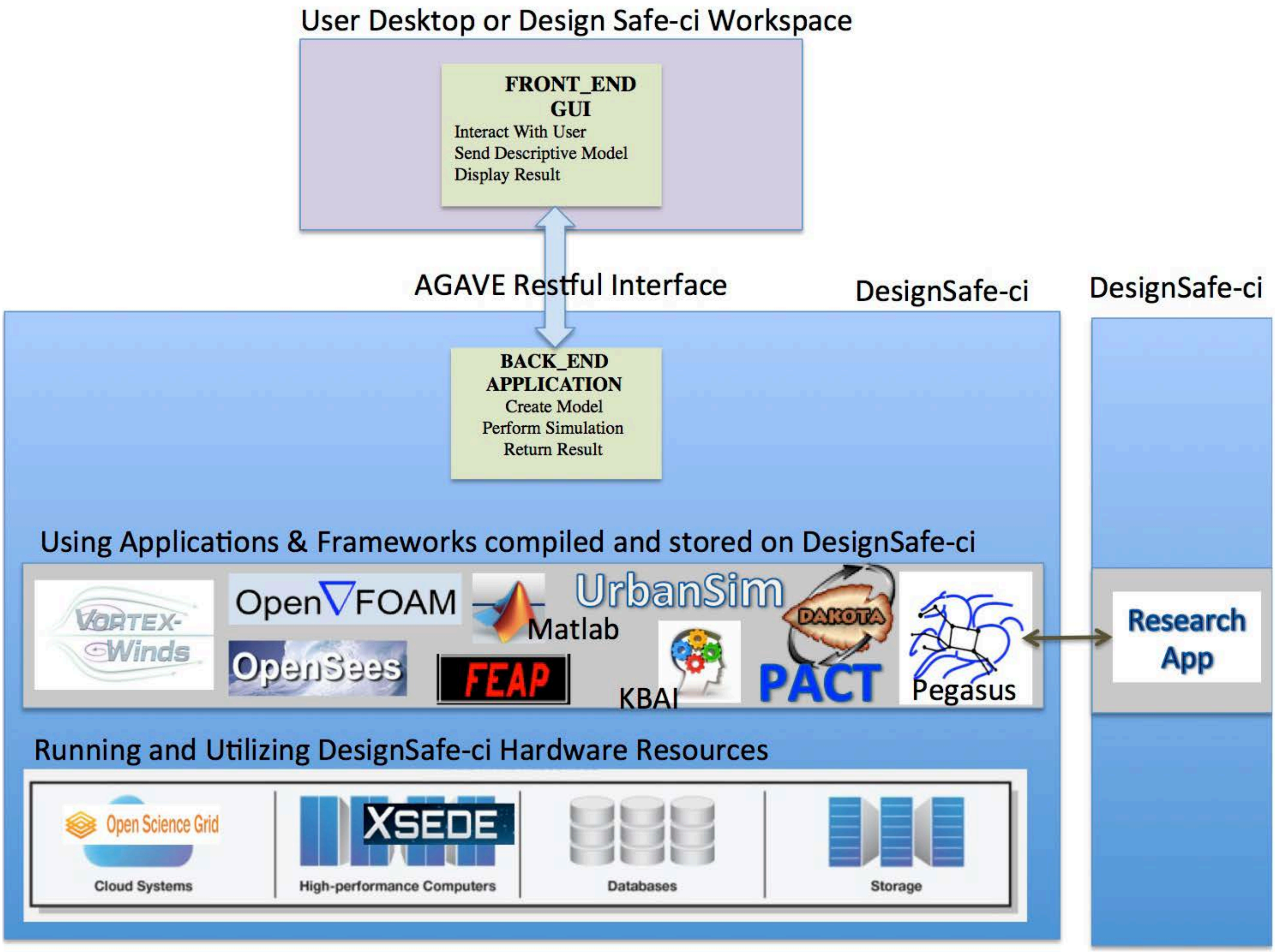
Software As a Service



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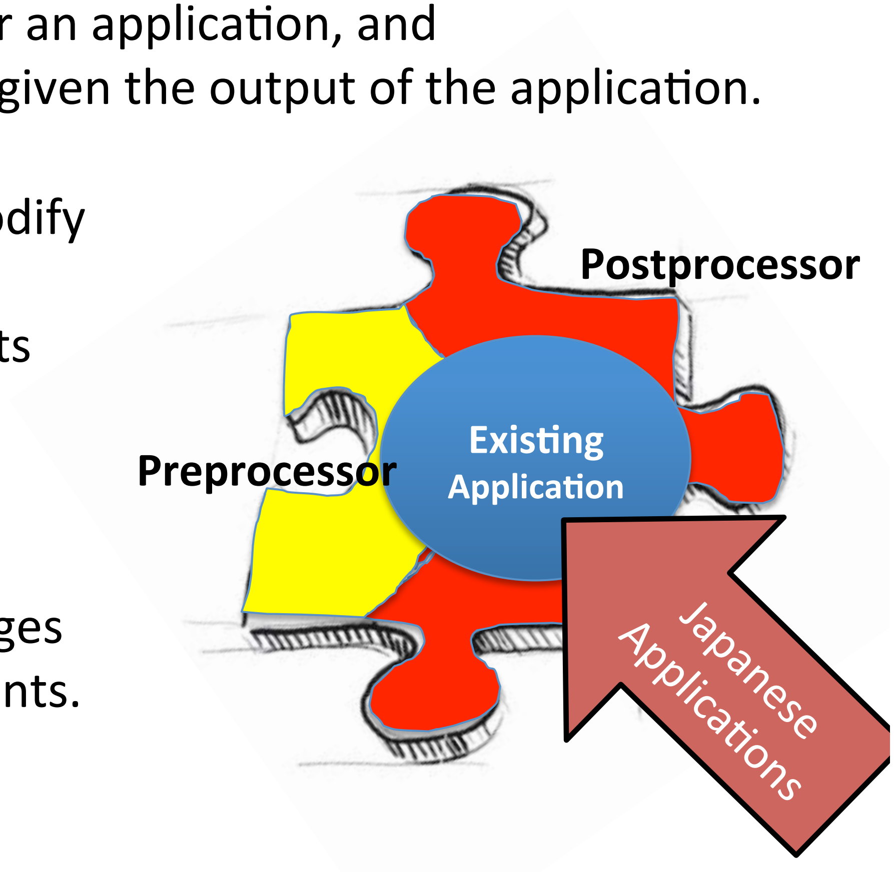
The SimCenter Framework

- The framework enables existing and new software applications to work together.
- Each application will have “Wrappers” in the form of pre- and post-processors based on well-defined and documented APIs
- These will create:
  1. The correct input for an application, and
  2. The correct output given the output of the application.

Using this approach we do not need to modify existing applications.
Developers can easily add new components



Pegasus

The Scientific Workflow Management Software Pegasus schedules components & manages data passing between components.

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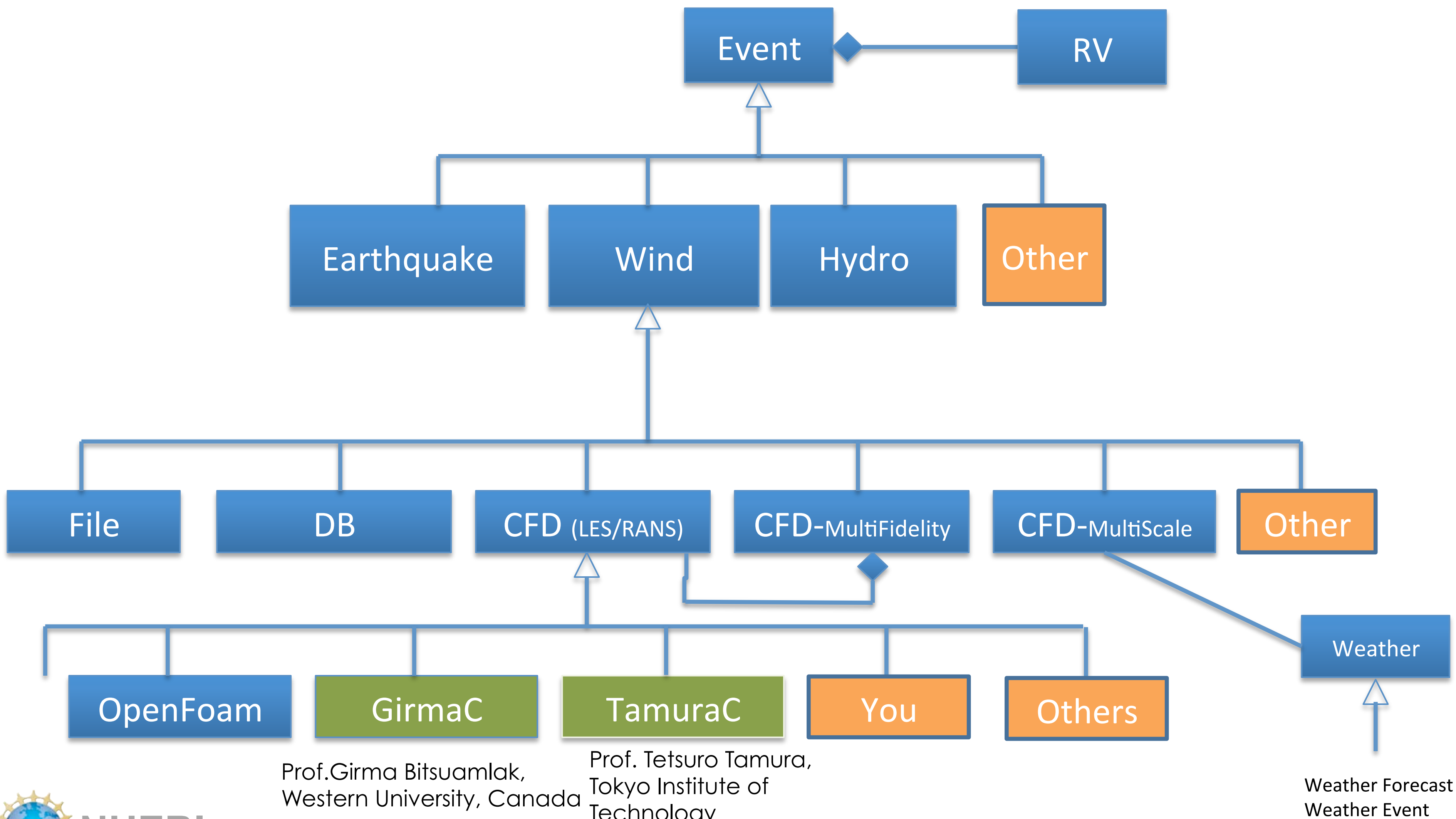
OO Format: Site,BIM, Event, etc.

Event (boundary condition & forces for model)



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Questions?

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