Politecnico
di Torino

Measuring Lifeline Emergency Response using temporal network models

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My research team:

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- Sarah Moretti
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...Disasters in the world

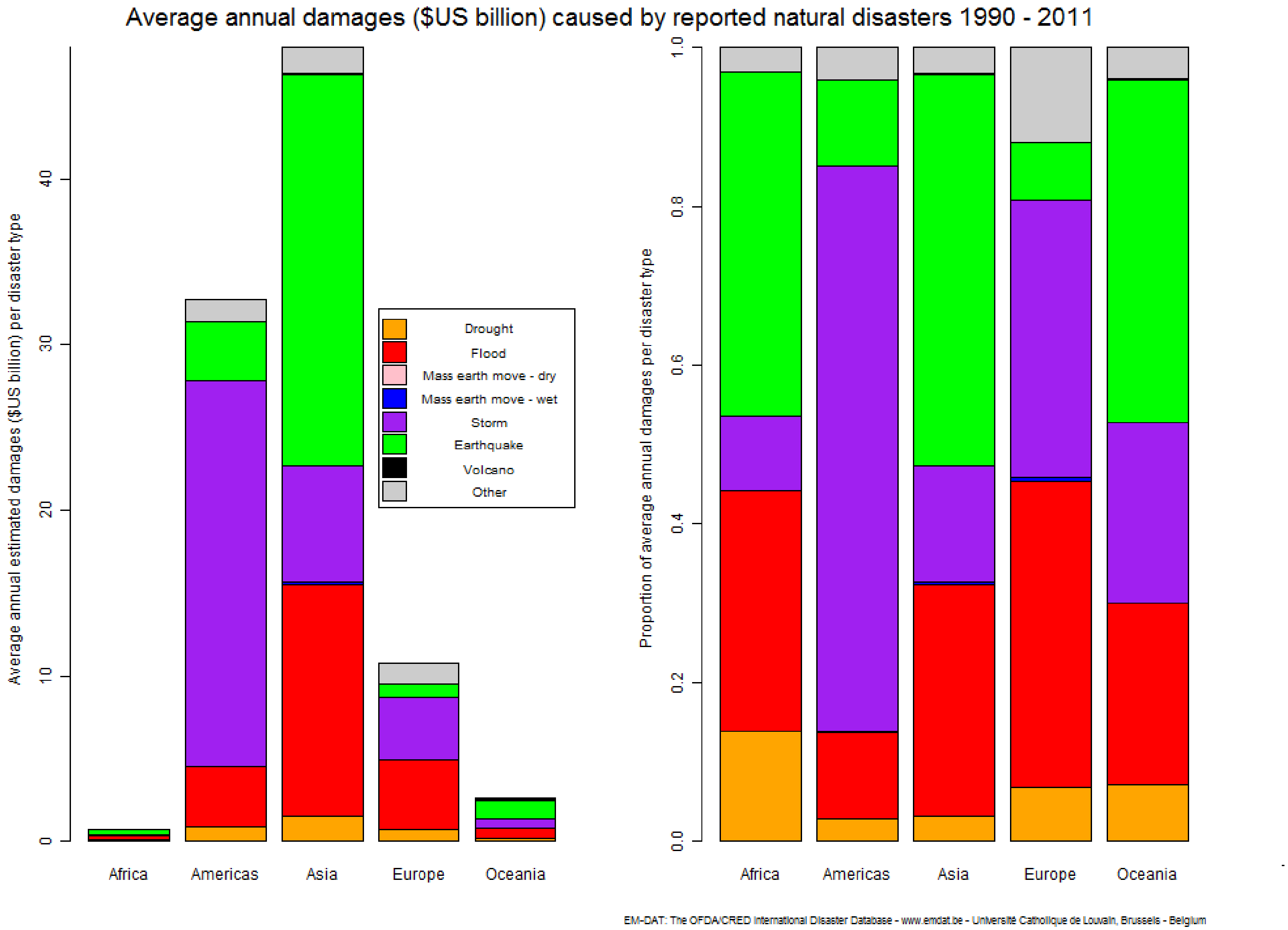
Terremoto l'Aquila 6 Aprile, 2014

Earthquake + Tsunami, 11 Marzo 2011

Crollo del Takoma Bridge, 1940

Genova 9 Ottobre 2014

Natural disasters reported 1900-2013



...from "Knowing", 2009

“Our greatest glory is not in never falling, but in always recover after a fall. “

Confucio

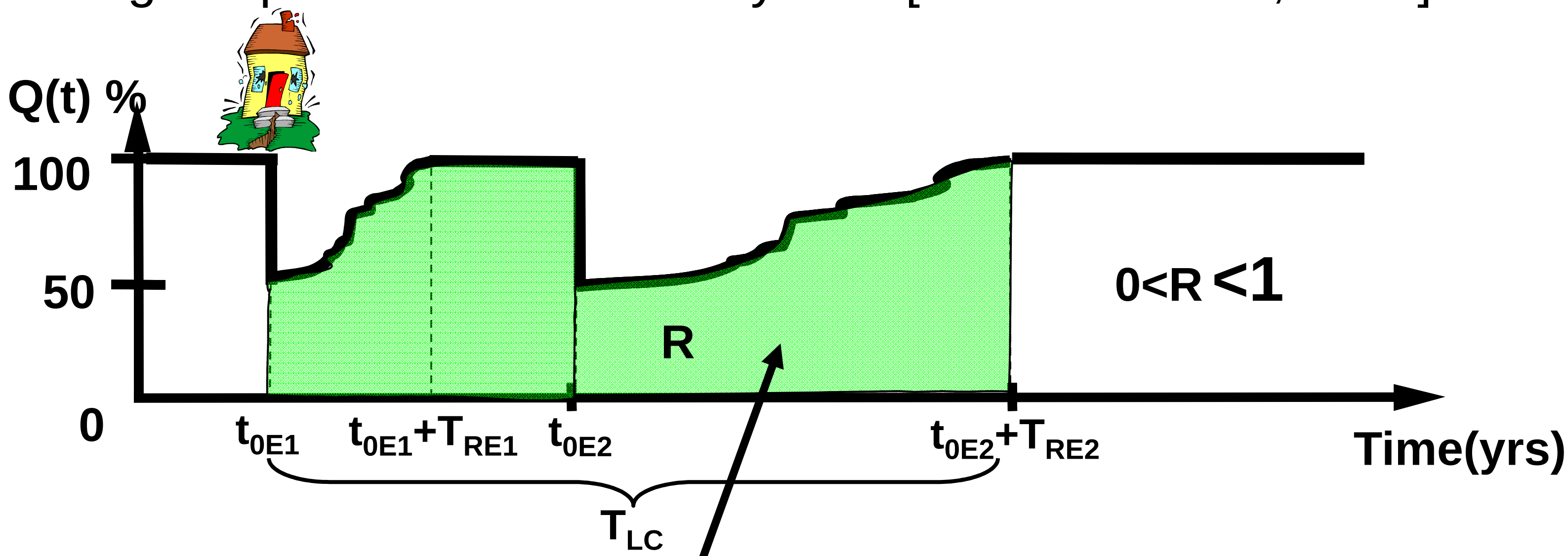
Resilience

The term resilience derives from the latin word "resilio" (da re e salio) which means bounch back, but also not being touch by something (of negative).

Disaster Resilience

Unique decision variable (DV)

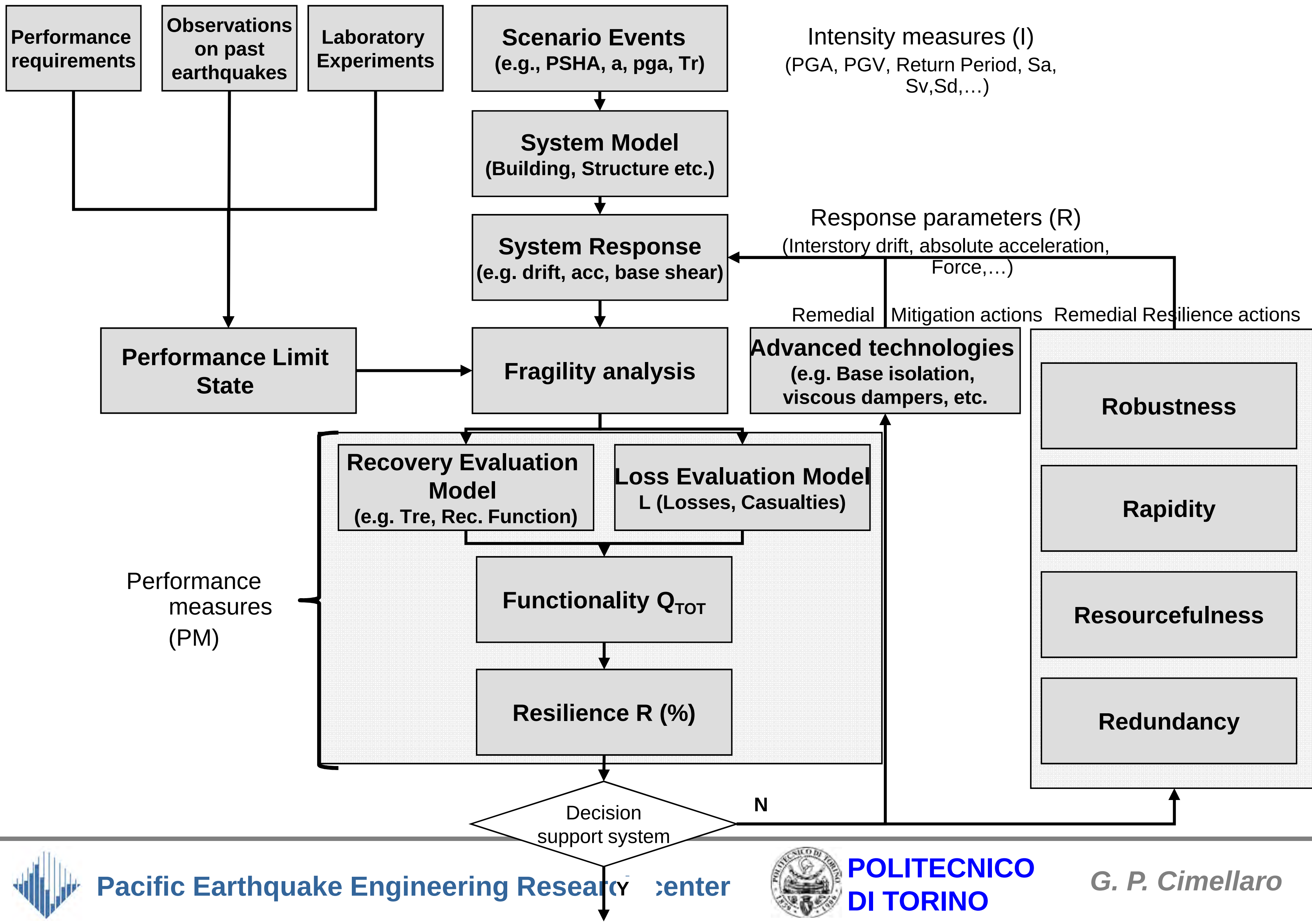
- Resilience: normalized function indicating the capacity to maintain a certain level of functionality or performance in a given building, bridge, lifeline, network for a given period T_{LC} (life cycle, etc.) including the post-disaster recovery time [Cimellaro et al., 2006].



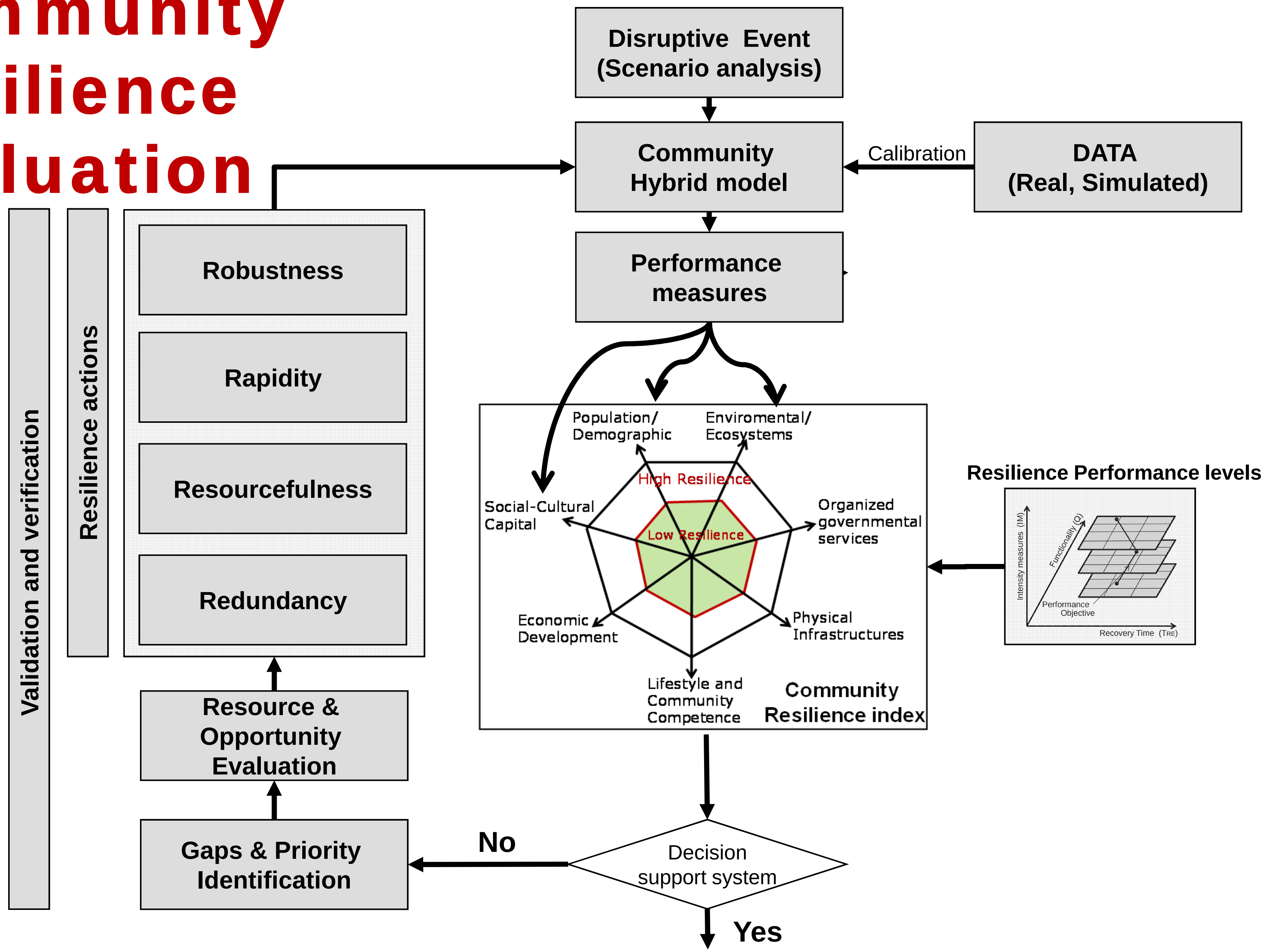
$$R_i = \int_0^{T_{LC}} \left(\frac{Q_i(t)}{T_{LC}} \right) dt$$

$$0 \le R_i \le 1$$

Resilience of Building structures



Community Resilience Evaluation



Dimensions of Community Resilience

P	**POPULATION AND DEMOGRAPHICS** Composition, Distribution, Socio-Economic Status, etc.
E	**ENVIRONMENTAL/ECOSYSTEM** Air quality, Soil, Biomass, Biodiversity, etc.
O	**ORGANIZED GOVERNMENTAL SERVICES** Legal and security services, Hygiene and health services, etc.
P	**PHYSICAL INFRASTRUCTURE** Facilities, Lifelines, etc.
L	**LIFESTYLE AND COMMUNITY COMPETENCE** Quality of Life, etc.
E	**ECONOMIC DEVELOPMENT** Financial, Production, Employment distribution, etc.
S	**SOCIAL-CULTURAL CAPITAL** Education services, Child and elderly care services, etc.

IDEal reSCUE - VISION

Project Goal

To develop a novel method to assess the performance of critical infrastructures and their interdependencies while taking in account the influence of **human behavior** and its **emotions**.

Gaps in Science

1. A comprehensive model of a metropolitan area while considering all infrastructures and their interactions is missing.

2. Modeling the human behavior within the context of infrastructure interdependencies using ABMS is not available.

2010 Haiti earthquake

9/11 Terrorist attack

2011 Fukushima Nuclear Disaster

2009 L'Aquila Earthquake

Multidisciplinary

interdisciplinary skills of Engineers, Social Scientists, software developers.

IDEal reSCUE - IMPACT

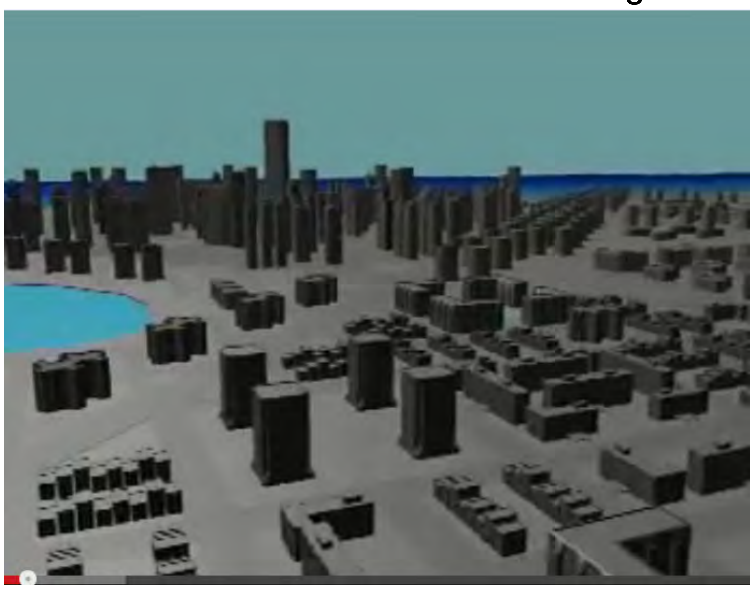
Scientific/Engineering

❑New techno-socio-economic models (feasible within the next 10-15 years).

❑ Open a new field of research in Hybrid modeling combining the potentialities of Network and agent-based models.

❑The project will answer some of the "open questions" on temporal networks.

❑ Different models of infrastructures (virtual 3D) will be linked in a decision making tool.

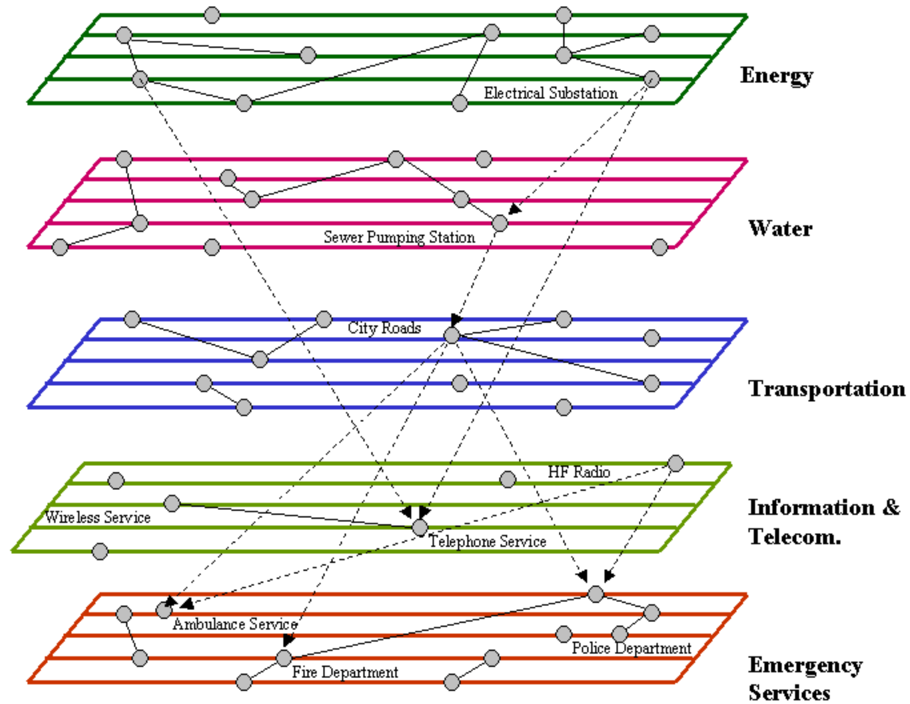


Social

❑ Improve resiliency of civil infrastructures after extreme events.

❑Aid infrastructure asset managers during emergency situations;

❑The model will be used for **TRAINING** and **EDUCATION** purposes;



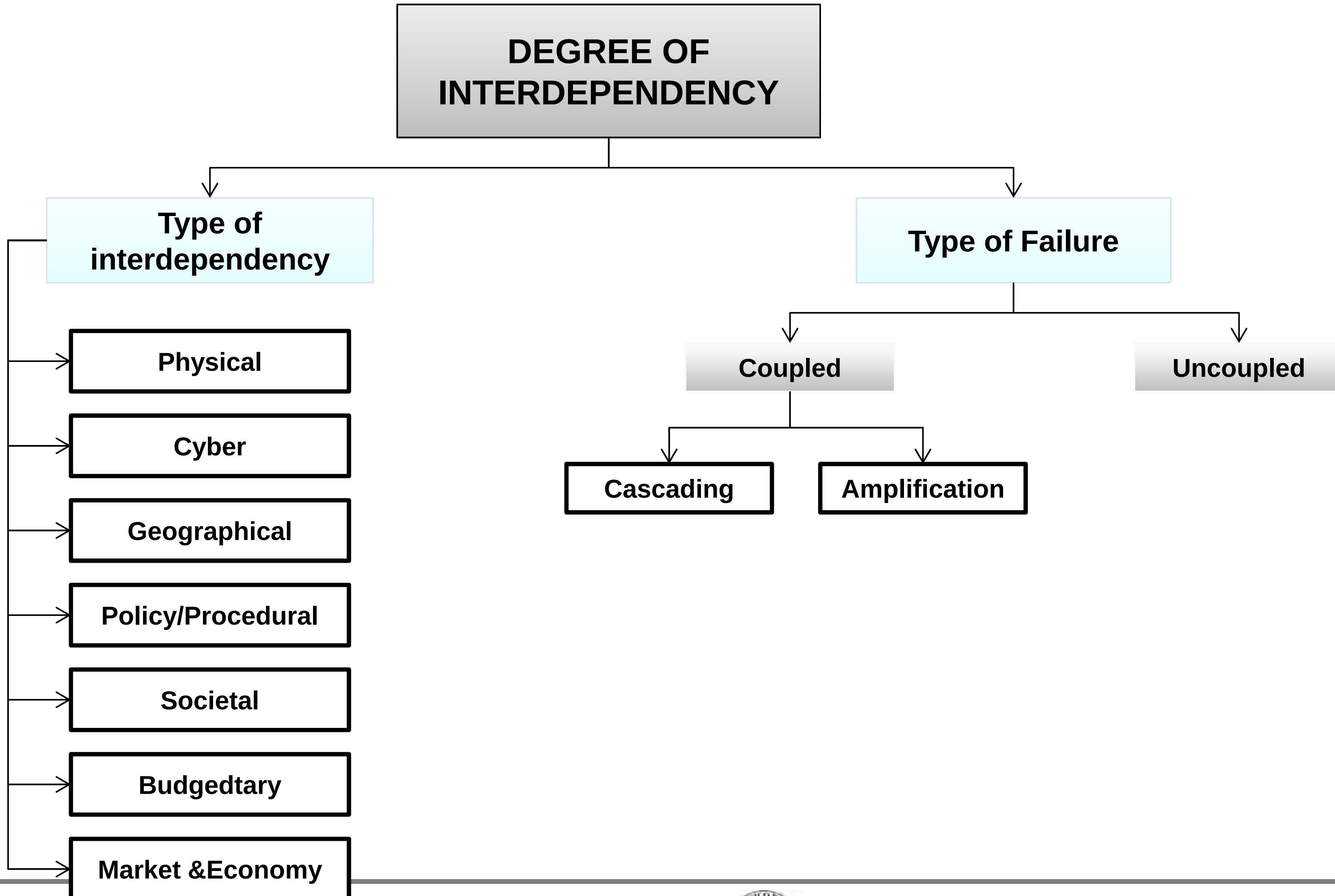
Outline

- ❑Framework to evaluate community resilience;

- ❑Applications on Resilience of Building structures;
  - ❑Hospital/school building;
  - ❑Emergency Department;

- ❑Applications on Resilience of infrastructures;
  - ❑Water distribution network;
  - ❑Natural Gas distribution network;
  - ❑Infrastructure interdependencies at different spatial scales (local vs. global level);
  - ❑Economic Resilience of a community (e.g. the Bay area case study);
  - ❑Emergency damage assessment using Smart phones;
  - ❑Evacuation plan from a museum;

General framework



Degree of interdependency

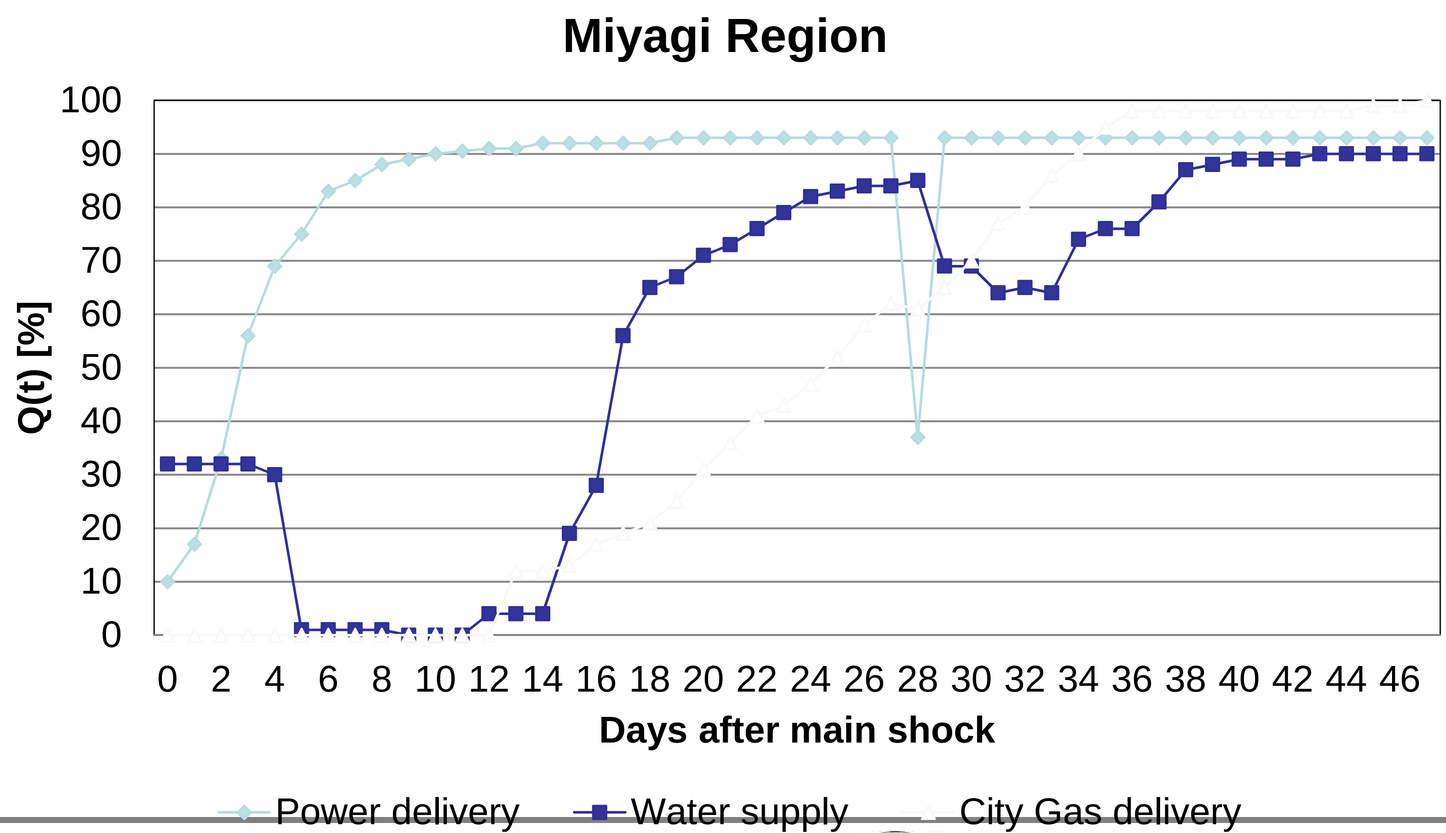
Infrastructure level

- The values are located in a community interdependency matrix.

the ↓ / can affects ↓ in this points:	Electricity	Oil delivery	Transportation	Telecomunication	Natural Gas delivery	Water supply	Wastewater tratment	Financial system	Building services	Business	Emergency services	Food supply	Government	Health care	Education	Commodities	Leadership index
Electricity	**1**	1	0,6	1	1	0,6	0,6	0,6	0,6	1	0,6	1	1	0,6	0,3	0,6	**12,1**
Oil delivery	0,6	**1**	0,6	0,3	0,3	0,3	0,3	0,6	0,6	0,6	0,6	0,6	0,6			0,6	**7,6**
Transportation	0,3	0,6	**1**		0,6			0,6	0,6	1	1	1	0,6	0,6	0,3	1	**9,2**
Telecomunication	0,3	0,3	0,3	**1**	0,3	0,3	0,3	1		1	1	0,6	1	0,3		0,3	**8**
Natural Gas delivery	0,6		0,3		**1**			0,6	0,3	0,6	0,6	0,6	0,6	0,3	0,3	0,3	**6,1**
Water supply	0,6	0,3		0,3	0,3	**1**		0,3	1	0,6	0,6	1	0,6	0,6	0,6	0,6	**8,4**
Wastewater tratment		0,3			0,3	0,6	**1**		0,3	0,6	0,3	0,3	0,3	0,6		0,3	**4,9**
Financial system	0,3	0,3	0,6	0,3	0,3	0,3	0,3	**1**	0,6	1	0,3	0,6	1	0,3		1	**8,2**
Building services	0,3	0,3	0,6	0,3	0,3	0,3	0,3	0,6	**1**	0,6	0,6		0,3			0,6	**6,1**
Business	0,3	0,6	1	0,6	0,6	0,3	0,3	1	0,6	**1**		0,6	1			1	**8,9**
Emergency services	0,6	0,6	0,6	0,6	0,6	0,6		1	0,3	1	**1**	1	1	1	0,6		**10,5**
Food supply	0,3	0,3	0,6		0,3	1	0,3	1	0,3	1	0,6	**1**	1	0,6	0,6	0,3	**9,2**
Government	0,6	0,6	0,6	0,6	0,6	0,6	0,6	1	0,6	1	1	1	**1**	1	1	0,6	**12,4**
Health care			0,3					0,3	0,3	0,3	1	0,6	1	**1**	0,3	0,3	**5,4**
Education	0,3	0,3	0,3	0,3	0,3	0,3	0,3	1	0,3	0,6	1	0,3	1	0,6	**1**	0,3	**8,2**
Commodities	0,3	0,3	1	0,3	0,3	0,3	0,3	1	0,6	1	0,3	0,3	1	0,3		**1**	**8,3**
Index of subordination (dependence)	**6,4**	**6,8**	**8,4**	**5,6**	**7,1**	**6,5**	**4,6**	**11,6**	**8,0**	**12,9**	**10,5**	**10,5**	**13,0**	**7,8**	**5,0**	**8,8**	

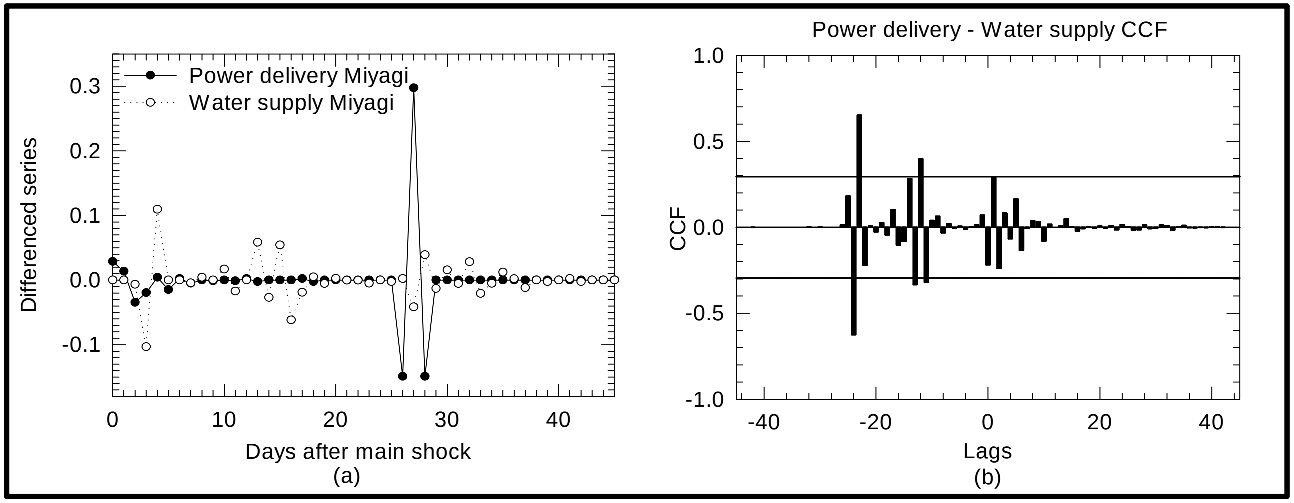
Degree of interdependency
Regional level

- The proposed analytical method uses the *<u>restoration curves</u>* (or functionality curves) to evaluate the index of interdependency



Degree of interdependency
Analytical method

- ❑ The available data correspond to 12 regions in Japan for 3 types of infrastructure (Power, water and gas distribution network);
- ❑ Logarithmic transformation and double differentiation of the series;
- ❑ Evaluation of the cross correlation function (*ρ(h)*) for each couple of transformed functionality curves



Regional Resilience index
Weight Coefficients

- The weight of each infrastructure (w_i) in every region is evaluated starting from the matrix of interdependency ($S_{i,j}$) evaluated using the following formula:

$$w_i = \frac{\sigma_i}{\sum_i \sigma_i}$$

where

$$\sigma_i = \sum_j S_{i,j} \qquad when \quad S_{i,j} > 0$$

Regional Resilience index

- The resilience assessment of a single infrastructure (R_i) is given by the following integral:

$$R_i = \int_0^{T_{LC}} \left(\frac{Q_i(t)}{T_{LC}} \right) dt$$

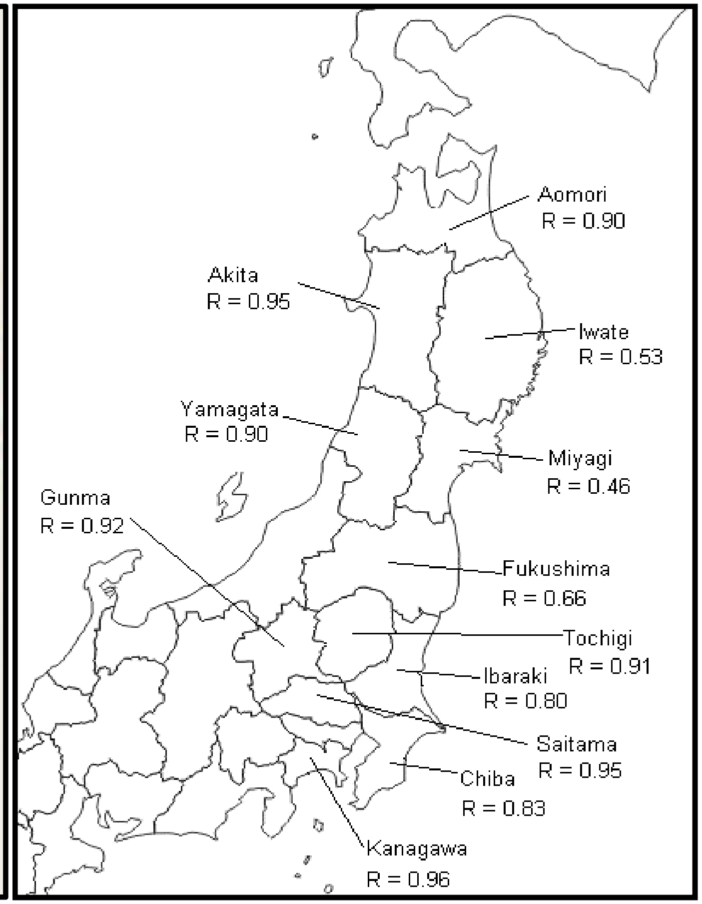
$$0 \le R_i \le 1$$

- The global resilience of a given region (R) can be evaluated through the weight average of the resilience index of each infrastructure of the region at hand:

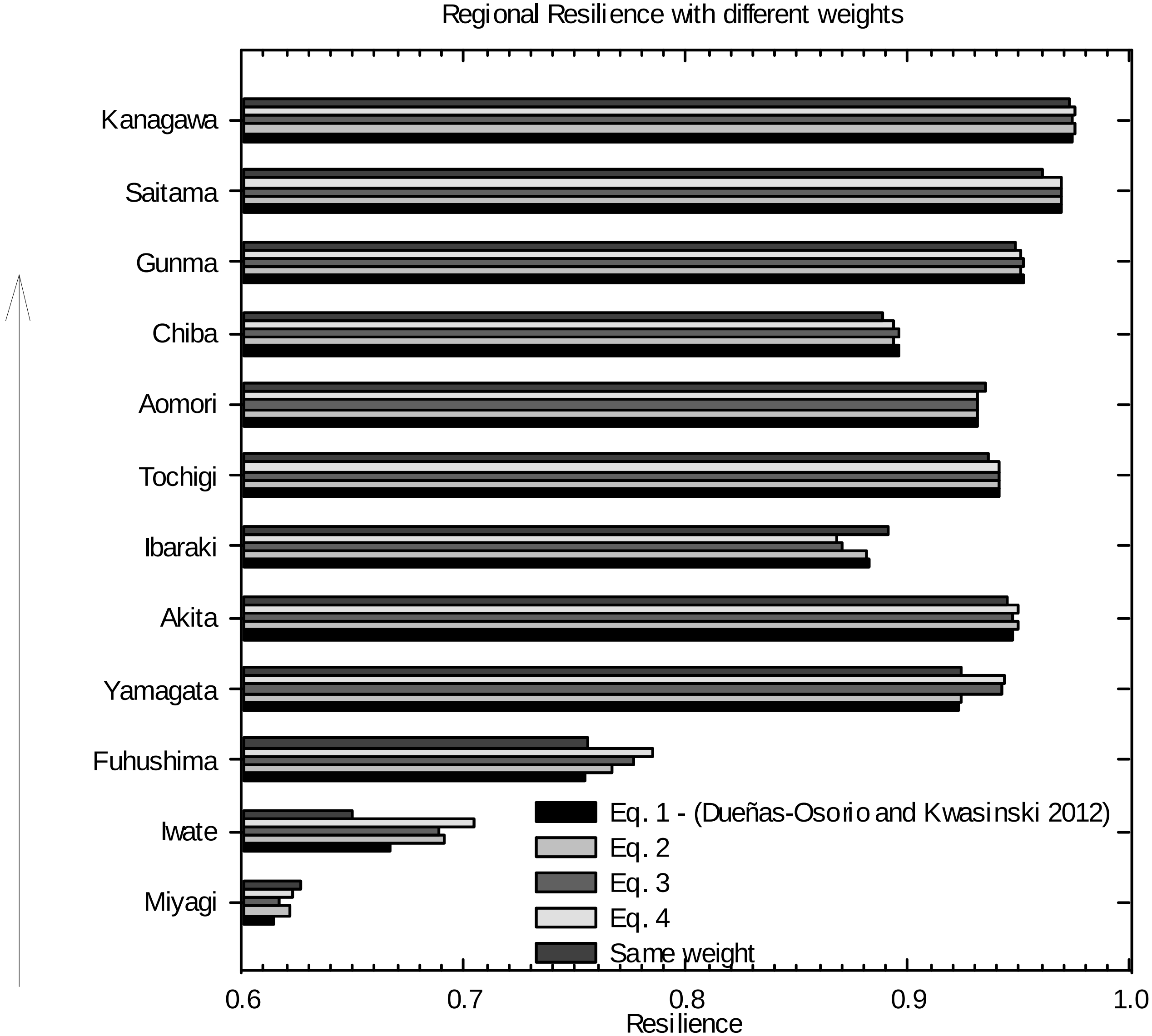
$$R = \sum_i \left(R_i \times w_i \right)$$

Case study: Tohoku earthquake
Global regional level

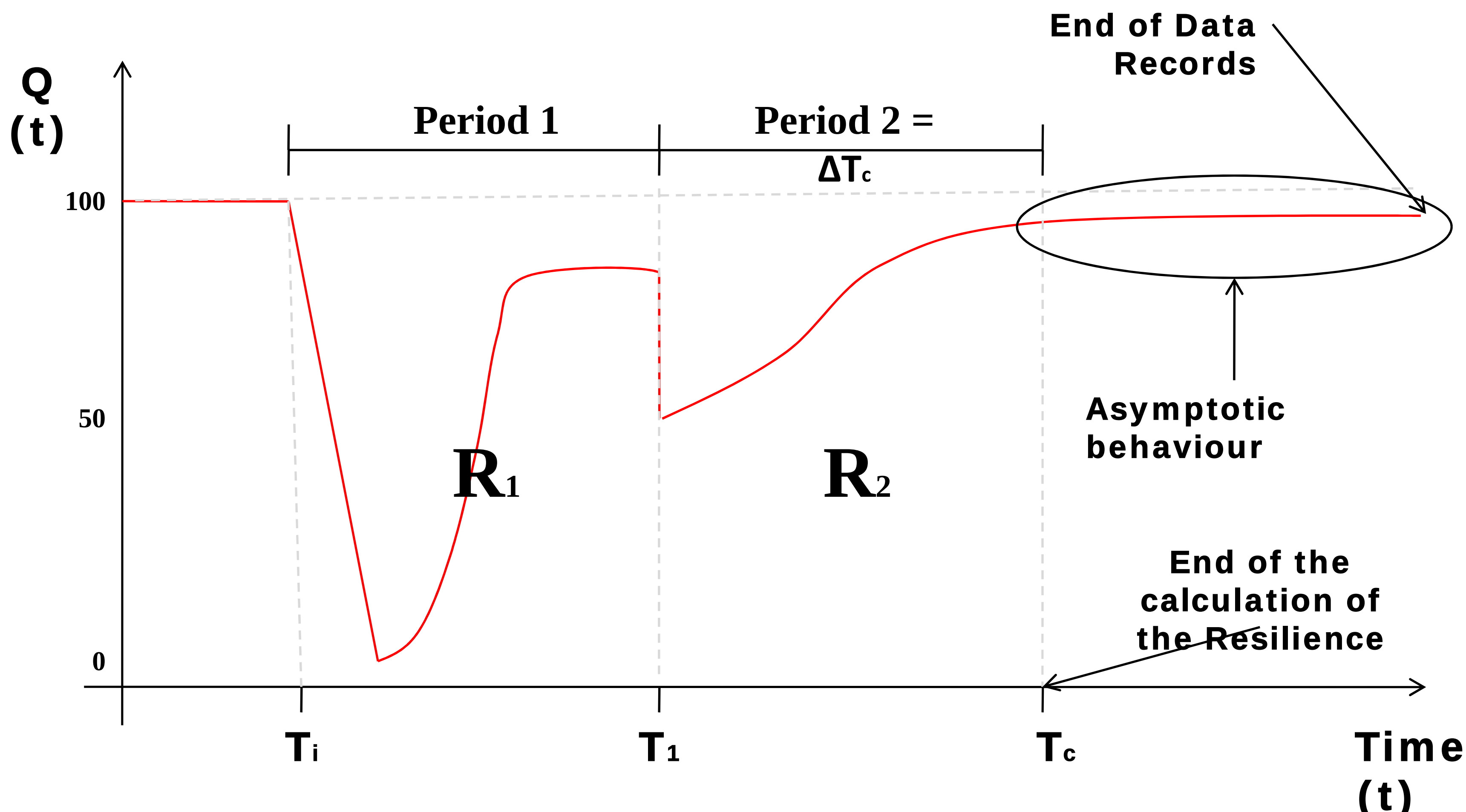
$0 \leq R \leq 1$



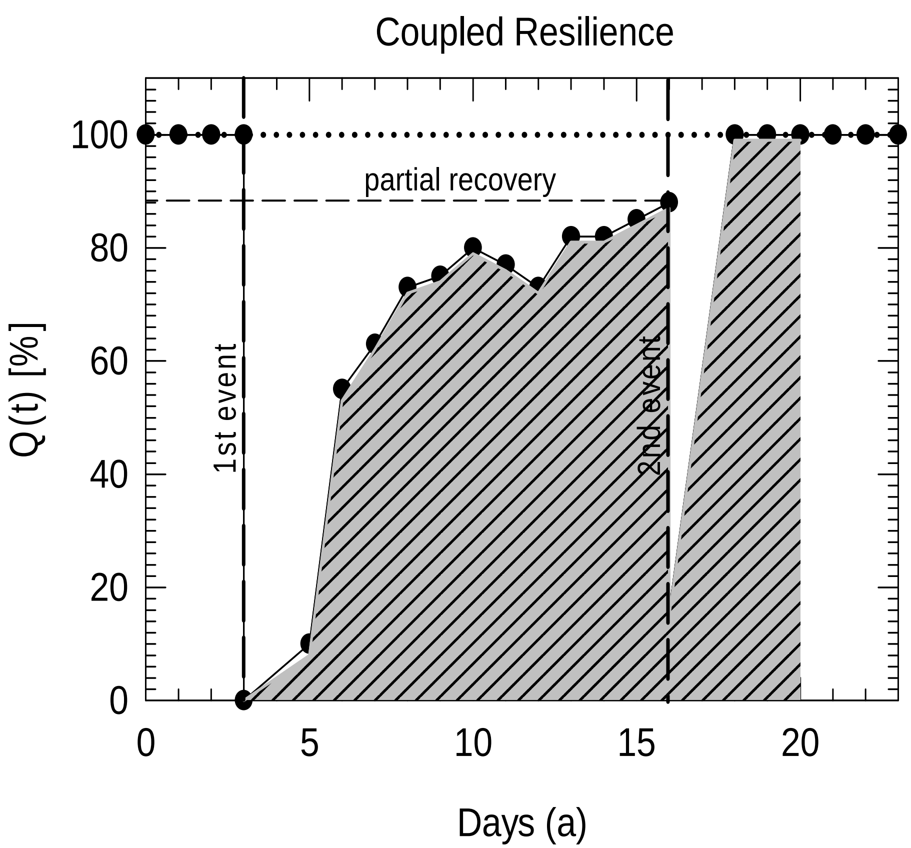
Regional Resilience indices

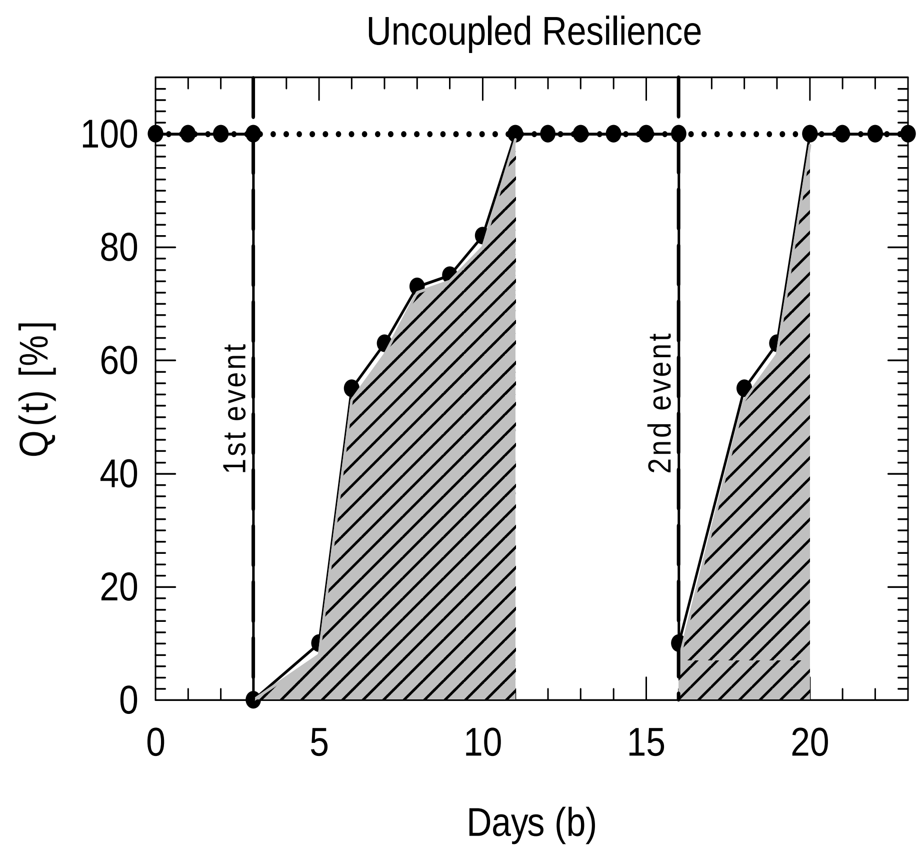


Coupled Resilience



Coupled vs. uncoupled Resilience

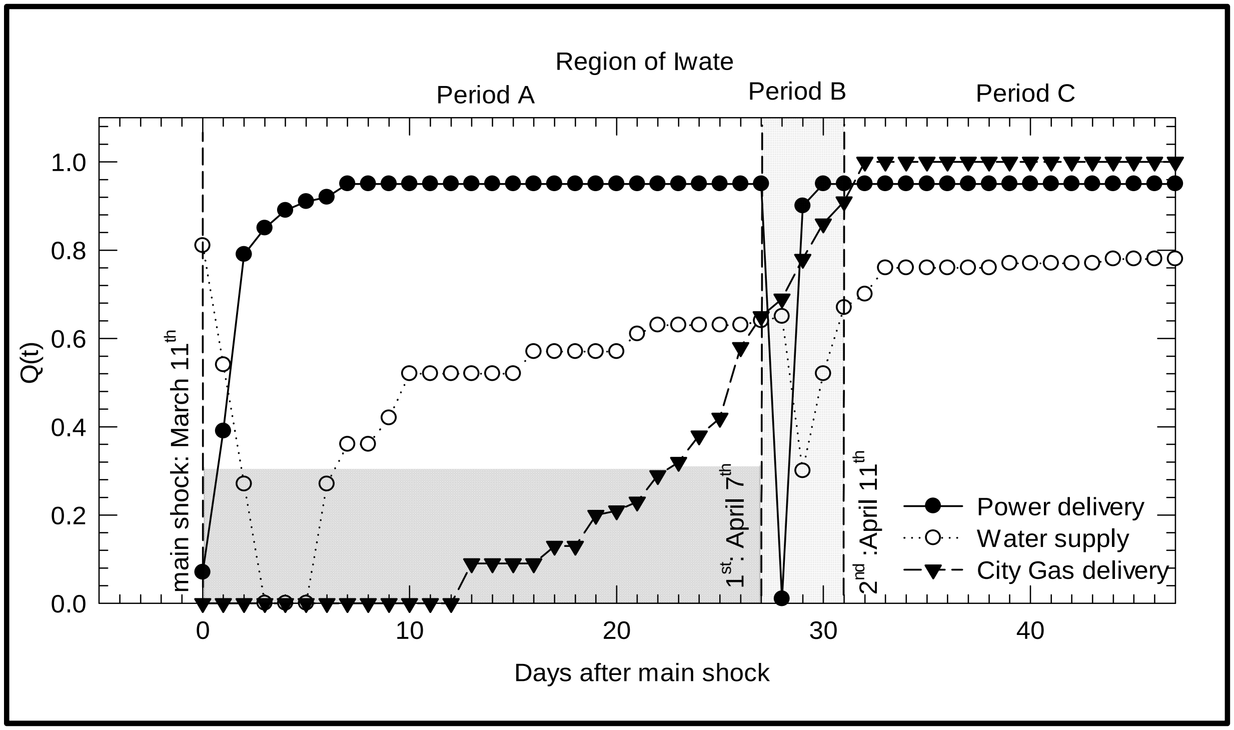




Optimal period range T_{LC}

Evaluation of weight coefficients w_i

- The restoration curves of a given region are divided according the period range between two subsequent aftershocks so that the functionality of at least one of the functionality curve has a drop of functionality



Optimal period range T_{LC}

Evaluation of weight coefficients w_i

Four options are possible:

1. ~~Evaluate w_i over the entire control period;~~
2. Evaluate w_i over the first interval between two aftershocks (Period A);
3. Evaluate w_i separately over all the intervals (Exact method);
4. Assume w_i equal and constant for all infrastructures;

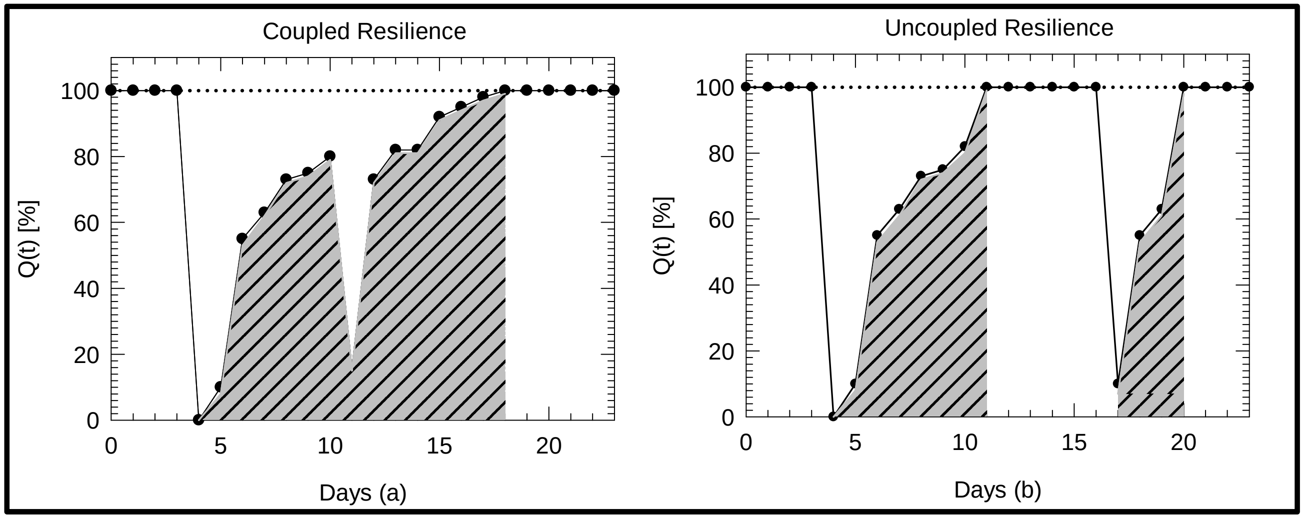
Optimal period range for the weight coefficient assessment wi

- The proposed **exact method** for the resilience assessment of a given region is given by the following equation:

$$R=\frac{1}{\int_0^{T_{Lc}} T_{Lc}dt}\left\{\sum_i\left[\int_0^{T_1} Q_i(t)dt\cdot w_{i,(0)}\right]+\ldots+\sum_i\left[\int_{T_{n-1}}^{T_n} Q_i(t)dt\cdot w_{i,(n-1)}\right]+\sum_i\left[\int_{T_n}^{T_{Lc}} Q_i(t)dt\cdot w_{i,(n)}\right]\right\}$$

- Some considerations can be added introducing the concept of coupled and uncoupled resilience;

Optimal period range for the weight coefficient assessment wi

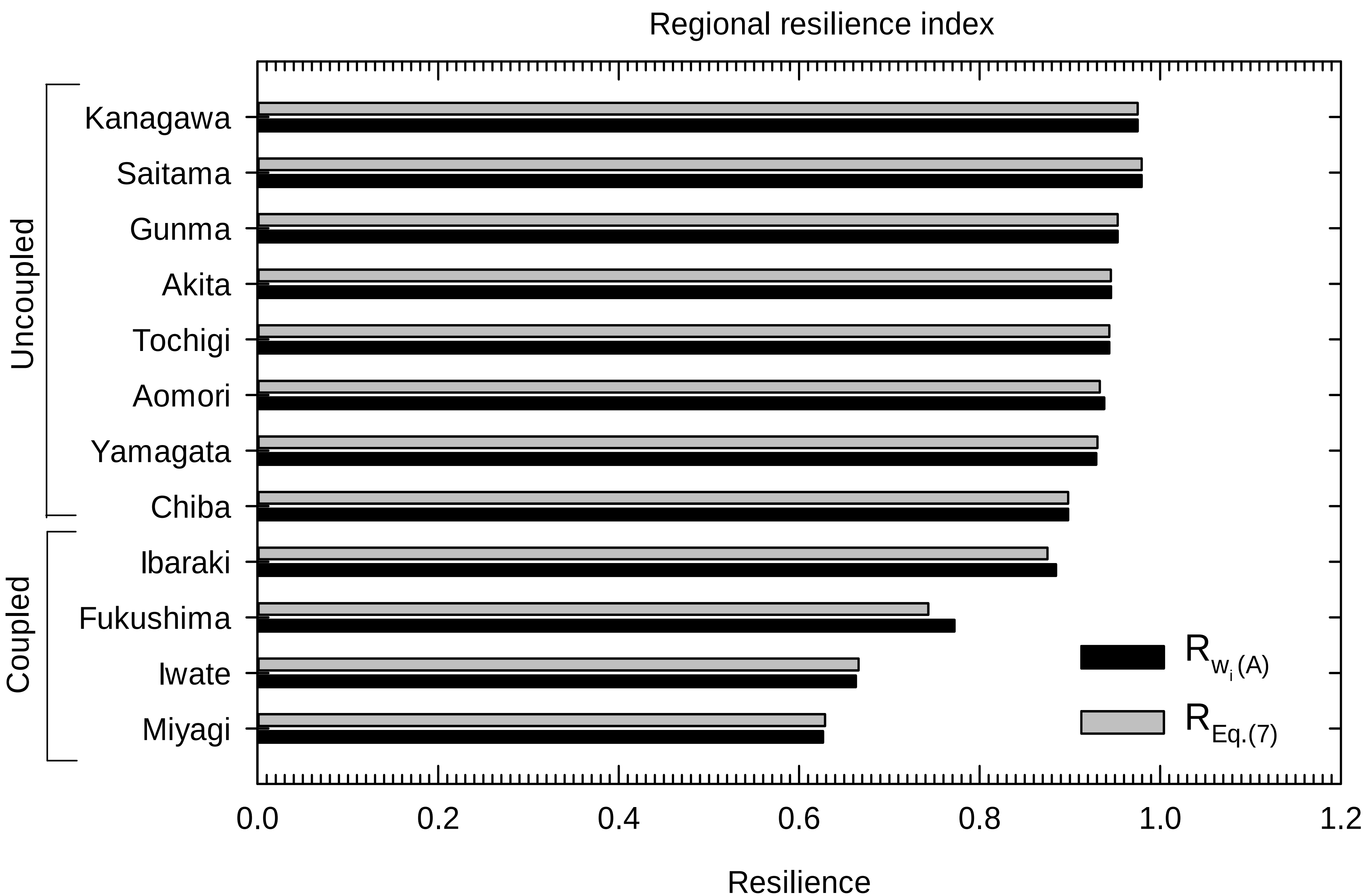


1. Assume wi equal and constant for all infrastructures;
2. Evaluate wi over the first interval between two aftershocks (Period A);
3. Evaluate wi separately over all the intervals (Exact method);

Uncoupled Resilience

Coupled Resilience

Regional resilience



MEASURING LIFELINE EMERGENCY RESPONSE USING TEMPORAL NETWORK MODELS

Paolo Fantini[1], Gian Paolo Cimellaro[2], Stephen Mahin[3]

1: Visiting student researcher at PEER
2: Visiting professor at UC Berkeley
3: Professor at UC Berkeley

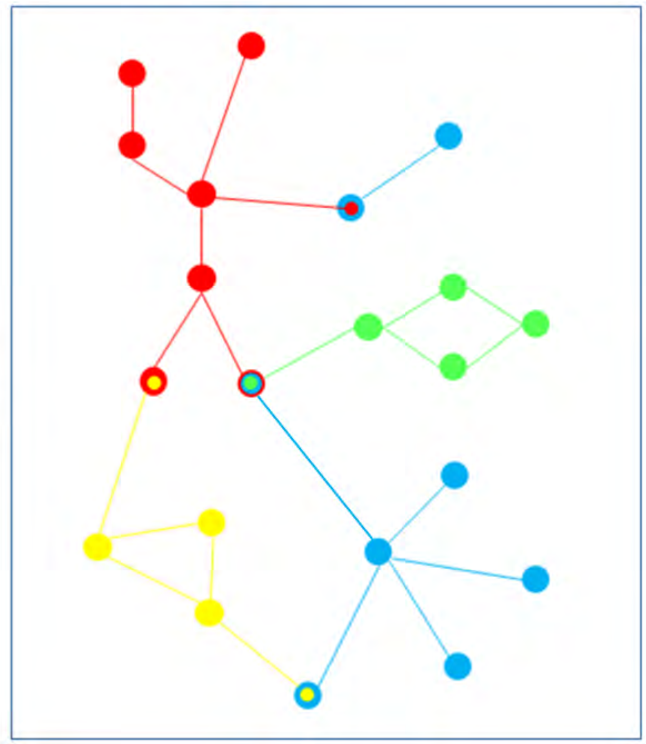
Motivations

Exploring new types of network models for modeling lifelines during emergencies

Why this research is important	- Governments consider lifelines resilience a **priority** - A good management of emergency response phase can limit **cascading effects** and damages.
Criticalities	Many models, like the IIM (Haimes and Jiang, 2001), attempt to simulate lifelines interdependence, but **temporal effects** can modify the topology of the system and invalidate their results.
Possible integrations	Studies of **dynamic networks** in fields like telecommunication engineering, social science, artificial intelligence can be applied in the risk management of critical infrastructure systems.
Our hypothesis	Implementing the IIM with a **probabilistic** and **multilayer** approach and introducing a **tensor** notation, which takes into account the time variable, is effective for obtaining <u>more realistic emergency scenarios</u>.

Graph theory

Lifelines can be model using graph theory where the network is modeled using: *source node*, *sink node*, *oriented edge*, *chain*, *adjacency matrix*.



The Input-output Inoperability Method (IIM)

Developed by Haimes an Jiang (2001) is a model for determining the propagation of the probability of inoperability in infrastructure systems. Its fundamental equation is:

$$q = [I - A]^{-1} \cdot c$$

- **c** (scenario vector): perturbation introduced in the systems;
- **A** (interdependency matrix): describes the topology of the systems;
- **q** (damage vector): result of the propagation of the perturbation.

Limitations of IIM and suggested implementations

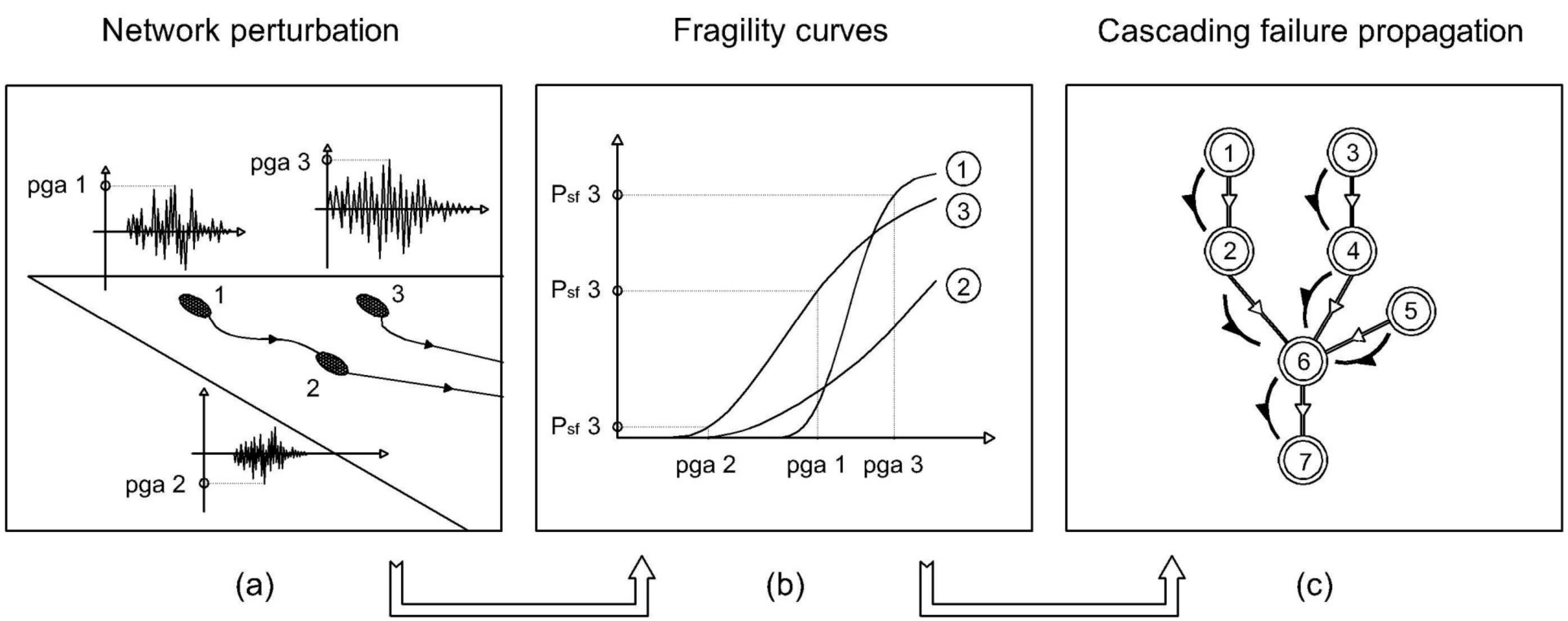
Limitations		Implementations
Does not model the advantages of having redundancies in the systems.	①	Introduction of probabilistic quantities and step by step calculation of propagation effects.
Difficulties in modeling interdependencies between different networks;	②	Model different infrastructures with interconnected layers.
Static model that does not consider the evolution of the system; Not accounting the temporal effects that can disrupt the systems.	③	Give a time dimension to the model by modeling the topology change with a tensor notation.

① Probabilistic formulation

The proposed model shift from the **c** and **q** vector of the IIM to probabilistic quantities.

Input	►	Event vector **E**	(Natural Hazard)
	►	Fragility curves	(Vulnerability)
Output	►	Prob. of self-failure $\mathbf{P_{sf}}$	*(from **E** vector and Fragility curves)*
	►	Prob. of cascading failure $\mathbf{P_{cf}}$	*(propagation of upstream $\mathbf{P_{sf}}$ computed step by step)*
	►	Prob. of failure $\mathbf{P_f}$	*(combination of $\mathbf{P_{sf}}$ and $\mathbf{P_{cf}}$)*

① Probabilistic formulation



Flowchart to determine the probability of failure $\mathbf{P_f}$

Limitations of IIM and suggested implementations

Limitations		Implementations
Does not model the advantages of having redundancies in the systems.	1	Introduction of probabilistic quantities and step by step calculation of propagation effects.
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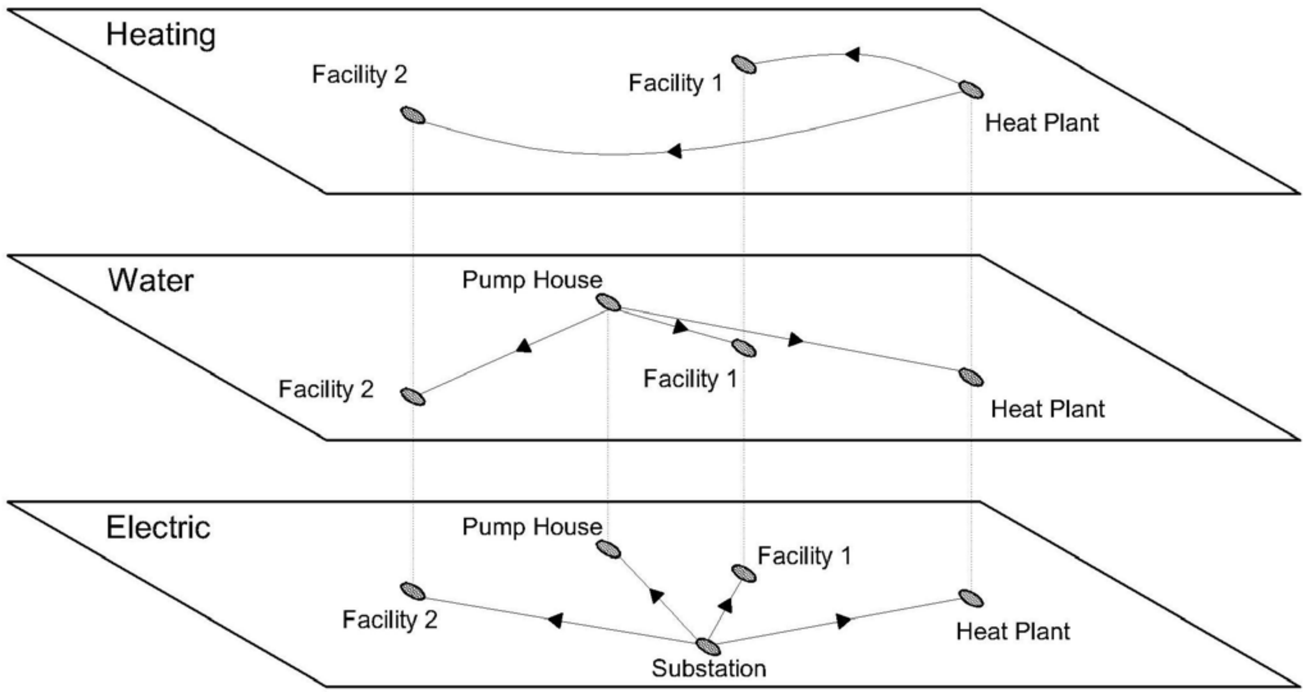
Static model that does not consider the evolution of the system; Not accounting the temporal effects that can disrupt the systems.	3	Give a time dimension to the model by modeling the topology change with a tensor notation.

② Multilayer approach for spatial interdependency

Different infrastructures can be modeled like separate layers of the same system. <u>Interdependent nodes</u> are projected on different layers and establish links between them.



② Multilayer approach for spatial interdependency

Every infrastructure is consider as a separate network described by its *adjacency matrix*:

$$A_i = \begin{bmatrix} (a_{11})_i & \cdots & (a_{1n})_i \\ \vdots & \ddots & \vdots \\ (a_{n1})_i & \cdots & (a_{nn})_i \end{bmatrix} \quad ; \quad A_j = \begin{bmatrix} (a_{11})_j & \cdots & (a_{1m})_j \\ \vdots & \ddots & \vdots \\ (a_{m1})_j & \cdots & (a_{mm})_j \end{bmatrix} \quad ; \quad \cdots$$

To take into account interdependencies ***inter-network matrixes*** are introduced:

$$\boldsymbol{I}_{j\to i} = \begin{bmatrix} (i_{11})_{j\to i} & \cdots & (i_{1n})_{j\to i} \\ \vdots & \ddots & \vdots \\ (i_{m1})_{j\to i} & \cdots & (i_{nn})_{j\to i} \end{bmatrix} \quad ; \quad \cdots$$

Cascading effects are evaluated transferring the *probability of failure* from the upstream network (here it is *j*) to the dependent one (here it is *i*):

$$\boldsymbol{P^*}_{\boldsymbol{sf}_i} = \left(\boldsymbol{I}_{\boldsymbol{j\to i}}{}^{T} \cdot \boldsymbol{P}_{\boldsymbol{cf}_i}\right) \cup \boldsymbol{P}_{\boldsymbol{sf}_i}$$

Limitation of IIM and suggested implementations

Limitations		Implementations
Does not model the advantages of having redundancies in the systems.	1	Introduction of probabilistic quantities and step by step calculation of propagation effects.
Difficulties in modeling interdependencies between different networks;	2	Model different infrastructures with interconnected layers.
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③ Tensor notation for accounting temporal effects

Probability of failure of nodes, and thus the topology of the system, can change over time.

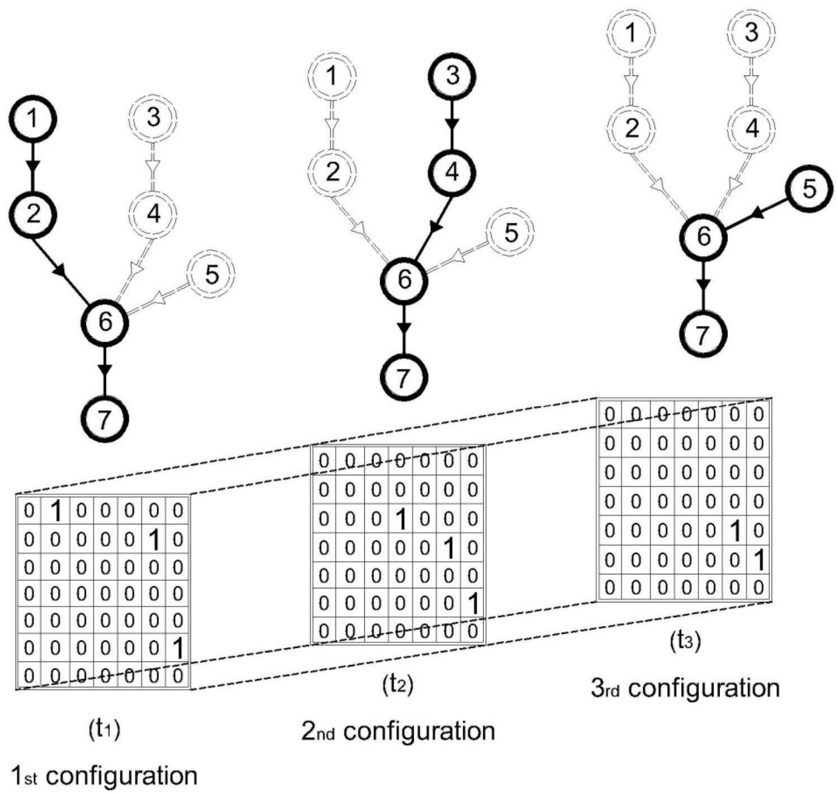
Being the lifelines critical and strategic infrastructures, they are designed to work also in unfavorable conditions. The flow from *source nodes* to *sink nodes* can follow different paths *(chains)*, characterized by an ***hierarchy*** position:

- Main supply line (1st in hierarchy)
- First back-up line (2nd in hierarchy)
- Second back-up line (3rd in hierarchy)
- …

These separate paths are considered mutually exclusive, so they are operative at different time.

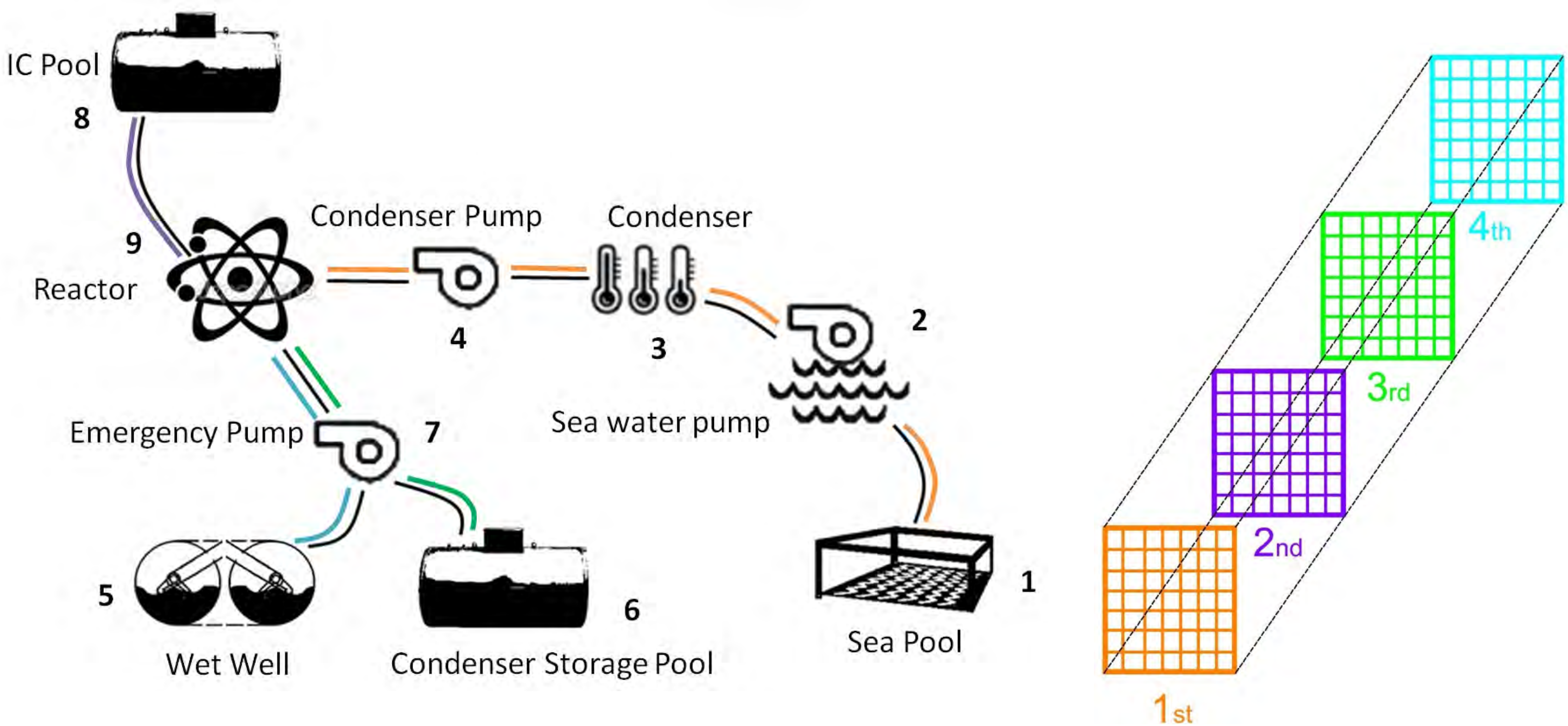
③ Tensor notation for accounting temporal effects

To model the presence of different configurations at different time steps, the ***adjacency tensor* A(t)** is introduced.



③ Tensor notation for accounting temporal effects

Case study – Adjacency tensor of a Nuclear Power plant cooling water network



③ Tensor notation for accounting temporal effects

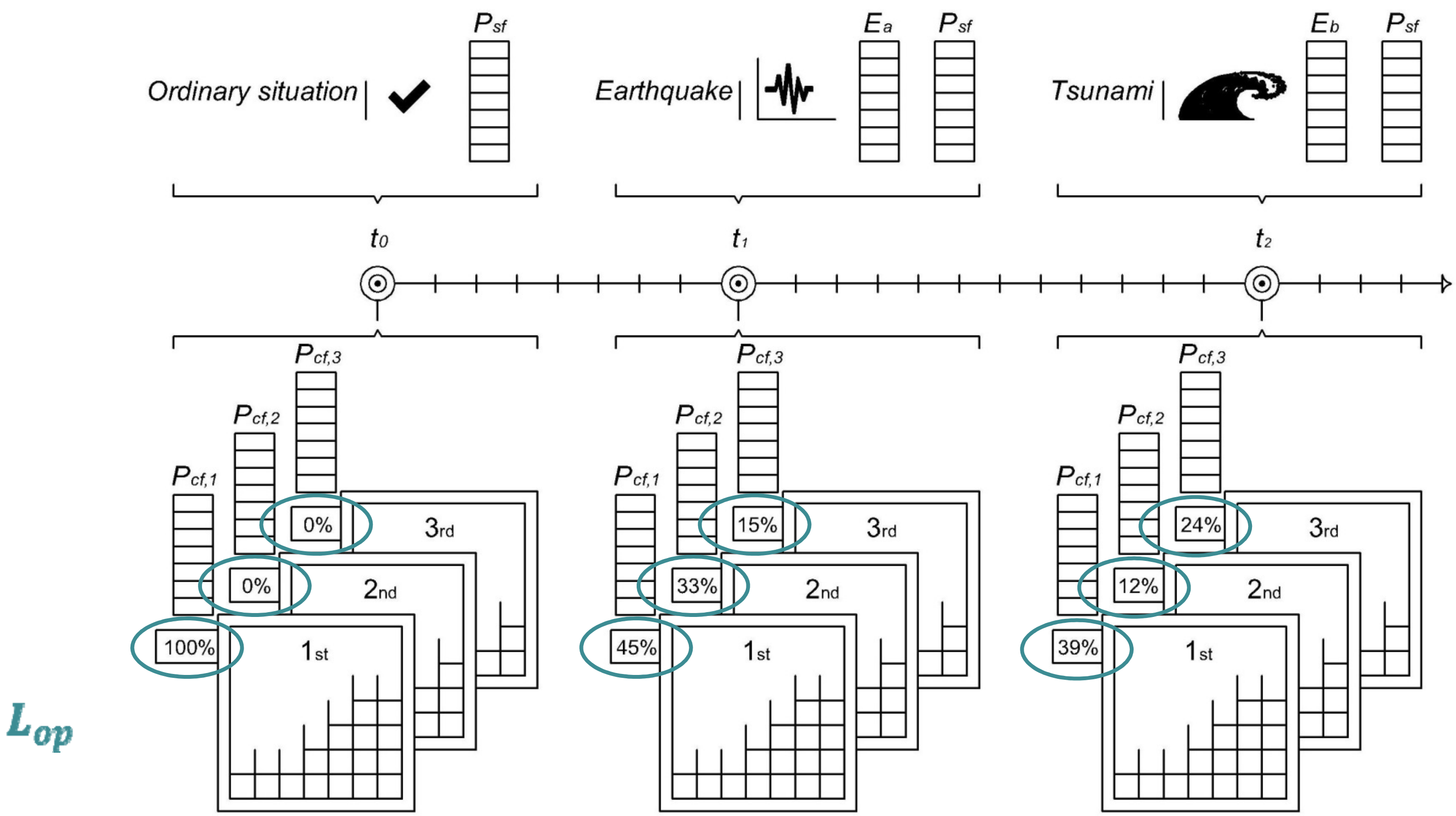
One configuration is active if its nodes do not fail and if configurations with higher hierarchy position are not activated. Knowing the probability of failure of each node of each configuration, it is possible to determine the probability that a configuration is active.

This probability is represented by the ***Operability Label*** ($\mathbf{L_{op}}$) and is associated to every layer of the *adjacency tensor*. It can vary over time due to disruptive events or simply aging.

- The value $1-\Sigma\mathbf{L_{op}}$ describes the probability that none of the possible configurations is active, and so corresponds to the loss of capacity of the system;
- Knowing when a back-up line is kicked off and for how long it is active, allows to quantify the temporal effects (e.g. the run out of autonomy of diesel tank serving a UPS).

③ Tensor notation for accounting temporal effects

Example



Concluding remarks

The proposed model is able to:

a) Evaluate the cascading effects generated by interdependencies using a multilayer approach (e.g. GIS platform)

b) take into account the temporal effects and the represent the evolution of the emergency response.

c) measure the robustness of an infrastructure system;

Outline

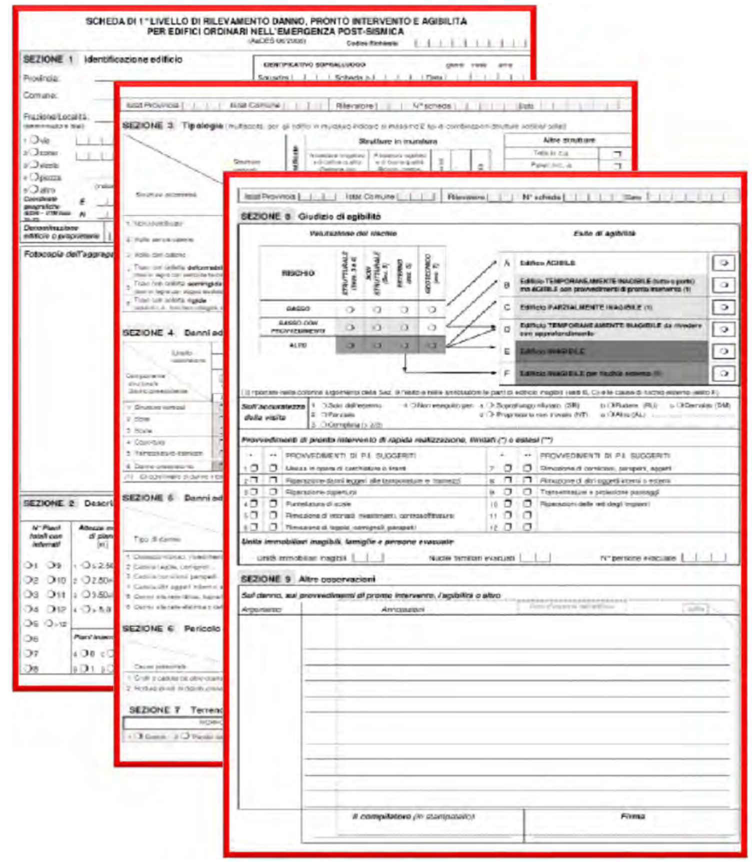
- ❑Framework to evaluate community resilience;

- ❑Applications on Resilience of Building structures;
  - ❑Hospital / school building;
  - ❑Emergency Department;

- ❑Applications on Resilience of infrastructures;
  - ❑Water distribution network;
  - ❑Natural Gas distribution network;
  - ❑Infrastructure interdependencies at different spatial scales (local vs. global level);
  - ❑Economic Resilience of a community (e.g. the Bay area case study);
  - ❑Emergency damage assessment using Smart phones;
  - ❑Evacuation plan from a museum;

AeDES Survey Form

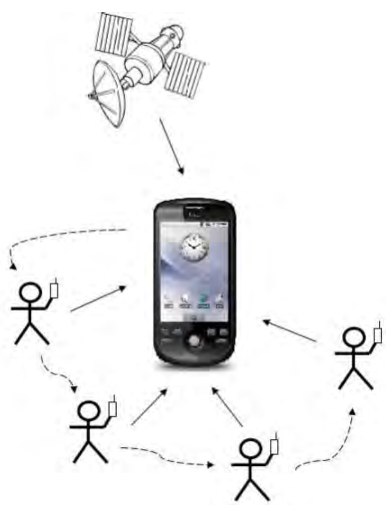
The AeDES survey form is composed by 9 sections:

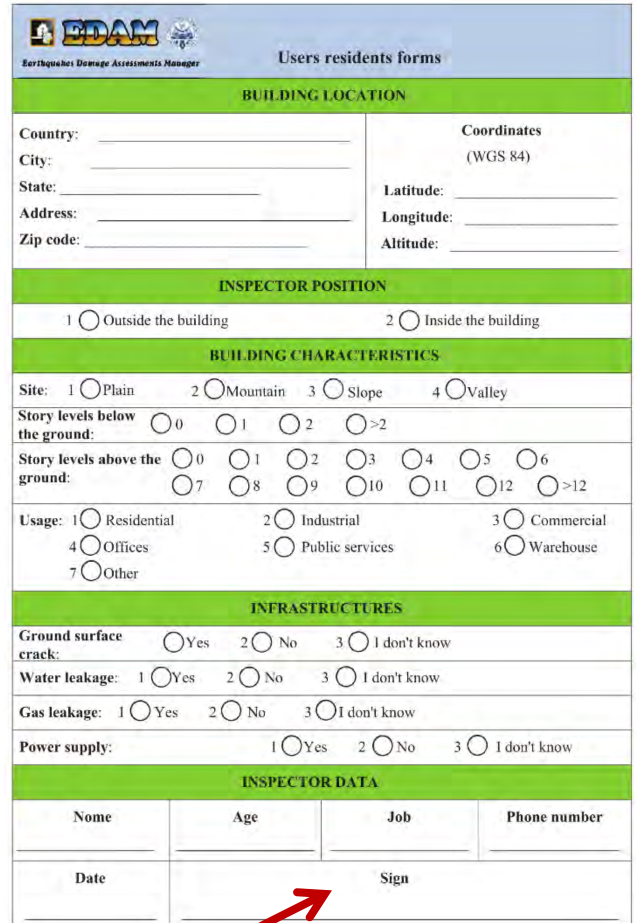


1. **Building identification**
2. **Building description**
3. **Typology**
4. **Damage to structural elements and short term countermeasures carried out**
5. **Damage to non structural elements and short term countermeasures carried out**
6. **External damage due to other constructions and short term countermeasures carried out**
7. **Soil and foundations**
8. **Usability judgment**
9. **Other observations**

Users Residents Mode

Damage assessment for non espert users





EDAM
Earthquakes Damage Assessments Manager

Users residents forms

BUILDING LOCATION

Country: ______
City: ______
State: ______
Address: ______
Zip code: ______

Coordinates (WGS 84)
Latitude: ______
Longitude: ______
Altitude: ______

INSPECTOR POSITION

1 ○ Outside the building 2 ○ Inside the building

BUILDING CHARACTERISTICS

Site: 1 ○ Plain 2 ○ Mountain 3 ○ Slope 4 ○ Valley

Story levels below the ground: ○ 0 ○ 1 ○ 2 ○ >2

Story levels above the ground: ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ 11 ○ 12 ○ >12

Usage: 1 ○ Residential 2 ○ Industrial 3 ○ Commercial 4 ○ Offices 5 ○ Public services 6 ○ Warehouse 7 ○ Other

INFRASTRUCTURES

Ground surface crack: ○ Yes 2 ○ No 3 ○ I don't know

Water leakage: 1 ○ Yes 2 ○ No 3 ○ I don't know

Gas leakage: 1 ○ Yes 2 ○ No 3 ○ I don't know

Power supply: 1 ○ Yes 2 ○ No 3 ○ I don't know

INSPECTOR DATA

Nome	Age	Job	Phone number

Date	Sign

Digitalized signature

Professional Mode (ATC-20)

Damage assessment for expert users

ATC-20 Detailed Evaluation Safety Assessment Form

Inspection

Inspector ID: ______
Affiliation: ______
Inspection date and time: ______ ☐ AM ☐ PM

Final Posting from page 2
☐ Inspected
☐ Restricted Use
☐ Unsafe

Building Description

Building name: ______
Address: ______
Building contact/phone: ______
Number of stories above ground: ____ below ground: ____
Approx. "Footprint area" (square feet): ______
Number of residential units: ______
Number of residential units not habitable: ______

Type of Construction
☐ Wood frame ☐ Concrete shear wall
☐ Steel frame ☐ Unreinforced masonry
☐ Tilt-up concrete ☐ Reinforced masonry
☐ Concrete frame ☐ Other: ______

Primary Occupancy
☐ Dwelling ☐ Commercial ☐ Government
☐ Other residential ☐ Offices ☐ Historic
☐ Public assembly ☐ Industrial ☐ School
☐ Emergency services ☐ Other: ______

Evaluation

Investigate the building for the conditions below and check the appropriate column. There is room on the second page for a sketch.

	Minor/None	Moderate	Severe	Comments
Overall hazards:				
Collapse or partial collapse	☐	☐	☐	
Building or story leaning	☐	☐	☐	
Other ______	☐	☐	☐	
Structural hazards:				
Foundations	☐	☐	☐	
Roofs, floors (vertical loads)	☐	☐	☐	
Columns, pilasters, corbels	☐	☐	☐	
Diaphragms, horizontal bracing	☐	☐	☐	
Walls, vertical bracing	☐	☐	☐	
Precast connections	☐	☐	☐	
Other ______	☐	☐	☐	
Nonstructural hazards:				
Parapets, ornamentation	☐	☐	☐	
Cladding, glazing	☐	☐	☐	
Ceilings, light fixtures	☐	☐	☐	
Interior walls, partitions	☐	☐	☐	
Elevators	☐	☐	☐	
Stairs, exits	☐	☐	☐	
Electric, gas	☐	☐	☐	
Other ______	☐	☐	☐	
Geotechnical hazards:				
Slope failure, debris	☐	☐	☐	
Ground movement, fissures	☐	☐	☐	
Other ______	☐	☐	☐	

General Comments: ______

Continue on page 2

ATC-20 Rapid Evaluation Safety Assessment Form

Inspection

Inspector ID: ______ Inspection date and time: ______ ☐ AM ☐ PM
Affiliation: ______ Areas inspected: ☐ Exterior only ☐ Exterior and interior

Building Description

Building name: ______
Address: ______
Building contact/phone: ______
Number of stories above ground: ____ below ground: ____
Approx. "Footprint area" (square feet): ______
Number of residential units: ______
Number of residential units not habitable: ______

Type of Construction
☐ Wood frame ☐ Concrete shear wall
☐ Steel frame ☐ Unreinforced masonry
☐ Tilt-up concrete ☐ Reinforced masonry
☐ Concrete frame ☐ Other: ______

Primary Occupancy
☐ Dwelling ☐ Commercial ☐ Government
☐ Other residential ☐ Offices ☐ Historic
☐ Public assembly ☐ Industrial ☐ School
☐ Emergency services ☐ Other: ______

Evaluation

Investigate the building for the conditions below and check the appropriate column.

Observed Conditions:	Minor/None	Moderate	Severe
Collapse, partial collapse, or building off foundation	☐	☐	☐
Building or story leaning	☐	☐	☐
Racking damage to walls, other structural damage	☐	☐	☐
Chimney, parapet, or other falling hazard	☐	☐	☐
Ground slope movement or cracking	☐	☐	☐
Other (specify) ______	☐	☐	☐

Estimated Building Damage (excluding contents)
☐ None
☐ 0–1%
☐ 1–10%
☐ 10–30%
☐ 30–60%
☐ 60–100%
☐ 100%

Comments: ______

Posting

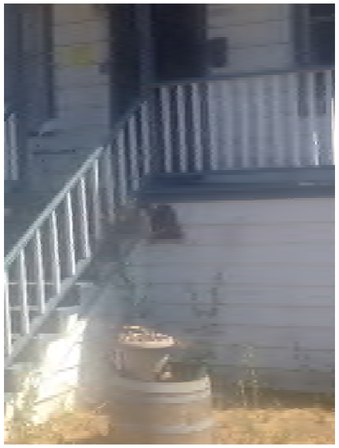
Choose a posting based on the evaluation and team judgment. *Severe* conditions endangering the overall building are grounds for an Unsafe posting. Localized *Severe* and overall *Moderate* conditions may allow a Restricted Use posting. Post INSPECTED placard at main entrance. Post RESTRICTED USE and UNSAFE placards at all entrances.

☐ **INSPECTED** (Green placard) ☐ **RESTRICTED USE** (Yellow placard) ☐ **UNSAFE** (Red placard)

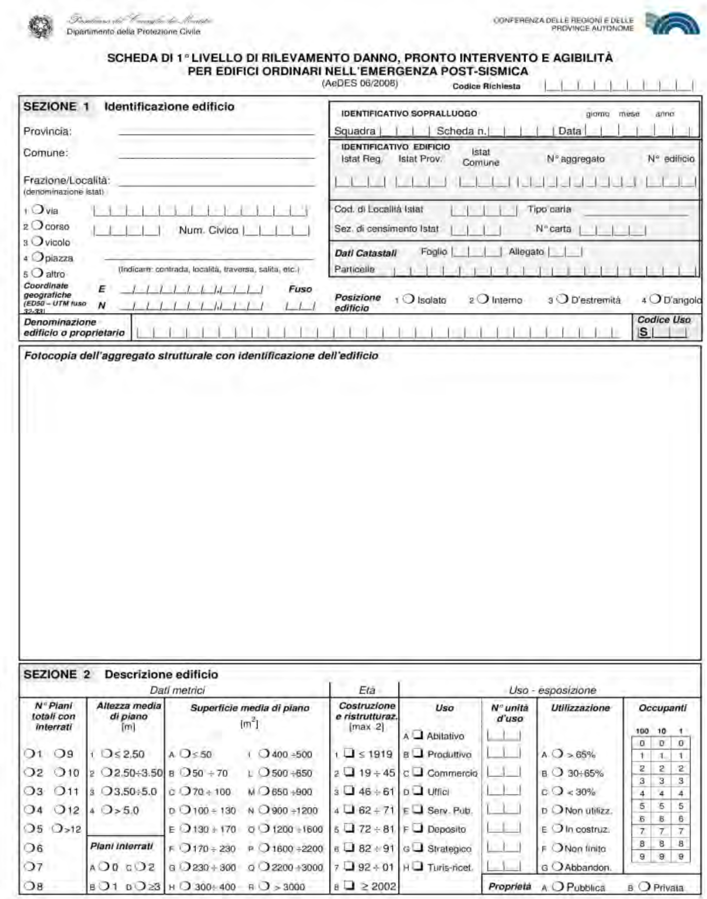
Record any use and entry restrictions exactly as written on placard: ______

Further Actions Check the boxes below only if further actions are needed.

☐ Barricades needed in the following areas: ______
☐ Detailed Evaluation recommended: ☐ Structural ☐ Geotechnical ☐ Other: ______
☐ Other recommendations: ______
Comments: ______



Professional Mode (AeDES)
Damage assessment for expert users



Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

CONFERENZA DELLE REGIONI E DELLE PROVINCE AUTONOME

SCHEDA DI 1° LIVELLO DI RILEVAMENTO DANNO, PRONTO INTERVENTO E AGIBILITÀ PER EDIFICI ORDINARI NELL'EMERGENZA POST-SISMICA
(AeDES 06/2008) **Codice Richiesta**

SEZIONE 1 Identificazione edificio

Provincia:
Comune:
Frazione/Località: (denominazione Istat)
1 ❍ via
2 ❍ corso Num. Civico
3 ❍ vicolo
4 ❍ piazza
5 ❍ altro (Indicare: contrada, località, traversa, salita, etc.)
Coordinate geografiche (ED50 – UTM fuso 32-33) *E* *N* *Fuso*

IDENTIFICATIVO SOPRALLUOGO giorno mese anno
Squadra Scheda n. Data
IDENTIFICATIVO EDIFICIO
Istat Reg. Istat Prov. Istat Comune N° aggregato N° edificio
Cod. di Località Istat Tipo carta
Sez. di censimento Istat N° carta
Dati Catastali Foglio Allegato
Particelle
Posizione edificio 1 ❍ Isolato 2 ❍ Interno 3 ❍ D'estremità 4 ❍ D'angolo
Denominazione edificio o proprietario *Codice Uso* S

Fotocopia dell'aggregato strutturale con identificazione dell'edificio

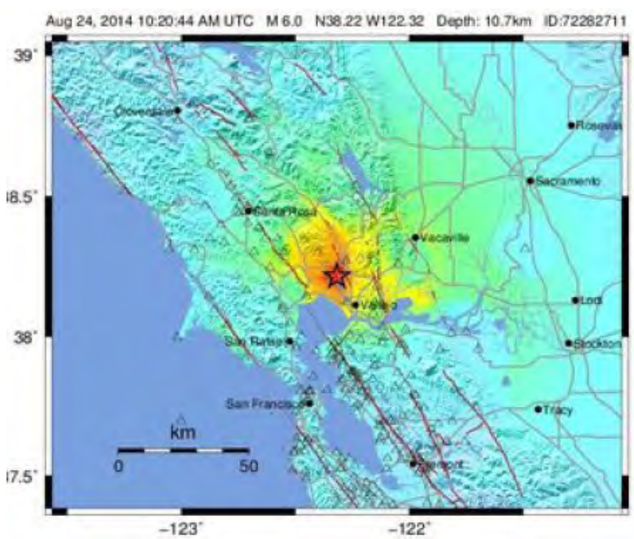
SEZIONE 2 Descrizione edificio

Dati metrici | *Età* | *Uso - esposizione*

N° Piani totali con interrati	*Altezza media di piano [m]*	*Superficie media di piano [m²]*		*Costruzione e ristrutturaz. [max 2]*	*Uso*	*N° unità d'uso*	*Utilizzazione*	*Occupanti*
					A ❑ Abitativo			100 10 1
❍1 ❍9	1 ❍ ≤ 2.50	A ❍ ≤ 50	I ❍ 400 ÷500	1 ❑ ≤ 1919	B ❑ Produttivo		A ❍ > 65%	0 0 0
❍2 ❍10	2 ❍ 2.50÷3.50	B ❍ 50 ÷ 70	L ❍ 500 ÷650	2 ❑ 19 ÷ 45	C ❑ Commercio		B ❍ 30÷65%	1 1 1 / 2 2 2
❍3 ❍11	3 ❍ 3.50÷5.0	C ❍ 70 ÷ 100	M ❍ 650 ÷900	3 ❑ 46 ÷ 61	D ❑ Uffici		C ❍ < 30%	3 3 3 / 4 4 4
❍4 ❍12	4 ❍ > 5.0	D ❍ 100 ÷ 130	N ❍ 900 ÷1200	4 ❑ 62 ÷ 71	E ❑ Serv. Pub.		D ❍ Non utilizz.	5 5 5 / 6 6 6
❍5 ❍>12		E ❍ 130 ÷ 170	O ❍ 1200 ÷1600	5 ❑ 72 ÷ 81	F ❑ Deposito		E ❍ In costruz.	7 7 7
❍6	*Piani interrati*	F ❍ 170 ÷ 230	P ❍ 1600 ÷2200	6 ❑ 82 ÷ 91	G ❑ Strategico		F ❍ Non finito	8 8 8 / 9 9 9
❍7	A ❍ 0 C ❍ 2	G ❍ 230 ÷ 300	Q ❍ 2200 ÷3000	7 ❑ 92 ÷ 01	H ❑ Turis-ricet.		G ❍ Abbandon.	
❍8	B ❍ 1 D ❍ ≥3	H ❍ 300÷ 400	R ❍ > 3000	8 ❑ ≥ 2002		*Proprietà*	A ❍ Pubblica	B ❍ Privata

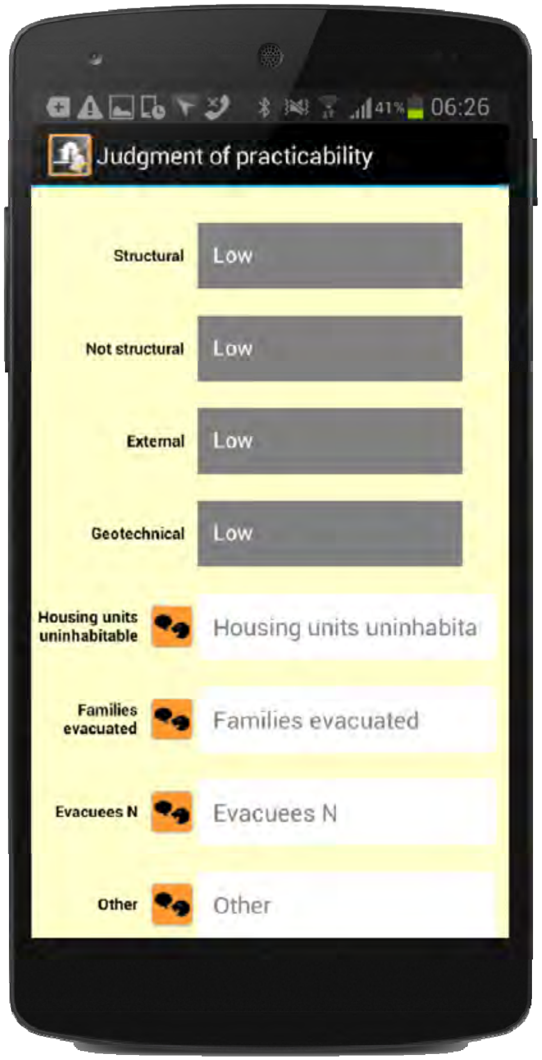
EDAM - Earthquakes Damage Assessments Manager

- Automatic localization (For now, Italian and English);
- Available for iOS and Android phones and tablets;
- Subsequently on Blackberry and Windows Phone based devices;
- Tested during the emergency response of South Napa earthquake for 20 citizens' buildings.



Source: http://www.vox.com/2014/8/24/6063599/earthquake-california-napa-vs-loma-prieta

Create new forms



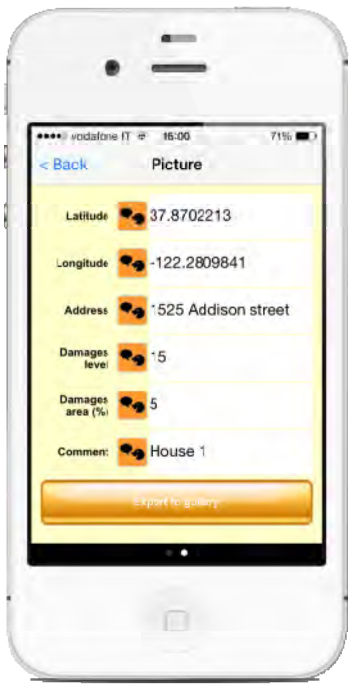
- **Fill all the required fields in a fast and intuitive way**
- **Voice commands to fill text fields**

Source: http://venturebeat.com/2011/09/26/iphone-5-virtual-assistant/

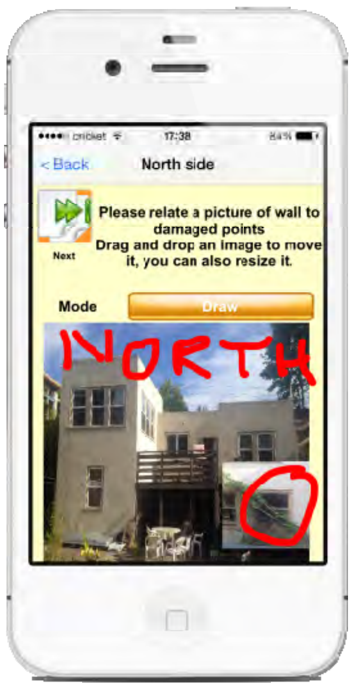
Multimedia data

Take pictures and record video with:

- **Geolocalization**
- **Damaged area (%) and level (1-5)**



Make a detailed collage about damages



Create personal drafts

And then...

Is possible to create .PDF files automatically populated with entered data (including multimedia contents) and send it by email.

Source: http://recursostic.educacion.es/observatorio/web/images/upload/1observatorio/iconos_art/pdf.png

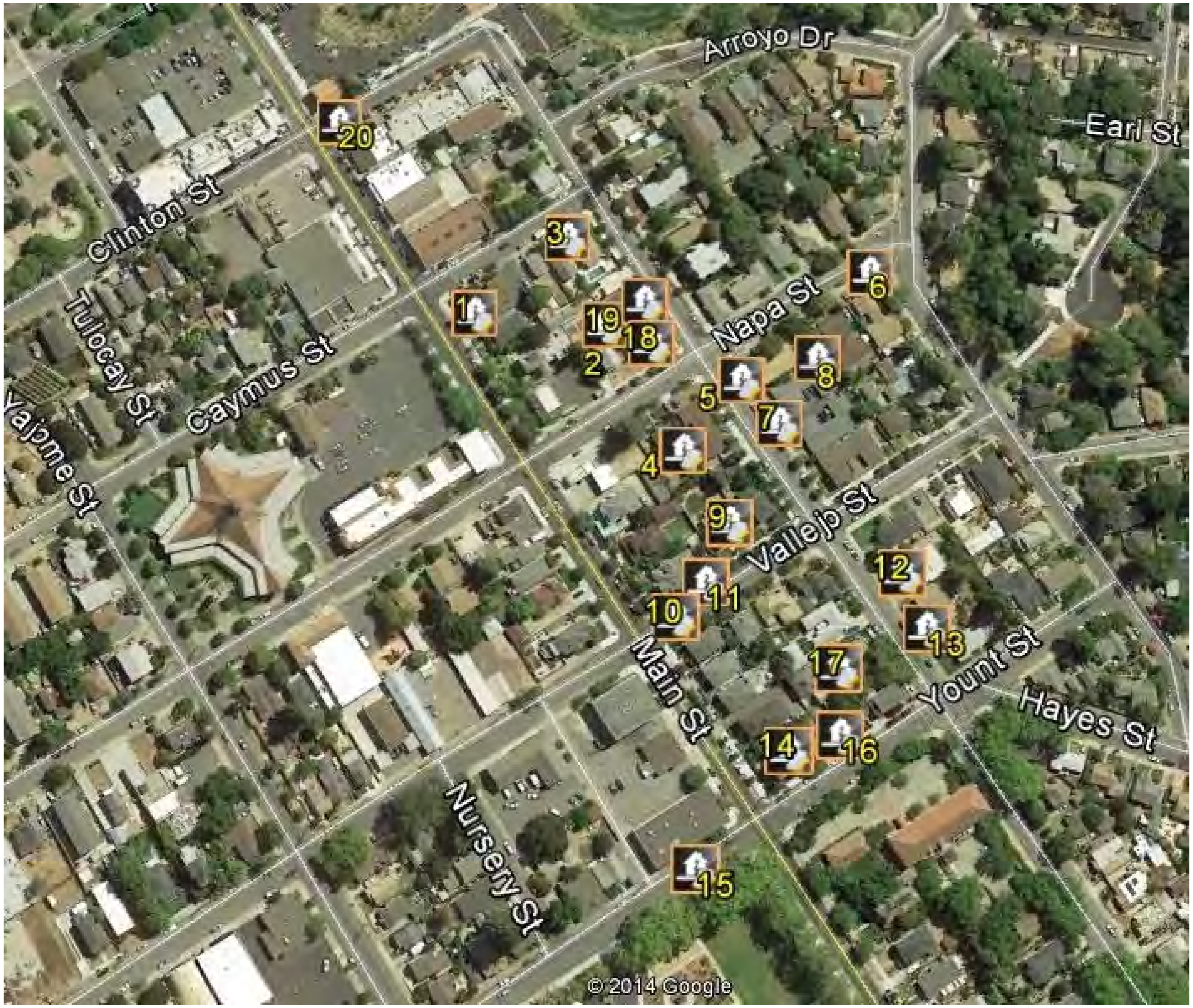
And synchronize the forms on EDAM's server

Maximum security

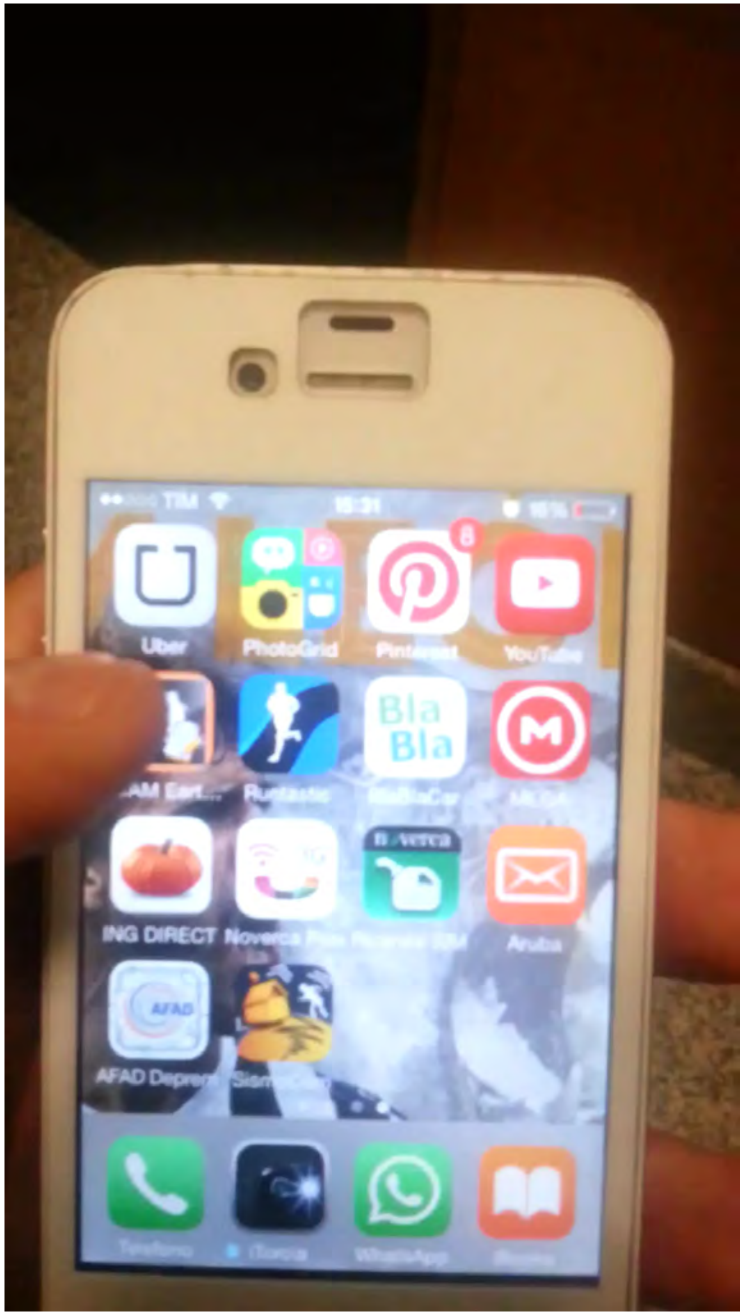
- HTTPS protocol;
- Password stored after salted SHA-512 elaboration;
- Session that expire after 30 minutes of inactivity;
- Encrypted data in the mobile phone.

Source: http://rjwestmore.com/wp-content/uploads/2013/02/Smartphone2-Corp.jpg

Test of EDAM at Napa (California)

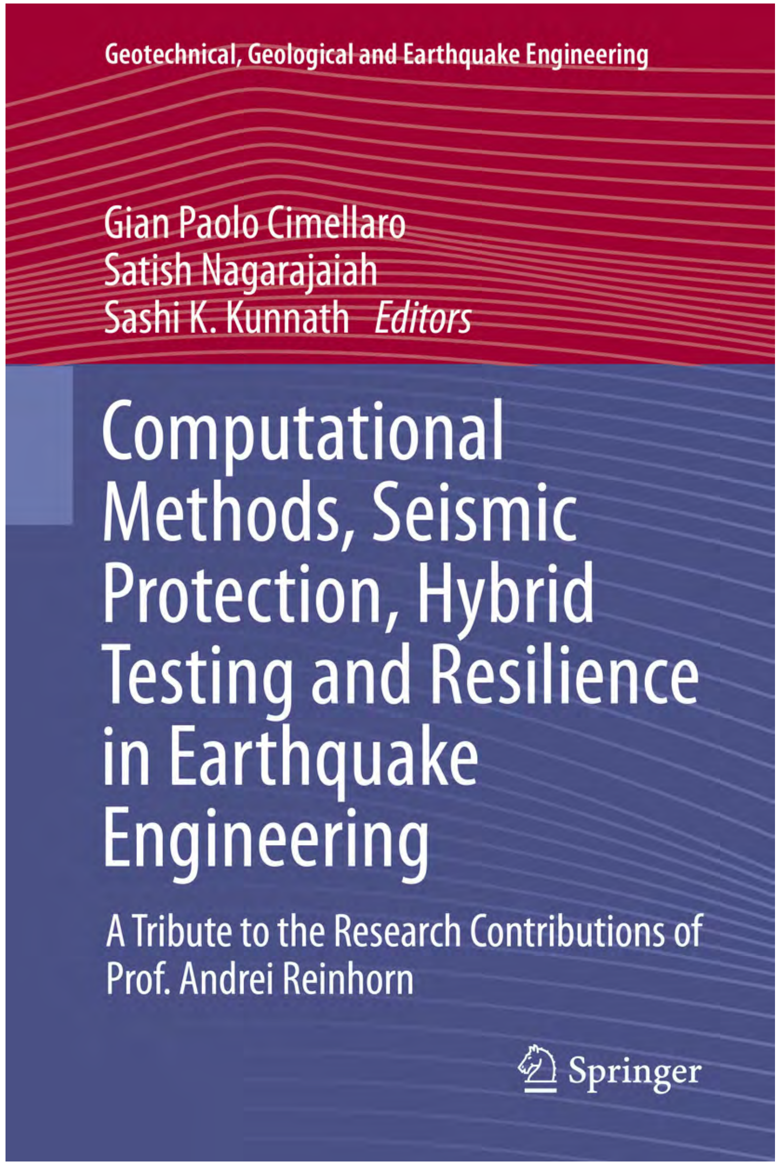


#	Address
1	1002 Caymus street
2	1428 Brown street
3	1406 Brown street
4	1050 Napa street
5	1104 Napa street
6	1132 Napa street
7	1515 Brown street
8	1132 Napa street
9	1043 Vallejo street
10	1017 Vallejo street
11	1029 Vallejo street
12	1625 Brown street
13	1631 Brown street
14	1013 Yount street
15	972 Yount street
16	1049 Yount street
17	1628 Brown street
18	1472 Brown street
19	1432 Brown street
20	1006 Clinton street



EDAM

Earthquakes Damage Assessments Manager


Geotechnical, Geological and Earthquake Engineering
Gian Paolo Cimellaro
Satish Nagarajaiah
Sashi K. Kunnath Editors
Computational Methods, Seismic Protection, Hybrid Testing and Resilience in Earthquake Engineering
A Tribute to the Research Contributions of Prof. Andrei Reinhorn
Springer

Thank You!

Questions?

References

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