ДГКМ
ДРУШТВО НА ГРАДЕЖНИ КОНСТРУКТОРИ НА МАКЕДОНИЈА
MASE
MACEDONIAN ASSOCIATION OF STRUCTURAL ENGINEERS
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Characterising Seismic Vulnerability of Bridge Structures + Infrastructure Vulnerability Assessment

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Ohrid

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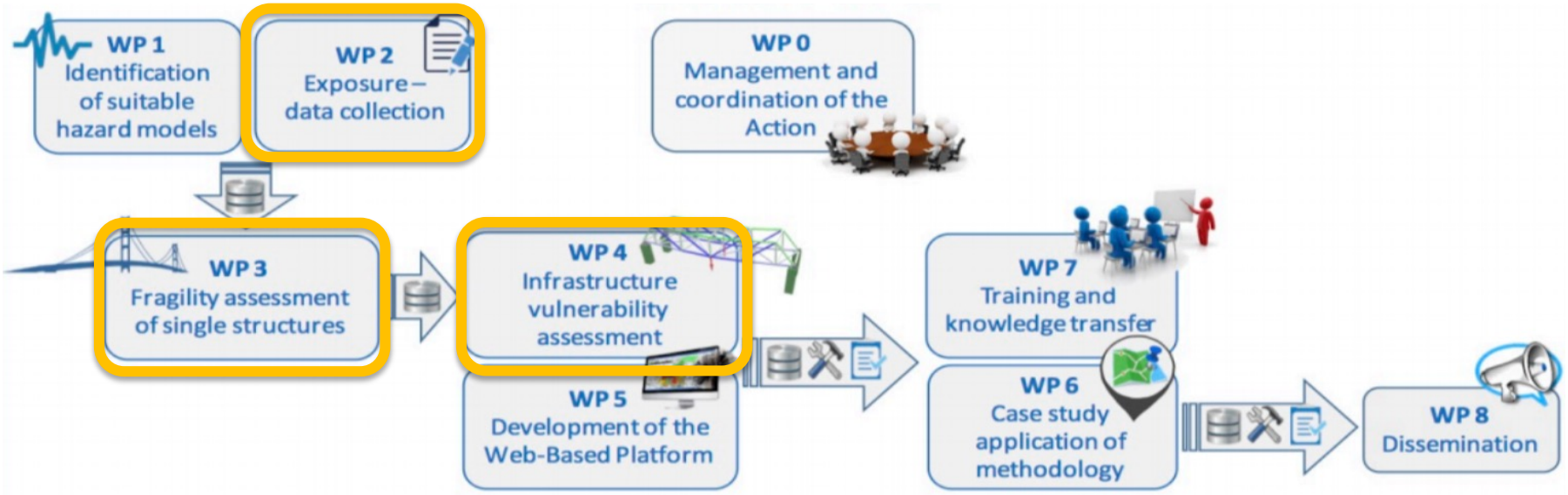
Infra NAT
Increased Resilience of Critical Infrastructure under Natural and Humaninduced Hazards (INFRA-NAT)
CIVIL PROTECTION PREPAREDNESS AND PREVENTION SCHEME 2017
European Commission

CONTENTS

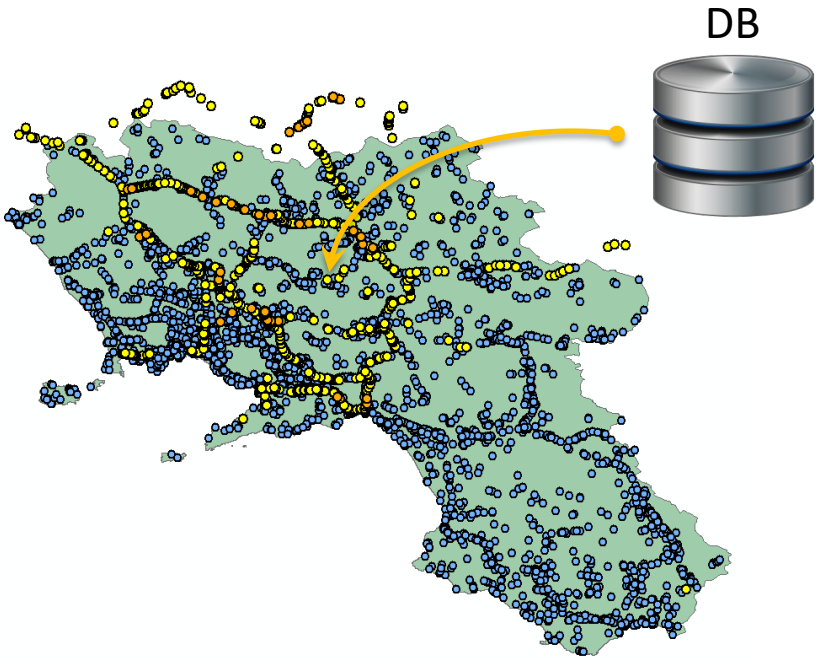
INTRODUCTION

- Outline the methodology for each of the following packages:



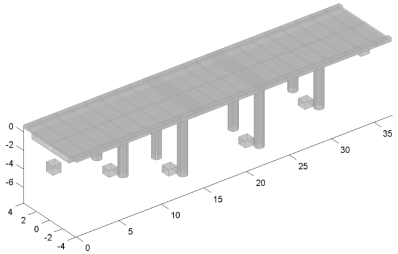
EXPOSURE METHODOLOGY

- An exposure model is a georeferenced inventory with standardised information



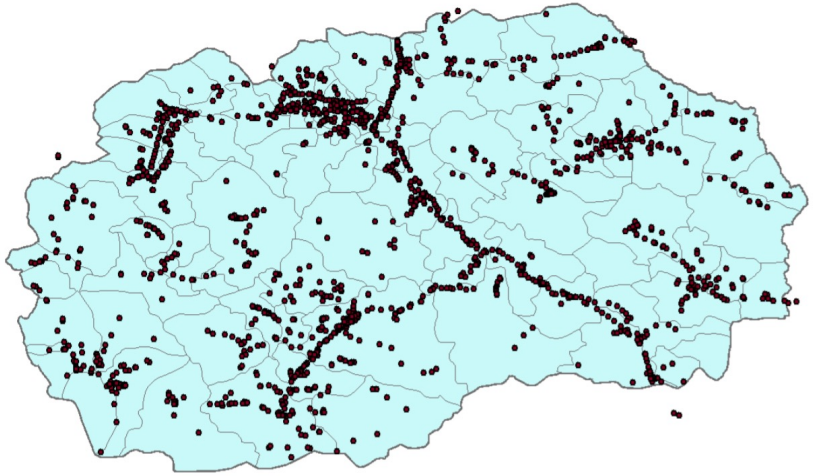
For any bridge:

- Location
- Structural System (taxonomy)
- Dimensions
- Detailing



EXPOSURE METHODOLOGY

- The bridge inventory of an entire country is large

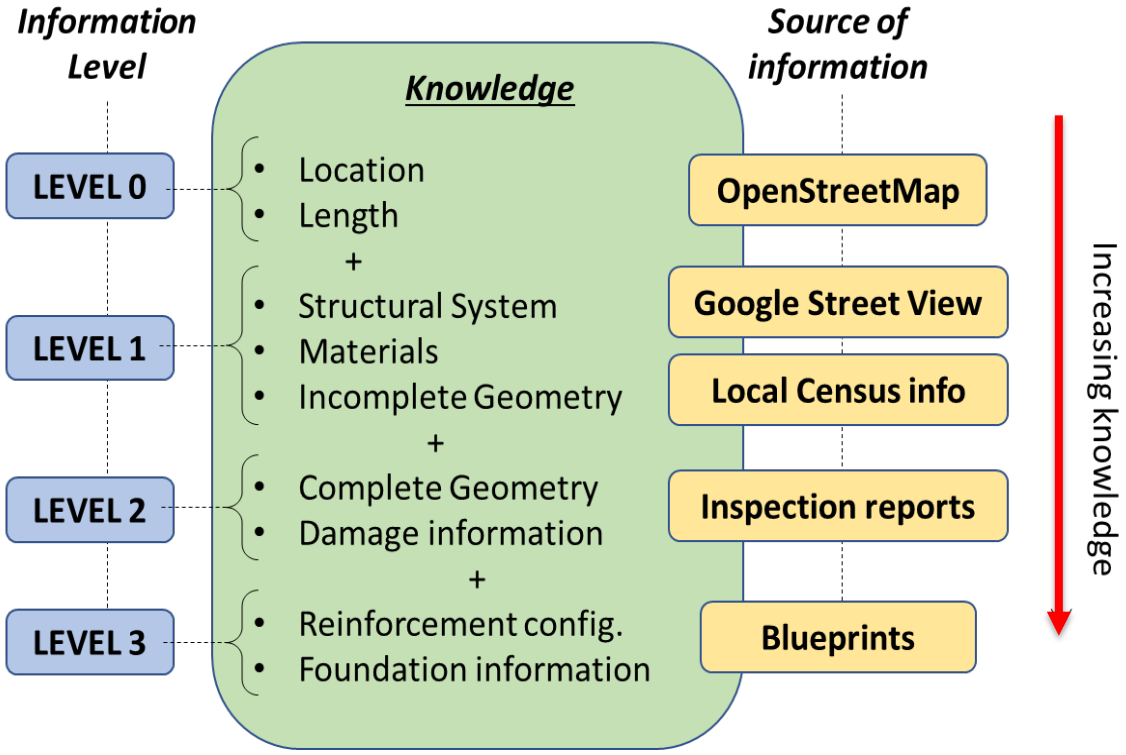


Initial screening for North Macedonia sets the total assets in the range of 2000 bridges

- It is not feasible to have complete information for all assets

EXPOSURE METHODOLOGY

- Information from multiple sources is collected, processed and classified



SEISMIC VULNERABILITY FRAMEWORK

In general

DATA COLLECTION

- *Level 0 (OSM)*
- *Level 1 (StreetView)*
- *Level 2 (Inspections)*
- *Level 3 (Blueprints)*

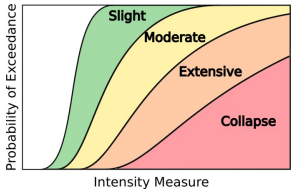
Bridge database

CALCULATION ENGINE

- *Matlab tool*
- *Taxonomy*
- *Fragility curves*

ANALYSIS TOOL

SETS OF FRAGILITY CURVES

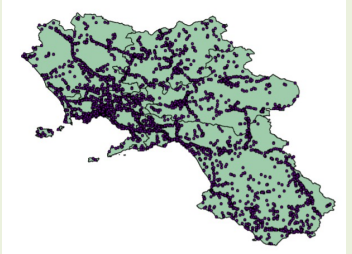


TAXONOMY DEFINITION

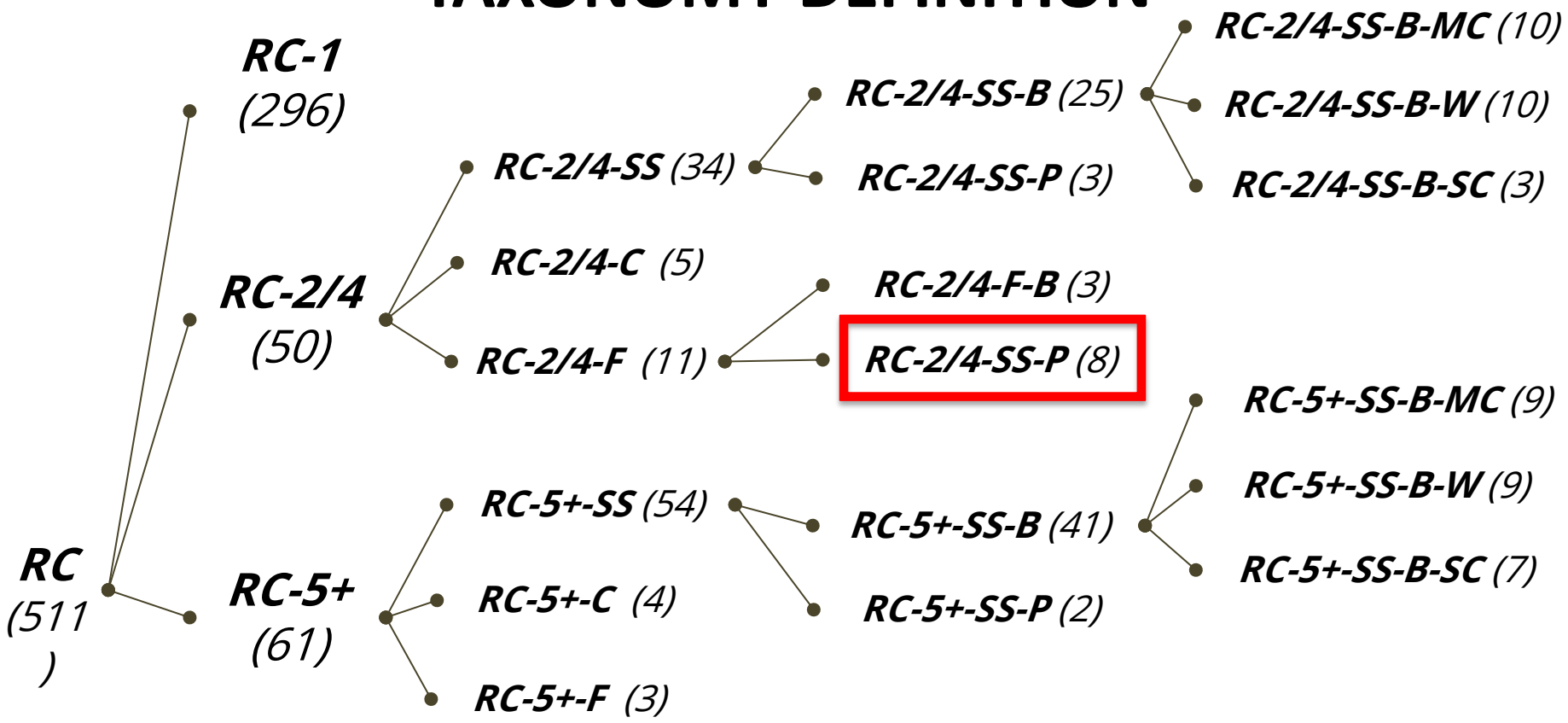
MAT	**Spans**	**Static Scheme**	**Deck Type**	**Pier Type**
RC	*1*	*S. S.*	*Beam*	*S. Column*
	2-4	*Cont.*	*Plate*	*Wall*
	6+	*Frame*		*M. Column*

CURVE ASSIGNMENT

- *Taxonomy based*
- *Considers level of knowledge*



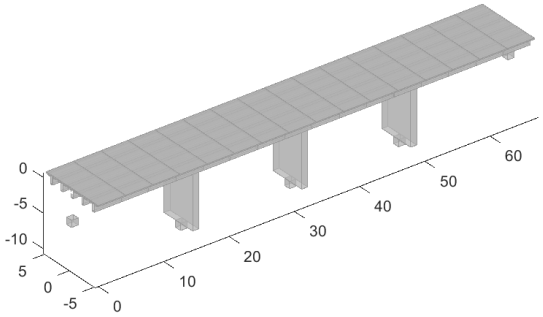
TAXONOMY DEFINITION



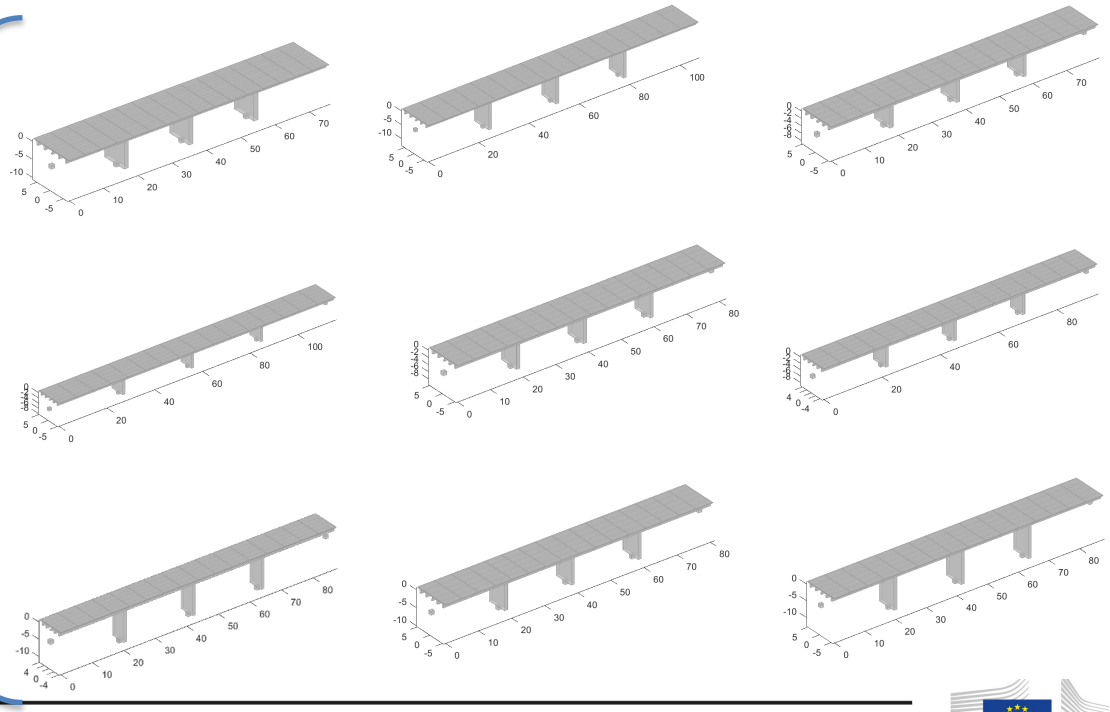
MAT	Spans	Static Scheme	Deck Type	Pier Type
RC	1 2-4 5+	Simply Supported Continuous Frame	Beam Plate	Single Column Wall Multiple Column

FRAGILITY CALCULATION

- Representative taxonomies are characterised
- 30/50 numerical models are created compatible with the taxonomy

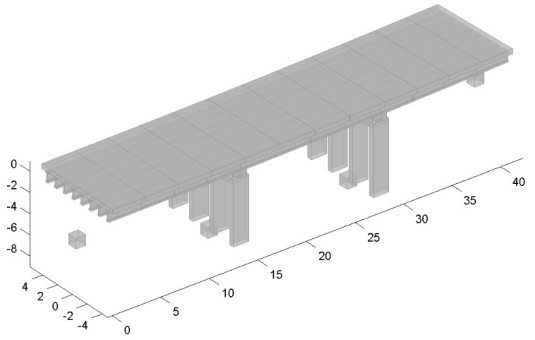


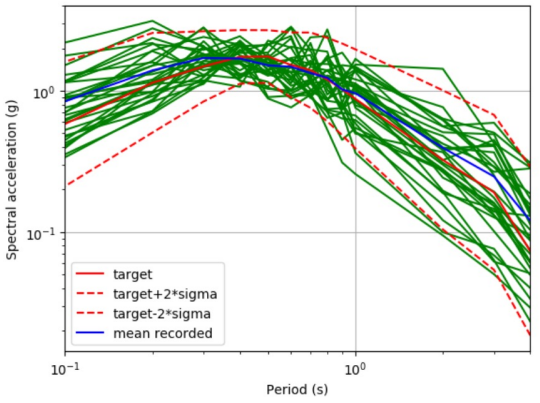
North Macedonia
Girder Bridge, 4 Span



FRAGILITY CALCULATION

- For each model
- NLTHA with selected records
- IM chosen is Avg(Sa) in the 0.2s – 1.0 s range
- 30 EQs x 7 R.P.s x 50 bridges = 10500 runs/taxonomy



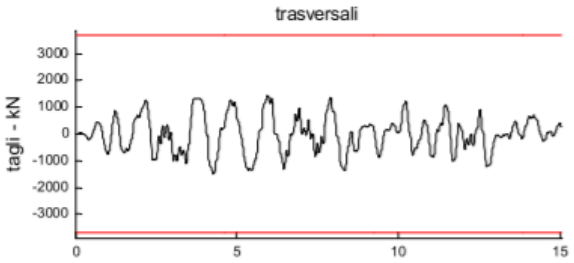


FRAGILITY CALCULATION

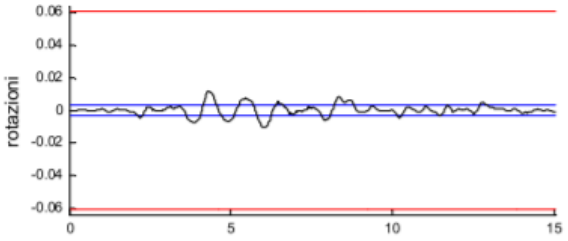
- Calculation per simulation

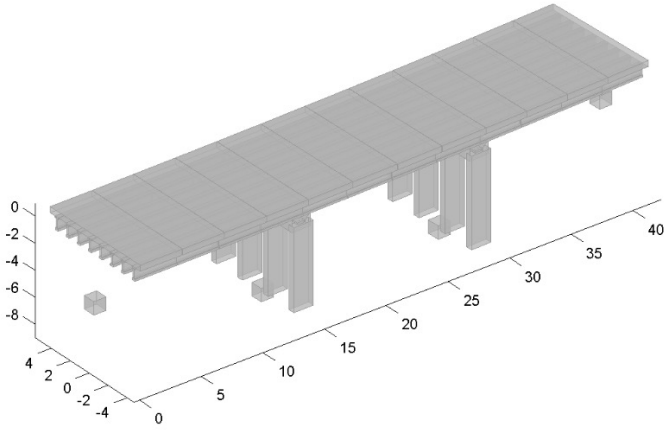
Transverse and longitudinal

Shear

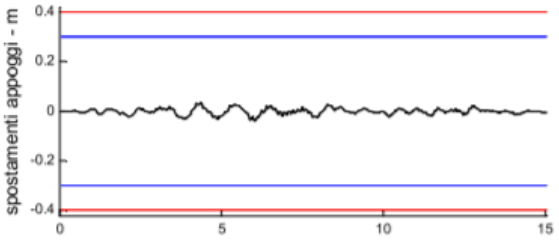


Rotation



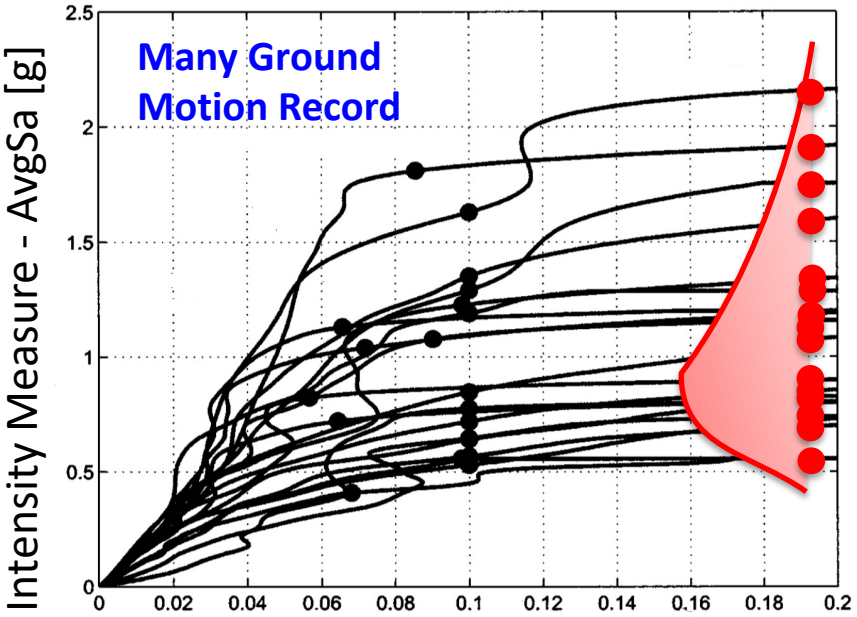


Bearing



FRAGILITY CALCULATION

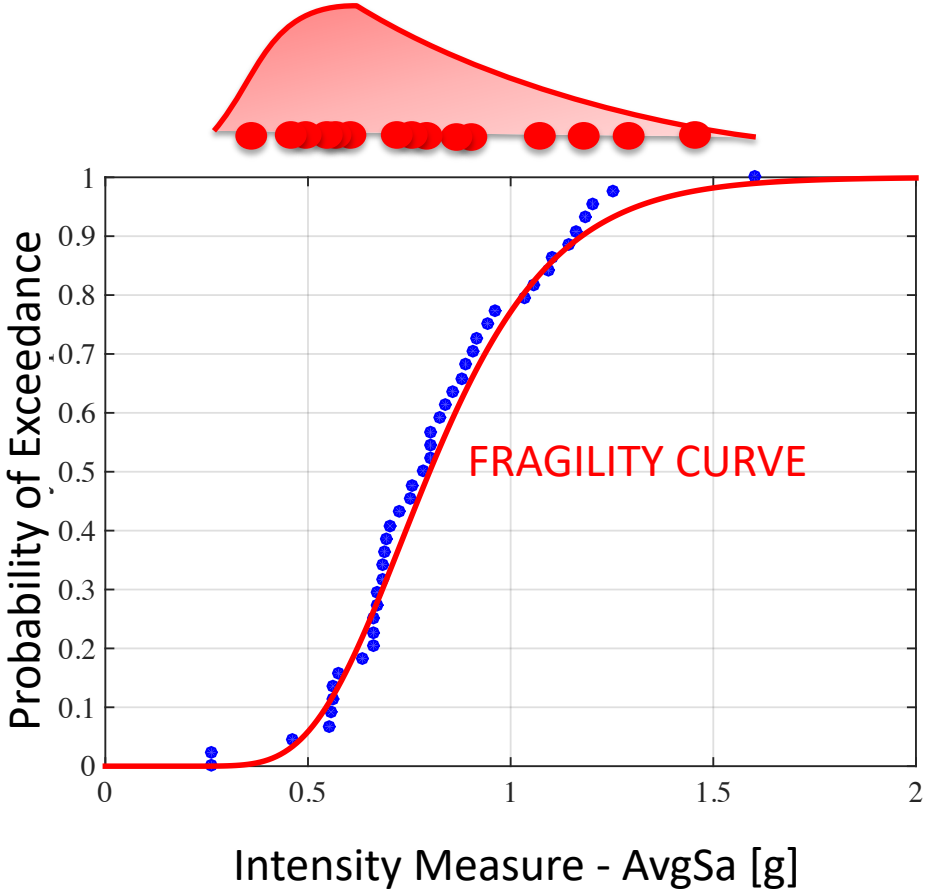
- If we plot the structural response versus ground motion intensity, we get this



Can use this information to describe performance probibalistically

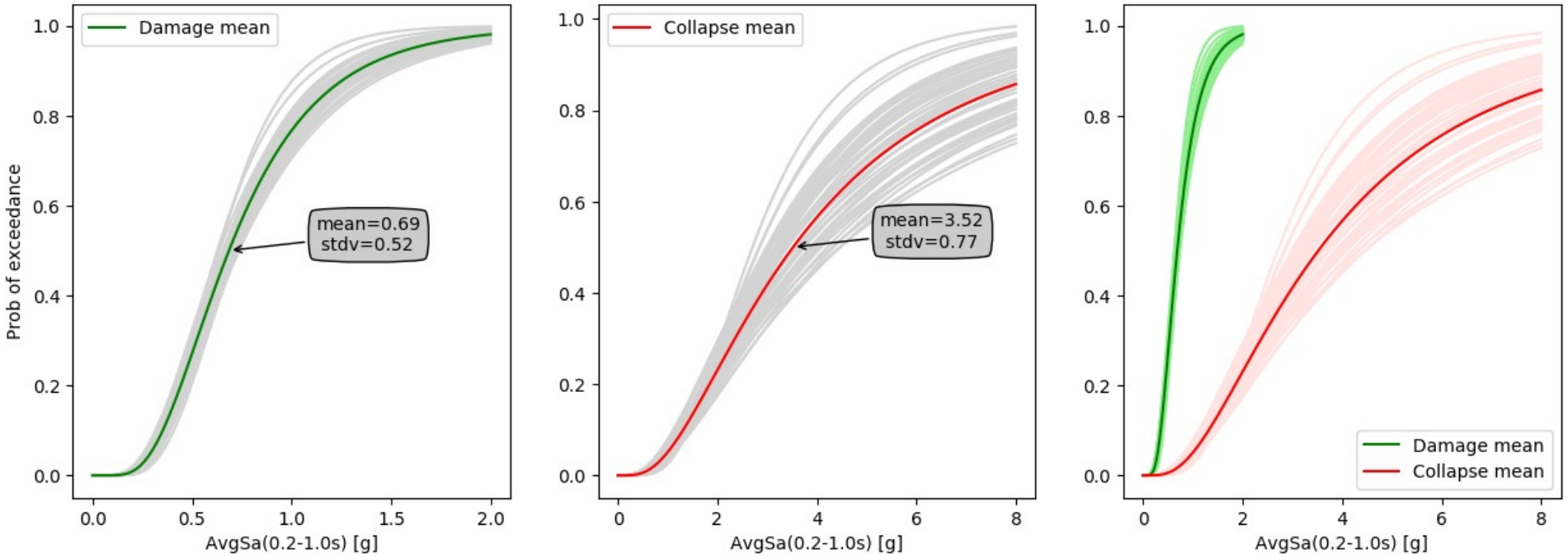
FRAGILITY CALCULATION

- By counting the number of exceedances with increasing intensity, we can start to build an empirical distribution
- By fitting a distribution such as a lognormal distribution, we arrive at what is known as a <u>fragility curve</u>



FRAGILITY CALCULATION

- Mean fragility is obtained and assigned to all elements in the database with same taxonomy



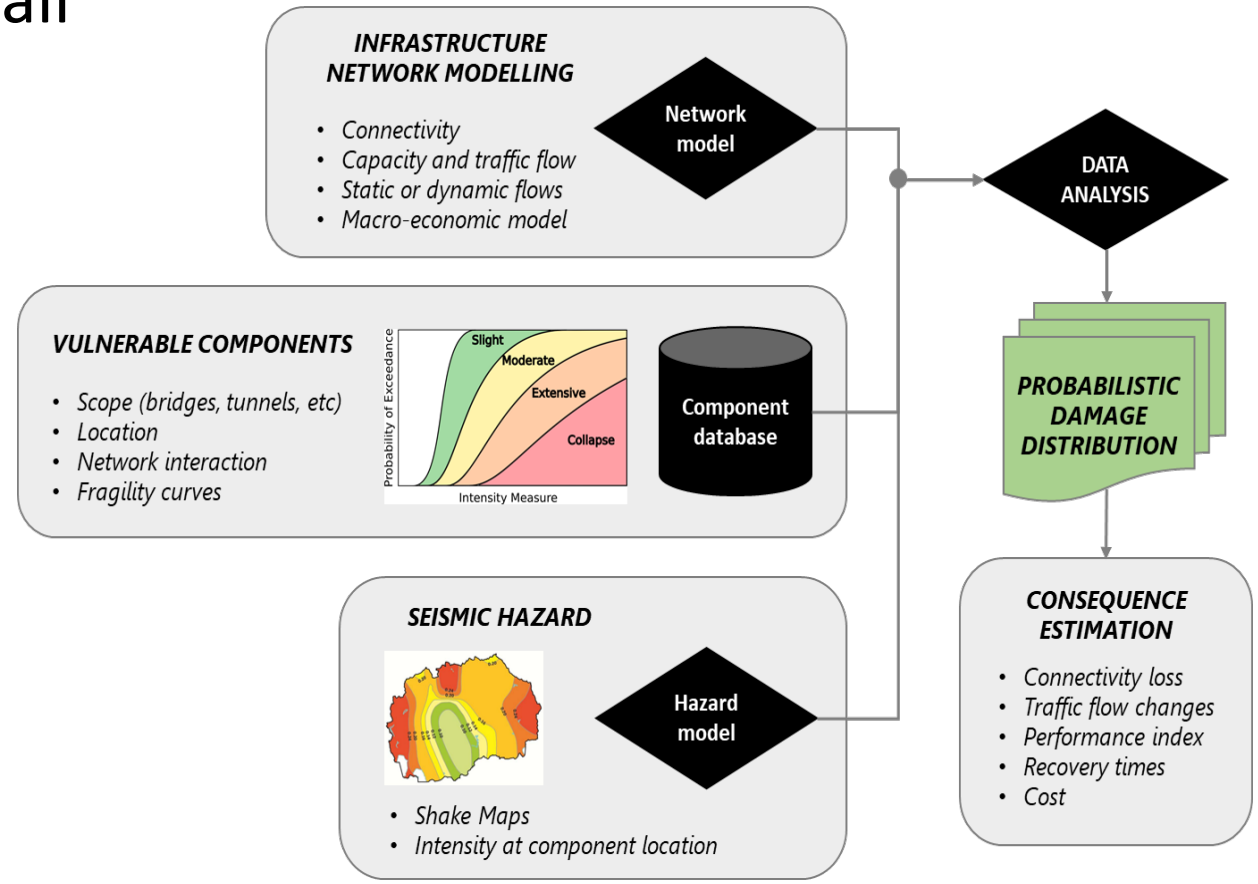
NETWORK VULNERABILITY ASSESSMENT

- Bridges are part of a road network

- Need to consider the effects of bridge collapse in the overall network system

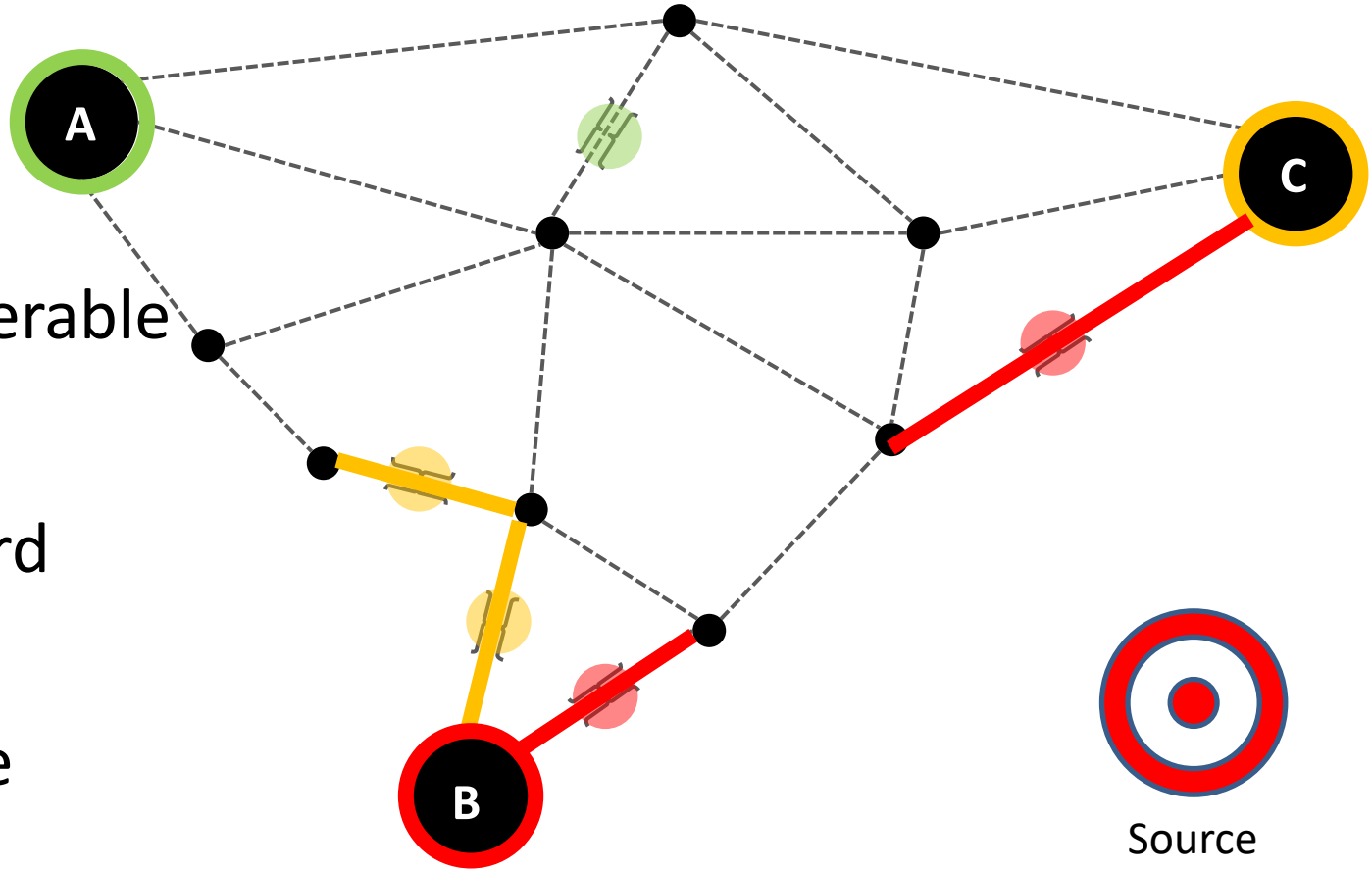
NETWORK VULNERABILITY ASSESSMENT

- Overall



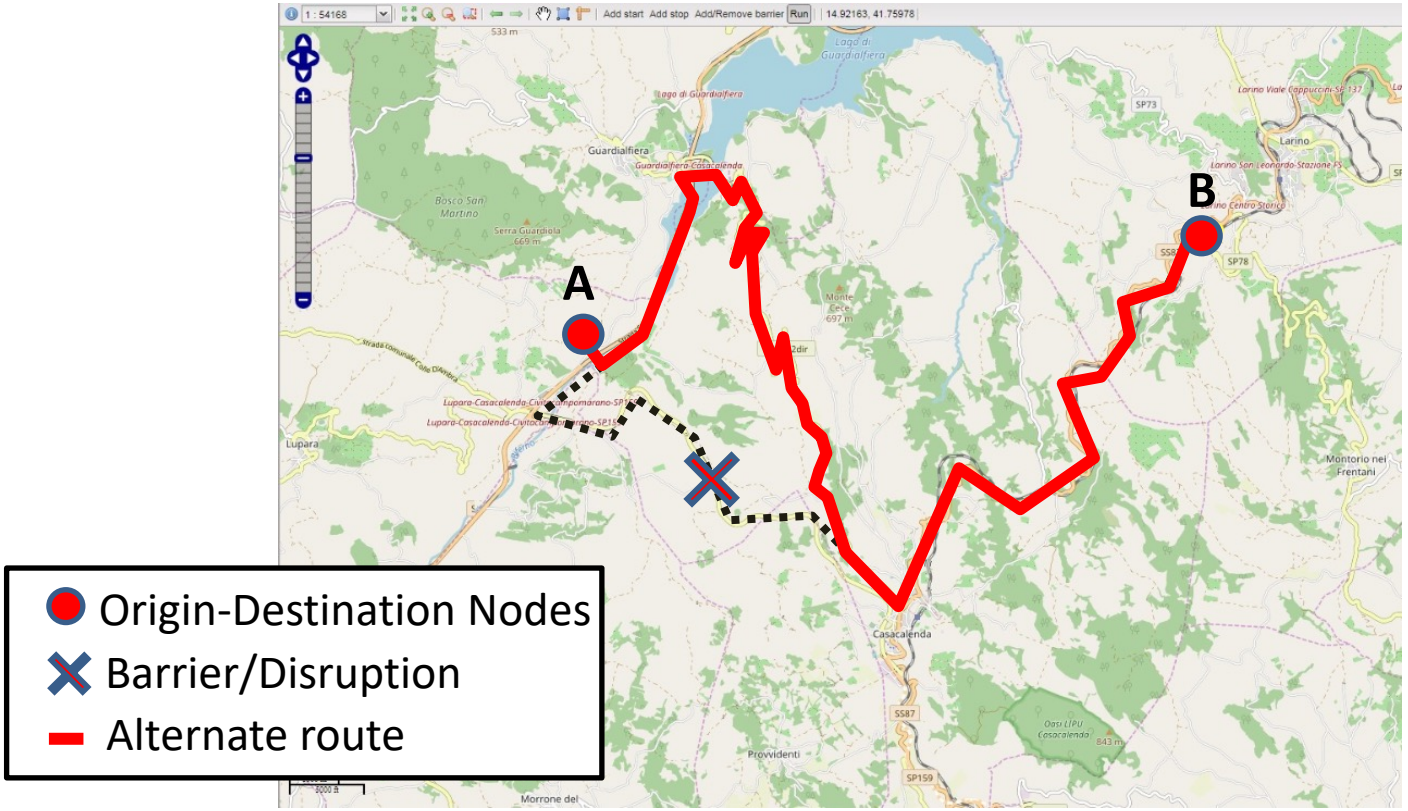
NETWORK VULNERABILITY ASSESSMENT

- Model the network
- Identify vulnerable components
- Seismic hazard event
- Consequence evaluation



NETWORK VULNERABILITY ASSESSMENT

- The platform can calculate optimal routes



NETWORK VULNERABILITY ASSESSMENT

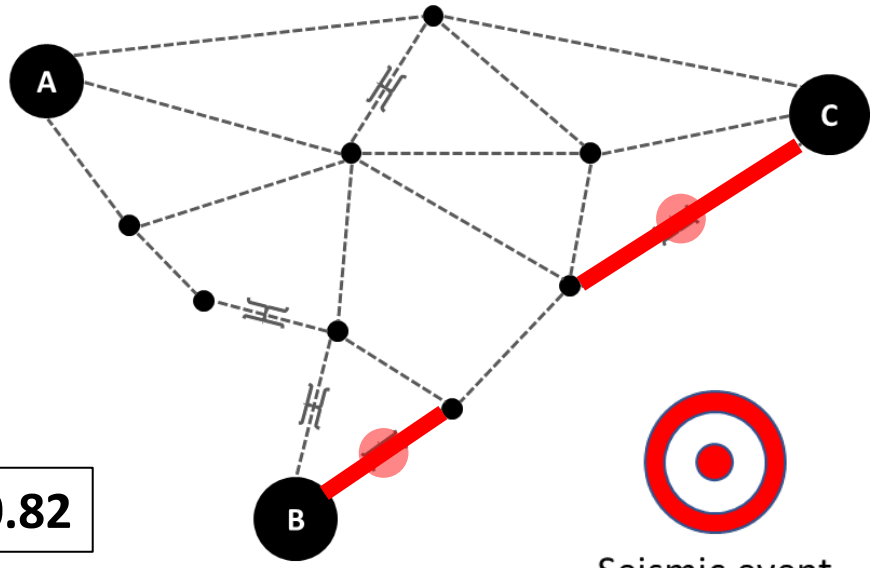
- Then implement for trips between cities

$$\begin{array}{c} \\ A \\ B \\ C \end{array} \begin{array}{c} \begin{array}{ccc} A & B & C \end{array} \\ \begin{pmatrix} 0 & 40 & 60 \\ 40 & 0 & 50 \\ 60 & 50 & 0 \end{pmatrix} \end{array}$$

Baseline Travel Time Matrix BTT (min)

$$\begin{array}{c} \\ A \\ B \\ C \end{array} \begin{array}{c} \begin{array}{ccc} A & B & C \end{array} \\ \begin{pmatrix} 0 & 40 & 60 \\ 40 & 0 & \mathbf{110} \\ 60 & \mathbf{110} & 0 \end{pmatrix} \end{array}$$

Interrupted Travel Time ITT (min)



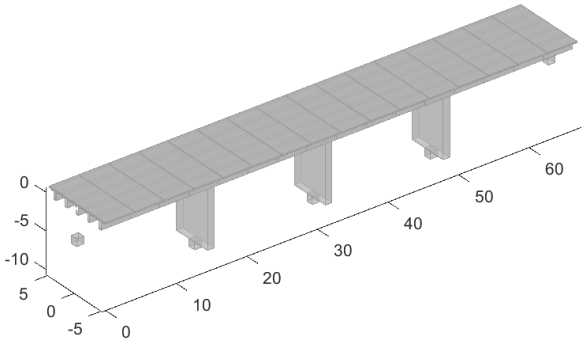
Seismic event source

$$\begin{array}{c} \\ A \\ B \\ C \end{array} \begin{array}{c} \begin{array}{ccc} A & B & C \end{array} \\ \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 0.45 \\ 1 & 0.45 & 1 \end{pmatrix} \end{array} \rightarrow \begin{array}{c} 1.00 \\ 0.72 \\ 0.72 \end{array} \rightarrow \boxed{0.82}$$

Interruption Coefficients BTT / ITT

Event Interruption Index

QUESTIONS?



Contents

- Introduction
- Exposure Methodology
- Seismic Vulnerability Framework
- Network Vulnerability Assessment