ASSESSMENT AND MANAGEMENT OF SEISMIC RISK

Risk Frontiers

Bruxelles 19 November 2015

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AXA MATRIX Risk Consultants

Your global partner for Risk Consulting and Risk Management

Risk Assessment → Risk Analysis → Risk Solutions

Risk Consulting

- Quantification and qualification of your risks applying remote and on-site assessment
- Provide pragmatic solutions to mitigate and control your risk globally
- Online data access – reports with action plans, targets, and status
- On-going and active support of your internal Risk Management initiatives

AXA MATRIX RISK CONSULTANTS
redefining / services

International Network with over 160 Dedicated Risk Engineers

Major locations with expansive local teams – we have resources where they are needed.

EUROPE

Benelux
France
Germany
Italy
Spain
Switzerland
UK

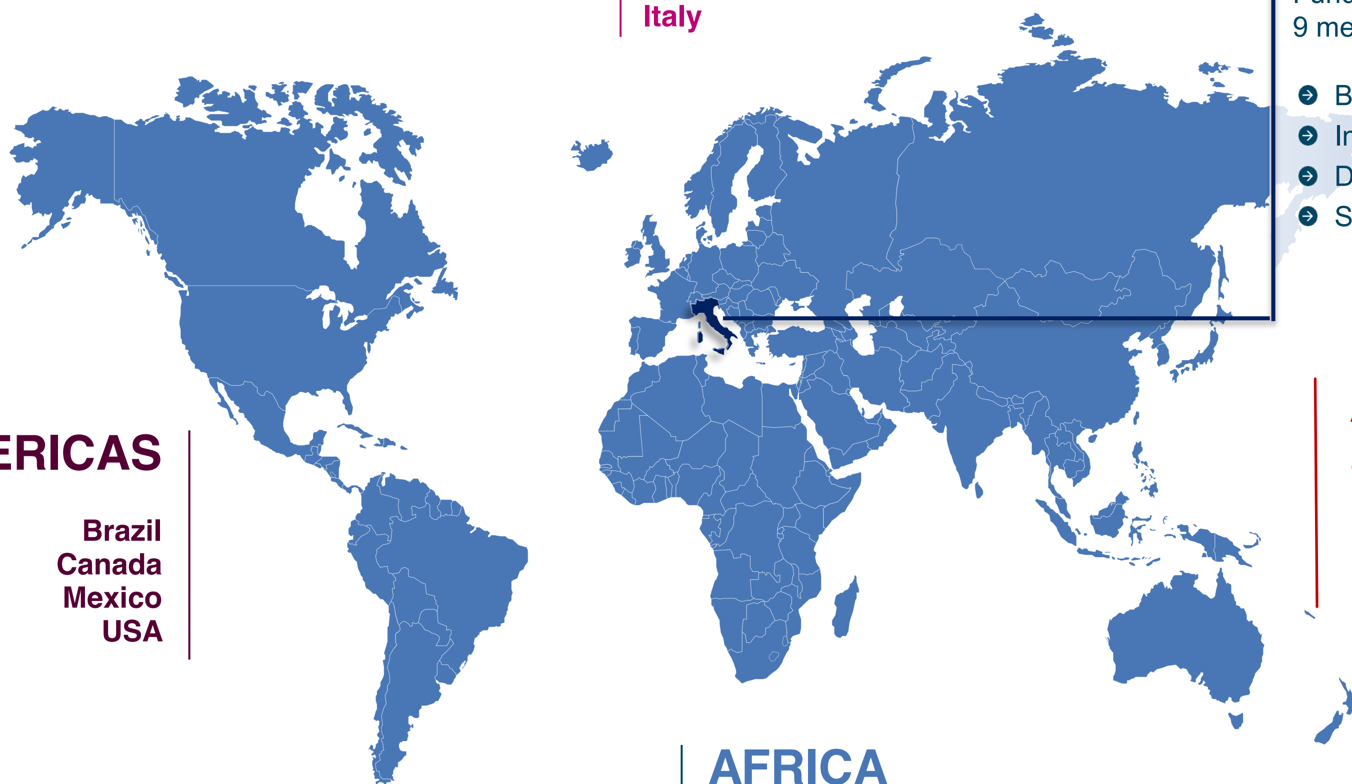
CENTER of EXPERTISE

for Earthquake and Tsunami

Funded in 2014

9 members coordinating local engineers

- Best Expertise;
- Innovation and Development;
- Dissemination and standardization;
- Support to other branches;



AMERICAS

Brazil
Canada
Mexico
USA

ASIA-PACIFIC & MIDDLE EAST

China
Dubai
Hong Kong
India
Malaysia
Singapore

AFRICA

Operations led from Europe

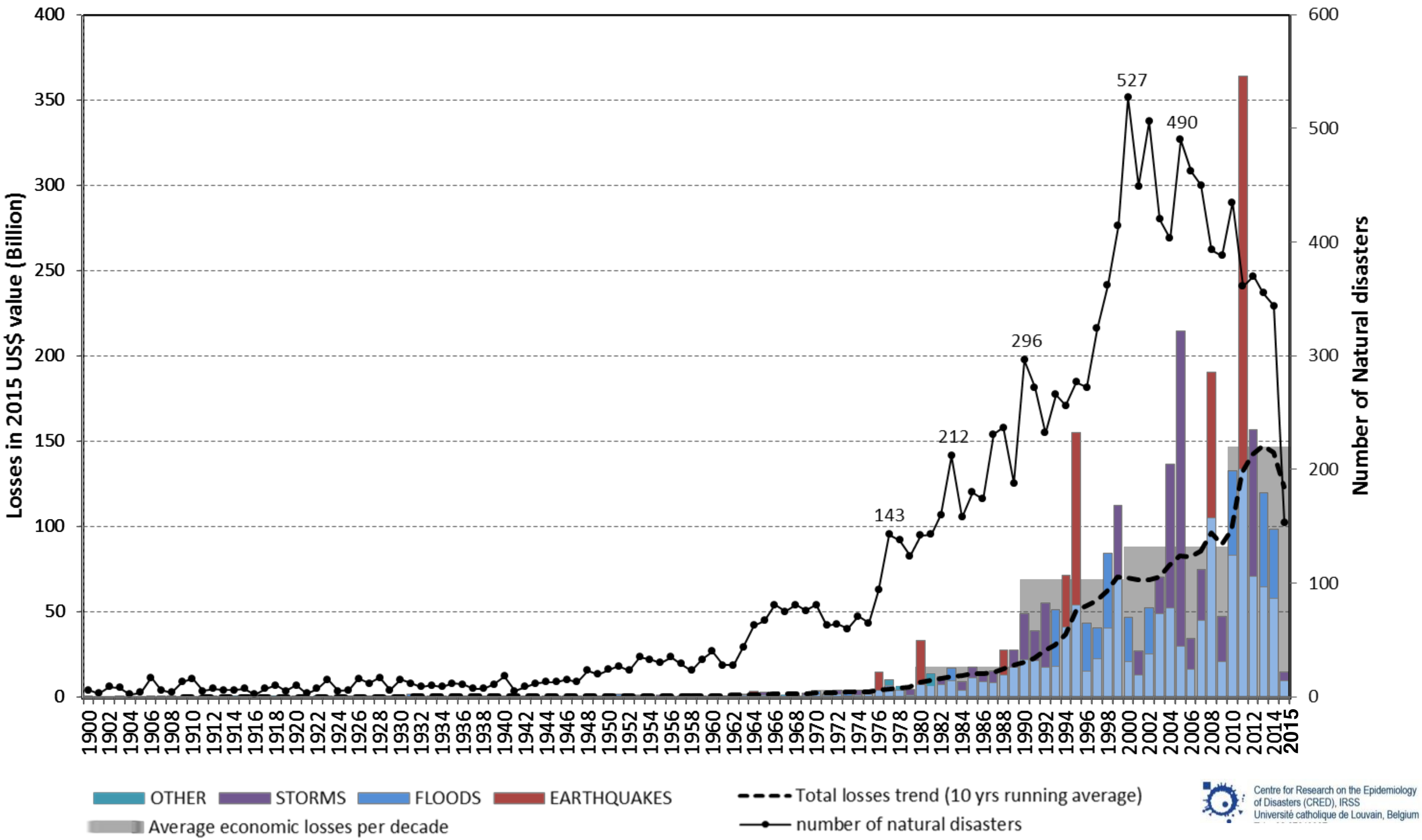
IMPACT OF EARTHQUAKES ON A GLOBAL SCALE

"Civilisation exists
by geological consent,
subject to change
without notice"

Will Durant, 1946

The impact of natural disasters on a global scale

- The **number of disasters** following natural events worldwide has been **rising rapidly**
- Similarly, **economic losses** due to natural disasters show an **increasing trend**



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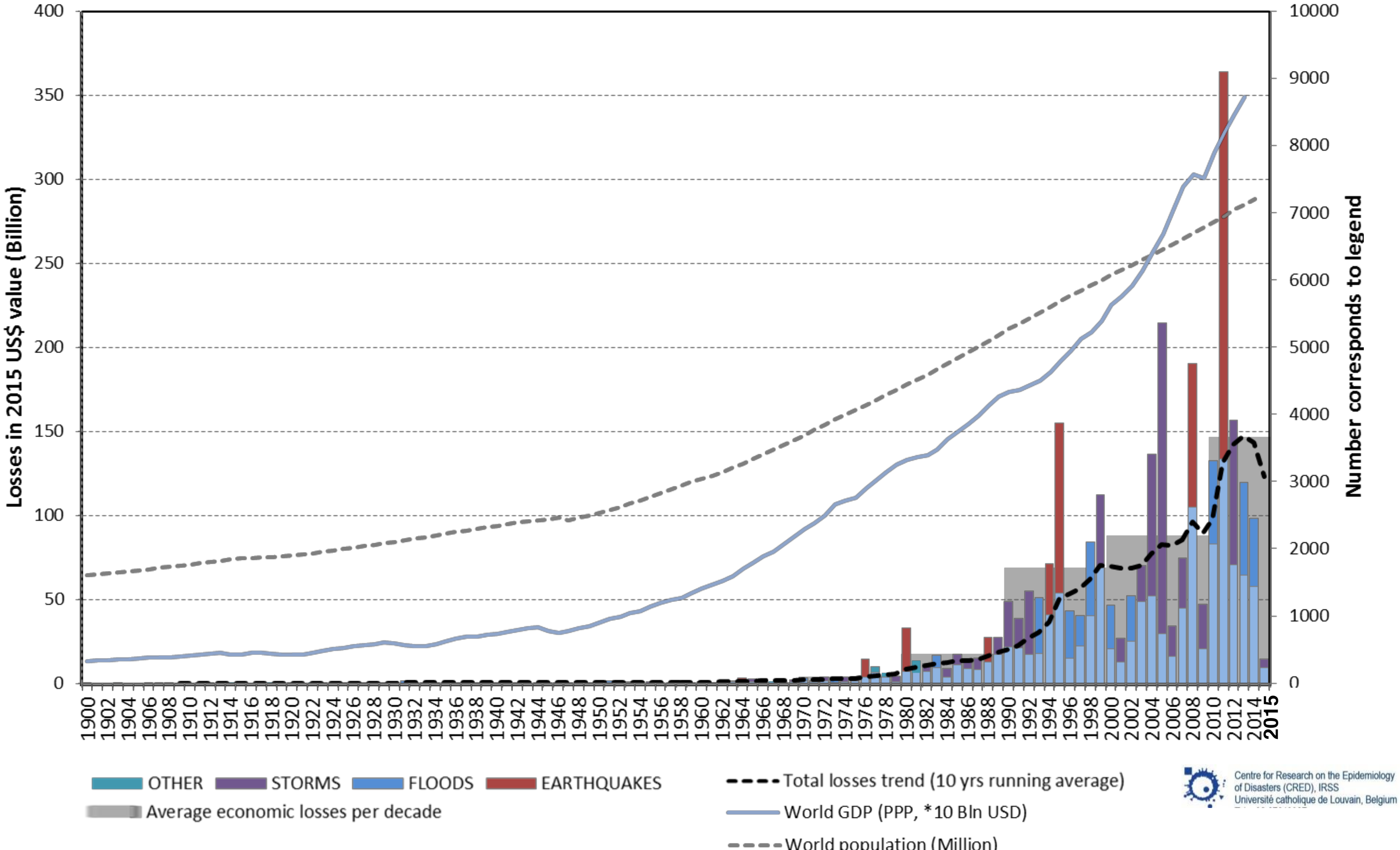
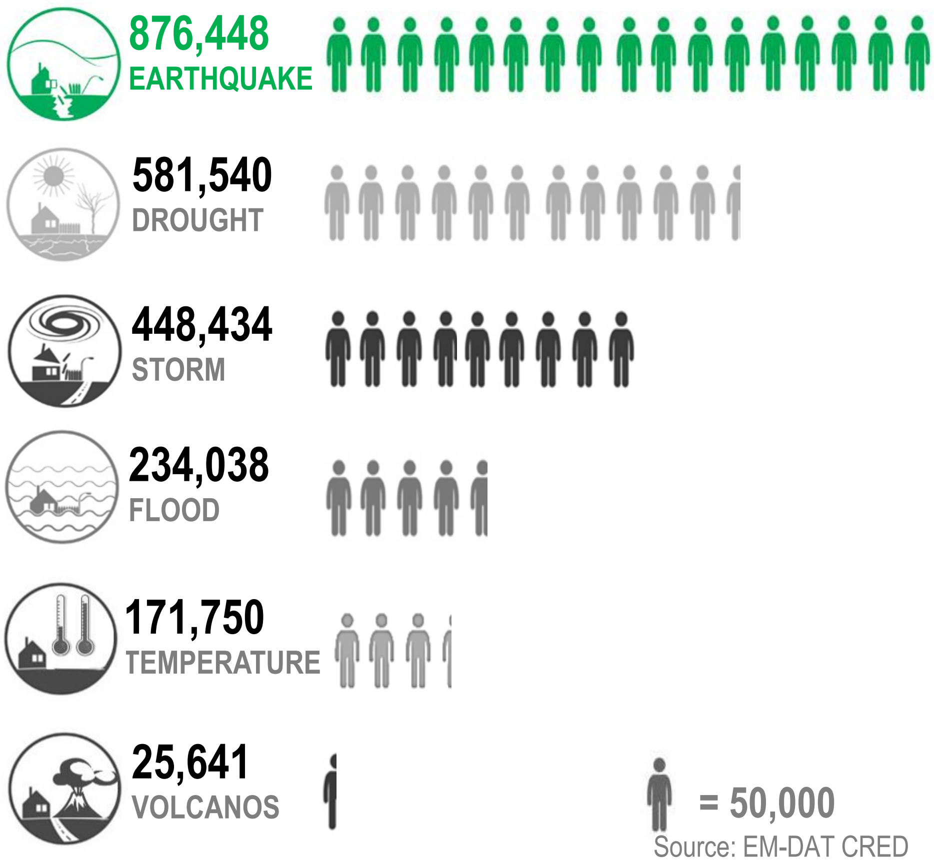


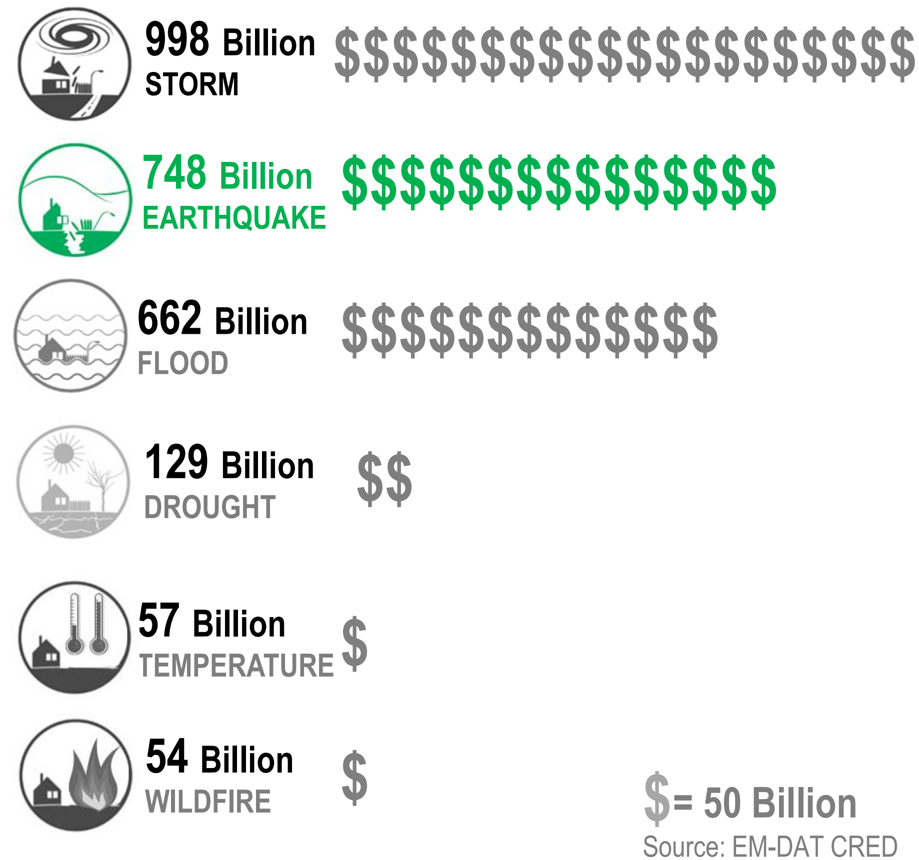
Earthquakes vs. other Natural Hazards

People killed in natural disasters from 1980 to 2015



Earthquakes have caused the largest death toll in the last thirty-five years

Cost of natural disasters from 1980 to 2015



Earthquakes are the second cause of economic losses in the last thirty-five years

QUANTIFYING SEISMIC RISK

"…earthquakes are quite harmless until you decide to put millions of people and two trillion dollars in real estate atop scissile fault zones" *Marc Reisner, 1993*

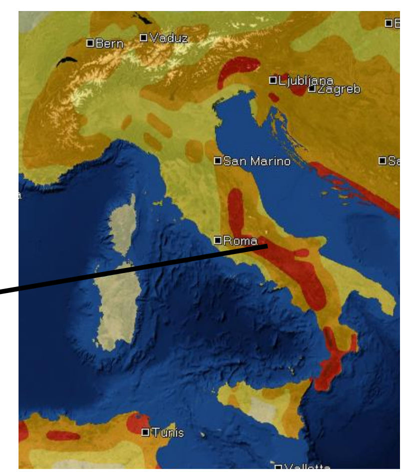
AXA MATRIX RISK CONSULTANTS redefining / services

Seismic risk assessment: *from a traditional qualitative approach…*

QUALITATIVE approach = traditional approach to seismic risk in insurance and risk management, based on the of the ***observed damage from past earthquakes in a given area*** (measured by a ***macroseismic intensity*** scale).

MMI	DESCRIPTION OF EFFECTS
VI. Strong	Felt by all; many frightened; some heavy furniture moved or overturned; a few instances of fallen plaster. Damage slight.
VII. Very Strong	Damage negligible in building of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII. Destructive	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture moved.
IX. Violent	Damage considerable in specially designed structures, well designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X. Intense	Some well built wooden structures destroyed; most masonry and frame structures destroyed with foundation. Rails bent.
XI. Extreme	Few, if any masonry structures remain standing. Bridges destroyed. Rails bent greatly.
XII. Cataclysmic	Total destruction – Everything is destroyed. Lines of sight and level distorted. Objects thrown into the air.

This approach **cannot be applied to individual buildings**, which may exhibit extremely different seismic behaviors



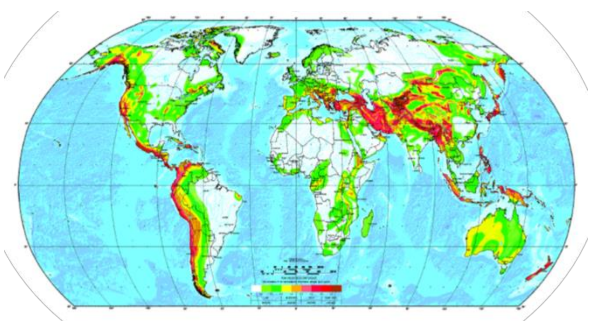
… towards a quantitative seismic risk assessment

QUALITATIVE approach = traditional approach to seismic risk in insurance and risk management, based on the of the **observed damage from past earthquakes in a given area** (measured by a **macroseismic intensity** scale).

↓

QUANTITATIVE approach= the only one allowing to ***measure the risk***, on sound, probabilistic, basis.
In a such an assessment the Risk is decomposed in three main components:

$$Risk = H \times V \times E$$

Hazard (H)	Vulnerability (V)	Exposure (E)
		
Frequency and intensity of earthquakes	*Fragility of the structures*	*Values (goods and activities) at risk*
Seismologists, Geophysicists	**Structural engineers**	**Risk Managers, Stakeholders, Planners**

CAUSE → EFFECT → CONSEQUENCE

AXA MATRIX

QUANTITATIVE APPROACH TO SEISMIC RISK ASSESSMENT AND MANAGEMENT

A scientific-based quantitative approach, which can be tailored to client's needs

MATRIX RISK CONSULTANTS
redefining / services

Project history

In the aftermath of the L'Aquila earthquake, in 2009, one major client operating in the Automotive sector asked us a support to re-engineer their traditional EQ risk assessment approach with the following inputs:

- ***Consistent*** and ***objective*** risk assessment and prioritization methodology
- ***Focused*** on industrial facilities
- Applicable ***worldwide***
- ***Multilayered*** approach (different levels/costs of investigation)

AXA MATRIX launched a four-year research project in cooperation with the University of Naples Federico II (Coordinator of the Italian laboratories of earthquake engineering) for the development of an **innovative analysis methods and pratical risk engineering tools**

These tools, developed in «team work» with our partners, are now part of a single,

Integrated approach for quantitative seismic risk assessment and management

Why a Multilevel approach ?

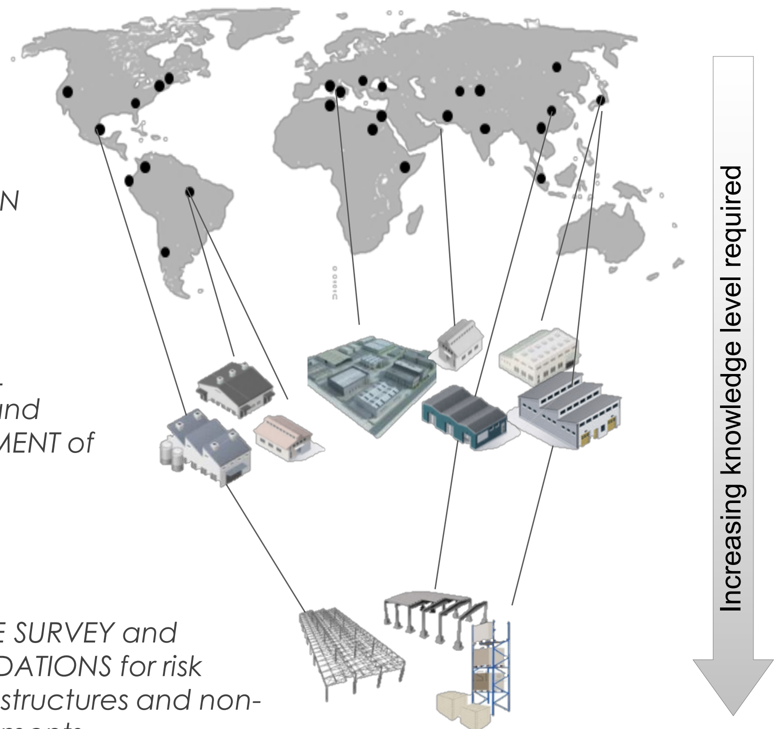
"AXA MATRIX Integrated Approach"

Is a three-step approach that is able to take into account the **specific client requirements and characteristics and** to **flexibly adapt** to the different *sizes of the portfolio*, *available resources*, and *time constraints*:

LEVEL 1:
DESK STUDY and RISK PRIORITIZATION

LEVEL 2:
RAPID VISUAL SCREENING and LOSS ASSESSMENT of structures

LEVEL 3:
DETAILED SITE SURVEY and RECOMMENDATIONS for risk reduction of structures and non-structural elements



What are the advantages?

1) An efficient allocation of available resources.

largest efforts can be dedicated to knowledge acquisition and to more refined analysis targeting just where real risks exist.

2) A rational and transparent support for risk management decisions.

Risk priorities among the portfolio and risk mitigation interventions can be selected on sound quantitative basis and, therefore, easily communicated.

3) A flexible approach, tailored to client's needs and profile.

No two building portfolios are alike. The multilevel approach can encompass all of the steps or just those that best suits to the portfolio under investigation

The AXA MATRIX Integrated Multilevel Approach

The three steps were developed in order to answer to **specific client's** needs and to produce different **quantitative outputs**

CLIENT'S NEED	AXA MATRIX SOLUTION	OUTPUT
• *Address risk priorities in portfolio* • *Limited resources to visually inspecting all facilities*	**LEVEL 1 assessment:** **Seismic Risk Gap Analysis,** a quantitative approach for seismic risk prioritization analysis	**RISK PRIORITIZATION** ***global quantitative picture of the risk over a building portfolio***, ideal for addressing the major risks
• *Need to perform seismic loss assessments* • *Need to understand the vulnerability of structures and the potential economic impact of earthquakes* • *Need a quantitative loss assessment to manage mitigation strategies*	**LEVEL 2 Assessment:** **Rapid visual screening and loss assessment through FRAME@Risk**, the innovative tool able to perform advanced risk assessments of structures	**LOSS ASSESSMENT** ***Building-by-building damage and loss assessment,*** allowing a rational and informed decision making.
• *Structures to be surveyed by a structural engineer* • *Portfolio is composed critical structures* • *Require engineering solutions*	**LEVEL 3 Assessment:** **Site Specific Risk Analysis** and **solution options by a structural specialist**, advanced risk analysis through FRAME@Risk or dedicated structural analysis.	**SOLUTIONS FOR LOSS PREVENTION** ***Loss prevention report and recommendations*** for the mitigation of future earthquakes impacts to individual buildings and relevant non-structural components.

Increasing knowledge level required

LEVEL 1 assessment

- For large portfolios, **in-depth information about structures are generally unavailable** and visually inspecting **all of the sites** could be **unfeasible**
- Stakeholders may be interested in addressing risk priorities to achieve a **"global" overview** of exposures to **address risk priorities** among the portfolio in a **quantitative and rational way**.

*LEVEL 1 assessment is the **quantitative prioritization analysis** of the portfolio, on the basis of a quantitative and structure-specific "Risk Priority Index":*

Exposure index — **Nominal Deficit**

Risk Priority Index = EI (Demand – Capacity)

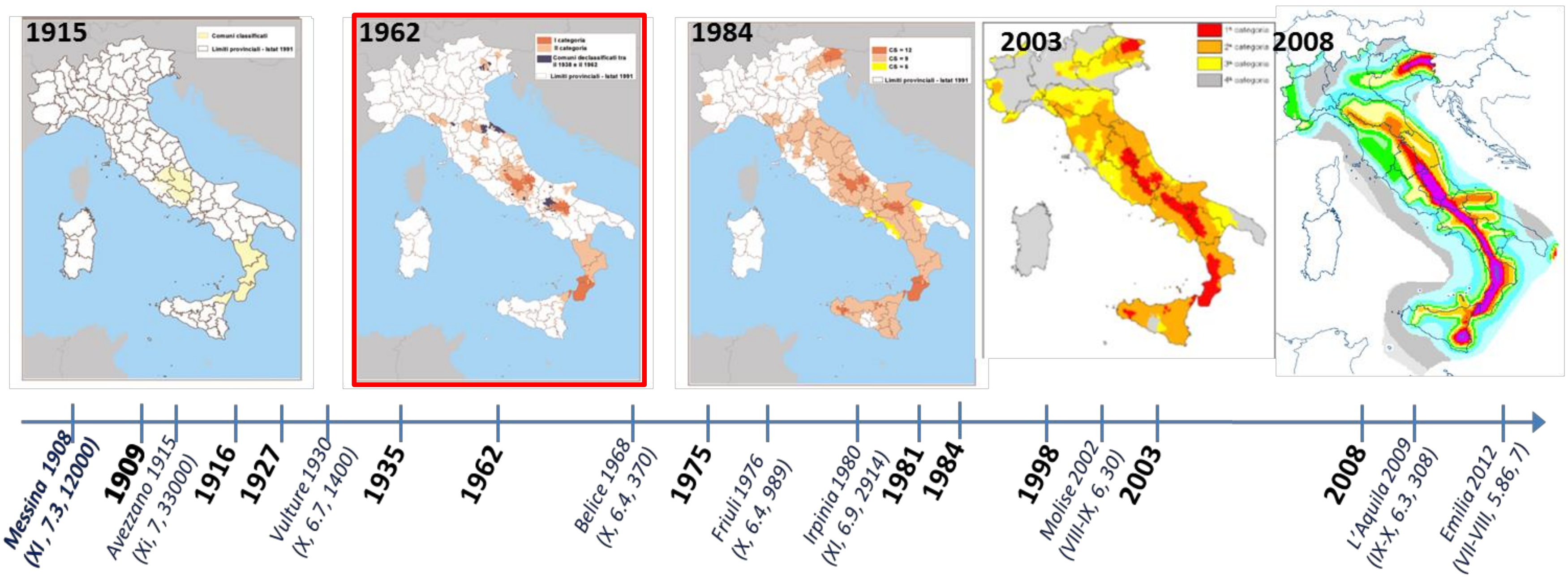
Current seismic demand imposed by the seismic code enforced

Seismic demand imposed by the seismic code at the **time of the design**

Objective of this study is to provide a quantitative and transparent seismic risk prioritization within the portfolio, taking into account not only the **«Hazard»** (where the plant is located) but also its **«Vulnerability»** (how it is built) and the **«Exposure»** (potential impact)

LEVEL 1 assessment

Summary of the seismic code evolutions



- Almost **70%** of Italian industrial structures erected in 60's and 70's, when **less than 30% of Italian territory** was seismically classified
- In many areas the **Nominal Deficit** can be significant.
- The lack in seismic design is the **most important cause for the actual seismic vulnerability** of structures as readily demonstrated by recent seismic events:

The Emilia 2012 Earthquakes

- **May 20, 2012, 4:03 a.m. , M 5.9 earthquake**
- **May 29, 2012, 9:00 a.m., M 5.8 earthquake.**

The earthquakes affected a **densely industrialized area, where** 7,000 industrial activities and 187,000 workers produce, every year, **2% of the Italian Gross Domestic Product**

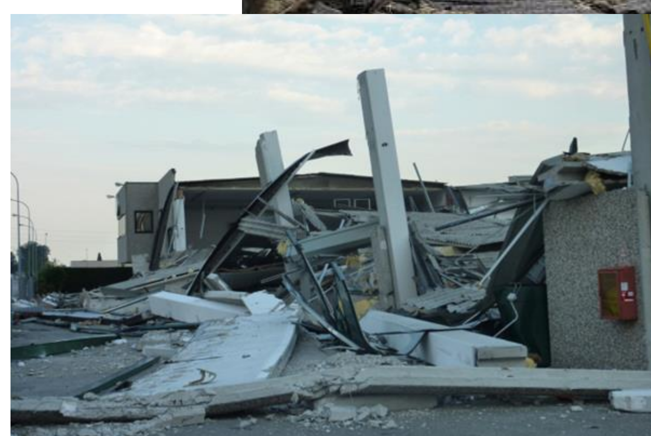

la Repubblica
Emilia, il terremoto infinito
Crollano capannoni industriali e chiese: 16 morti, 350 feriti. Si scava tra i detriti

"Emilia, the infinite earthquake"

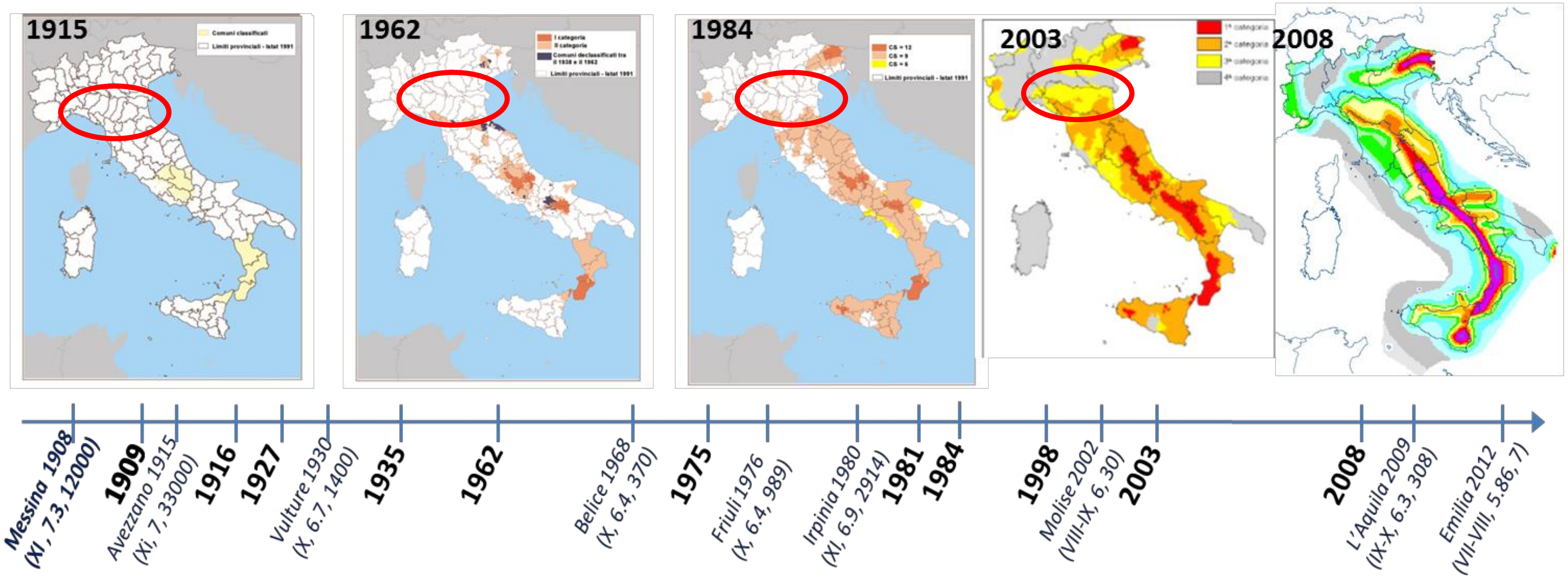
"9:00 am, the Monster enters into facilities"

CONSEQUENCES:

- 27 casualties
- 400 injured
- 15,000 homeless
- **15 billion USD of PD and BI** (*Italian Department for Civil Protection estimates*);
- **1.5 billion USD of Insured Losses** (10% of Total Losses; in L'Aquila 2009 the 2%)



The Emilia 2012 Earthquakes



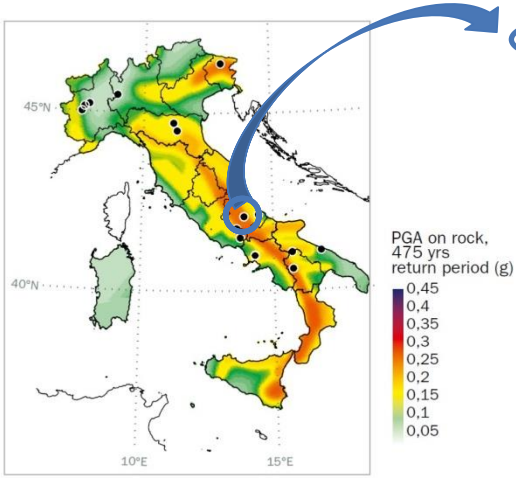
- One main reason for this huge losses was the late enforcement of seismic design prescription in the Emilia Region. In fact, the **area was recognized as a seismic-prone one only in 2003**.

- In fact in a mechanical connection between elements of precast structures was mandatory in seismic areas only. Therefore, **the loss of support of beams was the main collapse mechanism observed**.

LEVEL 1 assessment - Case study

Analysis results

Current seismic hazard map



Hazard-based prioritization	NODE index (**Hazard** and **Vulnerability** including **soil**)	RPI index (H, V, and **exposure**)
PLANT-01_WH_1971	PLANT-09_WH_1973	PLANT-09_WH_1973
PLANT-01_OFF_1971	PLANT-08_WH_1934	PLANT-08_WH_1934
PLANT-02_WH_1988	PLANT-08_WH_1971	PLANT-08_WH_1971
PLANT-03_WH_1988	PLANT-08_WH_1971	PLANT-04_WH_1970
PLANT-03_OFF_1988	PLANT-08_WH_1960	PLANT-08_WH_1971
PLANT-04_WH_1970	PLANT-10_WH_1974	PLANT-10_WH_1974
PLANT-05_WH_1993	PLANT-12_WH_2001	PLANT-15_WH_1969
PLANT-05_OFF_1993	PLANT-04_WH_1970	PLANT-17_WH_1919
PLANT-06_WH_1993	PLANT-03_WH_1988	PLANT-01_WH_1971
PLANT-07_WH_1987	PLANT-03_OFF_1988	PLANT-16_WH_1969
PLANT-07_WH_1987	PLANT-13_WH_1963	PLANT-19_WH_1968
PLANT-07_WH_2007	PLANT-02_WH_1988	PLANT-08_WH_1960
PLANT-08_WH_1934	PLANT-13_OFF_1963	PLANT-12_WH_2001
PLANT-08_WH_1971	PLANT-01_WH_1971	PLANT-02_WH_1988
PLANT-08_WH_1971	PLANT-01_OFF_1971	PLANT-05_WH_1993
PLANT-08_WH_1960	PLANT-05_WH_1993	PLANT-13_WH_1963
PLANT-09_WH_1973	PLANT-05_OFF_1993	PLANT-14_WH_1968
PLANT-10_WH_1974	PLANT-06_WH_1993	PLANT-18_WH_1976
PLANT-11_WH_1988	PLANT-16_WH_1954	PLANT-18_WH_1976
PLANT-12_WH_2001	PLANT-14_WH_1968	PLANT-11_WH_1988
PLANT-13_WH_1963	PLANT-15_WH_1969	PLANT-16_WH_1962
PLANT-13_OFF_1963	PLANT-11_WH_1988	PLANT-16_WH_1969
PLANT-14_WH_1968	PLANT-17_WH_1919	PLANT-05_OFF_1993
PLANT-14_STK_1998	PLANT-16_WH_1969	PLANT-16_WH_1954
PLANT-15_WH_1969	PLANT-07_WH_1987	PLANT-01_OFF_1971
PLANT-16_WH_1954	PLANT-14_STK_1998	PLANT-13_OFF_1963
PLANT-16_WH_1962	PLANT-16_WH_1962	PLANT-03_WH_1988
PLANT-16_WH_1962	PLANT-16_WH_1962	PLANT-07_WH_1987
PLANT-16_WH_1969	PLANT-16_WH_1969	PLANT-07_WH_1987
PLANT-16_WH_1969	PLANT-07_WH_1987	PLANT-06_WH_1993
PLANT-17_WH_1919	PLANT-18_WH_1976	PLANT-03_OFF_1988
PLANT-18_WH_1976	PLANT-18_WH_1976	PLANT-14_STK_1998
PLANT-18_WH_1976	PLANT-19_WH_1968	PLANT-16_WH_1962
PLANT-19_WH_1968	PLANT-07_WH_2007	PLANT-07_WH_2007

Plant 1

- Located in the area with the highest seismic hazard
- Erected in 1971
- Territory classified as seismic prone since 1915

- Founded on good subsoil
- Made of a workshop bld. (WH) with **high value** and office bld. (OFF) with **low value**

$$\text{Risk Priority Index} = \text{EI} \cdot (\text{Demand} - \text{Capacity})$$

Exposure index (EI) — **Nominal Deficit** (Demand – Capacity)

LEVEL 1 assessment - Case study

Analysis results

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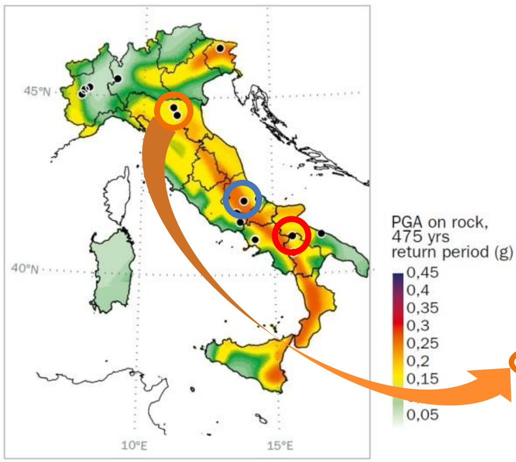

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PLANT-14_STK_1998	PLANT-16_WH_1969	PLANT-16_WH_1954
PLANT-15_WH_1969	PLANT-07_WH_1987	PLANT-01_OFF_1971
PLANT-16_WH_1954	PLANT-14_STK_1998	PLANT-13_OFF_1963
PLANT-16_WH_1962	PLANT-16_WH_1962	PLANT-03_WH_1988
PLANT-16_WH_1962	PLANT-16_WH_1962	PLANT-07_WH_1987
PLANT-16_WH_1969	PLANT-16_WH_1969	PLANT-07_WH_1987
PLANT-16_WH_1969	PLANT-07_WH_1987	PLANT-06_WH_1993
PLANT-17_WH_1919	PLANT-18_WH_1976	PLANT-03_OFF_1988
PLANT-18_WH_1976	PLANT-18_WH_1976	PLANT-14_STK_1998
PLANT-18_WH_1976	PLANT-19_WH_1968	PLANT-16_WH_1962
PLANT-19_WH_1968	PLANT-07_WH_2007	PLANT-07_WH_2007

Plant 9

- Located in the area with an average/low seismic hazard
- Erected in 1973
- Territory NOT classified as seismic prone until 2003

- Founded on POOR subsoil
- HIGH value at risk

Top ranking plant

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Increasing knowledge level required

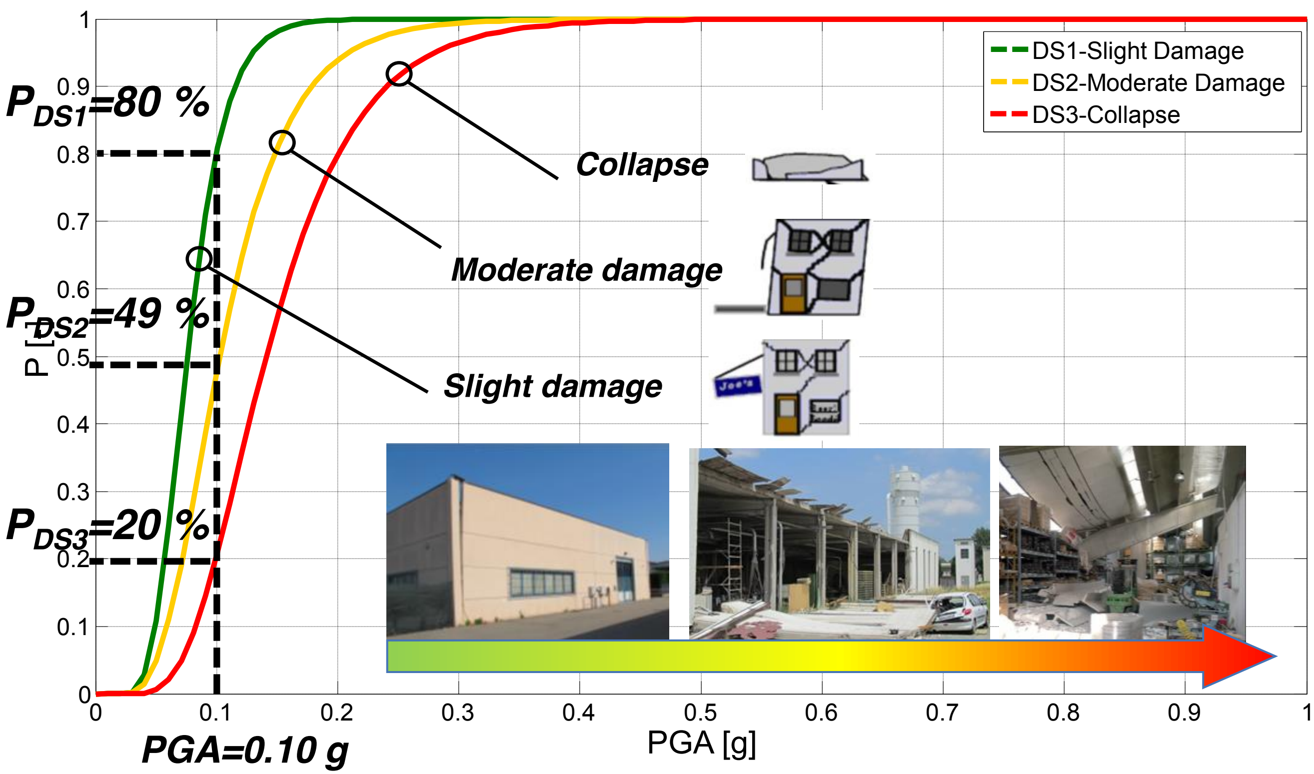
LEVEL 2 assessment:

Fragility-based seismic risk assessment

*In a LEVEL 2 approach, a rapid visual screening of structures is performed and **expected loss** is computed via the use of **fragility functions***

A fragility functions is the most comprehensive representation of the structural damage at **increasing seismic action**

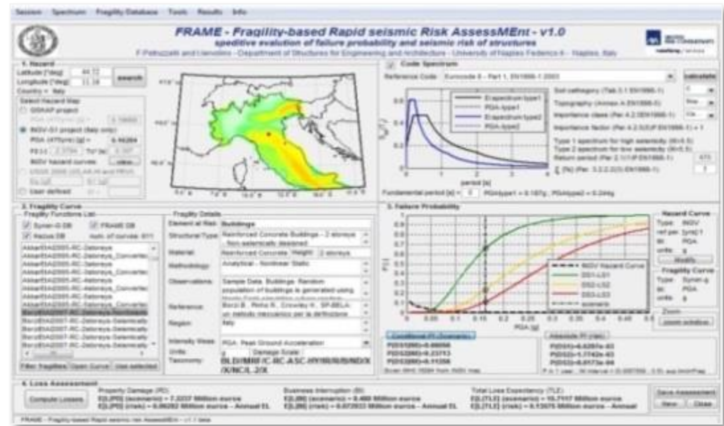
P = probability of exceeding a given damage condition



LEVEL 2 assessment:

The FRAME@Risk approach

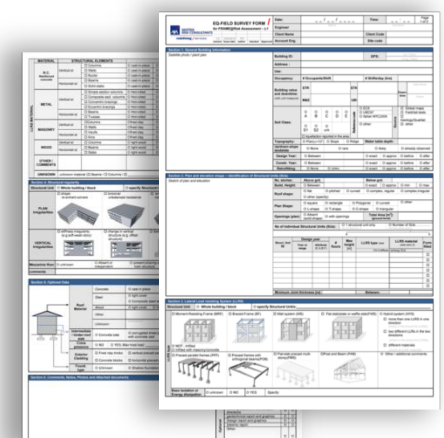
The Expected loss computation is performed by the **AXA MATRIX Center of Expertise on Earthquake and Tsunami**, employing the **AXA MATRIX *FRAME@Risk software tool***



Graphical Interface od the FRAME@Risk software (Fragility-based seismic Risk AssessMEnt)

ADVANTAGES:

- Worldwide applicable tool for **quantitative seismic loss assessment**
- It uses advanced studies of **seismic hazard, structural and non-structural fragility, and damage-to-loss functions**
- FRAME@Risk includes a **database of fragility functions that is much larger and more detailed** than any other of the traditional loss assessment and catastrophe modeling tools (more than 600 data points from scientific literature, continuously updated)



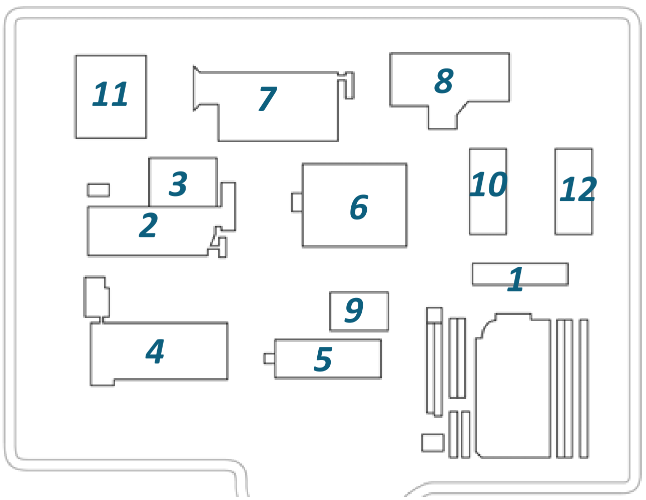
Dedicated Knowledge forms

OUTPUT:

- **Building-specific expected damage assessment**
- **Building-specific expected loss assessment**
- a transparent and informed **decision making** to implement the most effective mitigation strategies (insurance purchase, structural retrofitting, …)

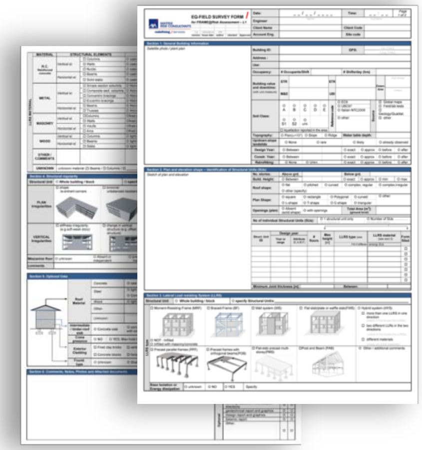
A real case-study: High-tech plant in Emilia region

- Plant dedicated to the production of hi-tech materials;
- Total property value = about **100 mln Euros** (buildings = 27 mln; machineries=47 mil; stock=28 mln);
- 12 buildings, built from 1966 to 2011;



Building characteristics		
name	**material**	**design year**
Bld.1-Offices	Cast in pl. r.c.	1990
Bld.2-Production	Precast r.c.	1983
Bld.3-Production	Precast r.c.	1983
Bld.4-Production	Precast r.c.	1990
Bld.5-Warehouse	Precast r.c.	2011
Bld.6-Production	Precast r.c.	1977
Bld.7-Production	Precast r.c.	2002
Bld.8-Warehouse	Precast r.c.	1982
Bld.9-Warehouse	Precast r.c.	2003
Bld.10-Warehs.	Precast r.c.	1993
Bld.11-Product.	Cast in pl. r.c.	1966
Bld.12-Warehs.	Precast r.c.	1972-1981

VISUAL SURVEY of the site



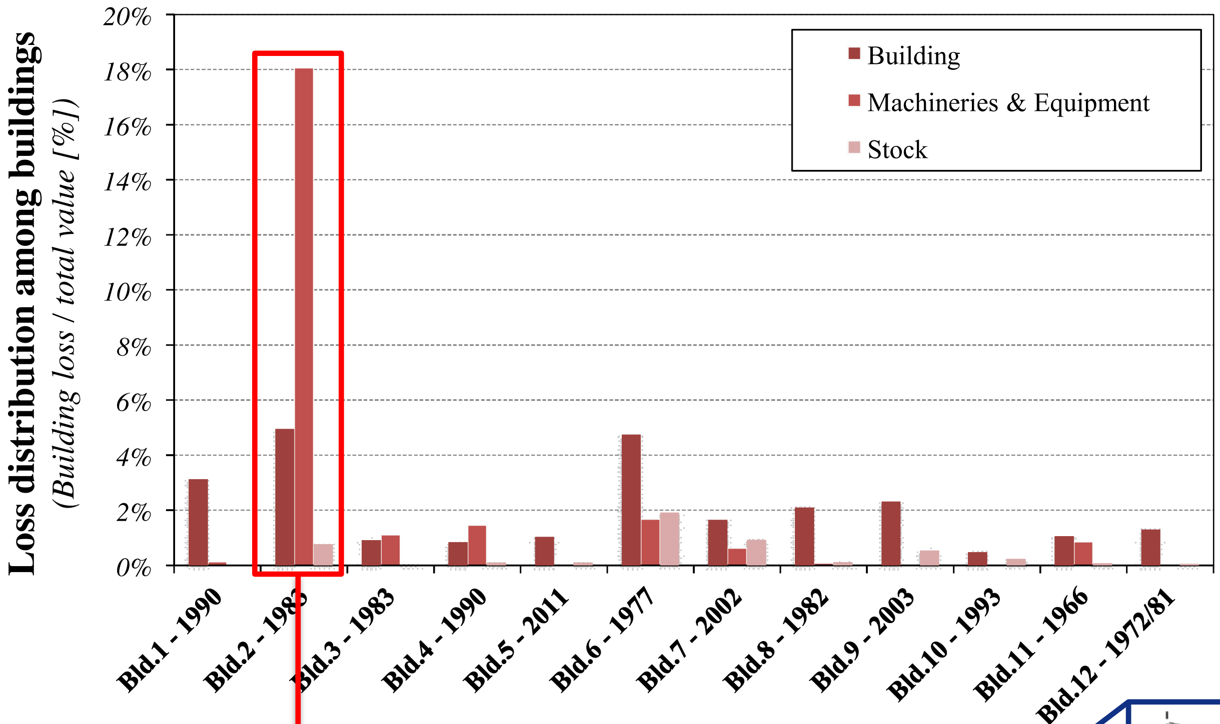
FRAME@RISK application

- **fragility functions specifically computed for Italian precast buildings** with different details in terms of member connections, reinforcement, structural regularities, cladding characteristics. ....
- **consequence functions** chosen on the basis of the occupancy and content vulnerability

A real case-study: High-tech plant in Emilia region

FRAME@Risk software loss estimates

Distribution of estimated losses inside the plant (normalized with respect to the total value of the component at risk)



Building characteristics			Building exposed value [% of the total plant value]		
name	material	design year	Building	Machineries &Equipment	Stock
Bld.1-Offices	Cast in pl. r.c.	1990	7,58%	0,6%	0,00%
Bld.2-Production	Precast r.c.	1983	12,6%	45,5%	2,9%
Bld.3-Production	Precast r.c.	1983	5,3%	19,3%	1,2%
Bld.4-Production	Precast r.c.	1990	5,0%	17,9%	1,1%
Bld.5-Warehouse	Precast r.c.	2011	12,7%	0,6%	8,7%
Bld.6-Production	Precast r.c.	1977	15,1%	5,2%	7,2%
Bld.7-Production	Precast r.c.	2002	9,7%	3,3%	3,5%
Bld.8-Warehouse	Precast r.c.	1982	6,7%	0,3%	9,5%
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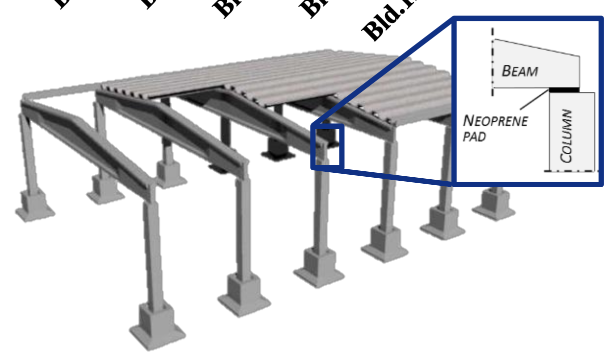
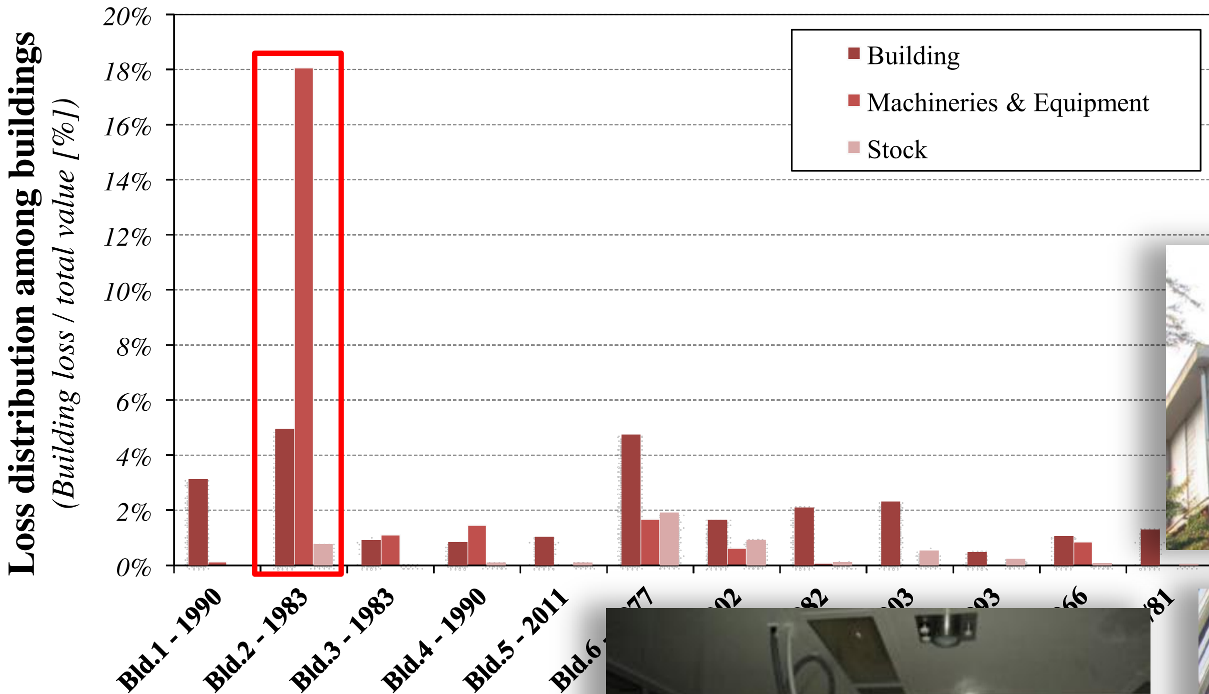
Bld.10-Warehs.	Precast r.c.	1993	3,3%	0,7%	18,5%
Bld.11-Product.	Cast in pl. r.c.	1966	2,6%	5,7%	0,9%
Bld.12-Warehs.	Precast r.c.	1972-1981	4,2%	0,2%	4,5%



A real case-study: High-tech plant in Emilia region

FRAME@Risk software loss estimates

Distribution of estimated losses inside the plant (normalized with respect to the total value of the component at risk)



Building characteristics			Building exposed value [% of the total plant value]		
name	material	design year	Building	Machineries &Equipment	Stock
Bld.1-Offices	Cast in pl. r.c.	1990	7,58%	0,6%	0,00%
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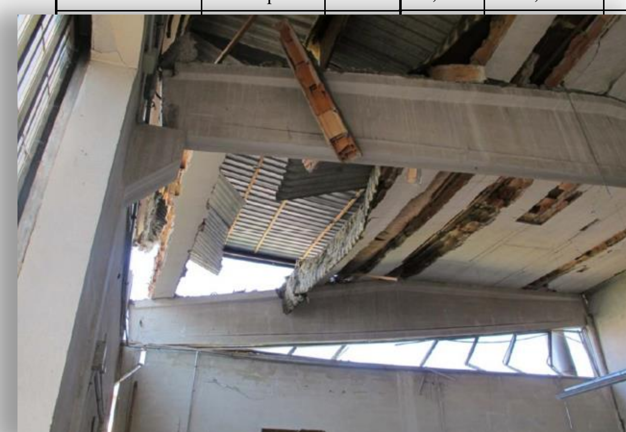
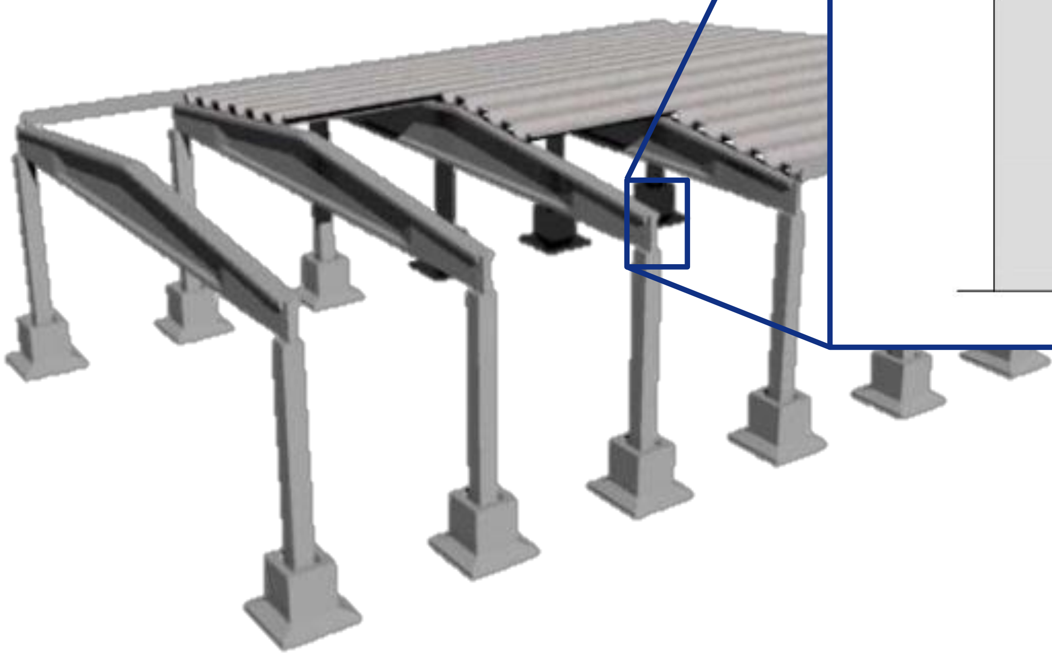


Bld.2 is the one for which the largest damage to building and machineries/equipment **<u>is estimated by FRAME@Risk</u>** and **<u>actually observed after the earthquakes</u>**

A real case-study: High-tech plant in Emilia region

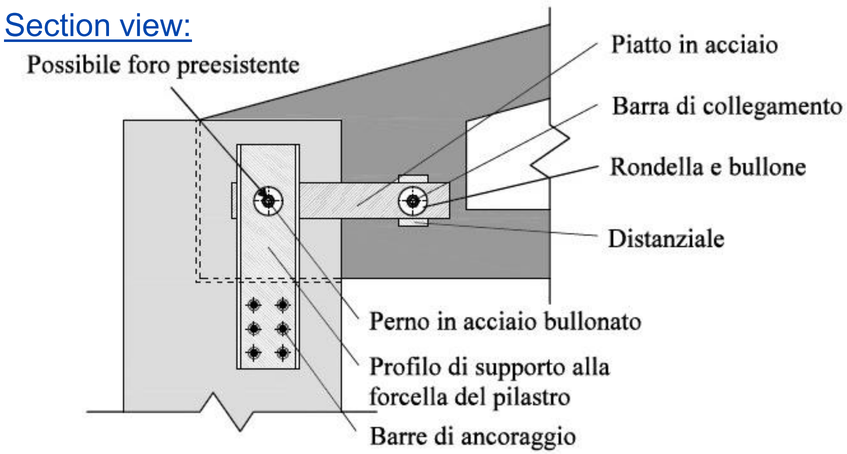
FRAME@Risk loss estimates: **what if… analysis**

What if Building 2 would have been retrofitted with devices avoiding the failure due to loss of support ?



beam-column connection by means of pins and steel plates

Section view:



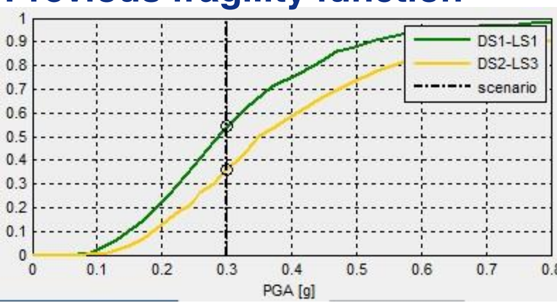
A real case-study: High-tech plant in Emilia region

FRAME@Risk loss estimates: **what if… analysis**

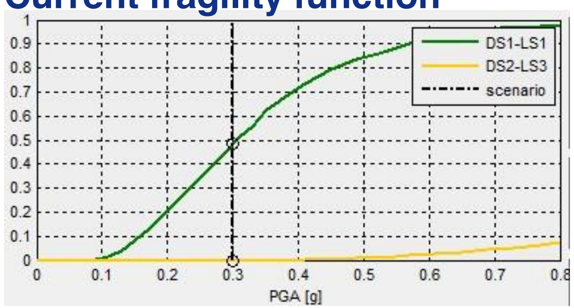
What if Building 2 would have been retrofitted with devices avoiding the failure due to loss of support ?

Same earthquake intensity measure
PGA = 0.3 g

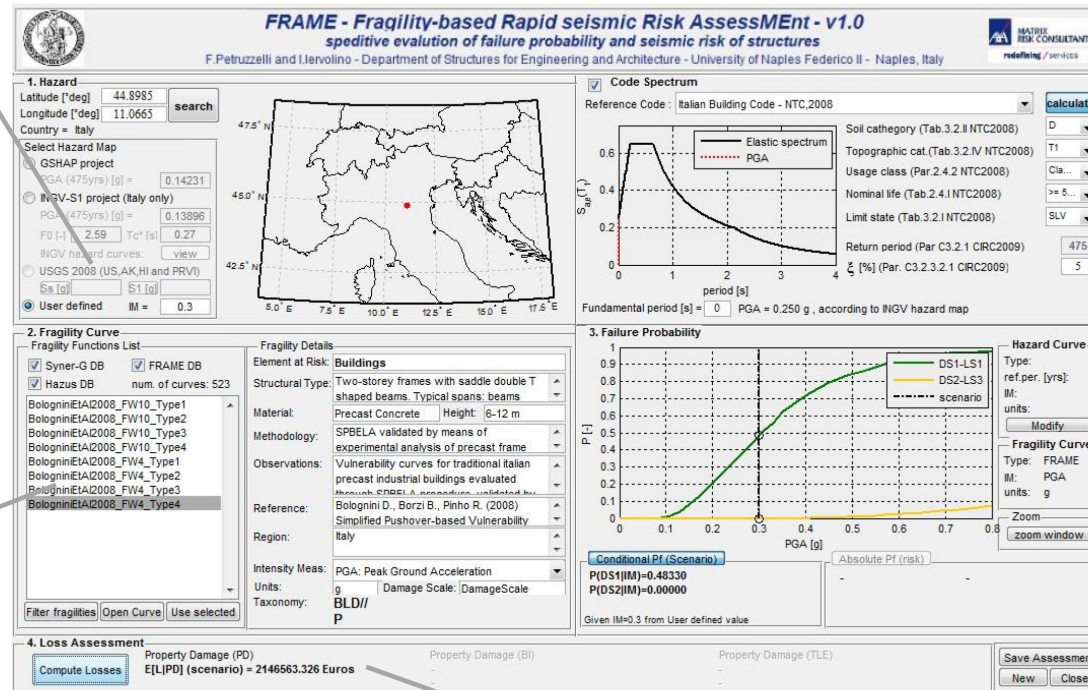
Previous fragility function



Current fragility function



Although very similar in the structural scheme (similar slight damage probabilities), the mechanical connection renders the collapse much more unlikely



Conditional expected loss:

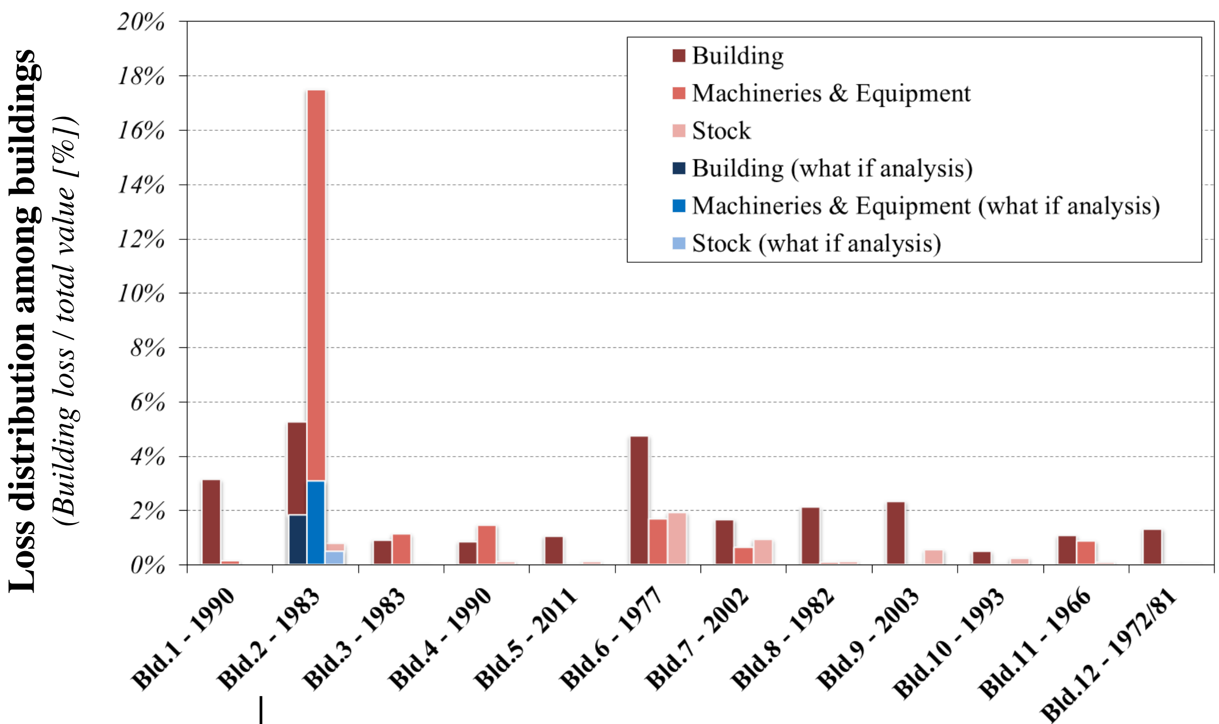
Previous total loss expectancy = 9.86 Mln EUR

"what if" total loss expectancy = 2.15 Mln EUR

A real case-study: High-tech plant in Emilia region

FRAME@Risk loss estimates: **what if… analysis**

Distribution of estimated losses inside the plant (normalized with respect to the total value of the component at risk)



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Bld.12-Warehs.	Precast r.c.	1972-1981	4,2%	0,2%	4,5%

- If Bld.2 had been adequately retrofitted , **the expected loss would have been significantly lower** to building, equipment and stock.
- **The peculiar occupancy (white rooms) render, in any case, the machinery component the most vulnerable one.**

The AXA MATRIX Integrated Multilevel Approach

Plants and structures resulting as risk priorities from Level-1, can be analyzed through more detailed assessment procedures (Level-2 and Level-3 assessments)

CLIENT'S NEED	AXA MATRIX SOLUTION	OUTPUT
• *Address risk priorities in portfolio* • *Limited resources to visually inspecting all facilities*	**LEVEL 1 assessment:** **Seismic Risk Gap Analysis,** a quantitative approach for seismic risk prioritization analysis	**RISK PRIORITIZATION** ***global quantitative picture of the risk over a building portfolio***, ideal for addressing the major risks
• *Need to perform seismic loss assessments* • *Need to understand the vulnerability of structures and the potential economic impact of earthquakes* • *Need a quantitative loss assessment to manage mitigation strategies*	**LEVEL 2 Assessment:** **Rapid visual screening and loss assessment through FRAME@Risk**, the innovative tool able to perform advanced risk assessments of structures	**LOSS ASSESSMENT** ***Building-by-building damage and loss assessment,*** allowing a rational and informed decision making.
• *Structures to be surveyed by a structural engineer* • *Portfolio is composed critical structures* • *Require engineering solutions*	**LEVEL 3 Assessment:** **Site Specific Risk Analysis and solution options by a structural specialist**, advanced risk analysis through FRAME@Risk or dedicated structural analysis.	**SOLUTIONS FOR LOSS PREVENTION** ***Loss prevention report and recommendations*** for the mitigation of future earthquakes impacts to individual buildings and relevant non-structural components.

Increasing knowledge level required

LEVEL 3 assessment:

*LEVEL 3 approach is a **Site-specific Seismic Risk Analysis** consisting in a field visit by a structural engineer with the aim of*

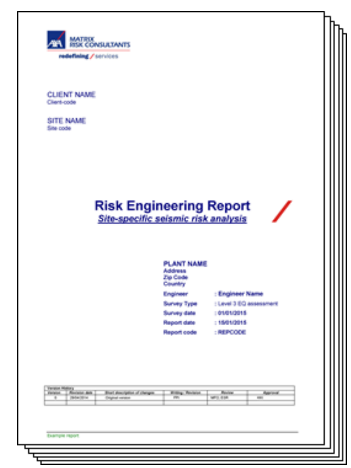
- **Assessing the seismic vulnerability of structures** on the basis of a detailed analysis of documents and visual survey;
- **Assessing the seismic behavior of the major non-structural elements**, machineries and equipment, potentially leading to significant direct damage and/or business interruption in case of an earthquake
- Performing a loss assessment of structures through **FRAME@Risk software** tool
- **Providing loss prevention recommendations and engineering solutions** for the reduction of the impact of future earthquakes

ADVANTAGES:

- It is **the most advanced risk analysis method**
- **It can take advantage of computer-simulated modelling** of structural seismic fragility and loss assessment

OUTPUT:

- A **full description of the structural response under probable earthquakes**
- **Full structure-specific report** with **recommendations** for earthquake loss reduction


MATRIX RISK CONSULTANTS
redefining / services
CLIENT NAME
SITE NAME
Risk Engineering Report
Site-specific seismic risk analysis
PLANT NAME

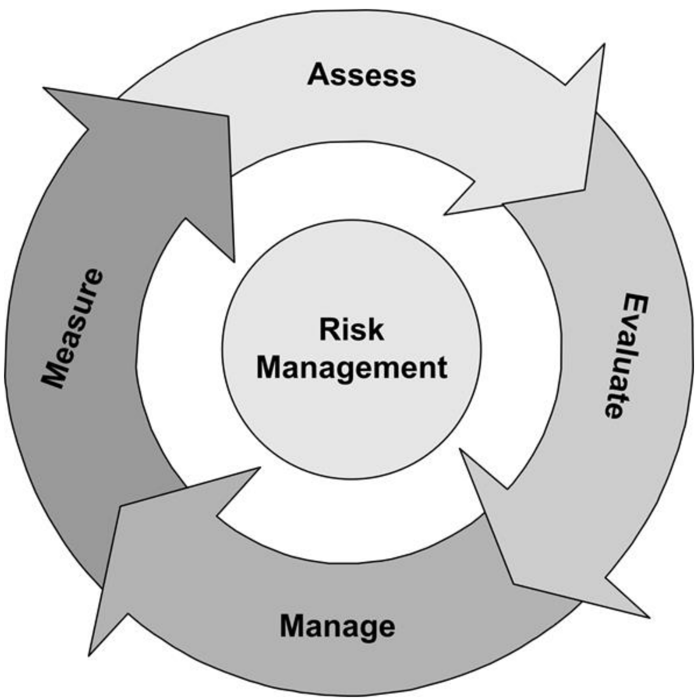
Risk engineering report

LEVEL 3 assessment:

Seismic Risk Mitigation Solutions

The main objective of AXA MATRIX Risk Consultants is to **support informed decision making with transparent, reliable and scientific-based solutions**

*"Risk assessment is all about risk management. The only reason you do an assessment is because **somebody has to make a risk-management decision**" - Smith, 2005.*



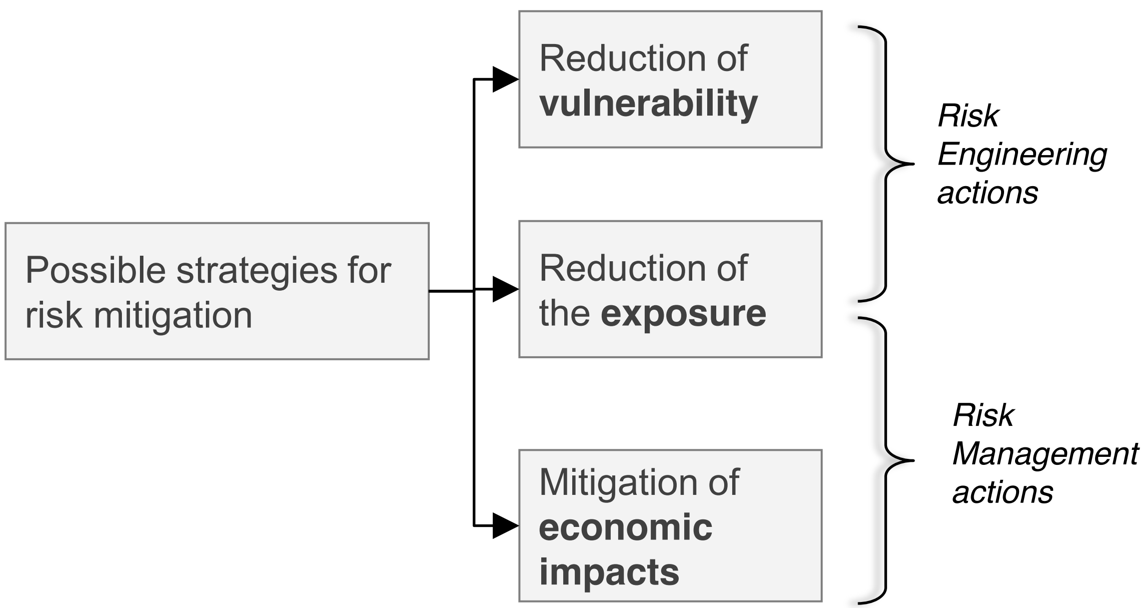
LEVEL 3 assessment:

Seismic Risk Mitigation Solutions

The main objective of AXA MATRIX Risk Consultants is to **support informed decision making with transparent, reliable and scientific-based solutions**

"Risk assessment is all about risk management. The only reason you do an assessment is because ***somebody has to make a risk-management decision****" - Smith, 2005.*

While it is impossible to reduce the seismic hazard of a site, it is possible to **reduce the structural vulnerability**, **exposure**, and/or **mitigate the economic consequences** of earthquakes:

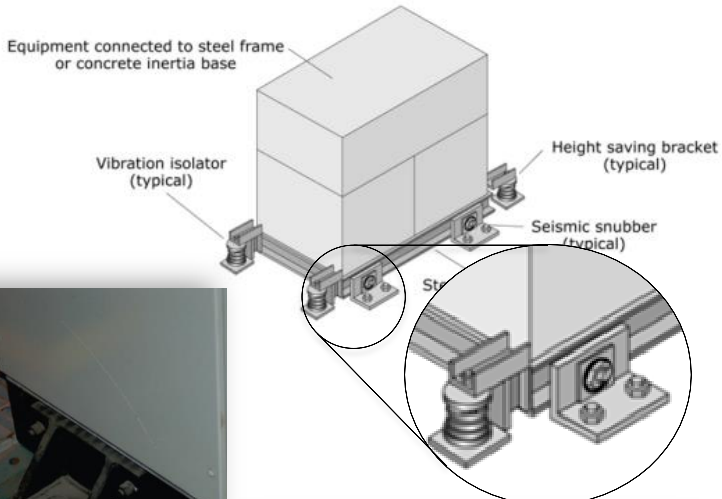


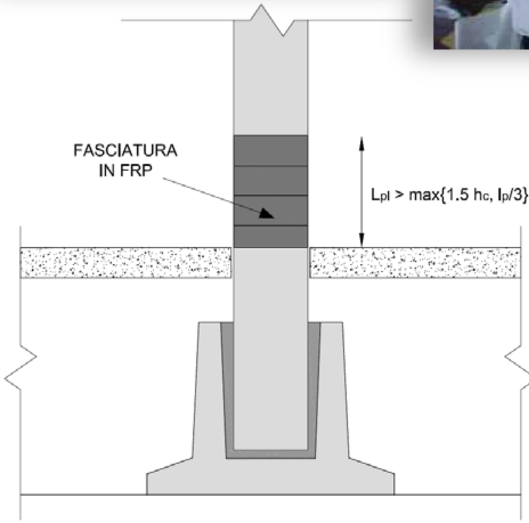
AXA MATRIX Risk Consultants can help clients in assessing seismic risk and ***choosing the best tradeoff between the wide range of available risk mitigation strategies***

LEVEL 3 assessment:

***Loss prevention recommendations**: reducing the loss in future earthquakes*

Example of loss prevention action for mechanical equipment



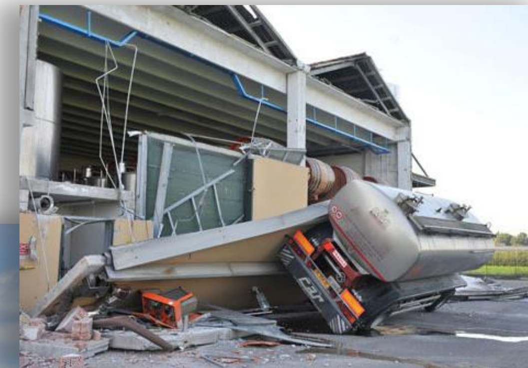


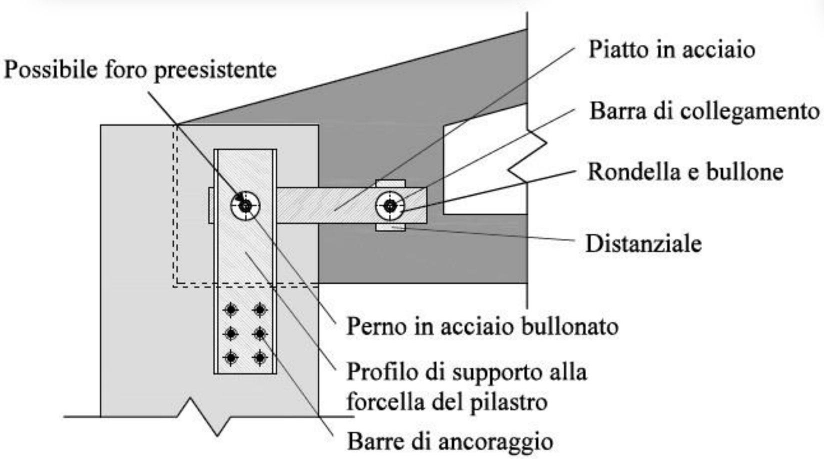
Example of loss prevention action for structural elements

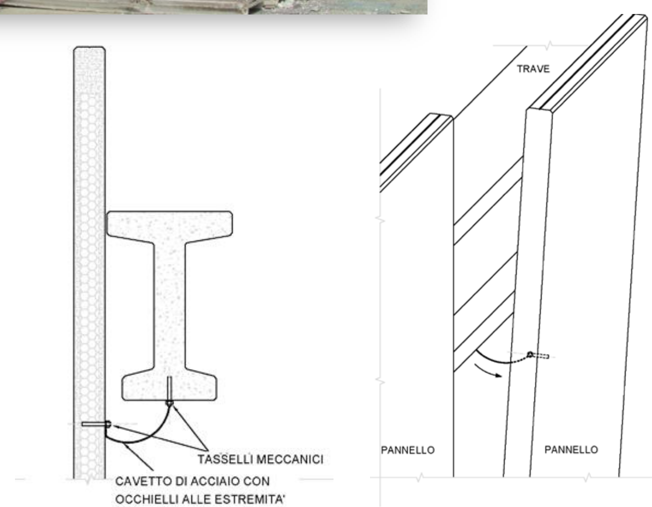
LEVEL 3 assessment:

***Loss prevention recommendations**: reducing the loss in future earthquakes*

Examples of loss prevention action for structural elements







Conclusions

- Although seismic risk is not an "emerging" risk, the magnitude of the potential losses, although relatively infrequent, **obligate stakeholders to prepare** for their occurrence and implement informed decision making actions.

- This calls for **innovative solutions** supporting stakeholders based on a thorough understanding of earthquakes, their probability, and the unique vulnerabilities of facilities and business operations.

- insurance industry and stakeholders must rely on structural engineering and geological and seismological expertise, as well as acknowledging scientific research advances to estimate potential losses using sound probabilistic-based seismic risk assessment approaches. Furthermore, **risk engineering** can make a big contribution to improving security for major assets mitigating earthquake impacts.

- The AXA Matrix Integrated Approach provides the right balance between **accuracy**, **feasibility** and **quality** of the results.
  This is crucial for an informed and transparent decision making aimed at finding the right balance between conservation and earthquake protection, extent of the intervention with available resources.

Thank you

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