URBAN EARTHQUAKE LOSS ASSESSMENT

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• In recent decades, earthquake disaster risks in cities have increased mainly due to a high rate of urbanization, faulty land-use planning and construction, inadequate infrastructure and services, and environmental degradation.

• Thus for urban centers under possible exposure to large earthquakes, it is imperative that certain preparedness and emergency procedures be contrived in the event of and prior to an earthquake, which in turn requires quantification of the effects of the earthquake on the physical and social environment.

• The main element of such quantification is the building losses, which is directly related to casualties, planning of emergency response, first aid and emergency shelter needs.
INPUT + INVENTORIES = OUTPUT

Earthquake Epicenter Location and Magnitude

Earth Attenuation Model

Soil Maps

Building Inventory Maps

Demographic Maps

Ground Shaking Maps

Direct and Indirect Economic Losses and Damage Estimates

Casualties and Shelter Demand Estimates
• A compilation of worldwide investigations on urban earthquake risk is presented in Tucker and Erdik (1994).

• In Japan, Oyo Corporation has produced an earthquake damage scenario development methodology (Komaru et al. 1995) that has found application in several cities (e.g., Kawasaki City, Saitama Prefecture, Kanagawa Prefecture, Quito, Tehran) as well as in the IDNDR RADIUS (http://geohaz.org/radius/) Project.

• EPEDAT (The Early Post-earthquake Damage Assessment Tool) (Eguchi et al. 1997) is a GIS-based system capable of modeling building and lifeline damage and estimating casualties in near real-time given the source parameters of an earthquake.

• HAZUS (http://www.fema.gov/hazus/) is a standardized earthquake loss estimation methodology intended for national application in the U.S. (Whitman and Lagorio 1999).
• A number of cities worldwide (Addis Ababa, Antofagasta, Bandung, Guayaquil, Izmir, Tashkent, Skopje, Tijuana and Zigong) were engaged in risk modeling in the UN-IDNDR program RADIUS.

• Several earthquake loss scenario assessment studies at various levels of sophistication have also been carried out in Europe; Basel; Barcelona; Catania; Istanbul; Izmir; Bucharest; Nice; Oslo. 

• EU-funded research project, RISK-UE has developed a general and modular methodology for creating earthquake-risk scenarios.

• EU-funded Safety Assessment for Earthquake Risk Reduction Project (SAFERR) - Investigations characterization of seismic hazard and risk assessment systems to provide tools for application of risk assessment.
DEVELOPMENTS IN THE EU ARENA (FP-5)

SAFERR – Safety Assessment for European Risk Reduction

RISK-UE -- An Advanced Approach To Earthquake Risk Scenarios
With Applications To Different European Towns
Cluster 2.4a - Disaster scenarios predictions and loss modelling
   Task 2.4a.1: Selection of case study sites
   Task 2.4a.2: Develop scenario earthquakes
   Task 2.4a.3: Develop building inventories
   Task 2.4a.4: Develop vulnerability data
   Task 2.4a.5: Adapt and develop loss modelling software
   Task 2.4a.6: Examination of uncertainty
   Task 2.4a.7: Definition and evaluation of mitigation actions, and dissemination
Cluster 2.4b - Disaster scenarios predictions and loss modelling for infrastructures
   Task 2.4b.1: Earthquake shaking scenarios
   Task 2.4b.2: Improved vulnerability functions
   Task 2.4b.3: Calibration of loss models
   Task 2.4b.4: Post earthquake operational analysis
EARTHQUAKE HAZARD – URBAN SEISMIC MICROZONATION

Earthquake hazard assessments, conducted in connection with risk analysis in urban centers can be conducted using probabilistic or deterministic approaches.

To obtain the probable losses in a given urban subdivision or geo-cell probabilistic approach would be appropriate.

Topics associated with the evaluation (probabilistic or deterministic) of ground motion involve consideration of:

- Earthquake Source Process
- De-aggregation of Probabilistic Hazard
- Empirical Attenuation Relationships
- Near Fault Effects (Radiation Pattern and Directivity)
- Site Response
- Analytical Simulation Procedures
Urban earthquake loss assessments have been traditionally linked to a (or set of) scenario earthquake in a deterministic manner.

The scenario earthquake can be assessed through de-aggregation of the probabilistic hazard to find the source that contributes most to the overall hazard.
The long-term seismicity of the Marmara region (Seismicity between 32 AD –1983 taken from Ambraseys and Finkel, 1991)
SOIL CLASSIFICATION (Istanbul)

BU

NEHRP-Based
INTENSITY DISTRIBUTION (Istanbul)

BU
Imax=IX

JICA
Imax=X
PGA DISTRIBUTION (Istanbul)

BU
A_{max} = 0.4g

Distribution of Peak Ground Acceleration: Model A

JICA
A_{max} = 0.6g
Intensity and PGA map for 1906 earthquake scenario (USGS)
BU - Distribution of Site-Dependent Spectral Accelerations (Istanbul)

SA (0.2s)

SA (1s)
LIQUEFACTION POTENTIAL (Istanbul)

Distribution of Liquefaction Potential: Model A

Legend

- Low Susceptibility
- Moderate Susceptibility
- High Susceptibility
- Rupture Scenario

Granular layers likely to have

- High Susceptibility
- Moderate Susceptibility
- Low Susceptibility

Return period

- 100 years
- 50 years
- 30 years

JICA

KOERI, 2001

THE STUDY ON A DISASTER PREVENTION/MITIGATION BASIC PLAN IN ISTANBUL INCLUDING SEISMO MICROZONATION IN THE REPUBLIC OF TURKEY

Source: JICA Study Team
This map is intended for planning use only. It is based on work by Wm. Lettis & Assoc. and USGS Susceptibility levels may be incorrect by one unit higher or lower. More detailed maps are needed for site development decisions. Hazard maps derived from this map are also available. A more detailed version of this map is available at http://quake.abag.ca.gov.
ELEMENTS AT RISK

Preparation of urban earthquake damage/loss scenarios encompass involve compilation of information on:

• Demographic structure for different times of the day;
• Building stock and its typification;
• Lifeline and infrastructure (major roads, railroads, bridges, overpasses, public transportation, power distribution, water, sewage, telephone, and natural gas distribution systems);
• and their nodal points (stations, pumps, switchyards, storage systems, transmission towers, treatment plants, airports, marine ports);
• Major and critical facilities (dams, power plants, major chemical and fuel storage tanks)

in the form of GIS databases.
A building inventory classification system groups buildings with similar damage/loss characteristics into a set of pre-defined building classes to commensurate with the relevant vulnerability relationship classes.

- Structural (system, height, and building practices),
- Nonstructural elements and
- Occupancy (residential, commercial, and governmental).

HAZUS (1999) the general building inventory includes residential, commercial, industrial, agricultural, religious, government, and educational buildings. 15 Basic Building Types

Building Types Based on ATC 13
- Wood, Steel, Concrete, Masonry

Further Categorizations
- Height, Design Level, Quality
Distribution of Building Types in Manhattan (New York Earthquake Risk)

<table>
<thead>
<tr>
<th>Age</th>
<th>Number</th>
<th>Pop./m²</th>
<th>Sq.Ft.</th>
<th>#Stories</th>
</tr>
</thead>
<tbody>
<tr>
<td>after 1990</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1915</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>before 1880</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AGE DISTRIBUTION
- after 1990
- 1960
- 1915
- before 1880

NUMBER DISTRIBUTION
- above 400
- 300
- 200
- below 100

POPULATION (per 1/4m²) AT 2AM
- above 15,000
- 8,000
- 4,000
- 1,000

SQUARE FOOTAGE (per 1/4m²)
- above 45,000
- 32,000
- 16,000
- 4,000

STORIES (per 1/4m²)
- above 30
- 20
- 10
- 2
Classification of Building Data (Istanbul)

✅ Structural systems category
   - I = 1: RC frame building
   - I = 2: Masonry building
   - I = 3: Shear wall building (Tunnel formwork system)
   - I = 4: Pre-fabricated building

✅ Number of building stories category
   - J = 1: 1 – 4 stories (including basement)
   - J = 2: 5 – 8 stories (including basement)
   - J = 3: > 8 stories (including basement)

✅ Construction Year category
   - K = 1: Construction year: pre-1979 (included)
   - K = 2: Construction year: post-1980
Distribution of all Buildings - Istanbul

kilometers

Marmara Sea

TOTAL
- 500 to 1,500
- 150 to 500
- 75 to 150
- 25 to 75
- 5 to 25
- 1 to 5

KOERI, 2002
Distribution of mid-rise R/C buildings (post-1980) Buildings - Istanbul
EARTHQUAKE VULNERABILITIES

Vulnerability functions (or fragility curves) of an element at risk represent the probability that its response to earthquake excitation exceeds its various performance limit states based on physical and socio-economic considerations. Vulnerability assessments are usually based on past earthquake damages (observed vulnerability) and on analytical investigations (predicted vulnerability). Primary physical vulnerabilities are associated with buildings, infrastructure and lifelines. Secondary physical vulnerabilities are associated with consequential damages and losses. Socio-economic vulnerabilities include casualties, social disruption and traumas and economic impacts.
Observed vulnerability (OV)

Advantages:
- Based on observed damage to actual building stock in area
- Takes account of real variety of failure modes
- Simple in concept and application to loss estimation – few assumptions

Limitations:
- Intensity measurement difficult when building stock is dynamic
- Does not fit with today’s engineering parameters of ground motion
- No real modelling of interaction between ground motion, soil and structure response
- Difficult to apply to new or modified building types
The damage distribution for mid-rise R/C frame buildings from 1999 Kocaeli earthquake (After A. Coburn, RMS).

The empirical vulnerability relationships for mid-rise R/C frame buildings obtained from 1999 Kocaeli earthquake damage distribution (After A. Coburn, RMS).
## European Macroseismic Scale

<table>
<thead>
<tr>
<th>Type of Structure</th>
<th>Vulnerability Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubble stone, fieldstone</td>
<td>A</td>
</tr>
<tr>
<td>Adobe (earth brick)</td>
<td>B</td>
</tr>
<tr>
<td>Simple stone</td>
<td>C</td>
</tr>
<tr>
<td>Massive stone</td>
<td>D</td>
</tr>
<tr>
<td>Reinforced, with manufactured stone units</td>
<td>E</td>
</tr>
<tr>
<td>Unreinforced, with RC floors</td>
<td>F</td>
</tr>
<tr>
<td>Masonry</td>
<td></td>
</tr>
<tr>
<td>Frame without earthquake-resistant design (ERD)</td>
<td>1</td>
</tr>
<tr>
<td>Frame with moderate level of ERD</td>
<td>2</td>
</tr>
<tr>
<td>Frame with high level of ERD</td>
<td>3</td>
</tr>
<tr>
<td>Walls without ERD</td>
<td>4</td>
</tr>
<tr>
<td>Walls with moderate level of ERD</td>
<td>5</td>
</tr>
<tr>
<td>Walls with high level of ERD</td>
<td>6</td>
</tr>
<tr>
<td>Wood reinforced concrete (RC)</td>
<td></td>
</tr>
<tr>
<td>Steel structures</td>
<td></td>
</tr>
<tr>
<td>Timber structures</td>
<td></td>
</tr>
</tbody>
</table>

- **Most likely vulnerability class:**
- **Probable range:**
- **Range of less probable, exceptional cases:**

### Classification of damage to buildings of reinforced concrete

- **Grade 1:** Negligible to slight damage
  - Light structural damage
  - Slight non-structural damage
  - Final cracks in plaster or frame members or in blocks at the base.
- **Grade 2:** Moderate damage
  - Damage to parts of the building.
  - Cracks in columns and beams of frame and in structural walls.
- **Grade 3:** Substantial to heavy damage
  - Damage to columns and beams, joints of frames at the base and at joints of coupled walls.
  - Spilling of concrete cover, breaking of reinforcement rods.
- **Grade 4:** Very heavy damage
  - Major cracks in partitions and infill walls, failure of individual infill panels.
- **Grade 5:** Destructive

### Damage level

<table>
<thead>
<tr>
<th>Damage level</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
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<tbody>
<tr>
<td>V</td>
<td>Few</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>Few</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>Many</td>
<td></td>
<td>Many</td>
<td>Few</td>
<td></td>
</tr>
<tr>
<td>VIII</td>
<td>Many</td>
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<td>Many</td>
<td>Few</td>
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<tr>
<td>IX</td>
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<tr>
<td>XI</td>
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</tr>
<tr>
<td>XII</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Empirical Intensity Based Vulnerability Relationships (Turkey)

**MSK-81 DAMAGE GRADES**
- Damage Grade: R/C Framed Building
- D1-Slight: Infill panels damaged
- D2-Moderate: Structural cracks < 1 mm
- D3-Heavy: Damage to structural members
- D4-Destruction: Failure of structure or major deflection
- D5-Collapse: Collapse of structural members and floor

1. **Low-Rise R/C (Including Masonry) Buildings (1-4 Stories)**
2. **Mid-Rise R/C Buildings (5-8 Stories)**
3. **High-Rise R/C Buildings (More than 8 Stories)**
Calculated vulnerability (CV)

Advantages:
- Relates to engineering ground motion
- Can be applied to building types not previously damaged
- Models interaction between ground motion, soil and structure response
- Avoids the use of intensity

Limitations
- Not based on damage data
- Not valid for buildings which fail in non-structural ways
- Complex structure – many assumptions
The diagram illustrates the relationship between ground motion parameters and damage states. The x-axis represents the ground motion parameter, while the y-axis indicates the damage state probability. The categories of damage are:

- **None**
- **Minor Shaking**
- **Slight Damage**
- **Moderate Damage**
- **Extensive Damage**
- **Complete Damage**
- **Pancake Collapse**

The curves show how the probability of each damage state increases with higher ground motion parameters.
HAZUS (1999) spectral displacement-based vulnerability and damage assessment methodology

Model Building Type
- Capacity Curve
- Fragility Curve

PESH - Spectral Response
- Reduced for Damping / Duration Effects

Cumulative PDS [Sd or Sa]

Structural

Non-structural Drift Sensitive

Non-structural Accel. Sensitive

Discrete PDS

Damage States: N - None, S - Slight, M - Moderate, E - Extensive, C - Complete
Spectral Displacement-Based Vulnerability Relationship for Mid-Rise Pre-1980 RC Buildings (Istanbul)

Spectral Displacement-Based Vulnerability Relationship for Mid-Rise Post-1980 RC Buildings (Istanbul)
LIHELINE VULNERABILITIES

Observations acquired from past urban earthquakes, supplemented by the worldwide experience can be used as a guide to assess their physical vulnerabilities.

An extensive compilation of lifeline vulnerability functions and estimates of time required to restore damaged facilities are provided in ATC-25, ATC-13 and HAZUS 1999.

FIRE FOLLOWING EARTHQUAKE AND HAZMAT RELEASE

Number of fires started initially
Density of combustible material available
Rate of spread
Ability of the fire fighting services
HAZUS

Vulnerability Relationships for Bridges and Tunnels

Fragility Curves for Conventionally Designed Major Bridges (HWB1).

Fragility Curves at Various Damage States for Bored/Drilled Tunnels Subject to Peak Ground Acceleration.
HAZUS
Vulnerability Relationships for Pipes and High Voltage Sub-Stations

Ground Shaking (Wave Propagation) Damage Model for Brittle Pipes

Fragility Curves for High Voltage Substations with Standard Components.
Casualty Vulnerabilities

Casualty vulnerabilities incorporate large uncertainties. Lethality ratios depend on:
- Population per building,
- Occupancy at the time of the earthquake,
- Occupants trapped by collapse,
- Mortality at collapse and,
- Mortality at post-collapse.
POPULATION

INVENTORY

Building type 1
....
....
....
....

Building type n

VULNERABILITY

Damage State 1
Damage State 2
Damage State 3
Damage State 4, with collapse
Damage State 4, without collapse

CASUALTY

Level 1
Level 2
Level 3
Level 4

Day time pop.
Night time pop.
## Lethality Rates (Turkey)

<table>
<thead>
<tr>
<th>Injury Severity</th>
<th>Casualty Rates for R/C structures (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Damage</td>
</tr>
<tr>
<td>Severity 1</td>
<td>0.05</td>
</tr>
<tr>
<td>Severity 2</td>
<td>0.005</td>
</tr>
<tr>
<td>Severity 3</td>
<td>0</td>
</tr>
<tr>
<td>Severity 4</td>
<td>0</td>
</tr>
</tbody>
</table>
Relationship between Number of deaths and Number of buildings damaged beyond repair
Casualty Relationships (Turkey)
SOCIO-ECONOMIC VULNERABILITIES

Losses due to collateral hazards and the indirect economic losses constitute a major portion of the total earthquake loss in an urban system.

Indirect economic losses arise from discontinued service of damaged facilities and include:

- Production and/or sales lost by firms in damaged buildings;
- Production and/or sales lost by firms unable to supplies from other damaged facilities;
- Production and/or sales lost by firms due to damaged lifelines;
- Losses arising from tax revenues and increased unemployment compensations.

Partial quantification of losses can be found in ATC-25 (1991).

Detailed economic models, practical rules need to be incorporated in the loss assessments for the evaluation of complex economic impacts.
KOERILoss estimation methodology (used for Istanbul Scenario)

- Building Damage Estimation based on Intensity and Spectral Displacement
- Direct Economic Loss Estimation
- Casualties

Software Essentials

- MapBasic Application
- Standard Windows Interface
- Fully Integrated with MapInfo
- Flexibility in Manipulating Display and Mapping
Intensity Based Loss Estimation Algorithm.

- Input Building Inventory Database for Geo-Cells
- Input Seismic Intensity database for Geo-Cells
- Input Intensity Based Vulnerabilities

Compute Building Damage Ratio for Each Building Types

Compute Number of Damaged Building for Each Building Types

Compute Direct Economic Loss for each Building Damage State

Compute Casualties for each Injury Groups

Casualties Losses for Geo-Cells, Sub-Districts, Districts
Economic Losses for Geo-Cells, Sub-Districts, Districts
Building Damage for Geo-Cells, Sub-Districts, Districts
Spectral Displacement Based Loss Estimation Algorithm.

1. Input Building Inventory Database for Geo-Cells
2. Input Spectral Accelerations database for Geo-Cells
3. Input Spectral Displacement Based Vulnerabilities

Input Capacity Curve for each Building Types

Compute Building Damage Ratio for Each Building Types

Compute Number of Damaged Building for Each Building Types

Input Economic Loss Data Parameters

Compute Direct Economic Loss for each Building Damage State

Input Demographic Database for Geo-Cells

Compute Casualties for each Injury Groups

Input Casualties Loss Data Parameters

Casualties Losses for Geo-Cells, Sub-Districts, Districts

Economic Losses for Geo-Cells, Sub-Districts, Districts

Building Damage for Geo-Cells, Sub-Districts, Districts
DAMAGE DISTRIBUTION
(Istanbul - Beyond Repair)

Number of Heavily Damaged Buildings: Model A

Legend
- Heavy Damage
- Moderate Damage
- Minor Damage
- No Damage

THE STUDY ON A DISASTER PREVENTION/MITIGATION BASIC PLAN IN ISTANBUL, INCLUDING SEISMIC MICROZONATION IN THE REPUBLIC OF TURKEY

Source: JICA Study Team
DISTRIBUTION OF LIVES
LOST (Istanbul)

Number of Dead People: Model A

JICA
CELLS WITH HIGH RISK OF CASUALTY - Istanbul
Damage scenario in Basel assuming an earthquake like the 1356 Basel earthquake with an Intensity of IX in the city (Fäh et al., 1999).
EMS-98 Loss Estimation
Mexico City
(Gomez-Bernal et al., 2006)
Building Losses

(New York Earthquake Risk)
Injuries

(New York Earthquake Risk)
Ratio Of Completely Damaged Buildings in Tashkent
For 2% Probability Of Exceedance In 50 Years
Expected Number Of Night-Time Deaths in Bishkek Per Grid Under Exposure To Earthquake With A 2% Probability Of Exceedance In 50 Years
RISKICG RESULTS: Oslo municipality example

One of the damage scenarios (moderate & complete) from the logic tree (Ambraseys et al. 1996 relationship + median capacity curve)
Disaggregation of the expected loss conditioned on $IM$, into the contribution of losses from collapse and non-collapse cases.

After Aslani and Mirenda, 2006
HIGH RISK BRIDGES
- Istanbul

BU

JICA
GAS SYSTEM - Istanbul

BU

JICA

NATURAL GAS PIPELINE

Site Dependent Deterministic
PGV (cm/s)

89 - 90
79 - 80
69 - 70
59 - 60
49 - 50
39 - 40
29 - 30
19 - 20

NATURAL GAS STATIONS
NATURAL GAS PIPE LINE

MARMARA SEA

Kilometers
Tele-Communication System - Istanbul
Hospital Functionality (New York Earthquake Risk)

M5
avg functionality 95%
BEDS
available: 9,300
needed: 0

M6
avg functionality 63%
BEDS
available: 6,100
needed: 200

M7
avg functionality 26%
BEDS
available: 2,000
needed: 2,900
Direct Economic Loss (Bay Area)

Direct Economic Losses for Buildings

Bay Area Risk Assessment
Magnitude 7.06 Earthquake
Rodgers Creek Fault
January 17, 2001

Total Building Loss in Thousands of Dollars
(By Occupancy for Census Tract)

- 0 - 9448
- 9449 - 27486
- 27487 - 67184
- 67185 - 153701
- 153702 - 361976

Cnty_dd.shp
Probable Maximum Losses (Building Damage only) in Istanbul
Assessment of Industrial Risk in Istanbul

Industrial inventory from
- 1:1000 Turkish Telecom Analog Maps (3000)
- Helicopter Flights (İBB)
- Site visits
- Satellite images

Data groups in 8 sectors:
- Mining, Construction, Ceramics, Glass
- Commercial facilities, Food and Beverage
- Textile, Leather
- Wood products, furniture, agriculture
- Chemical and petrochemical products
- Iron, steel and other metals
- Machinery and automotive
- Transportation and telecommunication
Iron, steel and other metals
ISTANBUL EARTHQUAKE RAPID RESPONSE STATIONS
Spectral displacements obtained from the SMS messages sent from stations are interpolated to determine the spectral displacement values at the center of each geo-cell (0.01° x 0.01°).

The seismic demand at the center of each geo-cell is computed using these spectral displacements.

Using the capacities of the buildings (24 types) in each geo-cell the building damage is computed by using the spectral-displacement based fragility curves (HAZUS Procedure).
Number of Collapsed Buildings per Cell (Simulated from random data and communicated to end users every day)
Communication of Rapid Response Message (Damage Maps)
(Mobile phones and PDA’s)
IMPROVEMENTS AND DEVELOPMENTS ARE NEEDED ON

- IMPROVEMENT OF HAZARD (Joint project with INGV)
- QUANTIFICATION OF UNCERTAINTIES
- IMPROVEMENT OF VULNERABILITIES (Structural, Non-structural, Socio-economic)
- TREATMENT FOR CULTURAL HERITAGE
- LOSSES ASSOCIATED WITH MICRO-ENTERPRISES
- INDIRECT LOSSES (Joint project with IIASA and CEDIM)
SIXTH FRAMEWORK PROGRAMME
Structuring the European Research Area Specific Programme
RESEARCH INFRASTRUCTURES ACTION

Contract for an
INTEGRATING ACTIVITY
 Implemented as
INTEGRATED INFRASTRUCTURE INITIATIVE (I3)

Annex 1 - “Description of Work”

Project acronym: NERIES
Project full title: Network of Research Infrastructures for European Seismology
JRA-3  Earthquake Loss Estimation  (1 Million EUROS)

Development of Earthquake Loss Estimation Routine – ELER = HAZ-EU

<table>
<thead>
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<th>JRA 3</th>
<th>Start month</th>
<th>End month</th>
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<td>Euro-Med Earthquake Loss Estimation</td>
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<tr>
<td>Participant short name</td>
<td>KOERI</td>
<td>IC</td>
<td>NORSAR</td>
</tr>
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</table>

Description of work:

Task-1: Evaluation of the existing tools on urban earthquake loss assessment.
Task-2: Development of “Earthquake Loss Estimation Routine (ELER)”.
  Task-2a – Earthquake shaking estimation .
  Task-2b – Earthquake Vulnerability
Task-3: Development of the ELER Software
Task-4: ELER Utilization/Applications

Resources:

Under the overall co-ordination of KOERI, the management of this JRA will be organized with different co-ordinators for each task according to the following scheme:

Task 1 Co-ordinator: IC ;
Task 2a Co-ordinator: NORSAR;
Task 2b Co-ordinator: KOERI;
Task 3 Co-ordinator: KOERI in cooperation with EUCENTRE
Task 4 Co-ordinator: EMSC
Other contributors to this JRA (ICC, DPC and ITSAK) will serve as sub-contractors
Earthquake Loss Estimation Routine (ELER)

ELER can be used either in real-time or in scenario mode. Improved real-time source parameters and an increasing number of online data streams will allow for much more rapid and reliable loss estimates.

Earthquake shaking estimation

- For post-earthquake applications, find the most likely location of the source of the earthquake using regional seismo-tectonic data-base, supported, if and when possible, by the estimation of fault rupture parameters from rapid inversion of data from on-line regional broadband stations.

- Estimate the spatial distribution of spectral amplitudes at engineering bedrock. Region-specific ground motion attenuation relationships and actual physical simulation of ground motion will be used.

- Estimate the spatial distribution of site-specific spectral amplitudes using regional-geology (or urban geotechnical information) data-base using spectral amplification models and sophisticated mathematical simulations, pending the availability of data.

- Correlate/verify/enrich the estimated spectral amplitudes with the available on-line strong motion data.
END OF PRESENTATION

THANK YOU