MIRISK

Mitigation Information and Risk Identification System
outline

• Brief Introduction
• MIRISK Purpose and Objectives
• MIRISK Structure and Data
• Demonstration
• Caveats and areas for Improvement
Kyoto University

10 Faculties
16 Graduate Schools
13 Research Institutes,
21 Research Centers.

Disaster Prevention Research Institute
Kyoto University

1 Yoshida Campus
2 Uji Campus
3 Katsura Campus

Research Laboratory for Lifeline Engineering / Earthquake Disaster Prevention Systems
Department of Urban Management, Kyoto University
C. Scawthorn, 2007
Project Management

Kyoto University Core Management Group
- Charles Scawthorn, Professor, Department of Urban Management
- Rajib K. Shaw, Associate Professor, Graduate School of Global Environmental Studies
- Junji Kiyono, Associate Professor, Department of Urban Management
- Norio Okada, Professor, Department of Urban Management
- Kiyoshi Kobayashi, Professor, Department of Urban Management

Methods / Programming Group
- C. Scawthorn
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- T. Tsutsumiuchi
- K. Porter – internal QA

External Review
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- S.K. Jain – IIT (India)

World Bank
GFDRR
S. Jha

Japan Consultant Trust Fund

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Purpose of MIRISK

• To provide a user friendly computer-based tool to aid World Bank users in decision making

• To increase awareness and provide guidance for Natural Hazards risk analysis and mitigation
MIRISK Objectives

• Provide information for Natural Hazards design guidelines, norms and good practices – a reference tool for use by task managers

• Enable assessment of infrastructure risk and vulnerability of damage and losses in past disasters

• Develop a user-friendly tool for risk assessment of critical infrastructure

• Within a non-proprietary software package subscribing to the AGORA framework
AGORA
Alliance for Global Open Risk Analysis

AGORA Mission

• promote and coordinate open risk analysis of natural and technological hazards,

• development of open-source risk software and methodologies to perform end-to-end risk modeling.

End-to-end refers to the modeling of hazardous events and their impacts, from the event occurrence through site effects, physical damage to the built environment, to economic and human impacts.

AGORA Members Institutions

• California Institute of Technology
• Cambridge University (UK)
• Extreme Situations Research Center (Moscow)
• Imperial College (London)
• Kandili Observatory (Bogazici University, Istanbul)
• Kyoto University (Japan)
• Lloyd’s of London
• Mid-America Earthquake Center – MAE
• NEES - Network for Earthquake Engineering Simulation
• Russian Academy of Sciences
• Southern California Earthquake Center
• SPA Risk LLC
• University of California, Berkeley
• University of Pavia (Italy)
• US Geological Survey
• Virginia Tech (USA)

WWW-RISK-AGORA.ORG
Uses of MIRISK

• Determine what hazards might potentially impact a region?
• What impacts might these hazards have on a specific project?
• Quantitatively assess direct impacts
• Quantitatively assess indirect impacts
• Determined what sorts of structural, locational, operational and risk transfer alternatives are available to reduce the direct and indirect impacts?
• Determine which of the available alternatives are most cost-beneficial?
• What are the design parameters and best practices to actualize these alternatives within the overall project?
MIRISK Structure

GIS SYSTEM
- Mapserver, Mapscript
- PostGIS

Central DB
- PostgreSQL

Scripting
- PHP, JpGraph, HTML, Javascript

Web Server
- Apache

GUI
- Web Browser

USER

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Geographical Information System

PURPOSE: To provide a user-friendly GUI for:

- Selecting the location of a potential project worldwide
- Visualize natural hazards at the project location
- Provide other useful geographical information to the user

CAPABILITIES:

- Zoom in/out, pan
- Turn on/off hazard layers
- Mark project locations and extract information such as hazard intensities, co-ordinates, etc.
The client requests a map from the server. The mapserver processes the request from the server, generates an image map using mapfiles and returns the image to the server to be delivered to the client.

DATA SOURCES
- Raster images
- Vector images (shapefiles)
- PostGIS Database
- Remote Source
GIS: Mapserver Datasources
Raster image

Image from NASA earth observatory
Gazeteer

• Search and find 1000s town and cities
GIS: Mapserver Datasources

Vector images (shapefiles)

• ESRI shapefiles
  – Boundaries
  – Map grid
  – Gazetteer

• Hazard data
  (from Global Hotspots* and other data)
  – Earthquake
  – Tropical Cyclone
  – Flood
  – Volcanoes
    (Hotspots and Global Volcanic data)

Global Hotspots

- 2005 assessment of natural disaster risk
- innovative, high impact – first such global analysis
- employed ‘off-the-shelf’ data
- “1st order” analysis – “crude” (authors’ term)
- data freely available

Global distribution of flood mortality risk

GIS: Mapserver Datasources

Earthquake shapefile details

- **Parameter:** Expected pga $> 2 \text{ m/s}^2$, 10% probability of exceedance in 50 years.
- **Data Source:** Global Seismic Hazard Program (GSHAP).
- **Resolution:** 1 minute grid.
- **Classification:** Into deciles.
GIS: Mapserver Datasources

Tropical Cyclone shapefile details

- **Parameter**: Frequency by wind strength (based on storm track data and wind speeds)
- **Data Source**: UNEP/GRID-Geneva Preview
- **Resolution**: 30 seconds grid.
- **Classification**: Into deciles.
GIS: Mapserver Datasources
Flood shapefile details

- **Parameter:** Counts of extreme flood events
- **Data Source:** Dartmouth Flood Observatory, Atlas of Large Flood Events
- **Resolution:** 1 minute grid.
- **Classification:** Into deciles.
GIS: Mapserver Datasources
Volcanic Hazard shapefile details

- **Parameter:** Counts of volcanic activity
- **Data Source:** UNEP/GRID-Geneva and NGDC
- **Resolution:** 2.5 degree grid.
- **Classification:** Into deciles.
GIS: Mapserver Datasources
Volcano data shapefile details

- **Parameter:** Basic geographic and geologic information for volcanoes that are active during the last 10000 years.
- **Data Source:** Global Volcanism Program
- **Number of Volcanoes:** 1546.
Central Database

- Stores and processes all data of MIRISK, including text, raster images and vector images.
- Built using:
  - Postgre SQL* – Open Source relational DB
  - PostGIS – Extension to Postgre SQL for dealing with GIS

* Postgre SQL info at: http://www.postgresql.org/about/
Central Database

**USER**
- Locational Data
- Asset Data
- Additional Data

**Project Table**
- Project ID
- Geometry
- Hazard
  - Frequency
- gid
- Asset Category
- Asset Class
- K Factor
- Asset Value
- B/C Ratio
- Study ID
- Project Name
- pga
Client-server relation
Scripting / Programming

- GUI is created using HTML, Javascript and PHP
- Part of the GIS system utilizes PHP
- The analysis module uses PHP and JpGraph

![Diagram of GUI creation using HTML, Javascript, and PHP]
Analytical Framework

• Loss Estimation Methodology

• Benefit-cost analysis
Loss Estimation Methodology

Objective: To provide a quantitative estimate of incremental cost given project design level, cost of repair, duration of disruption, and benefit cost.

Loss Metric: Expected Annual Loss (EAL), i.e. the average loss per year due to the occurrence of a natural hazard.

Assumptions

- Loss is estimated for a specified design level
- A specified type of hazard $H$ is considered
- Loss $L = f(H) = kH$
- The hazard curve follows the Ishimoto-Iida relationship $[P(H) = a \exp (bH)]$
- Total damage is defined as direct damage plus indirect damage
- Direct damage is given by the construction cost times the EAL $[EAL = \text{Expected Annual Loss} = \sum PV(L|D) p(D|H) p(H) \text{ for all future losses}]$
- Indirect cost is given by the direct damage times the benefits to cost ratio (BCR) of the project
## Typical K values

<table>
<thead>
<tr>
<th>Asset Type</th>
<th>k</th>
<th>Asset Type</th>
<th>k</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Buildings</strong></td>
<td></td>
<td><strong>Utilities and Industry</strong></td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>0.20</td>
<td>Chimneys</td>
<td>0.30</td>
</tr>
<tr>
<td>Light Metal</td>
<td>0.15</td>
<td>Cranes</td>
<td>0.30</td>
</tr>
<tr>
<td>LR RM or RC</td>
<td>0.25</td>
<td>Conveyor Systems</td>
<td>0.20</td>
</tr>
<tr>
<td>MR RM or RC</td>
<td>0.30</td>
<td>Elect. T&amp;D</td>
<td>0.10</td>
</tr>
<tr>
<td>HR RM or RC</td>
<td>0.40</td>
<td>Elect. Substations (&gt;100kv)</td>
<td>0.20</td>
</tr>
<tr>
<td>LR Steel</td>
<td>0.20</td>
<td>Towers (Non-electrical T&amp;D)</td>
<td>0.15</td>
</tr>
<tr>
<td>MR Steel</td>
<td>0.25</td>
<td>Tanks Underground</td>
<td>0.10</td>
</tr>
<tr>
<td>HR Steel</td>
<td>0.30</td>
<td>Tanks &amp; Basins on Ground</td>
<td>0.20</td>
</tr>
<tr>
<td>RC Panel and Precast</td>
<td>0.40</td>
<td>Tanks Elevated</td>
<td>0.40</td>
</tr>
<tr>
<td>URM or Stone or Earthen Walled</td>
<td>0.70</td>
<td>Equipment (Electrical)</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>0.30</td>
<td>Equipment (Mechanical)</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Transportation</strong></td>
<td></td>
<td>Equipment (Other)</td>
<td>0.40</td>
</tr>
<tr>
<td>Bridges (Conventional)</td>
<td>0.50</td>
<td>Treatment Plants &amp; Process Facilities</td>
<td>0.30</td>
</tr>
<tr>
<td>Bridges (Major, Engineered, L&gt;100m)</td>
<td>0.10</td>
<td>Pipelines (Ordinary Soil)</td>
<td>0.05</td>
</tr>
<tr>
<td>Tunnels</td>
<td>0.10</td>
<td>Pipelines (Liquefiable Soil)</td>
<td>0.20</td>
</tr>
<tr>
<td>Railroad (Roadbed)</td>
<td>0.15</td>
<td>Concrete Dams</td>
<td>0.10</td>
</tr>
<tr>
<td>Highway (Roadbed)</td>
<td>0.10</td>
<td>Earthfill &amp; Rockfill Dams</td>
<td>0.15</td>
</tr>
<tr>
<td>Runways</td>
<td>0.20</td>
<td>Canals</td>
<td>0.20</td>
</tr>
<tr>
<td>Waterfront Structures</td>
<td>0.25</td>
<td>Earth Retaining Structures (&gt;6m High)</td>
<td>0.20</td>
</tr>
<tr>
<td>Vehicles (Trains, Trucks, Airplanes, etc)</td>
<td>0.15</td>
<td><strong>Average</strong></td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>0.20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Loss Estimation Methodology

\[ L(A) = kA \]

\[ p(A) = \frac{d}{dA} (1 - P_E) = \frac{d}{dA} (1 - e^{a=bA}) = be^{a=bA} \]

\[ EAL = \int_{-\infty}^{+\infty} L(A)p(A)dA = \int_{-\infty}^{+\infty} kAp(A)dA = \frac{e^{a}k}{b}[1 - e^{-b}(b+1)] \]

Asset Lifecycle Loss: \[ L_t = \frac{EAL}{r} \]
Benefit-Cost Analysis

Objective: Determine most cost-effective project design level considering natural hazard impacts

Procedure
- Derive EAL for base design level
- Total cost for each design level = initial construction cost + EAL* project
- BCR Optimum design level = minimum total cost
MIRISK Demonstration
MIRISK
Mitigation Information and Risk Identification System

STUDY DATA
General info about the study goes HERE!

Choose Study

2 study data is now saved.

choose study

hospital project

Go!

New Study Data Input (or load previous study)

Study ID (the serial number, used as index): 1

Study name: hospital

Study date (to begin): 2007-02-07

Study deadline (supposed): 2008-02-07

District (country, province, city... each level is OK): Turkmenistan

Study components (i.e. projects): 10

Team members: World

Team leader: World

Other notes:

ok

delete
WORLD MAP

Location and Hazard Data

Legend

- [metadata name=DESCRIPTION]
- Volcano data
- Gaz
- Earthquake hazard (PGA)
  - PGA LV1
  - PGA LV2
  - PGA LV3
  - PGA LV4
  - PGA LV5
  - PGA LV6
  - PGA LV7
  - PGA LV8
  - PGA LV9
  - PGA LV10
- Cyclone hazard

Pan
Zoom In
### ASSET DATA

**Asset information!**

#### Asset Taxonomy and Class

<table>
<thead>
<tr>
<th>Asset Category</th>
<th>Asset value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings</td>
<td></td>
</tr>
</tbody>
</table>

**Category class**

- Wood

**PGA-MDF Relation for Wood Buildings**

- Benefit/Cost rate

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Description

Wood is a very common building type, with many variations:

**Heavy timber** frame buildings with brick, stone or wattle-and-daub wall infill. This is a common building type in older societies and developing economies where wood is plentiful. Its performance is discussed under Masonry buildings.

**Light wood framing** with matting, thatching and other coverings. This is
Typical seismic damage, and seismic performance

Light wood framing generally performs well in earthquakes – failure of connections and collapse is the major weakness, as well as deteriorated condition.

Stud wall framing buildings have performed very well in past earthquakes due to inherent qualities of the structural system and because they are lightweight and low rise. From a seismic perspective, this is a preferred...
Seismic resistant design

The essence of earthquake resistant design is a continuous load path from the roof to the ground, which requires good connections between members. Such connections, especially able to transmit tension, can be difficult to understand and achieve for unskilled workers. Therefore, some involvement of skilled crafts (i.e., experienced carpenters) and supervision is preferred. Lateral bracing of wood walls, via diagonal braces, or sheathing (e.g., plywood) and good connection details are essential. Nailing patterns and detailing must be thought through and, if so, can easily achieve economical design. Combination of these factors allows the attainment of...
ANALYSIS

Choose the study and project you want to get result!

study: hospital project  project: hospital1

display the output  get the graph

Result of Analysis

85000
80000
75000
70000
65000
60000
Result of Analysis

- Construction cost (based on normal code)
- Expected loss by earthquake
- Total cost (based on normal code)

Cost ($)

Design Code Increment

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### Project information on hospital1

<table>
<thead>
<tr>
<th>study id</th>
<th>project id</th>
<th>project name</th>
<th>Long-Lat geometry</th>
<th>EQ frequency</th>
<th>HR frequency</th>
<th>FL frequency</th>
<th>VL frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>37</td>
<td>hospital1</td>
<td>59.38.2</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Asset category</th>
<th>Category Class</th>
<th>Asset value</th>
<th>B/C rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings</td>
<td>MR</td>
<td>1000000</td>
<td>6</td>
</tr>
</tbody>
</table>

### Output table of EQ Analysis

<table>
<thead>
<tr>
<th>Code (normal)</th>
<th>Construction cost (asset value)</th>
<th>Δ (Construction cost)</th>
<th>Benefit</th>
<th>Direct Loss</th>
<th>Indirect Loss</th>
<th>Total Loss</th>
<th>Total cost (Based on normal code)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code*1.05</td>
<td>1005000</td>
<td>5000</td>
<td>6000000</td>
<td>7100.2663664</td>
<td>42601.5981984</td>
<td>49701.8645648</td>
<td>49701.8645648</td>
</tr>
<tr>
<td>Code*1.1</td>
<td>1011000</td>
<td>11000</td>
<td>6000000</td>
<td>5041.18912014</td>
<td>30247.1347209</td>
<td>35288.323841</td>
<td>46288.323841</td>
</tr>
<tr>
<td>Code*1.15</td>
<td>1018000</td>
<td>18000</td>
<td>6000000</td>
<td>4260.15981984</td>
<td>25560.95891909</td>
<td>29821.1187389</td>
<td>47821.1187389</td>
</tr>
<tr>
<td>Code*1.20</td>
<td>1026000</td>
<td>26000</td>
<td>6000000</td>
<td>3692.13851053</td>
<td>22152.8310632</td>
<td>25844.9695737</td>
<td>51844.9695737</td>
</tr>
<tr>
<td>Code*1.25</td>
<td>1037000</td>
<td>37000</td>
<td>6000000</td>
<td>3195.1198648</td>
<td>19170.71191893</td>
<td>22365.8390542</td>
<td>59365.8390542</td>
</tr>
<tr>
<td>Code*1.30</td>
<td>1050000</td>
<td>50000</td>
<td>6000000</td>
<td>2769.10388289</td>
<td>16614.6232974</td>
<td>19383.7271803</td>
<td>89383.7271803</td>
</tr>
<tr>
<td>Code*1.35</td>
<td>1065000</td>
<td>65000</td>
<td>6000000</td>
<td>2343.08790091</td>
<td>14058.5274055</td>
<td>16401.6153064</td>
<td>31401.6153064</td>
</tr>
</tbody>
</table>
Caveats

Many improvements are possible:

- more detailed assets classes and information
- more detailed hazards data
- better vulnerability functions
- other hazards (landslides, tsunami, drought….)
- more sophisticated consideration of natural hazards impacts on Bank projects
- more sophisticated and alternative economic analyses
- additional scripting (eg, automated ‘what-ifs’)
- multi-hazard multi-criteria analysis and decision-making (currently only single hazard analysis)
- integration with other Bank tools
More Caveats

Other issues:

• integrate other factors (sustainability, energy efficiency…)
• incorporate national design standards
• beta-testing
• how best to deploy and support
• training
• feedback and MIRISK experience-based enhancement
Thank you