



The Use of HAZUS for Earthquake Scenarios

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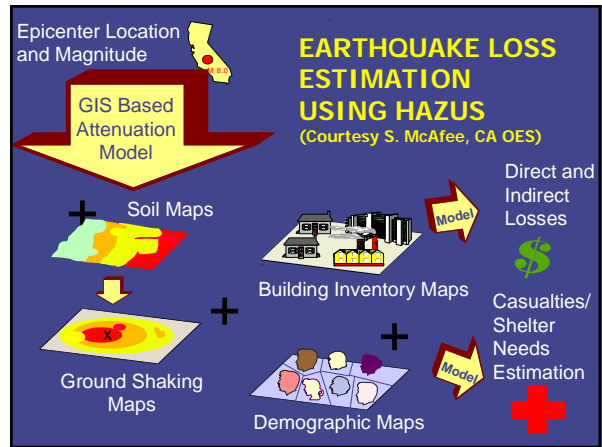
Presentation Overview

- Very brief HAZUS overview
- Examples of HAZUS use in previous scenarios
- Strategies for improving HAZUS results
- HAZUS resources




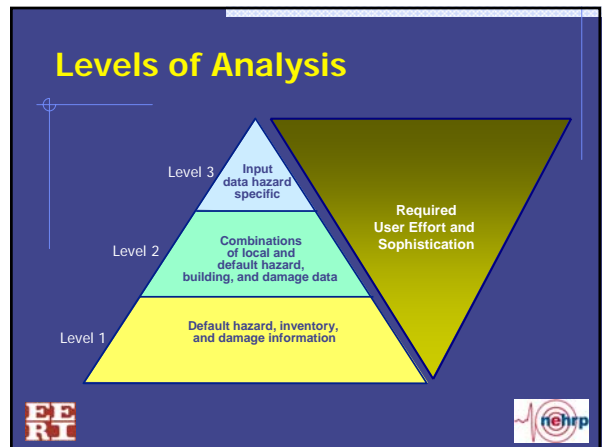
Overview of HAZUS (Hazards US) Software

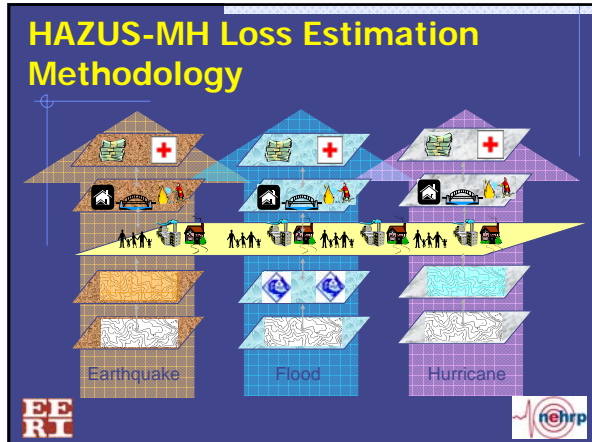
- Standardized, nationally applicable earthquake, flood and wind loss estimation methodologies.
- Developed by FEMA, under a cooperative agreement with NIBS (see <http://nibs.org/hazusweb/> and <http://www.fema.gov/plan/prevent/hazus/>).
- Uses PC-based Geographic Information System (GIS) software, ArcGIS (Requires installation of ArcGIS 9.2, Service Pack 5, and Spatial Analyst for flood modeling)
- HAZUS is distributed to users free of charge.
- Most recent release – HAZUS-MH MR-3 (9/2007), Patch 2 (8/2008)

HAZUS-MH Outputs

	Earthquake Ground Shaking Ground Failure	Flood Frequency Depth Discharge Velocity	Hurricane Wind Pressure Missile Rain
Direct Damage			
General Building Stock	✓	✓	✓
Essential Facilities	✓	✓	✓
High Potential Loss Facilities	✓	✓	✓
Transportation Systems	✓	✓	✓
Utility Systems	✓	✓	✓
Induced Damage			
Fire Following	✓	✓	✓
Hazardous Materials Release	✓	✓	✓
Debris Generation	✓	✓	✓
Direct Losses			
Cost of Repair	✓	✓	✓
Income Loss	✓	✓	✓
Crop Damage	✓	✓	✓
Casualties	✓	Generic Output	✓
Shelter Needs	✓	✓	✓
Indirect Losses			
Supply Shortages	✓	✓	✓
Sales Decline	✓	✓	✓
Opportunity Costs	✓	✓	✓
Economic Loss	✓	✓	✓



HAZUS-MH Default Inventory Data

Default inventory data includes:

- ◆ “General building stock” - proxy representation of all buildings in the U.S.
- ◆ Essential facilities* – hospitals, schools, etc.
- ◆ Transportation lifelines* – highway, railway, etc.
- ◆ Utility Lifelines* – water, power, gas, etc.
- ◆ Demographics
- ◆ Economic values

* In some cases, default data may be limited or unavailable

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Building Inventory Data in HAZUS

- ◆ Exposure data: total building square footage & dollars, by occupancy (33), and census tract for entire US. (→ proxy data)

- Mapping scheme data: for each occupancy, provides a % distribution across structural or “model building” types. → ~Based on ATC-13 profiles.

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Data Improvement Strategies

- ◆ Custom ground motions (→ USGS, State Geological Survey, local universities, etc.)
- ◆ Update Inventory Databases:
 - General Building Stock – aggregate data on building count, square footage and \$ by census tract (→ Assessor’s data)
 - Essential Facilities
- ◆ Mapping Schemes (→ Structural Engineering expertise)

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Selected HAZUS Scenario Applications & Improvements

SCENARIO EFFORT	IMPROVEMENTS
Seattle EQ Scenario	Custom ground motions; HAZUS baseline results: Some analyses conducted outside HAZUS (e.g., transportation, utilities) http://seattlehazus.scrc.org/documents.php
Puente Hills EQ Scenario	Custom ground motions (multiple representations); default HAZUS configuration http://www.scec.org/research/050525puentehills.html
1906 EQ Scenario	Custom ground motions; improved “Mapping Schemes” for 19 County Area calibrated using available detailed data, casualties adjustment, narrative impact assessment for selected utilities. http://www.1906eqconf.org/mediadocs/BigonestrikesReport.pdf
“ShakeOut” Scenario	Custom ground motions & hazard data (exposure-weighted); Inventory data replaced for Los Angeles County; Improved “Mapping Schemes” for all 8 counties; custom shelter parameters; results summarized by City & County. Additional analyses conducted outside of HAZUS (e.g., FFE, steel buildings, utilities, transportation), or using HAZUS outputs as inputs (e.g., IEL, casualties) http://pubs.usgs.gov/of/2008/1150
Essential Facilities Risk Assessment Projects (EQ & Flood) – Orange, Riverside, & San Bernardino Counties	ShakeMap scenario ground motions; Updated inventories being collected for essential facilities (Police, Fire, EOC, hospitals & schools); Available assessor’s data being used to develop replacement inventory databases.

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Data Improvement – Inventory Data (GBS)

- ◆ Replace default inventory data (SQFT, \$) using real-world data (e.g., Assessor’s data). Can be time-consuming, expensive.
- ◆ Guidelines & Tools have been developed for OES to help users. Tested for LA (2.3M records) and SLO (105k records) Counties.

Available on-line at:
http://www.hazus.org/CAHUG/OES_Guidlines.htm

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Los Angeles County - Comparison to HAZUS default

Difference Between Assessor's Data And HAZUS Default Data (Relative To Assessor's Data)

General Occupancy	# Bldgs (MR-2)	Sq. Ft. (MR-2)	Sq. Ft. (MR-3)
Residential	18%	6%	6%
Commercial	-68%	-46%	-41%
Industrial	-81%	-55%	-40%
All Occupancies	10%	-13%	-10%

→ Lesson Learned: HAZUS default data may underestimate non-residential exposure (sq ft) in large, urban counties.



San Luis Obispo County - Comparison to HAZUS default

Difference Between Assessor's Data And HAZUS MR-2 Default Data (Relative To Assessor's Data)

General Occupancy	Number of Buildings (MR-2)	Square Footage (MR-2)
Residential	29%	28%
Commercial	-76%	240%
Industrial	18%	1725%
All Occupancies	23%	42%

→ Lesson Learned: HAZUS default data may overestimate exposure (sq ft) in smaller, less urban counties.



Improvement of HAZUS EQ Loss Estimates: 2003 San Simeon EQ

Loss Comparison (Relative to Observed Losses)	Economic Losses - Building Damage	Total Direct Economic Losses
Default HAZUS Analysis (MR-2)	Overestimated by ~73%	Overestimated by 50%
HAZUS Analysis w/ "Enhanced Inventory Data"	within 20%	within 3%

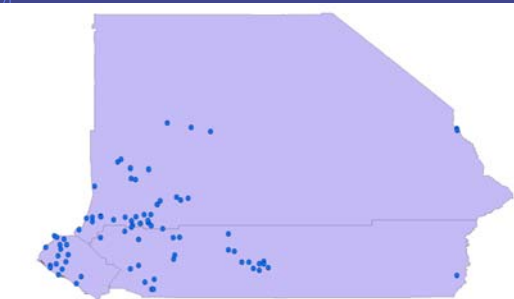


Data Improvement – Inventory Data (Essential Fac.)

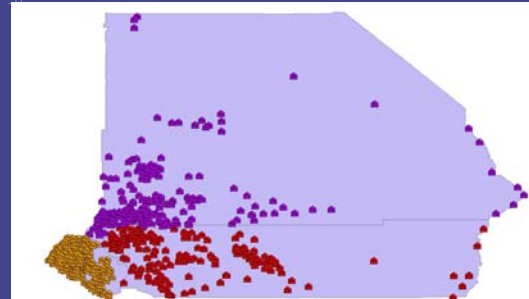
- ◆ Default data limited in scope (e.g., does not include all facilities)
- ◆ Default data assumes default/typical configuration (e.g., W2, MC).
- ◆ Default replacement values may underestimate current value
- ◆ May represent multi-building campus' as a single typical building
- ◆ Challenge – no single data source



Default Fire Station Data (83 Total)



Updated Fire Station Data (483 Total)



School Data Collection

- ◆ Issue: default data for Schools represents entire campus as a single building – assumed uniform performance.
- ◆ Building-specific data generally available within school insurance appraisal reports, including:
 - School district, School name, School location
 - Building name
 - Basic construction class (including portables)
 - Year Built, number of stories, basement
 - Building square footage/floor area
 - Building & content replacement value



Example OC District - Detailed Data Compared to HAZUS Default

	School Appraisal Data	HAZUS Default
# School Sites	57	50
# Buildings	1109	Individual building data not included (<i>Each school campus treated as a single "building"</i>)
Building Area (sq ft)	4.45 Million	No Data
Building Value	\$626.9 Million	\$29.5 Million
Contents Value	\$83.6 Million	Not included
Enrollment	57,346	57,994
Year Built	1932 – 2006 Median = 1991	No Data
# Portable Buildings	706 (64%) Typ. 960 SF, \$72,000 bldg	No Data



School Data Collection

School data collection for FEMA-funded Essential Facilities Risk Assessment Pilot Studies has been very successful:

County	# Districts	# Buildings	Building Value
Orange	15 (of 28)	5,412 (24 MSF)	\$3.5 billion
Riverside	All 23 public school districts + 4 community college districts	>10,000 (>38 MSF)	>\$6 billion
San Bernardino	All 33 public school districts + 3 CCDs	>11,000 buildings	>\$5.9 billion



HAZUS Mapping Schemes

- ◆ Mapping schemes provide the percent distribution of square footage among various structural or "model building types" for each specific occupancy class.
- ◆ → Default scheme for each seismic zone, vary by region of the U.S. (i.e., east coast, mid-west and west coast)
- ◆ → Default construction is all low-rise
- ◆ IMPROVEMENT REQUIRES STRUCTURAL ENGR EXPERTISE.

MBT	Height	Description
W1	Low	Wood Light Frame (< 5,000 sq. ft.)
W2	Low	Wood, Commercial and Industrial (>5,000 sq. ft.)
S1M	Mid	Steel Moment Frame
S1H	High	
S2	Low	Steel Braced Frame
S2U	Mid	
S2H	High	
S3	Low	Steel Light Frame
S4L	Low	Steel Frame with Cast-in-Place Concrete Shear Walls
S4M	Mid	
S4H	High	
S5	Low	Steel Frame with Unreinforced Masonry Infill Walls
S5M	Mid	
S5H	High	
S6L	Low	
C1M	Mid	Concrete Moment Frame
C1H	High	
C2	Low	Concrete Shear Walls
C2M	Mid	
C2H	High	
C3L	Low	Concrete Frame with Unreinforced Masonry Infill Walls
C3M	Mid	
C3H	High	
PC1	Low	Precast Concrete Tilt-Up Walls
PC2	Low	Precast Concrete Frames with Concrete Shear Walls
PC2M	Mid	
PC2H	High	
RM2L	Low	Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms
RM2M	Mid	
RM2H	High	
UR2L	Low	Unreinforced Masonry Bearing Walls with Precast Concrete Diaphragms
UR2M	Mid	
UR2H	High	
UR3L	Low	Unreinforced Masonry Bearing Walls
UR3M	Mid	
UR3H	High	
MB	Low	Mobile Homes



Data Improvement – Mapping Schemes: 1906 Scenario

- ◆ Custom mapping schemes developed for 11 different mixes of building age & height. Assigned using available building density and construction age data.
- ◆ Custom adjustments to reflect specific conditions in individual counties & knowledge of local mitigation (e.g., URM).



Data Improvement – Mapping Schemes: ShakeOut

- ◆ Incorporating local structural engineering input & expertise, 24 custom mapping schemes were developed reflecting:
 - Distribution of Building Heights: urban core (e.g., inc high-rise) vs. non-urban core (low- & mid-rise only), applied based on density of construction
 - Age: three age "mixes" reflecting varying age and design levels, applied based on median year built of census tracts
 - URM: calibrated mapping schemes to approximate amount of URM present in each County and % mitigated (as documented by Ca. Seismic Safety Commission Survey, 2006)



"After-Market" Tools – USAR Needs Calculator

Table courtesy of Doug Bausch

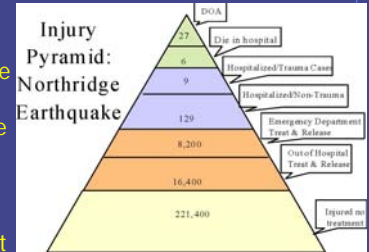
URBAN SEARCH & RESCUE GAP ANALYSIS-Mw 7.0 SALT LAKE SEGMENT		
Resource	Metric	Required
Total number of USAR Type I Task Forces required? (Approximately 70 members, trained & equipped for light frame, heavy wall, heavy floor and concrete-steel construction (heavy reinforced concrete)).	Number of: Task Forces Trained Personnel	11 770
Total number of USAR Type II Task Forces required? (Approximately 32 members, trained & equipped for light frame, heavy wall, heavy floor and concrete-steel construction.)	Number of: Task Forces Trained Personnel	3 210
Total number of Collapse S&R Type III Teams required? (Approximately 22 members, trained & equipped for light frame construction.)	Number of: Teams Trained Personnel	261 18,270
Total number of Collapse S&R Type IV Teams required? (Approximately 6 members, trained & equipped for light frame construction.)	Number of: Teams Trained Personnel	15 1,050

- ◆ Uses HAZUS outputs to estimate USAR team needs
- ◆ Spreadsheet based
- ◆ Developed by FEMA (Doug Bausch).



"After-Market" Tools – Casualty Calibration

- ◆ Northridge EQ casualty data used to determine casualty estimates in more medically meaningful categories.



- ◆ Used in ShakeOut Scenario



Developed in Conjunction with the UCLA Center for Public Health & Disasters



FEMA Resources

- ◆ HAZUS-MH Overview, Ordering Information
- ◆ Resource Materials
- ◆ Conference/Training Information
- ◆ FAQs
- ◆ *Note: Patch 2 and CDMS are now available...*



<http://www.fema.gov/plan/prevent/hazus/index.shtml>



HAZUS-MH Online

(slide courtesy of Jamie Caplan)

- ◆ Web-based Resources
 - FEMA.gov www.fema.gov/plan/prevent/hazus
 - National Institute for Building Sciences www.nibs.org
 - USEHAZUS www.usehazus.com
 - www.hazus.org
 - HAZUSNET-USA Listserve www.nesec.org
- ◆ Email Help
 - General HAZUS Questions HAZUSGenHelp@nibs.org
 - Earthquake hazusquakehelp@pbsj.com
 - User Groups hazususergrouphelp@jamiecaplan.com



HAZUS User Groups (HUGs)

- Facilitate training
- Data collection
- Sharing resources



HAZUS-MH Education

(slide courtesy of Jamie Caplan)

- ◆ FEMA's Emergency Management Institute
- ◆ ESRI Online Training Courses and Podcasts
- ◆ Regional Courses
- ◆ Trainers
 - ▶ Sanctioned by FEMA
 - ▶ Able to modify and customize course materials
- ◆ Introduction to Using HAZUS-MH for Decision Makers—Free
- ◆ Introduction to Using HAZUS-MH to Assess Losses from a Riverine Flood Hazard
- ◆ HAZUS-MH Flood Model Output and Applications
- ◆ Integrating User-Supplied Hazard Data into the HAZUS-MH Flood Model
- ◆ Introduction to Using HAZUS-MH for Hurricane Loss Estimation
- ◆ Introduction to Using HAZUS-MH for Earthquake Loss Estimation



To learn more about these courses and to enroll, visit www.esri.com/hazusmhtraining.



Questions?

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