Tips and Tricks for Customizing

HAZUS® MH (Hazards U.S.-Multihazard)

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ABSTRACT

HAZUS is a widely used loss estimation software developed for the Federal Emergency Management Agency (FEMA) under a cooperative agreement with the National Institute of Building Sciences (NIBS). The most recent version, HAZUS®MH incorporates several fundamental changes, for example: the capability to assess the impacts of flooding and hurricanes, which expands usefulness significantly, an ArcObjects GIS component integrates hydraulic analysis into a development environment, and attribute data storage in MSDE databases. Each change presents new challenges and opportunities for updating the underlying data and customizing assumptions for a specific area, which greatly improves the accuracy of results. This paper will review several methods to update HAZUS®MH base data and assumptions, including integrating publicly available data; using remote sensing data; evaluating default replacement costs; and making sure the data makes sense geographically.

INTRODUCTION

Effective emergency response depends on quick and precise estimates of damage extent and magnitude. Loss estimates are key in prioritizing the allocation of limited resources, as well as preventing cascading events that can exacerbate the initial effects of a disaster. GIS-based programs like HAZUS (Hazards US, developed by the National Institute of Building Sciences under agreement with the Federal Emergency Management Agency) enable cities and communities to estimate loss from earthquakes, floods and hurricanes. Following extensive peer review, the program was initially released in 1997, with an additional major release in 1999. HAZUS-99 supports both the ArcView 3 and MapInfo desktop GIS platforms. A multi-hazard version, HAZUS®MH, has recently been released that supports the ArcGIS 8.3 platform, and requires Spatial Analyst for flood analysis. Hypothetical scenarios provide results for emergency response training exercises, response plans, and resource assessment. Advanced GIS users can provide managers with quantitative loss projections for planning purposes, including cost benefit analysis of building codes and proposed mitigation efforts. After an event, loss estimation programs can provide answers at the critical time when damage extent and distribution is unclear. Additionally, risk assessments that incorporate HAZUS help local governments become eligible for Stafford Act Disaster Assistance and comply with DMA 2000 planning provisions. This paper presents several "Tips and Tricks" to help users through the process of prioritizing data collection efforts and collecting enhanced data to populate the HAZUS databases.

Reveal the underlying Data Model

Although the relational nature of the HAZUS®**MH** data model is well documented, it is difficult to comprehend the multitude of building inventory databases and how they are linked. Even with simple geodatabases, spatial objects and attributes are stored in separate tables, so users must be careful with identifiers and joins. Only the most advanced users should modify the underlying data. However, linking to the underlying databases for custom queries can lead to a better understanding of the inventory and enable users to create custom reports that are not possible through the program interface.

HAZUS®**MH** tables are stored in a SQL server database. Once HAZUS is started, the user can replicate the database structure within Microsoft Access 2002 by starting a new project (existing data option), selecting the HAZUSPLUSSRVR connection, and attaching to the database associated with the study region. Any queries created in the project will represent the relational structure, and enable the user to examine data from more than one table at a time.
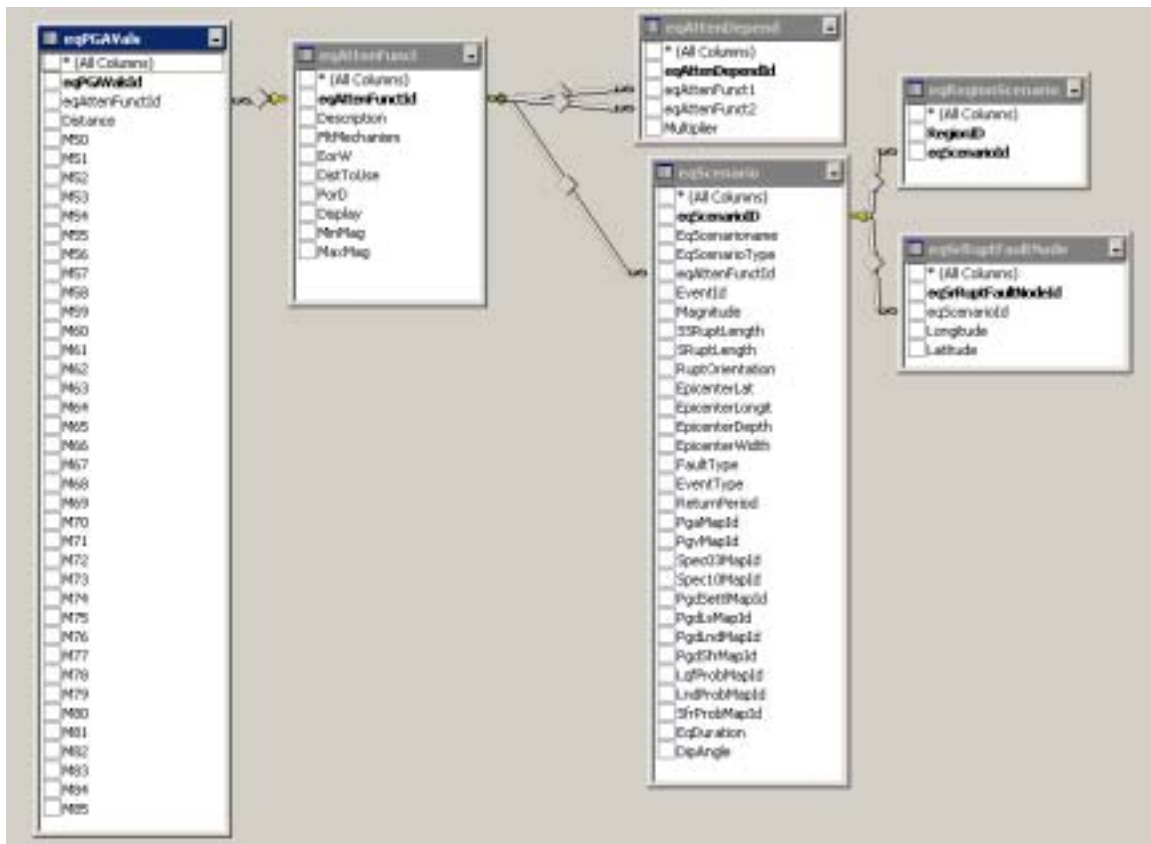

Figure 1: The data structure above illustrates the use of attenuation functions.

Prioritize data collection efforts

Prioritizing data collection efforts generally depends on three essential factors:

- Is the given component a primary contributor to losses?
- Is the default HAZUS database complete and comprehensive?
- Are there better data (more precise and/or robust) readily available?

Each of these elements must be considered together when assessing update priority. If a given data component is important, and there is no data in HAZUS, but can not be collected for homeland security reasons, the end user should not expend the resources available to collect the data. Likewise, if the data can be downloaded and processed rather quickly, but the HAZUS data is quite accurate it may not be worth updating, depending on the contribution to loss. All three questions should be addressed in a formal manner to make accurate comparisons for update priority. For example, Power substation voltage is a key parameter in inferring substation seismic vulnerability. Although this data is very difficult to obtain, it is essential for accurately modeling earthquake losses. Railroad facility information is also difficult to collect, but damage to railroads represents a very small portion of the total losses. Under such circumstances, less effort should be expended to collect enhanced data for railroad facilities but it is worthwhile to explore data sources for power substation attributes. Additional high priority items include cranes at port facilities, electrical substations, regional cost modifiers, and building replacement costs for the earthquake model and elevation data for the flood model.

Finding Additional Data

Various federal, state, and local agencies collect and maintain geospatial data. These datasets may be useful for loss estimation within HAZUS$^{\text{®MH}}$, or as supplementary data for emergency response. In the private sector, the following companies redistribute public data for free, or at very little cost:

- Environmental Systems Research Institute (http://www.esri.com/data/)
- GIS Data Depot (http://data.geocomm.com/)

Federal data warehousing programs often have detailed HAZUS compatible data, which can be found through technical list-serves, bulletin boards, online GIS data libraries, geography departments, and government search directories. The federal agencies or programs listed below have provided data or information used in HAZUS$^{\text{®MH}}$:

BLWM	Bureau of Land and Water Management
BTS	Bureau of Transportation Statistics
EIA	Energy Information Administration

EPA   Environmental Protection Agency
FAA   Federal Aviation Administration
FERC   Federal Energy Regulatory Commission
FHWA   Federal Highway Administration
HPMS   Highway Performance Monitoring System
NERC   North American Electric Reliability Council
NHPN   National Highway Planning Network
USACE   U.S. Army Corps of Engineers
USDOT   Department of Transportation
USGS   U.S. Geological Survey

The metadata of potential data sources should be reviewed to assess their applicability for a specific project. If possible, it is advisable to contact the agency to discuss the data (for example, there may be mistakes in metadata, and descriptions are easy to misinterpret), and confirm its applicability. This is a good opportunity to introduce the project, so that the agency knows how their data is being used. Furthermore, agency analysts may suggest additional data sources. When contacting analysts or managers by telephone, have a form letter ready to fax, mail, or e-mail with an official project description and references.

Updating the Default Data

When updating HAZUS$^{\textbf{®MH}}$ tables, use existing tables as templates, and add data through append queries or conditional update queries. To enable future updates and data verification, always maintain a unique identifier from the original database as it was received. Save all SQL queries for future reference. Using Excel to open or edit data is not recommended, as data types are sometimes changes, and fields can be truncated.

Default replacement costs should be reviewed and updated when necessary. Improved replacement cost estimates can be found by contacting external sources or refined from defaults in HAZUS, or the size of a facility can be used to refine the default replacement cost. When detailed information is collected for HAZUS, the default cost may no longer be representative. For example, HAZUS categorizes water treatment facilities as small (10-50 millions of gallons a day or MGD), medium (50-200 MGD), or large (greater than 200 MGD). Many smaller water treatment facilities process less than 2 million gallons of water a day. If the data collection effort in a region is very successful, the default estimate may not apply.

If supplementary elevation data is used for flood analysis, "Bare-earth" algorithms, (sometimes "Bald-earth" is used), must be used to separate the ground elevation from the height of buildings, trees and other things on the ground. This allows the two components of elevation to be analyzed separately. Once the height of the built environment and vegetation has been separated from the natural terrain, elevations associated with trees can be separated from the built environment through a spectral analysis. Figure 2 illustrates several neighborhood statistics from ArcGIS Spatial Analyst that isolate probable ground locations and interpolate a ground surface. The height and square footage information can be used to update the general building stock in HAZUS$^{\textbf{®MH}}$ earthquake or flood, and the elevation of the ground can be used in the flood model.

| 1. Minimum | 2. Median | 3. Slope | 4. Change in Slope |

5. Estimated location
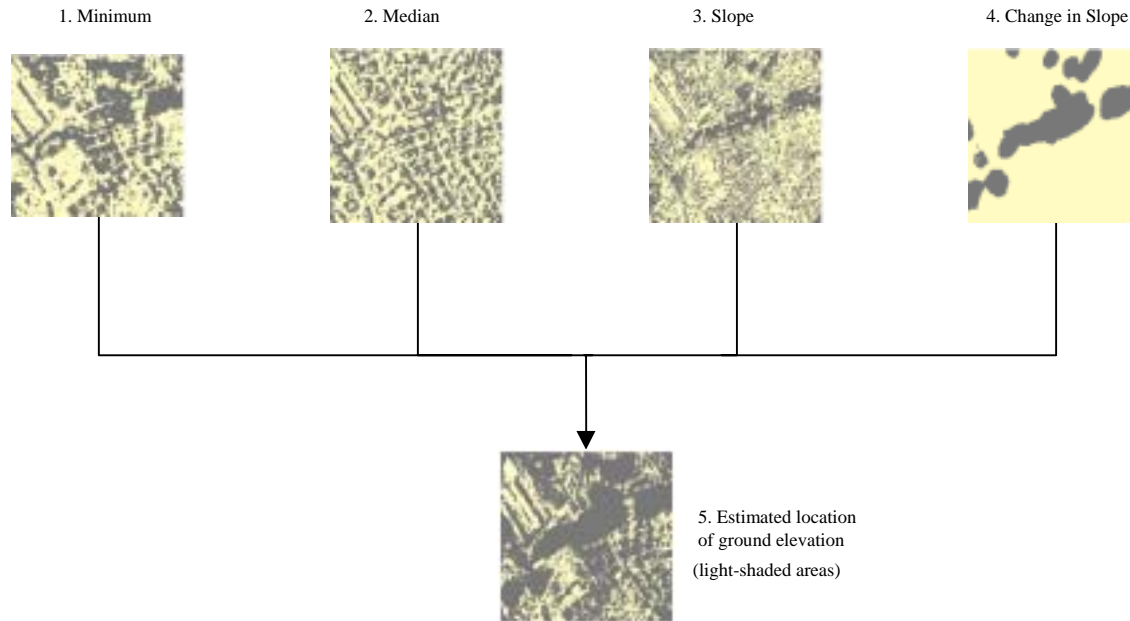of ground elevation

(light-shaded areas)

Figure 2: Multiple Criteria Bare Earth Algorithm

High-resolution remote sensing data provides a geo-referenced photographic backdrop that allows an analyst to adjust location or key attributes in a HAZUS database. This data may prove useful for various specific facilities where accurate square footage, height, or location justifies the additional effort. Figure 3 is a portion of a Digital Ortho Quarter Quad (DOQQ) collected by the USGS. In this image, it is easy to see the rails that determine help determine the class of Crane for HAZUS.

Figure 3: Rail Mounted Cranes in a Port Facility

Reviewing Updates

Once you have collected additional data for HAZUS, the data must be reviewed for completeness and accuracy. Evaluating the data can be a qualitative task, but should not be skipped. Analysts should convince him or herself that updated facilities are in the right place in the world by overlaying the data with other layers from HAZUS or commercial databases. Geocoding facilities or using online map sites to obtain coordinates provides a good cross check for the locations provided. Look for projection problems like DATUM shifts. The density of facilities and infrastructure should correlate closely with population density. Most types of facilities should occur in every county and every major city within the study area. Spatial databases should be correlated, for example rail facilities should be along train track and major bridges should be along highways. Utility pipelines are often collocated as well. Spot check the data for completeness, and spend time examining the data with no specific objective. Erroneous data often stands-out, and can aid the user in discovering larger issues. Frequently, units are not well documented, or are missing from the metadata. Check updated values against default data to assure that the units are correct.

Verify the Results

Verifying results from a complex modeling program is difficult, as one frequently has nothing to compare the results against. Nevertheless, there are some simple procedures one can follow to assure the results are reasonable. If there has been an actual event, it is good to compare the loss estimates with initial media reports. If the model predicts thousands of fatalities, but there are no deaths reported, the source of the fault may be incorrect. The loss contribution of specific components should agree with the priority estimates. If there is a disconnect, there may be a data valuation or input problem. Where possible, check your results against known events, or events of a similar severity.

Concluding remarks

The accuracy of HAZUS loss estimates are largely dependent on the quality of the underlying data. As the user adjusts the default parameters for a specific study site or imports additional data, the accuracy of the estimates generally increase. HAZUS will provide estimates as delivered, based on national data sets delivered with the software package. But in most cases, these data sets originate from agencies other than FEMA, and the initial purpose of the data collection was not loss estimation. Therefore, data detail and applicability to loss estimation varies by data type. Additionally, components analyzed by the program vary greatly in their contribution to loss. Collecting GIS data for a specific data type can be simple or extremely difficult. Given these complexities, the user should proceed with updating data very cautiously, following the principles put forth in this paper, and checking their work every step of the way.

ACKNOWLEDGEMENTS

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