GIS/GPS Applications in Emergency response

By
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Key stages of emergency management

• Planning & Mitigation
• Preparedness
• Response
• Recovery
Definitions

- **Planning & Mitigation**: Evaluating the potential types of disasters and developing plans for reducing their probability or their impact on life & resources.

- **Preparedness**: Actions undertaken when mitigation efforts have not prevented or are unable to prevent a disaster from taking place.

- **Response**: Activities that occur in the wake of a disaster that are intended to identify and assist victims and stabilize the overall disaster situation.

- **Recovery**: Actions following a disaster that aim to restore human and environmental systems back to normal.
GIS

- For emergency managers, a GIS can facilitate critical decision-making before a disaster impacts an area. In the early, crucial stages of a disaster or emergency and throughout the disaster process, managers use GIS products because they provide important information, quickly and in easy-to-understand formats.
Some of frequently requested maps include: storm track and damage prediction maps, remote sensing maps, maps of high risk-declared zones in an affected state, basic census demographics about an affected area by district and census block, street locations, and summaries of tele registered and service center applicants, housing inspection numbers, Helpline calls, disaster unemployment claims, Small Business Administration (SBA) applicants, etc.
GIS

• Prior to making landfall, Emergency staff can generate maps that depict the track of a hurricane or tropical storm. The E-GIS Team uses a hurricane wind model to develop estimates for projected damages in affected states or areas. The staff then maps these results. Typical model output maps include estimated wind damage to homes, single family homes, and multi-family homes in affected areas along the track of the storm.
Why do you need a selection?

Selected features

- Analysis
- Use to select other features
- Edit
- Create a new flyer
- Calculate statistics
- Convert to graphics
- Report
- Export
Tools in GIS

Interactive, attributes, location, graphics
Tools

Interactive, attributes, location, graphics
Selection Methods

Specify from **Selection** menu

- **Create new selection**
- **Add to the selection**
- **Remove from the selection**
- **Select from selection**

- Interactive Selection Method
Interactive Selection

Options from Selection menu

– Select features partially or completely within the box or graphic(s)

– Select features completely within the box or graphic(s)

– Select features that the box or graphic are completely within
Selection Layers

The Set Selectable Layers option allows you to choose the layers that you can select by clicking on the map.
Attribute Selection

Select features based on an attribute value.
Select by Location (spatial query)

Use features in one layer to select features in another.
Calculating Statistics

1. Select some features and open the feature attribute table.

2. Choose **Statistics** from the field context menu.

3. Review the summary statistics and close the Statistics box when you are finished.
User Levels

Level 1
Default hazard, inventory, and damage information

Level 2
Combinations of local and default hazard, building, and damage data

Level 3
Input hazard specific data

Required User Effort and Sophistication
Supported Hazards

- Hurricanes
- Riverine and Coastal Floods
- Earthquakes
Figure 4. Earthquake loss estimation using HAZUS.
Damage/Loss Functions

• Assess damage and losses based on hazard conditions

• Example – Hurricane damage for different building categories
  – 45 damage/loss functions for each building model
  – ~85,000 unique damage/loss curves
<table>
<thead>
<tr>
<th>Direct Damage</th>
<th>Earthquake Ground Shaking Ground Failure</th>
<th>Flood Frequency Depth Discharge Velocity</th>
<th>Hurricane Wind Pressure</th>
<th>Missile</th>
<th>Rain</th>
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</thead>
<tbody>
<tr>
<td>General Building Stock</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Essential Facilities</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>High Potential Loss Facilities</td>
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<td>✓</td>
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<tr>
<td>Utility Systems</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Induced Damage</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Following</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
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<tr>
<td>Hazardous Materials Release</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Debris Generation</td>
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<td></td>
<td></td>
<td></td>
<td>✓</td>
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<tr>
<td>Direct Losses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Repair</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Income Loss</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Crop Damage</td>
<td>✓</td>
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<tr>
<td>Casualties</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
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<tr>
<td>Shelter Needs</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Indirect Losses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply Shortages</td>
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<td>Sales Decline</td>
<td>✓</td>
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<td>✓</td>
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<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>Economic Loss</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Supported States

- Model includes 22 gulf and east coast states as well as Hawaii
Hurricane Scenarios

- Individual storms
  - User-defined
  - Historical
- Probabilistic
Hurricane/Wind Model

- Meteorology (wind speed, storm surge, forecast)
- Emergency response
- Wind engineering
- Building codes, zoning
- Mitigation and preparedness activities (evacuation routes, shelters, awareness)
- Debris removal
- Infrastructure and utilities
- Vulnerability
Flood Scenarios

- Specific Return Intervals
- Specific Discharge Frequency (riverine)
- Annualized Losses
- Quick Look
- What-If
  - Levees
  - Flow Regulation
  - Velocity
Flood Model

- Meteorology, Geology, and Hydrology (data input, forecast)
- Building codes, zoning
- Emergency response
- Army Corps of Engineers
- NIRD and SDMA
- Mitigation and preparedness activities (buyouts, dams, 100 year flood, cost-benefit analysis, awareness)
- Emergency response
- Infrastructure
Map A37. Depth and extent of 100-year flood in Somerset County

Flood Depth (ft)
High: 10.65
Low: 0.00

100-year Flood Boundary
Map A38. Direct economic losses from buildings by census block in Somerset County

Thousands of Dollars
- 2986 - 5851
- 1212 - 2985
- 395 - 1211
- 0 - 394

100-year Flood Boundary
Earthquake Model Overview
Earthquake Scenarios

- User defined events
- Historic events
- Probabilistic events
Earthquake Model

- Geophysics (shaking, liquefaction, landslides)
- Geology (soils)
- Earthquake engineering
- Building codes
- Mitigation and preparedness activities (e.g. retrofitting, awareness programs)
- Utilities
- Infrastructure
- Emergency response
Transportation Plan and Implementation Strategy

Emergency Route Planning: Scenario Impact on Bridges

Greater Memphis Region
- Approx 15% of Bridges Operational
- 10 Operational
- 47 Operational w/ Damage
- 16 Restored w/in 30 Days
- 365 Restored after 30 Days
- Surface Streets most viable Alternate Routes
- Majority of 5-State Region Bridges are Undamaged
## HAZUS-MH Loss Estimation

### Estimated Economic Loss (5 Billion)

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Building Stock</td>
<td>Building Damage</td>
<td>1.40 - 5.40</td>
</tr>
<tr>
<td></td>
<td>Building Contents</td>
<td>0.10 - 0.40</td>
</tr>
<tr>
<td></td>
<td>Business Interruption</td>
<td>0.20 - 0.80</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Lifelines Damage</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>2.00 - 8.10</td>
</tr>
</tbody>
</table>

### Estimated Building Damage (Thousands of Buildings)

<table>
<thead>
<tr>
<th>Description</th>
<th>Residential</th>
<th>Commercial</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor</td>
<td>20 - 80</td>
<td>0 - 1</td>
<td>&lt;1.0</td>
<td>20 - 90</td>
</tr>
<tr>
<td>Major</td>
<td>4 - 16</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>4 - 17</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>50 - 100</td>
<td>0 - 1</td>
<td>&lt;1.0</td>
<td>30 - 100</td>
</tr>
</tbody>
</table>

### Estimated Casualties: Day Time

<table>
<thead>
<tr>
<th>Severity Level</th>
<th>Description</th>
<th># Persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Medical AM</td>
<td>1,000 - 4,000</td>
</tr>
<tr>
<td>Level 2</td>
<td>Hospital Care</td>
<td>300 - 1,100</td>
</tr>
<tr>
<td>Level 3</td>
<td>Life-threatening</td>
<td>40 - 160</td>
</tr>
<tr>
<td>Level 4</td>
<td>Fatalities</td>
<td>80 - 300</td>
</tr>
</tbody>
</table>

### Estimated Shelter Needs

<table>
<thead>
<tr>
<th>Type</th>
<th>Households</th>
<th>People</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displaced Households</td>
<td>2,000 - 9,000</td>
<td></td>
</tr>
<tr>
<td>Public Shelter</td>
<td></td>
<td>600 - 2,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>24,570</td>
</tr>
</tbody>
</table>

## Earthquake Information

- Location: 
- Origin Time: 
- Magnitude: 6.00
- Epicenter Latitude/Longitude: 41.04 / -74.29
- Depth & Type: 10.00 km
- Fault Name: NA
- Maximum PGA: 1.00
- Ground Motion/Attenuation: Project 2000 East

### Information Sources:

### Comments:

### Building Exposure (2002 D&B) (2000 Census)

- Population: 460,049
- Building Exposure: 19,218
- Commercial: 3,689
- Other: 1,853
- **Total**: 24,570

### Counties:
- Passaic, NJ

### Comments:
GPS in Emergency Response

A critical component of any successful rescue operation is time. Knowing the precise location of landmarks, streets, buildings, emergency service resources, and disaster relief sites reduces that time -- and saves lives.
How GPS works

• The GPS space segment consists of a constellation of satellites transmitting radio signals to users.

• The United States is maintaining the availability of at least 24 operational GPS satellites, 95% of the time.

• Indian GPS Satellite constellation GAGAN.
How GPS works

• GPS satellites fly in medium Earth orbit (MEO) at an altitude of approximately 20,200 km (12,550 miles). Each satellite circles the Earth twice a day.

• The satellites in the GPS constellation are arranged into six equally-spaced orbital planes surrounding the Earth. Each plane contains four "slots" occupied by baseline satellites. This 24-slot arrangement ensures users can view at least four satellites from virtually any point on the planet.
How GPS works

• Control Segment: Stations on Earth monitoring and maintaining the GPS satellites.
• User Segment: Receivers that process the navigation signals from the GPS satellites and calculate position and time
GPS in Disasters

• This information is critical to disaster relief teams and public safety personnel in order to protect life and reduce property loss. The Global Positioning System (GPS) serves as a facilitating technology in addressing these needs.
GPS in Disasters

• GPS has played a vital role in relief efforts for global disasters such as the tsunami that struck in the Indian Ocean region in 2004, Hurricanes Katrina and Rita that wreaked havoc in the Gulf of Mexico in 2005, and the Pakistan-India earthquake in 2005.

• Search and rescue teams used GPS, geographic information system (GIS), and remote sensing technology to create maps of the disaster areas for rescue and aid operations, as well as to assess damage.
GPS in Disasters

• Another important area of disaster relief is in the management of wildfires. To contain and manage forest fires, aircraft combine GPS with infrared scanners to identify fire boundaries and "hot spots."

• Within minutes, fire maps are transmitted to a portable field computer at the firefighters' camp. Armed with this information, firefighters have a greater chance of winning the battle against the blaze
GPS in Disasters

• In earthquake prone areas such as the Pacific Rim, GPS is playing an increasingly prominent role in helping scientists to anticipate earthquakes.

• Using the precise position information provided by GPS, scientists can study how strain builds up slowly over time in an attempt to characterize, and in the future perhaps anticipate, earthquakes.
GPS in Disasters

- Meteorologists responsible for storm tracking and flood prediction also rely on GPS. They can assess water vapor content by analyzing transmissions of GPS data through the atmosphere.
GPS in Disasters

• GPS has become an integral part of modern emergency response systems -- whether helping stranded motorists find assistance or guiding emergency vehicles.

• Today, many ground and maritime vehicles are equipped with autonomous crash sensors and GPS. This information, when coupled with automatic communication systems, enables a call for help even when occupants are unable to do so.
GPS and emergency response

• As the international industry positioning standard for use by emergency and other specialty vehicle fleets, GPS has given managers a quantum leap forward in efficient operation of their emergency response teams.
GPS and emergency response

- The ability to effectively identify and view the location of police, fire, rescue, and individual vehicles or boats, and how their location relates to an entire network of transportation systems in a geographic area, has resulted in a whole new way of emergency response.
GPS and emergency response

- Location information provided by GPS, coupled with automation, reduces delay in the dispatch of emergency services
GPS and emergency response

• The modernization of GPS will further facilitate disaster relief and public safety services. The addition of new civil signals will increase accuracy and reliability all over the world. In short, GPS modernization translates to more lives saved and faster recovery for victims of global tragedies.
Benefits

• Deliver disaster relief to areas in a more timely and accurate manner, saving lives and restoring critical infrastructure.
• Provide position information for mapping of disaster regions where little or no mapping information is available.
• Enhance capability for flood prediction and monitoring of seismic precursors and events.
• Provide positional information about individuals with mobile phones and in vehicles in case of emergency.
Thank you
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