GIS and Critical Infrastructure Resiliency
Hampton Roads, VA

Changing the Paradigm

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GIS and Critical Infrastructure Resiliency in Hampton Roads Region

- The Team, Sponsors and Project
- Hampton Roads Region
- Potential Hazards
- Critical Services and Facilities
- Critical Infrastructure
- Data and Issues
- Collaborative GIS and Resiliency
Virginia University Partnership

Disaster Risk Reduction Program

Center of Risk Management for Engineering Systems

VA Modeling Simulation and Analysis Center
Project Objectives

1. Infrastructure vulnerabilities and interdependencies

2. Natural, technological and terrorist risk scenario resilience

3. Resilience, preparedness and response capabilities gaps

4. Military and civilian infrastructure interdependencies

5. Economic and social impacts of selected scenario events

6. Regional resilience investment priorities based risk, cost and benefit trade-offs

7. A Hampton Roads region methodology as a national model
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- **Potential Hazards**
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Potential Hazards

Hurricane

Flood

Cyber-Attack

Large-Scale “Accidents”

Dirty Bomb

Flu Pandemic
GIS and Critical Infrastructure Resiliency in Hampton Roads Region

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- **Critical Services and Facilities**
- Critical Infrastructure
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Critical Services and Facilities

- Airports
- Police Stations
- Fire Stations
- Chemical Facilities
- Fuel Storage/Refueling Facilities
- Radio Facilities
- Transmission Towers
- Communication Central Offices
- Electric / Gas Utility Dispatch Ctrs
- EOCs
- 911 Call Centers
- Large Population Venues
- Large Rail / Port Facilities
- Major Bridges / Tunnels

- Military / National Guard Facs.
- Transportation Hubs
- Public Shelters
- Water Treatment Facilities
- Water Storage Facilities
- Wastewater Treatment Plants

- Hospitals
- Medical & Treatment Centers
- Schools / Colleges
- Public Shelters
- Camp Grounds
- Trailer Parks
Critical Facility Service Analysis

Critical Jurisdiction & Infrastructure Facilities

- Communications
  - Computer, Communications, and SCADA

- Electric Power

- Energy
  - Liquid, gas, and solid fuels

- Personnel
  - Supervision, Oper’n, & Maint.

- Transportation
  - Highways, Roads, Railways, Mass Transit, Air, and Marine Systems

- Storm Water Systems

- Fresh Water Systems

- Wastewater Systems
HR State and Local Critical Facilities

Note: Data Incomplete
CAT-3 Hurricane Storm Surge

Essential Facilities, HAZUS-MH2
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Critical Infrastructure

- Agriculture and Food
- Banking and Finance
- Chemical and Hazardous Materials
- Defense Industrial Base
- **Energy**
- Emergency Services
- Information Technology
- **Telecommunications**
- Postal and Shipping
- Healthcare and Public Health
- **Transportation**
- **Water**
- National Monuments and Icons
- Commercial Assets
- Government Facilities
- Dams
- Nuclear Facilities

*Source: DHS National Plan - Critical Infrastructure and Key Resource Areas*
Project Focus – 4 Critical Infrastructures

**Energy**
- Electric Power
- Gas (Natural & LNG)
- Nuclear
- Oil

**Communications**
- Telephone Landlines
- Wireless - Cell
- Wireless - Microwave
- Cable

**Water**
- Potable Water Supply
- Wastewater

**Transportation**
- Roads
- Bridges & Tunnels
- Rail
- Airports
- Ports
HR Roads Transportation System
HR Sanitary District Wastewater System

Legend
- NS_Treatment Plant
- NS_Pumping Station
- NS_Pressure Reducing Station
- NS_FM Interceptor
- NS_Gravity Interceptor
- SS_Treatment Plant
- SS_Pumping Station
- SS_Pressure Reducing Station
- SS_FM Interceptor
- SS_Gravity Interceptor
- HR_ServiceArea
FCC Registered Communications Antennas
Critical Infrastructure Interdependencies

Communications

Interdependencies

Power

Transportation

Water – Potable / Wastewater
Interdependencies

HR Project Area – Macro View

- Overall capabilities and limitations of four infrastructures
- Federal, Commonwealth, county, city, military, and infrastructure critical facilities identified
- Areas of disaster impacts
HR Project Area – Meso View

- HR Critical Facilities Matrix development
- Select areas for further evaluation
- Critical facility evaluation
- Infrastructure services to facility
- Resilience of facility & service infrastructures
Critical Facility – Values & Filters

• Estimated Critical Facilities in HR Region: 2,000 - 3,000
• Potential Decision Filters
  – Availability of Infrastructure & GIS Data
  – Demography
  – Economic & Time Replacement
  – Critical Functions & Services
  – Topographic & Geographic Characteristics
  – History of Disaster Impacts
  – Infrastructure Service Characteristics
  – Organization Preferences or Priorities
  – Ownership
  – Political
• Select ~20 Representative Critical Facilities for Evaluation
Critical Facilities: Candidate Analysis Areas
Example Potential Analysis Area

Virginia Beach Potential Analysis Area Showing:
Critical Facilities, Estimated 100 YR Depth Grid & Cat 3 Storm Surge

Analysis Area is just over 11 Square Miles and has approx. 100 Critical Facilities.
Modeling and Simulation

- Model Review and Selection
- Model Modification and Adaptation
- Model Validation
- Simulation of Infrastructure Interdependencies
- Simulation of Event Scenarios
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- Collaborative GIS and Resiliency
Project Data Management Process
Data Collection Summary

• 16 Local Jurisdictions have GIS

• >1,000 Geospatial Data Layers (>50 GB)

• ESRI Shapefiles with Attribute Tables

• Some Geodatabases
Data Sources

• Federal
  – DOT
  – FCC
  – NGA (HSIP-Gold)
  – NOAA
  – USDA
  – USGS

• State
  – VGIN
  – VEDP
  – VDEM
  – VDEQ
  – VIMS

• Regional
  – HRSD
  – HRPDC

• Local
  – 16 Local Jurisdictions

• Private
  – Telecommunications
  – Natural Gas Utility
  – Electrical Utility
  – ESRI

• Other
Data Management Issues

- Lack of Metadata (*Data about Data*)
- No Common Data Format
- Critical Facilities
  - Format
  - Symbology
- Difficulty in Obtaining Certain Data
  - Private Utility Sources
  - Federal - HSIP Gold (NGA/USGS) and iCAV (DHS)
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The Dilemma

We must *protect* our data to help keep us safe

We must be able to see/use the data to help *protect* us
Relevant Issues

- Hazards don’t recognize political boundaries
- Infrastructure is often multi-jurisdictional
- Resiliency Planning requires spatial knowledge
- Planning requires intra- and inter-agency coordination
- Is the right spatial data available?
- Data security? How much?
Collaborative GIS Framework

• Adopt **common data format**

• Ensure **adequate metadata**

• Create a **distributed data sharing structure** -
  – Establish Cooperators Council
  – System to allow “looking but not touching”
  – Data owners retain and update data
  – Share with appropriate security
  – Joint modeling training and application
Do You Know Your Critical Infrastructure?
End Slideshow
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VA Emergency Management Association (VEMA) Annual Conference

• March 11-14, 2008
• Hampton Roads Convention Center
• GIS and Emergency Management Day
  – Preparedness
  – Response
  – Recovery
  – Mitigation
  – Resiliency
  – HAZUS
Data Opportunities

• **Regional Multi-Organization Data Collaborative**
  – Data Consistency (structure, format, metadata)

• **Training and Model Applications** —
  – Regionally-coordinated HAZUS-MH3 Modeling
  – Future Critical Infrastructure Resiliency Interdependency Modeling
  – Future Critical Infrastructure Resiliency Decision Modeling

• **Emergency Management Activities**
Base Map

Danville, VA
Flood Plain

Danville, VA
Major Roads & Traffic Signals

Danville, VA
Transit, Rail & Airport

Danville, VA
Analysis Objectives

• **Characterize** Current Infrastructures: Communications, Energy, Transportation, & Water

• **Identify** Vulnerabilities of Critical Jurisdiction & Infrastructure Facilities

• **Identify** Major Infrastructure Interdependencies

• **Examine** Impacts of Potential Cascading Failures

• **Identify** Opportunities to Isolate or Limit Cascading Failures
Vulnerable Population Facility Examples

Medical & Mental Health Facilities
- Hospitals
- Medical centers
- Clinics
- Kidney Dialysis centers
- Hospice

Schools
- Primary, Secondary, High
- Colleges, Universities
- Trade
- Public, private & religious
- Day-care centers

Correction Facilities
- Juvenile, adult, other
- City, County, State, Federal

Assisted Living Facilities
- Medical
- Mental Health
- Half-way houses

Retirement Facilities
- Group homes
- Apartments/Condos
- Retirement communities

Social Service Facilities
- Salvation Army, Goodwill Industries
- United Way
- Religious
- City, County, State, Federal

Recreational/Social Facilities

Nursing & Recovery Facilities
Example: Electric Service Analysis

1. Jurisdiction
   Critical Facility

2. Local Dist'n Xfmr
   Facility Service Entrance
   Secondary Distribution (120V, 240V or 480V)
   Primary Distribution

3. Local Dist'n Xfmr
   Backup Service

4. Alternate Service Route

5. Distribution Substation
   (5kV, 15kV, 25kV, or 35kV)
   Transmission Substation
   (69kV, 138kV, 230kV, or 500kV)

Example: Electric Service Analysis
## Infrastructure Interdependency Matrix

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<th>Communications</th>
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<th>Transportation</th>
<th>Water</th>
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Population Concentrations

Total population by census track

Population Yr 2000
- 0 - 3000
- 3001 - 5000
- 5001 - 8000
- 8001 - 37000

Total population by census track
CAT-3 Hurricane Storm Surge

Total population by census track

Population Yr 2000
- 0 - 3000
- 3001 - 5000
- 5001 - 8000
- 8001 - 37000
CAT-4 Hurricane Storm Surge

Total population by census track

Population Yr 2000
- 0 - 3000
- 3001 - 5000
- 5001 - 8000
- 8001 - 37000
Recent Wastewater Spill

“Difference between 200 and 300 is 400,000”, Daily Press, Sept. 2007

Source: construction near incorrectly identified force main location