Using Geographic Information Systems (GIS) for Safety Analysis and Data Integration

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The aim of this GIS training is to introduce attendees to the uses of GIS rather than to give them a hands-on training on a particular software.
Agenda

• GIS Concepts and Terminology
• GIS at NHTSA
• Geo-Spatial Analysis at NHTSA
• Data Integration
• GIS in the Safety Community
• Discussion
What is GIS

Database → Maps → Model

NHTSA
National Center for Statistics & Analysis
GIS Concepts – Co-ordinate Systems

Earth – Spherical Coordinate System

Maps – Projected Coordinate System
GIS Concepts – Latitude and Longitude
GIS Concepts – Latitude and Longitude

USA
GIS Concepts – Layers

- Roads
- Land use
- Boundaries
- Hydrography
- Elevation
- Image base
Why GIS?

- It’s a vast country
  - 6.4 Million miles of roadways
- Pin-point location of crashes
- Target Enforcement in Problem Areas
- Assess location based improvements
- Analyze effect of crackdowns, etc.
GIS Concepts – Points, Lines and Polygons
GIS @ NHTSA

- Fatality Analysis Reporting System
  - Lat-Long for fatal crashes
- Crash Location Maps
- Geo-Spatial Analysis
- Data Collection
C5. Crash Location

Definition: The exact location on the roadway to document where the first harmful event of the crash occurred.

Attributes: • Latitude/Longitude Coordinates

The optimum definition of Crash Location is a route name and GPS (global positioning system)/GIS (geographic information system), if a highway agency has a linear referencing system that can relate geographic coordinates to specific locations in road inventory, traffic, driver, and other files. The location information in a crash file must have the capability to be linked to location information in these other important files required to study site-specific safety issues. GPS/GIS provides the latitude/longitude coordinates indicating where the crash occurred.
MMUCC Element: Rationale

- Critical for Problem Identification
- Design Countermeasures
- Conduct Engineering Evaluations
- Mapping
- Linkage
GIS @ NHTSA
Fatality Analysis Reporting System (FARS)

- Lat-Longs available since 2001
  - Location of fatal crashes
- High rates of reporting (98%+)
- Co-ordinates entered by analyst
- Location based on narrative and location information on PAR
- Some automatic entry through electronic-PARs.
GIS @ NHTSA

FARS: Reporting Rates for Lat-Longs

[Bar chart showing reporting rates from 2001 to 2008, with a steady increase from 80% in 2001 to 100% in 2008]
GIS @ NHTSA

Reporting Rate for Lat-Longs (Annual File)

- Colorado
- Delaware
- Kentucky
- Michigan
- Mississippi
- Montana
- New Hampshire
- New Mexico
- North Dakota
- Ohio
- Vermont
- Wisconsin

- Dist of Columbia
- Idaho
- Maine
- Michigan
- Minnesota
- Missouri
- Montana
- Nebraska
- New Hampshire
- New Jersey
- New Mexico
- North Carolina
- Ohio
- Pennsylvania
- South Carolina
- South Dakota
- Alabama
- Alaska
- Arizona
- Arkansas
- Texas
- Washington
- Oregon
- Nevada
- Arizona
- Alaska
- Georgia
- Georgia
- Hawaii
- Iowa
- Illinois
- Indiana
- Louisiana
- Kansas
- Idaho
- Arkansas
- Texas
- Washington
- Oregon
- Nevada
- Arizona
- Alaska
- Georgia
GIS @ NHTSA
Reporting Rate for Lat-Longs (Final File)
GIS @ NHTSA
Location of Fatal Crashes in the US
State Traffic Safety Information (STSI) website now upgraded

Crash-Location Based Mapping

- Latitude-Longitude Information in FARS
- Google-Earth Plug-In Tool
Fatal Crashes in Louisiana, 2006-08
GIS @ NHTSA: Fatal Crashes in Vicinity (Poydras / Canal)
GIS @ NHTSA

Louisiana, Speeding-Related Fatal Crashes
News Article: Most Dangerous Intersections in the U.S.

The City of Phoenix Transportation Department plans for these two dangerous intersections. Hopefully, when State Farm Insurance does the next study, they will be on the list.

Here is the list of the nation's most dangerous intersections, as compiled by State Farm Insurance:

1. Pembroke Pines, FL: Flamingo Road and Pines Boulevard

2. Philadelphia, PA: Red Lion Road and Roosevelt Boulevard

3. Philadelphia, PA: Grant Avenue and Roosevelt Boulevard

4. Phoenix, AZ: 7th Street and Bell Road

5. Tulsa, OK: 51st Street and Memorial Drive
Roosevelt Boulevard, Philadelphia, PA
• 3 years of ‘Pin-Maps’ for fatal crashes
• Uses Google-Earth Browser Plug-In
• State Map + Neighboring States
• Maps for Crashes Involving
  • Pedestrians, Pedal-cyclists
  • Large Trucks, Speeding, Motorcycles
• Nexus of Crime and Traffic Safety
• NHTSA and Bureau of Justice Assistance (BJA)
• Uses strategies already approved by Law Enforcement
• Traffic Analysis is combined with Crime Analysis
GIS @ NHTSA

Data Driven Approaches to Crime and Traffic Safety (DDACTS)
• 54% of traffic fatalities occur in rural areas
• SAFETEA-LU High Risk Rural Road Program – A Core Program
• Binary (Rural versus Urban) Land-Use Reporting
• Use GIS software to determine spatial extent of rural fatalities
  • Especially proximity to Urbanized Areas
GIS Analysis @ NHTSA

Rural versus Urban Fatalities
GIS Analysis @ NHTSA

Urbanized Boundaries (Census Bureau)
How many rural fatalities occur in close proximity to Urban Areas

Compute percent of overall fatalities within 2.5, 5, 7.5 and 10 mile buffers around urban areas

Compute percentages for each state

Examine variation

Guidance to Highway Safety Planners / Enforcement involved in Rural Highway Safety
## GIS Analysis @ NHTSA

### % of Fatalities in Buffers around Urbanized Areas

<table>
<thead>
<tr>
<th>Category</th>
<th>Urban</th>
<th>Urban+2.5 mi.</th>
<th>Urban+5.0 mi.</th>
<th>Urban+7.5 mi.</th>
<th>Urban+10 mi.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>44%</td>
<td>63%</td>
<td>73%</td>
<td>81%</td>
<td>86%</td>
</tr>
<tr>
<td>Speeding-Related</td>
<td>43%</td>
<td>61%</td>
<td>71%</td>
<td>79%</td>
<td>85%</td>
</tr>
<tr>
<td>Motorcyclist</td>
<td>53%</td>
<td>71%</td>
<td>80%</td>
<td>86%</td>
<td>90%</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>74%</td>
<td>88%</td>
<td>92%</td>
<td>94%</td>
<td>95%</td>
</tr>
<tr>
<td>Involving Large Trucks</td>
<td>35%</td>
<td>55%</td>
<td>67%</td>
<td>75%</td>
<td>81%</td>
</tr>
<tr>
<td>Alcohol-Impaired Driving Fatalities</td>
<td>44%</td>
<td>63%</td>
<td>73%</td>
<td>81%</td>
<td>86%</td>
</tr>
<tr>
<td>Unbelted Passenger Vehicle Occupants</td>
<td>37%</td>
<td>56%</td>
<td>68%</td>
<td>76%</td>
<td>83%</td>
</tr>
<tr>
<td>Fatalities during the Weekend</td>
<td>45%</td>
<td>64%</td>
<td>73%</td>
<td>81%</td>
<td>86%</td>
</tr>
<tr>
<td>Nighttime Fatalities</td>
<td>49%</td>
<td>67%</td>
<td>77%</td>
<td>84%</td>
<td>88%</td>
</tr>
</tbody>
</table>
GIS Analysis @ NHTSA

% Point Change from Urban to Urban + 5.0 mile

- Urban to Urban + 5.0 Miles

States with the highest percentage point change from Urban to Urban + 5.0 mile:

1. South Carolina
2. West Virginia
3. Arkansas
4. Kentucky
5. Indiana
6. West Virginia
7. Delaware
8. Vermont
9. Maine
10. North Carolina

States with the lowest percentage point change from Urban to Urban + 5.0 mile:

1. Rhode Island
2. New Hampshire
3. New Mexico
4. Maine
5. Iowa
6. Oklahoma
7. Utah
8. Oregon
9. Washington
10. Idaho

Urban to Urban + 5.0 miles increases the point change for different states.
GIS Analysis at NHTSA: Click It or Ticket Campaign: Unbelted Fatalities
GIS Analysis at NHTSA: Native American Fatalities and BIA Layer

Native American Fatalities in the United States, 2007 (652 out of 672 fatalities display due to availability of lat/longs, 209 within Indian Reservations as indicated by blue dots)
GIS Analysis at NHTSA: EMS (Land and Air within 60 minutes) Coverage

Source: American Trauma Society (ATS)
Advanced Automatic Collision Notification (AACN)

- 83% of U.S. Population covered (ATS)
- Proportion of Traffic Crashes?
- Estimate Potential Benefits of AACN
- Land versus Air-Based EMS Services
- State-by-State Analysis
Advanced Automatic Collision Notification (AACN)

Vehicle Collision

Injury Severity Analysis

Risk of Severe Injury ISS ≥ 15

< 20%

Yes

Occupant Contact

No

Contact PSAP and advise them of a collision

≥ 20%

Yes

Occupant Contact

Interrogate Occupant:
- Voice Communication
- Injury Presence
- Number of Patients
- Number of Vehicles
- Age

Risk Stratification for Injury

Risk for Severe Injury Decreased

Risk for Severe Injury Increased

Contact PSAP and advise them of a High Risk for severe injury

Unchanged or Unknown
GIS Analysis @ NHTSA
Tools Used

- ArcGIS 9.2 (ESRI, Inc.)
- Urbanized Area Boundaries (Census Bureau data provided by ESRI)
- NHTSA FARS Crash Data
- Buffering Tool in ArcGIS
• Shape-files processed by geo-apps
• U.S. Census Bureau
  • Urbanized Areas, Census Tracts, etc.
• Federal Highway Administration
  • Highway Performance Monitoring System
• Street Maps
  • Numerous Private Vendors
• U.S. Geological Survey
  • Topology, Contours, etc.
Data Integration
(Census Tracts)

66,172 Tracts
Smallest Unit of Census
Demographic Information
Population Changes
Data Integration
(Example: Arizona Census Tracts)

1,107 Tracts
Demographic Changes
Data Integration (Zip Code Areas)

30,223 Zip Codes
Population Data
Area Data
3,580 Urbanized Areas or Clusters
Census Definition
Population and Area Data
Data Integration
(Federal Lands)

BLM
National Parks
Indian Reservations
Forest Service
Data Integration
(Public and Private Schools)

Public Private School Locations
Data Collection – Enterprise GIS

Crash Notification

FARS/State Crash Database

(33.658, -111.502)

GIS Servers

Speed Limits

Roadway

Demographics

Traffic Counts
Data Collection Potential– Enterprise GIS
NHTSA FARS Example

Crash Notification

FARS/State Crash Database

(33.658, -111.502)

GIS Servers

Speed Limits

Rural/Urban

Population Changes

AADT Road Segment

National Center for Statistics & Analysis
GIS in the Safety Community
Air Medical Services and NHTSA
GIS in the Safety Community
Potential Ideas

- EMS and Crashes
  - Determine Coverage Areas for Rural Crashes
- Highways and Crashes
  - Intersection Taxonomy and Crash Risk
- Congestion and Crash Risk
  - AADT and Crash Risk Correlation
- Motorcycle Crashes
  - Crashes along Bike Routes, Bike Events, etc.
Wish-List for Safety Analyst

- All Police-Reported Crashes are geo-coded
  - Electronic PARS should facilitate this?
- Automated Data Integration (RSS) with geo-coded Crashes
  - Reduces load on data entry
  - Minimizes Errors
- Information are geo-referenced
  - Demographic, Traffic and Infrastructure Data
  - Location of Bars, for example
Useful NHTSA Resources

- **STSI: State Traffic Safety Information**

- **CATS: Customer Automated Tracking System**

- **STSI Google-Earth Maps (e.g., Arizona)**

- **GIS Resources**
  - [www.gis.com](http://www.gis.com)