Geocoding health & other types of data

Thomas Talbot
Environmental Health Surveillance Section
NYS Department of Health
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Geocoding turns data records containing address or location information into geographic objects that can be displayed on a map.
Geocoding Examples

Geocoding patients to a ZIP code centroid or ZIP Code area.

Geocoding patients to their street address.

Geocoding can be either automated or done manually.
Population weighted centroids or geographic centroids are sometimes added to health records when street addresses are not available.
Calculating a Population Weighted Centroid
Using GIS we know the centroid of every block within a ZIP Code and how many people live in each block

### Block Centroids for ZIP Code 12180

<table>
<thead>
<tr>
<th>Census Block ID</th>
<th>Population</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Latitude * Population</th>
<th>Longitude * Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>40300\2000</td>
<td>19</td>
<td>42.7638</td>
<td>-73.6739</td>
<td>812.5114</td>
<td>-1399.8046</td>
</tr>
<tr>
<td>40300\3000</td>
<td>80</td>
<td>42.7606</td>
<td>-73.6753</td>
<td>3420.8462</td>
<td>-5894.0214</td>
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<tr>
<td>40300\3007</td>
<td>86</td>
<td>42.7605</td>
<td>-73.6823</td>
<td>3677.4011</td>
<td>-6336.6769</td>
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<tr>
<td>40300\3010</td>
<td>65</td>
<td>42.7613</td>
<td>-73.6813</td>
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<td>-4789.2854</td>
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<tr>
<td>40300\3011</td>
<td>91</td>
<td>42.7610</td>
<td>-73.6803</td>
<td>3891.2490</td>
<td>-6704.9078</td>
</tr>
<tr>
<td>40300\3012</td>
<td>85</td>
<td>42.7606</td>
<td>-73.6791</td>
<td>3634.6534</td>
<td>-6262.7275</td>
</tr>
<tr>
<td>40300\3013</td>
<td>20</td>
<td>42.7608</td>
<td>-73.6781</td>
<td>855.2151</td>
<td>-1473.5622</td>
</tr>
<tr>
<td>40300\4007</td>
<td>80</td>
<td>42.7599</td>
<td>-73.6811</td>
<td>3420.7902</td>
<td>-5894.4856</td>
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<tr>
<td>40300\4008</td>
<td>215</td>
<td>42.7578</td>
<td>-73.6815</td>
<td>9192.9223</td>
<td>-15841.5322</td>
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<tr>
<td>40300\4009</td>
<td>247</td>
<td>42.7575</td>
<td>-73.6802</td>
<td>10561.1094</td>
<td>-18199.0116</td>
</tr>
<tr>
<td>40300\5000</td>
<td>59</td>
<td>42.7541</td>
<td>-73.6776</td>
<td>2522.4907</td>
<td>-4346.9787</td>
</tr>
<tr>
<td>40300\5001</td>
<td>0</td>
<td>42.7551</td>
<td>-73.6770</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>40300\5002</td>
<td>53</td>
<td>42.7552</td>
<td>-73.6783</td>
<td>2266.0271</td>
<td>-3904.9495</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>52,496</strong></td>
<td></td>
<td></td>
<td><strong>2243120.5114</strong></td>
<td><strong>-3867135.5137</strong></td>
</tr>
</tbody>
</table>
It is a simple calculation to determine the population centroid of an area.

Latitude of the ZIP Population Centroid =

\[
\frac{\text{Sum (Latitude } \times \text{ Population)}}{\text{Total Zip Code Population}}
\]

\[
\frac{2,243,120.5114}{52496} = 42.7294
\]

Longitude of the ZIP Population Centroid =

\[
\frac{\text{Sum (Longitude } \times \text{ Population)}}{\text{Total Zip Code Population}}
\]

\[
\frac{-3,867,135.5137}{52496} = -73.6653
\]

Note: If a spherical coordinate system, such as latitude/longitude is used, the longitudes should theoretically be adjusted to account for the curvature of the earth. This adjustment however will be negligible over small areas like ZIP codes.
Types of data which is geocoded

- Residential addresses
- Schools, hospitals
- Emission sources, hazardous waste sites
- Wells, air monitoring stations
Examples

• **Street address:**
  – 118 Lincoln Ave, Altamont, NY 12009

• **Other location information:**
  – World Trade Center
  – Wood Lake Mobile Home Park
  – Yankee Stadium
  – ZIP or ZIP+4
Key Elements of Street Geocoding

• Table of street addresses to match
  – 118 Lincoln Ave. Altamont, NY 12009

• Reference file to match with, includes range of street numbers, street name, ZIP & geographic coordinates.

• More accurate geocoders also have the point location for individual addresses

• Software to relate the your table of addresses to the reference files and assign coordinates.

• People to check for errors and match rejects.
Typical Geocoding Process

- Standardizes addresses
- Finds Street within area (ZIP Code)
- Finds street segment within the range
- Determines side of street by parity of street number
Geocoding Process #2

• Interpolates between nodes

• Adds an offset from the road (~15 meters)

• Record is linked to geographic object (point)
Select input columns from your table

Select a column name from the list and drag it to the desired box. To remove a selection, select the column name '<Clear>' and drag it to the desired box.

Table: cmr_matchrates8.TAB

<table>
<thead>
<tr>
<th>Column</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm</td>
<td></td>
</tr>
<tr>
<td>Address</td>
<td>ADDRESS</td>
</tr>
<tr>
<td>Address2</td>
<td></td>
</tr>
<tr>
<td>City</td>
<td>CITY</td>
</tr>
<tr>
<td>State</td>
<td>STATE</td>
</tr>
<tr>
<td>Zipcode</td>
<td>ZIP</td>
</tr>
<tr>
<td>Zip+4</td>
<td></td>
</tr>
<tr>
<td>Urb</td>
<td></td>
</tr>
</tbody>
</table>

Modify/Add Columns

Laura Jones
MapInfo Corp.
113 W. Elk Street
Troy NY 12180 - 1234
Geocoding Street Addresses

- Address is split into fields –
  - Street number, street name, town, ZIP

<table>
<thead>
<tr>
<th>Number</th>
<th>Street</th>
<th>Type</th>
<th>Other</th>
<th>Town</th>
<th>ZIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1209</td>
<td>ROUTE 20</td>
<td></td>
<td>SUITE A</td>
<td>GUILDERLAND</td>
<td>12456</td>
</tr>
<tr>
<td>118</td>
<td>LINCOLN</td>
<td>AVENUE</td>
<td>APT 4</td>
<td>ALTAMONT</td>
<td>12009</td>
</tr>
<tr>
<td>37</td>
<td>W MAIN</td>
<td>STREET</td>
<td></td>
<td>TROY</td>
<td>12567</td>
</tr>
</tbody>
</table>
Address Standardization

Purpose: Produce Single, Standard Address

123 Oak Street West → 123 Oak ST W
Fifth Avenue 2105 → 2105 Fifth AV
83 La Gata Lane → 83 La Gata LA
# Standard Street Type Abbreviations

<table>
<thead>
<tr>
<th>CR</th>
<th>Crescent</th>
<th>CR</th>
<th>FWY</th>
<th>FRWY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crescent</td>
<td>CR</td>
<td>CR</td>
<td>CR</td>
<td>CR</td>
</tr>
<tr>
<td>CRSG</td>
<td>CRSG</td>
<td>CRSG</td>
<td>CRSG</td>
<td>CRSG</td>
</tr>
<tr>
<td>CSWY</td>
<td>CSWY</td>
<td>CSWY</td>
<td>CSWY</td>
<td>CSWY</td>
</tr>
<tr>
<td>DR</td>
<td>DR</td>
<td>DR</td>
<td>DR</td>
<td>DR</td>
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<tr>
<td>Drive</td>
<td>Drive</td>
<td>Drive</td>
<td>Drive</td>
<td>Drive</td>
</tr>
<tr>
<td>DRV</td>
<td>DRV</td>
<td>DRV</td>
<td>DRV</td>
<td>DRV</td>
</tr>
<tr>
<td>EXP</td>
<td>EXWY</td>
<td>EXWY</td>
<td>EXWY</td>
<td>EXWY</td>
</tr>
<tr>
<td>Expressway</td>
<td>EXWY</td>
<td>Expressway</td>
<td>EXWY</td>
<td>Expressway</td>
</tr>
<tr>
<td>EXPWY</td>
<td>EXWY</td>
<td>EXWY</td>
<td>EXWY</td>
<td>EXWY</td>
</tr>
<tr>
<td>Freeway</td>
<td>FRWY</td>
<td>Freeway</td>
<td>FRWY</td>
<td>Freeway</td>
</tr>
<tr>
<td>FRWY</td>
<td>FRWY</td>
<td>FRWY</td>
<td>FRWY</td>
<td>FRWY</td>
</tr>
</tbody>
</table>

etc.

Highway
HWY
HY
LA
Lane
LA
LN
LA
Loop
Motorway
MTWY
MTWY
PKWY
PKWY
## Alias Tables

<table>
<thead>
<tr>
<th>Alias</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMU</td>
<td>5000 Forbes Av</td>
</tr>
<tr>
<td>Carnegie Mellon</td>
<td>5000 Forbes AV</td>
</tr>
<tr>
<td>Carnegie Mellon Univ</td>
<td>5000 Forbes AV</td>
</tr>
<tr>
<td>Carnegie Mellon University</td>
<td>5000 Forbes AV</td>
</tr>
</tbody>
</table>
Once addresses are standardized, they are matched to reference files which have geographic coordinates.
Assigning a Coordinate

Address
123 Oak St
333 Pine Av
18 Bay Dr

Streets

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Street</th>
<th>Type</th>
<th>Side</th>
<th>Parity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>98</td>
<td>Oak</td>
<td>St</td>
<td>L</td>
<td>E</td>
</tr>
<tr>
<td>1</td>
<td>99</td>
<td>Oak</td>
<td>St</td>
<td>R</td>
<td>O</td>
</tr>
<tr>
<td>100</td>
<td>198</td>
<td>Oak</td>
<td>St</td>
<td>L</td>
<td>E</td>
</tr>
<tr>
<td>101</td>
<td>199</td>
<td>Oak</td>
<td>St</td>
<td>R</td>
<td>O</td>
</tr>
</tbody>
</table>
Offset & Inset Adjustment

Inset

Offset
Geocoding Result Codes or Score

- Represents success or failure of geocoding

- Information on the quality of the match.

- Code
  - S5HPNTSZA

- Score
  - 80
# Geocode Result Codes

<table>
<thead>
<tr>
<th>Result Code</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>House number</td>
<td>118</td>
</tr>
<tr>
<td>P</td>
<td>Street Prefix</td>
<td>North</td>
</tr>
<tr>
<td>N</td>
<td>Street name</td>
<td>Lincoln</td>
</tr>
<tr>
<td>T</td>
<td>Street type</td>
<td>Ave</td>
</tr>
<tr>
<td>S</td>
<td>Street suffix</td>
<td>SE</td>
</tr>
<tr>
<td>C</td>
<td>City Name</td>
<td>Oakland</td>
</tr>
<tr>
<td>Z</td>
<td>ZIP Code</td>
<td>94607</td>
</tr>
<tr>
<td>A or U</td>
<td>Address or User Reference File</td>
<td>A</td>
</tr>
</tbody>
</table>
ArcMap Geocoding

• Assigns a score 0->100 related to how well each case address matches the reference address file

• User decides on what score is considered an acceptable match

• The lower the scores will tend to have greater positional error
Geocoding Result Scores

Original address: 127 West Birmingham Drive, 92373

Score of each potential match established:

<table>
<thead>
<tr>
<th>Street</th>
<th>Number</th>
<th>Direction</th>
<th>MatchScore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birmingham</td>
<td>129</td>
<td>W</td>
<td>90</td>
</tr>
<tr>
<td>Birmingham</td>
<td>125</td>
<td>W</td>
<td>85</td>
</tr>
<tr>
<td>Burnington</td>
<td>1100</td>
<td>W</td>
<td>60</td>
</tr>
<tr>
<td>Brunton</td>
<td>129</td>
<td>N</td>
<td>70</td>
</tr>
<tr>
<td>Broomstick</td>
<td>145</td>
<td>S</td>
<td>30</td>
</tr>
</tbody>
</table>

From ESRI
Balance

Match
Rate

Positional
Error

“I can geocode everyone they just might not be in the right location”
Problems:

• Addresses may be duplicated
  Two 118 Lincoln Aves in Albany County

• Variations in Street Names
  Western Ave, Route 20

• Data Entry Errors
  Fidth Avenue
  Maine vs. Main

• Intersections
  5th AV and Craig St
Problems

- Rural Routes, Post Office Boxes
- Mobile home parks
- Apartment Complexes
- Street Ranges incorrect in reference file
- Positional error of street reference files
More Problems

• Renumbering of streets
  E911

• Street Number problems
  147 ½  Pine Court

• Abbreviations
  BNX  Bronx

• Extra Info
  38 Maple Ave Apt 5B
Problems with Parity

Digital Reference File

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>33</td>
</tr>
<tr>
<td>20</td>
<td>32</td>
</tr>
</tbody>
</table>

Actual

21 22 23 24 25 26 27 28 29 30 31 32 33
Geocoding Match Rates & Geocoding Positional Error often vary by Population Density
Areas Classified by Population Density

- Urban
- Suburban
- Rural
- No data

New York State Capitol District

Locations:
- Saratoga
- Schenectady
- Rensselaer
- Albany
Automated Geocoding Match Rates
NY Capitol Region

Urban 94%
Suburban 87%
Rural 62%
Positional error automated geocoding
New York State Capitol Region

<table>
<thead>
<tr>
<th>Area</th>
<th>75%</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>62</td>
<td>152</td>
</tr>
<tr>
<td>Suburban</td>
<td>158</td>
<td>421</td>
</tr>
<tr>
<td>Rural</td>
<td>498</td>
<td>2,872</td>
</tr>
</tbody>
</table>

Cayo & Talbot, 2003
## Geocoding Accuracy in New York Real Property vs. TIGER Based

<table>
<thead>
<tr>
<th></th>
<th>95% Accuracy (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parcels</td>
</tr>
<tr>
<td>Urban</td>
<td>21</td>
</tr>
<tr>
<td>Suburban</td>
<td>39</td>
</tr>
<tr>
<td>Rural</td>
<td>195</td>
</tr>
</tbody>
</table>

Cayo & Talbot, 2003
Disparities between the Census TIGER files and Local Street Files

- More accurate reference street files can cause cases to be geocoded in the correct location but in the wrong census area.

- More accurate street files need to be incorporated into the census database.
Census Boundary Positional Error

Census Block Boundaries

Real Property Centroids

Albany County, NY
New Streets may not be in Reference Files

Census 2000 TIGER Streets & 2001 Aerial Imagery
Obtain Newer Reference Files
Automated Geocoding Percent By Year
New York State Birth Records

Year

Percent Geocoded

Creation of Zip Code Boundaries Using Real Property Centroids

LEGEND
- Miscoded Addresses
- NYSDOH Zip Code Boundary
- Commercial Zip Code Boundary
Other Sources

• Digital phone directories
• Property assessment data
• Aerial photography
• Paper Maps
• Internet
Other Sources

- Postal Service Files
- Department of Motor Vehicles
- City Directories
- E911
Finding mobile home parks & apartments

[Map showing locations of mobile home parks and apartments, including Midway Mobile Village, Bishop Hubbard Apts, Woodcrest Apts, Crescent City Mobile Home Pk, and others.]
Locating Things with Aerial Photography

1 ft. Pixel Imagery from NYS OFT
Finding things with USGS Digital TOPO Maps
Digital Phone Directories

MS-DOS Prompt - PD

Enter Name: TALBOT, THOMAS_
(press Tab to limit) | UPSTATE NEW YORK AREA JAN - 1997 |
TALBOT, TAIN E 4635 N MAIN ST HEMLOCK, NY 14466 716-367-8845
TALBOT, TAMMY COPE CORNERS RD GILBERTSVILLE, NY 13776 607-783-2589
TALBOT, THEODORE STATE ROUTE 26 CARTHAGE, NY 315-493-3603
TALBOT, THOMAS 118 LINCOLN AVE ALTAMONT, NY 12009 518-861-5398
TALBOT, THOMAS 8397 COUNTY ROUTE 125 CHAUMONT, NY 13622 315-649-5246
TALBOT, THOMAS E MYERS MILLS RD NEW LISBON, NY 13415 315-263-5606
TALBOT, THOMAS L 3419 STONE QUARRY RD CAZENOVIA, NY 13035 315-655-2328
TALBOT, THOMAS N SR 5740 WOODSIDE RD SPRINGVILLE, NY 14141 716-592-7830
TALBOT, THOMAS Y 113 KATTELVILLE RD BINGHAMTON, NY 13901 607-648-9407
TALBOT, THOS F 8 CURRIE CT BALLSTON SPA, NY 12020 518-885-7134
TALBOT, THOS L 26 FORMAN ST CAZENOVIA, NY 13035 315-655-9216
TALBOT, THOS P 9 APPLEBLOSSOM LN VOORHEESVILLE, NY 12186 518-765-2509
TALBOT, TIMOTHY 233 W BANK ST ALBION
TALBOT, TIMOTHY 242 CAROLINA ST BUFFAL
TALBOT, TODD COPE CORNERS RD GILBERTS
TALBOT, V R 2 ALLMAN PL NEW HARTFORD
TALBOT, VALERIE 543 AVERILL AVE ROCHES
TALBOT, VANE 39 SOUTH ST EDMESTON, NY
TALBOT, VERA 2185 LANGFORD RD NORTH CO
TALBOT, VINCENT A 159 LYNDALE AVE BUFF
TALBOT, WALTER 135 BRUNSWICK RD TROY

TALBOT, THOMAS
118 LINCOLN AVE
ALTAMONT, NY 12009
518-861-5398 * Residence *

F1-Help Tab-Limit F4-?Index F5-Dial F6-Disc F8-Prt F9-Count Esc-Quit
Geocoding Software Selection

- Match Rate
- Positional Accuracy
- Quality of reference files
- Ease of use
- Clean & Standardize addresses
- Produces Geocoding Result Codes or Scores
# NYS SAM Composite Geocoder


<table>
<thead>
<tr>
<th>Locator Name</th>
<th>Source Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A_SAM_AP_ZipName</td>
<td>SAM Address Points</td>
<td>SAM rooftop address points (as it is developed) using the postal zip code name for the city name in the locator.</td>
</tr>
<tr>
<td>1B_SAM_AP_CTName</td>
<td>SAM Address Points</td>
<td>SAM rooftop address points. The city or town name is used for the city name in the locator</td>
</tr>
<tr>
<td>1C_SAM_AP_PlaceName</td>
<td>SAM Address Points</td>
<td>SAM rooftop address points. The city name is populated using the NYS Villages and Indian Reservations, the Census Designated Places and Alternate Acceptable Zip Code Names from the USPS. These names do not exist everywhere so there will be a limited number of points in this locator.</td>
</tr>
<tr>
<td>1D_SAM_LandmarkAliasName</td>
<td>SAM Address Points</td>
<td>This allows for geocoding to the name of a landmark instead of the street address. (e.g. NYSDOT Hornell NY, 14843) The street address of that landmark will be returned. This locator has been temporarily disabled while bugs are worked out.</td>
</tr>
<tr>
<td>2A_AP_ZipName</td>
<td>Parcel Address Points</td>
<td>Parcel address point using the postal zip code name for the city name in the locator.</td>
</tr>
<tr>
<td>3A_SS_ZipName</td>
<td>NYS Street Segments</td>
<td>NYS Street Segments dataset using the postal zip code name for the city name in the locator. The location is interpolated from an address range on the street segment. The city name can be different for the left and right sides of the streets.</td>
</tr>
</tbody>
</table>
NY SAM Locator has 6.5 Million Individual Addresses

<table>
<thead>
<tr>
<th>AddressSource</th>
<th>DateUpdate</th>
<th>CityTownNa</th>
<th>PlaceName</th>
<th>AddressLab</th>
</tr>
</thead>
<tbody>
<tr>
<td>County Parcels</td>
<td>9/27/2013</td>
<td>Cohoes</td>
<td>Boght Corners</td>
<td>3 Erie St</td>
</tr>
<tr>
<td>County Parcels</td>
<td>9/27/2013</td>
<td>Cohoes</td>
<td>Boght Corners</td>
<td>2 Mohawk St</td>
</tr>
<tr>
<td>GDR AP</td>
<td>12/24/2014</td>
<td>Cohoes</td>
<td>Boght Corners</td>
<td>1 Mohawk St Suite 1</td>
</tr>
<tr>
<td>County Parcels</td>
<td>9/27/2013</td>
<td>Cohoes</td>
<td>Boght Corners</td>
<td>1 Mohawk St</td>
</tr>
<tr>
<td>County Parcels</td>
<td>9/27/2013</td>
<td>Cohoes</td>
<td>Boght Corners</td>
<td>3 Mohawk St</td>
</tr>
<tr>
<td>County 911 AL</td>
<td>12/24/2014</td>
<td>Cohoes</td>
<td>Boght Corners</td>
<td>3 Mohawk St Floor 1</td>
</tr>
<tr>
<td>GDR AP</td>
<td>12/24/2014</td>
<td>Cohoes</td>
<td>Boght Corners</td>
<td>5 Mohawk St Apartment 1</td>
</tr>
<tr>
<td>County Parcels</td>
<td>3/20/2014</td>
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<td>Boght Corners</td>
<td>19 Remsen St Floor 1 Apartment C</td>
</tr>
</tbody>
</table>
The NY Composite SAM Locator uses address points for geocoding. If address point is not found the locator will approximate the location using address ranges for individual street segments.
Other Online Tools

- Google can be linked with applications such as SAS to geocode addresses and calculate driving distances. See Mike Zdeb website.
  http://www.albany.edu/~msz03/
Texas A&M University
Online Geocoding Service
http://geoservices.tamu.edu/Services/Geocode/
Texas A&M Drag & Drop Mapping.

Drag and drop your csv file with latitude/longitude information from windows explorer to the map.

Note: The CSV file must store the location in fields with one of the following names:

latitude fields: (lat, latitude, y, ycenter)
longitude fields: (lon, long, longitude, x, xcenter)
Comparing Point Results from Different Geocoders using Spider Diagrams

Spider Diagram Tool

NYS SAM Locator  TAMU Geocoder

Readings

• Chapter 3 of Cromley and McLafferty

• Chapter 6 GIS Tutorial for Health

• Cayo MR, Talbot TO. Positional Error in Automated Geocoding of Residential Addresses. International Journal of Health Geographics 2003, 2:10 (this is available online)
References

Liadis, John S. GPS TIGER Accuracy Analysis Tools (GTAAT) Evaluation and Test Results - TIGER Operations Branch Geography Division  May 24, 2000


Positional Accuracy Handbook - Using the National Standard for Spatial Data Accuracy to measure and report geographic data quality October 1999