Feasibility Study for a Statewide Road Centerline Data Set

Larry Spraker
Fountains Spatial
Schenectady, NY

Andrew Rowan
Douglas M Schleifer
NJOIT-OGIS

Geocoding
Mapping
Routing
Analysis

OGIS
NEW JERSEY

Accuracy Completeness Addresses
Vintage Topology Attributes
Linear Referencing Turn Restrictions
Statement of Problem

• In 2006, the *NJ Geospatial Forum Transportation Task Force* conducted a survey of public agencies using road centerline data.

• The survey results indicated that:
  – A wide variety of centerline data sets were being used and maintained throughout the state.
  – The data varies greatly in coverage, completeness, accuracy, vintage, attributes, licensing, etc.

• The usage of varied data sets has resulted in:
  – Inconsistency
  – Confusion
  – Redundancy
  – Significant duplication of effort in maintenance
  – Increased costs
Objective

• The Task Force recommended that a study be conducted to evaluate the feasibility of developing and maintaining a single, statewide road centerline data set.

• In June 2007, Fountains Spatial was contracted by the state to conduct the feasibility study.
Work Approach

- Project Initiation
- Requirements Workshops
- Data Analysis
- Research Other States Efforts
- Feasibility Analysis
- Implementation Recommendations and Strategies
- Quantitative Analysis
- Report Development and Final Presentation
Requirements Analysis

• Conducted a series of workshops with stakeholders in state, county, regional, and private organizations
• Objective was to identify and understand the following:
  – Current and potential uses of centerline data
  – Characteristics of existing centerline data
  – Limitations and issues surrounding the current usage
  – Current maintenance procedures and issues
  – Potential issues of a single, statewide data set
  – Needs and requirements for centerline data
  – Cost, legal, security and other issues
Workshop Participants

• New Jersey State Agencies
  – NJOIT
    • Office of GIS
    • Office of Emergency Telecommunication Services
  – NJDOT
    • Transportation Data Development, GIS, Trucking Services, Transportation Security, OEM Operations, Right of Way, Geotechnical Services, Traffic Operations, System Planning, Railroad Engineering
  – NJ State Police
    • Computer-Aided Dispatch
    • Emergency Management
Workshop Participants (cont’d)

• Regional Planning/Management Organizations
  – Delaware Valley Regional Planning Commission (DVRPC)
  – NJ Transit
  – NJ Turnpike Authority
  – North Jersey Transportation Planning Authority
  – Port Authority of NY & NJ
  – South Jersey Transportation Planning Organization
Workshop Participants (cont’d)

- County 911 Coordinators
  - Burlington, Camden, Gloucester, Mercer, Monmouth

- County GIS Coordinators
  - Atlantic, Burlington, Hunterdon, Mercer, Monmouth, Morris, Passaic, Salem, Sussex, Union

- Private Sector
  - Verizon
  - Geodecisions
Data Analysis

- Statewide Centerline Data Sets
  - NJDOT Centerlines
  - TeleAtlas Centerlines
  - NavTEQ Centerlines
  - TIGER 2007 Centerlines

- County Centerline Data Sets
  - Burlington County
  - Hunterdon County

- Related Data Sets
  - NJ Master Street Address Guide (MSAG)
  - Statewide Orthophotos
  - 2008 NJ Municipal Boundaries
Research Efforts in Other States

- Researched road centerline programs in ten (10) other states
  - Arizona
  - Arkansas
  - Connecticut
  - Illinois
  - Kentucky
  - Maine
  - Massachusetts
  - Montana
  - New York
  - Vermont
Current Status

• Two primary, state-wide road centerline data sets in use throughout the state
  – NJ DOT
  – TeleAtlas

• NJ Transit licenses NavTEQ data for a forty (40) county area covering four (4) states

• Many counties maintain and use their own centerline data
NJDOT Road Centerlines

• The Bureau of Transportation Data Development (BTDD) maintains centerlines for the state
• Driven by FHWA requirement to provide mileage totals by road classification on which federal funding is based
• Mandate is only for publicly maintained roads
• Originally developed via “heads-up” digitizing from 2002 orthophotos at a scale of 1:2,400
• New roads now captured using in vehicle GPS
• Centerlines are continuously updated with quarterly releases within NJDOT, and annual releases to the rest of the user community
NJDOT Road Centerlines (cont’d)

• Positive Characteristics
  – Excellent spatial accuracy and topology
  – Contains robust linear referencing system (LRS)
  – Aligns with new municipal boundary data
  – Accurate road classifications

• Issues
  – Only contains publicly maintained roads (41,045 miles)
  – Primary road name is often route rather than local name
  – No address ranges
  – Centerlines are not segmented at intersections
  – No attributes for routing (turn restrictions, one way)
  – Alternate names are not readily usable for geocoding
TeleAtlas Road Centerlines

- NJ licenses centerline data from TeleAtlas for the entire state, plus the 17 neighboring counties from NY, DE and PA
- Annual license cost is $413,500
- License covers state, county, municipal gov’t as well as Port Authority of NY & NJ, and Delaware River Port Authority
TeleAtlas Road Centerlines (cont’d)

• Positive Characteristics
  – Contains all (public and private) roads in the state (50,435 miles)
  – Contains address ranges for geocoding
  – Contains attributes to support routing
  – Centerlines are segmented at intersections

• Issues
  – Spatial accuracy is good in many areas, but more generalized in some areas (not as accurate as NJDOT)
  – No linear referencing system (LRS)
  – Does not align with new municipal boundary data
  – Road names not completely standardized/consistent
Other Centerline Data Sets

• NavTEQ
  – Licensed for exclusive use by NJ Transit
  – Study area is 40 county/4 state area
  – Required a consistent data source across the entire study area

• County Maintained Centerlines
  – Many counties maintain their own centerline data
  – Eleven (11) counties are either GPS derived, aligned to the orthophotos, or aligned to parcel boundaries
  – Many do not have address ranges, but have additional attributes such as number of lanes, striping, etc.
  – Many still use TeleAtlas data for address matching

• OGIS Routing Service
  – OGIS provides a web-based routing service based on ArcIMS Route Server which utilizes the TeleAtlas centerlines as the reference data
Spatial Accuracy

- NJDOT in Red
- TeleAtlas in Green
Private Roads

- NJDOT in Red
- TeleAtlas in Green
Stakeholder Requirements

• Geographic Extent
  – Many stakeholders require the 17 neighboring counties
  – County 911 dispatch (wireless calls as x,y coordinates)
  – Mutual aid and emergency response
    • NJ State Police
    • NJ Office of Homeland Security and Preparedness
    • Port Authority of NY & NJ
    • NJ Turnpike Authority
  – The neighboring counties must continue to be provided
Stakeholder Requirements

- **Completeness**
  - Stakeholders require both public and private roads
  - Several require “internal” roads for larger facilities (airports, malls)
  - Port Authority of NY & NJ has mapped the internal roads for the 22 facilities they manage

- **Spatial Accuracy/Alignment**
  - The accuracy of the TeleAtlas centerlines is adequate for many uses
  - NJDOT requires highly accurate centerlines to support the mileage reporting
  - NJDOT cannot utilize another data set maintained by a third party with inferior accuracy
  - Stakeholders require alignment with political boundaries (and other features)
Stakeholder Requirements

• Road Naming and Classification
  – Road Name - Require local name as primary road name
  – Alternate Names – Require alternate names in core attributes for each segment
  – Road Classification – NJDOT classification is sufficient, TeleAtlas classification is not

• Address Ranges
  – One of the most important attributes (with postal codes) required
  – Most use TeleAtlas for address matching and NJDOT for geocoding by milepost
  – A single data set that could be used for both types of geocoding is very important
Stakeholder Requirements

• Timeliness
  – Current quarterly update cycle is not sufficient for many users
  – TeleAtlas is particularly slow since it may be several update cycles before a new road appears
  – Timeliness issues contribute to many counties maintaining their own data
  – 911 dispatch and emergency response require new roads and addresses immediately
  – For 911 dispatch, new roads and addresses are ideally integrated PRIOR to construction in case they have to dispatch emergency services during construction
Stakeholder Requirements

• Linear Referencing
  – LRS is mission critical within NJDOT
  – LRS is also widely used by many stakeholders for milepost geocoding

• Segmentation
  – Stakeholders require physical segmentation at intersections (and other related features)
  – Core attributes assigned to each segment

• Routing
  – Most stakeholders do not actively conduct routing
  – However, many had interest in the future
  – NJ OGIS offers a routing service but is used by very few
Stakeholder Requirements

• Other Attributes
  – Number of Lanes
  – Average Speed
  – Height and Weight Restrictions

• Related Features
  – Bridges
  – Rail Crossings
  – Toll Booth Locations
Other State Programs

• Multiple Centerline Data Sets
  – Similar to NJ, have robust data with LRS in-house, plus commercial data
  – Continue to use multiple centerline data sets (but many have plans)
  – Vermont, Maine, Kentucky, Wisconsin

• Commercial Vendor Maintenance
  – Enhancing commercial data set with state provided data (e.g., LRS)
  – State licenses the data and contracts with vendor for maintenance
  – New York, Illinois, Massachusetts, Connecticut

• State Owned and Maintained
  – Developed a centerline data set in-house from multiple sources
  – No commercial data vendor assistance
  – Arkansas, Kansas, Montana
Implementation Options

1. Commercial Data Vendor
   - Contract with data vendor (e.g., TeleAtlas) to make the required enhancements to their data set
     • Adding LRS, align to orthos, align to municipal boundaries, adjust road names/alternate names
   - Continue to license data and contract maintenance

2. Contract Enhancements/In-house Maintenance
   - Contract with consultant to enhance the NJDOT data
   - Develop a business process for maintaining the enhanced data set in-house
Constraints

• NJDOT cannot migrate to a different centerline geometry
  – FHWA mileage reporting requirements
  – TeleAtlas and NavTEQ are less accurate
  – TeleAtlas and NavTEQ classify their roads differently
  – NJDOT cannot rely on a third party to maintain the data set for FHWA reporting
  – NJDOT has nine (9) enterprise information systems that rely on the specific structure of the current data set

• Option 1 is not feasible
Implementation Recommendation

• Option 2 is recommended for consideration
  – Contract with consultant to enhance the NJDOT data
  – Develop a business process for maintaining the enhanced data set in-house
  – Discontinue the TeleAtlas license
  – State would fully own the centerline data set

• Routing Exception
  – However, creating and maintaining full routing attributes at a statewide level would be difficult and cost prohibitive
  – The existing routing web service should continue to be offered
  – Centerline data can be shared with TeleAtlas and NavTEQ which can improve their completeness and accuracy
Creating the Statewide Data Set

• Data Model Design
• Segmenting Centerlines
• Adding Private Roads
• Conflation/Attribute Population
• Primary and Alternate Road Names
• Neighboring Counties
• Pilot Project
Data Model Design

• Design data model to accommodate required enhancements and minimize impact on NJDOT

• Unique segment id for physical attribution and related tables for dynamic attribution (via LRS)

• Initial focus on populating “core attributes”
  – Road Name/Alternate Names
  – Address Ranges
  – ZIP Code

• SRI numbering extended for privately maintained roads

• Design should facilitate adding additional attributes

• Include routing fields in design as placeholders
Segmenting Centerlines

- Segment the NJDOT centerlines at intersections as well as boundary changes (ZIP, Municipal)
- Fully automated procedure
- First step in process to enable conflation, attribution and private road addition
- If routing attributes are populated, turn restrictions will be required due to full segmentation (overpasses, etc.)
Adding Private Roads

- TeleAtlas cannot be used due to licensing
- Multiple sources
  - County maintained data
  - TIGER 2007 (improved geometry and addresses)
  - Orthophotos
- Evaluate best source for each County
- Primary Method - Transfer centerlines from best vector source and align to orthos as necessary
- Secondary Method - Heads-up digitize from orthophotos
- Based on mileage comparison between TeleAtlas (50,000) and NJDOT (41,000), as many as 9,000 miles to be added
- This is likely an overestimate
Conflation/Attribute Population

• Conflate road names, address ranges and ZIP codes for new roads from TIGER 2007
• A majority of the state can be conflated in an automated manner, with balance interactively
• Based on TIGER mileage (45,000), approximately half of the 9,000 miles of new roads may not have a corresponding segment for conflation
• These segments will require manual attribute tagging using reference data (ZIP, parcels, 911)
• Recalibrate LRS measures (automated procedure)
Primary/Alternate Road Naming

• Primary and Alternate road names stored in separate fields (do not disrupt NJDOT names)
• During conflation, add alternate name when names mismatch
• Add process for swapping primary and alternate name if desired
• Standardize naming as needed
• Use conflated names as well as existing NJDOT alternate name table as sources
Neighboring Counties

- Neighboring 17 counties still required
- Select the best available source and arrange partnerships to acquire regularly (data cooperative)
- For example, 8 of the 17 counties are from NY which maintains statewide centerlines (ALIS)
- Additional resources include DVRPC, PennDOT, individual counties, and TIGER
- This is often the best data source
- Acquire and redistribute to end users (with documentation)
- Two components: NJ centerlines and neighboring counties
Pilot Project

- Pilot project is recommended
  - Test/refine the data model
  - Evaluate the enhancements required
  - Identifying issues
  - Defining specific processing procedures
  - Refine required costs

- Study area of 3 – 5 municipalities (~1,500 miles)

- Representative sample
  - Road types (NJ Turnpike, GSP, County, local, private, airports)
  - Urban/Rural
  - County centerline data vs no county data (TIGER)
  - Good alignment vs poor alignment with NJDOT roads
Data Maintenance Program

- Development of the centerline data is one time effort/cost.
- An effective maintenance program is **critical** to the long term success of a centerline program.
- Change detection and notification is likely the most challenging aspect of the maintenance program.
- Insures data quality and timeliness.
- Allows end users to have confidence in data.
- Encourages active and continued participation in change notification.
Structure and Business Process

- Joint responsibility between OGIS and BTDD
  - BTDD responsibilities expand to include private roads
  - Focus on minimizing the changes to BTDD process
  - OGIS responsible for maintaining the extended attributes (address ranges, ZIP, names) and coordinate changes with county/local officials and Verizon
  - New “maintenance coordinator” position within OGIS to serve as the liaison with organizations, review/manage change requests, and coordinate with BTDD
Change Detection/Notification

- Critical to have several mechanisms in place to notify the state of changes/additions
- County 911 programs are already responsible for change detection
- Burlington County has a unique program where the municipalities are mandated to submit changes
- Implementing a process that aligns with the 911 programs is recommended
- Although challenging, a mandate similar to Burlington would be ideal
- State can also review other data sources (e.g., assessor) regularly to identify changes (check/balances)
Quantitative Analysis – Upfront Costs

- Estimated costs are based on the highest hourly rate for *GIS Data Conversion* on state contract ($60)
- Segmenting Centerlines
  - Fully automated procedure via overlays
  - Estimate of 80 hrs @ $60 = $4,800 (~ $5,000)
- Adding Private Roads
  - Estimate of up to 9,000 miles of private roads
  - Estimate of 30 minutes per road mile
  - 9,000 miles x 30 min/mile = 270,000 minutes
  - 270,000 minutes/60 min = 2250 hrs * $60/hr = $270,000
Quantitative Analysis – Upfront Costs

• Conflation/Attribute Population
  – TIGER contains 45,000 miles (conflation candidates)
  – Automated conflation is estimated at 80% (36,000/45,000)
  – 20% of TIGER segments will require manual conflation (9,000 mi.)
  – Estimate of 30 minutes per road mile
  – 9,000 miles x 30 min/mile = 270,000 minutes
  – 270,000 minutes/60 min = 2250 hrs * $60/hr = $270,000
  – 4500 miles of private roads created via heads up dig.
  – Conflation is not available, therefore manual attribute entry required
  – Using similar rate of 30 minutes per mile, 4500 x 30 = 135,000 min.
  – Cost of $135,000 for manual entry
  – Total cost of $270,000 + $135,000 = $405,000
Quantitative Analysis – Upfront Costs

- Primary/Alternate Names
  - Primarily a database manipulation task requiring automated scripts/programs
  - Resolve issues of swapping primary/alternates
  - Standardization
  - Estimated as fixed cost of approximately $50,000
Quantitative Analysis – Upfront Costs

• Quality Assurance/Quality Control (QA/QC)
  – General level of effort throughout the project
  – Primarily reviewing operator-assisted tasks
  – Can include general tasks that arise
  – Estimated as 25% of operator-assisted hours (1500 hrs)
  – 1,500 hours @ $60/hr = $90,000
Quantitative Analysis – Upfront Costs

• Pilot Project
  – Assuming a study area of approximately 1,500 miles
  – Vast majority of estimated cost is in the design and development of automated tools and techniques in each area
  – Tools and techniques can be re-used
  – Operator assisted time is approximately $30,000 (@ $60/hr)
  – Estimate of ~$120,000 for GIS Consultants/Developers to design and develop tools and techniques
  – Total estimated cost of $150,000
# Upfront Cost Summary

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segmentation</td>
<td>$5,000</td>
</tr>
<tr>
<td>Adding Private Roads</td>
<td>$270,000</td>
</tr>
<tr>
<td>Conflation/Attribute Population</td>
<td>$405,000</td>
</tr>
<tr>
<td>Primary/Alternate Names</td>
<td>$50,000</td>
</tr>
<tr>
<td>QA/QC</td>
<td>$90,000</td>
</tr>
<tr>
<td>Pilot Project</td>
<td>$150,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$970,000</strong></td>
</tr>
</tbody>
</table>
Quantitative Analysis - Maintenance

- **Adding Private Roads**
  - BTDD will not be responsible for re-inventorying private roads annually (only adding new private roads)
  - Based on BTDD cost of $158.59 per mile
  - Avg. increase in road mileage from 2004 – 2007 is 187 miles
  - Private roads appear to be no more than 20% of total
  - Estimated 37 miles of new private roads annually
  - At the above cost, results in cost of ~ $6,000 per year (37 miles * $158.59)

- **Maintenance Coordinator Position**
  - Experienced GIS professional (mgmt and communication skills)
  - Full time position with fringes/benefits estimated at $100,000
## Annual Maintenance Cost Summary

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adding Private Road Update Responsibility to BTDD</td>
<td>$6,000</td>
</tr>
<tr>
<td>Maintenance Coordinator Position at OGIS</td>
<td>$100,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$106,000</strong></td>
</tr>
</tbody>
</table>
Cost/Benefit Summary

- **Upfront Costs**
  - Estimated upfront costs of creating the enhanced centerline data set is $970,000

- **Annual Savings**
  - Current annual TeleAtlas license fee is $413,500
  - Estimated increase in annual maintenance costs is $106,000
  - Annual savings of approximately $307,000

- **The upfront costs are recaptured in approximately three (3) years**
Benefits

- Provides a single, comprehensive data set
- Owned by the State of New Jersey
- Eliminates redundancy, inconsistency and confusion
- Provides a single source for geocoding
- Cost effective, resulting in significant savings
- Offers more control over design and attributes
- Allows more control over road naming and standardization
- Provides more timely updates for 911 and homeland security
- Leverages the existing investment by NJDOT
- Data set is extensible
Conclusions

- The current use of multiple centerline data sets results in redundant effort and costs, and breeds inconsistency and confusion.
- There is overwhelming support among stakeholders for a single, centerline data set.
- The implementation option examined in this study appears both feasible and cost effective.
- It is recommended that the state strongly consider implementing a statewide, road centerline data set.