Feasibility Study for a Statewide Road Centerline Data Set

Larry Spraker
Fountains Spatial
Schenectady, NY

fountains spatial

Andrew Rowan
Douglas M Schleifer
NJOIT-OGIS

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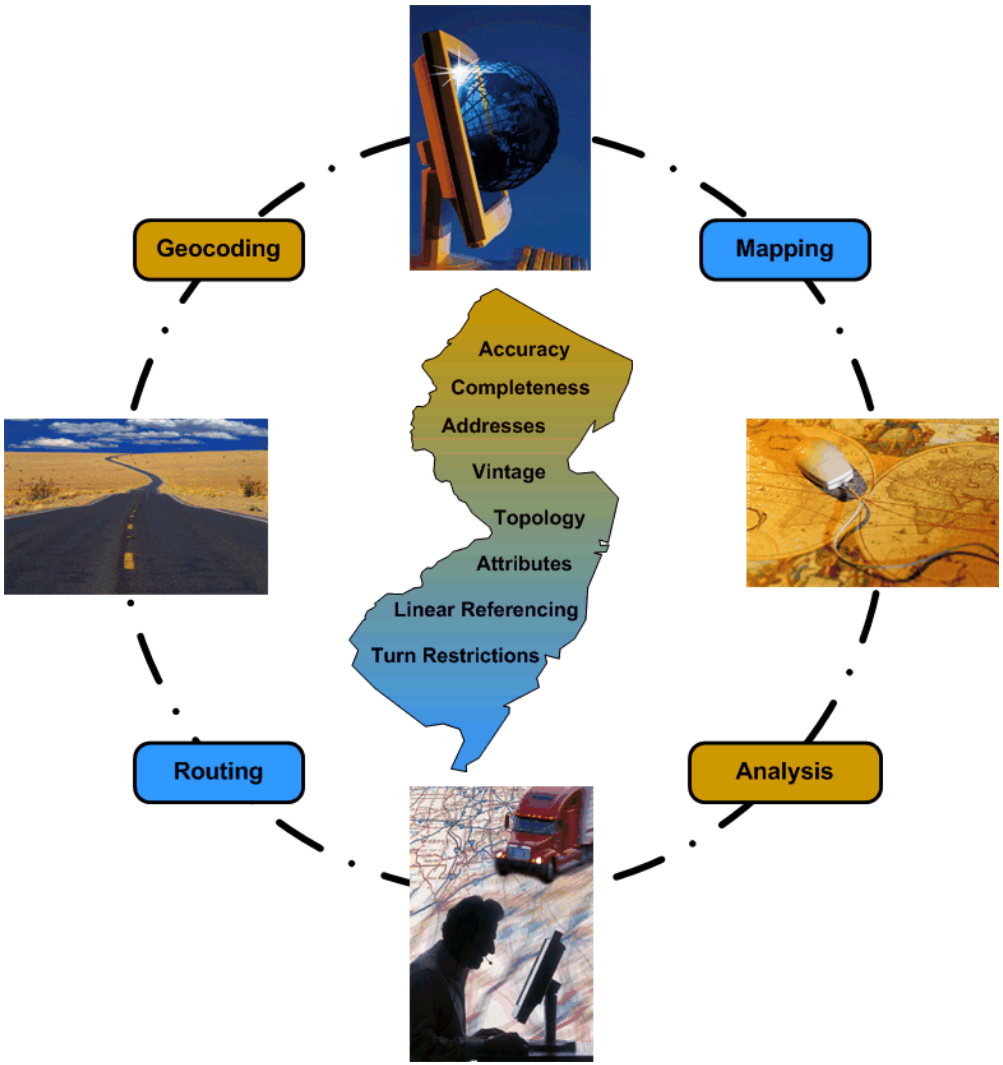

Statement of Problem

- 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

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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

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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

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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

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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 Office of Homeland Security and Preparedness
  - NJ State Police
    - Computer-Aided Dispatch
    - Emergency Management

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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

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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

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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

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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

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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

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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

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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

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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

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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

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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

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Spatial Accuracy

- NJDOT in Red
- TeleAtlas in Green

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Private Roads

- NJDOT in Red
- TeleAtlas in Green

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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

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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)

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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

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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

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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

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Stakeholder Requirements

- Other Attributes
  - Number of Lanes
  - Average Speed
  - Height and Weight Restrictions
- Related Features
  - Bridges
  - Rail Crossings
  - Toll Booth Locations

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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

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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

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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

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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

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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

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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

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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.)

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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

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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)

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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

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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

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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

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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

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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)

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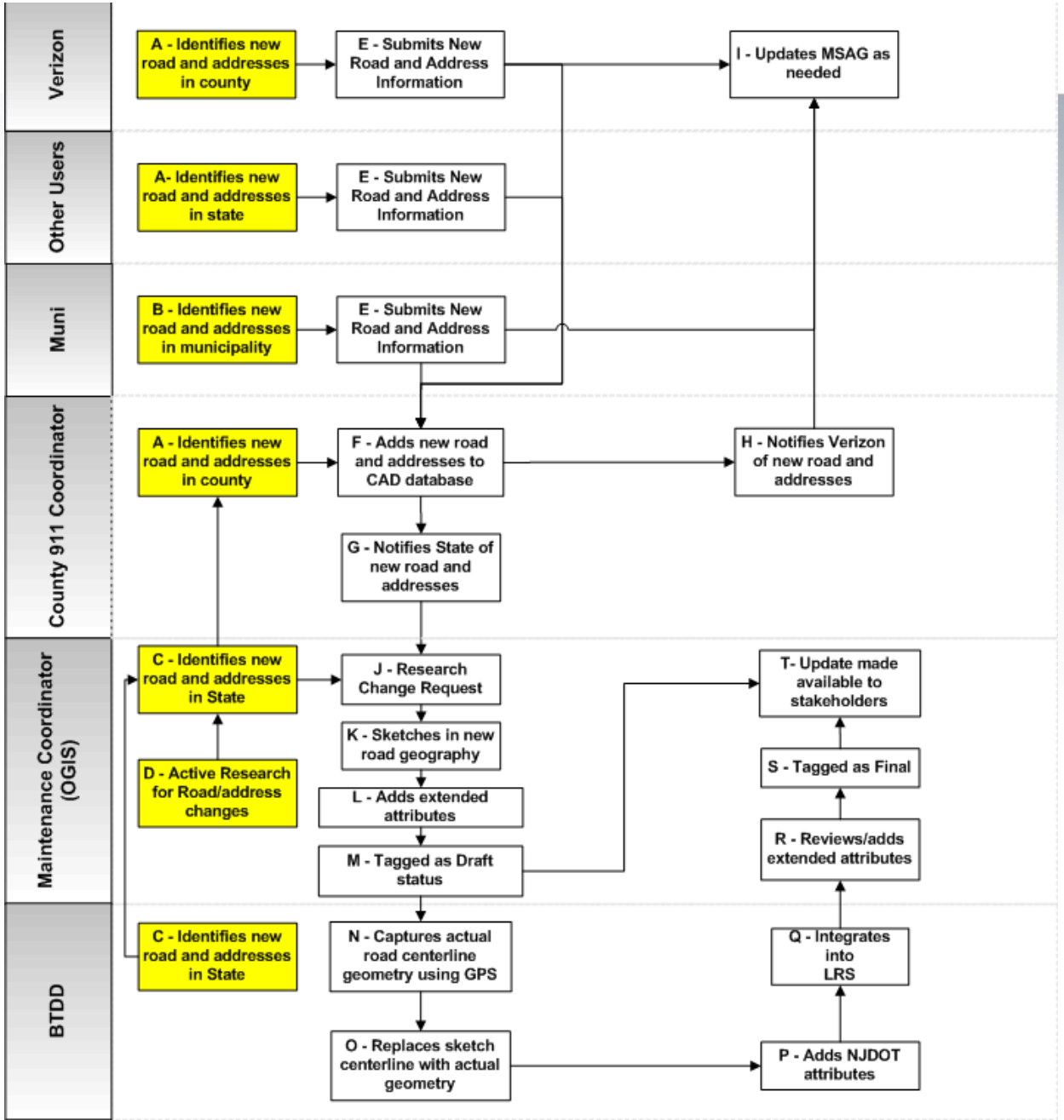
General Workflow



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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

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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

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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

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Upfront Cost Summary

Segmentation	$5,000
Adding Private Roads	$270,000
Conflation/Attribute Population	$405,000
Primary/Alternate Names	$50,000
QA/QC	$90,000
Pilot Project	$150,000
Total	**$970,000**

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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

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Annual Maintenance Cost Summary

Adding Private Road Update Responsibility to BTDD	$6,000
Maintenance Coordinator Position at OGIS	$100,000
Total	**$106,000**

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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*

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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

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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

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