Roadway Geometry and Inventory Trade Study for Connected Vehicle Highway Applications

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Connected Vehicle Highway Initiative*

Improve transportation safety and mobility, and reduce environmental impacts of surface transportation through the use of networked wireless communication between vehicles, infrastructure and traveler's personal communication devices.

Connected vehicle highway applications require:

- Accurate Positioning
- Up-to-date attribute information

on roadway geometry and specific roadway features

* formerly IntelliDrive^{SM}

Study Objectives

1. Investigate current and emerging sources of roadway geometry and inventory data:
   - Commercial and public databases
   - New data collection technologies

2. Assess ability of data sources to deliver roadway geometry and inventory data needed by potential near-term connected vehicle highway applications.

Study Approach

1. Identify and vet roadway data needs among connected vehicle highway stakeholders
2. Identify current sources of roadway geometry and inventory data
3. Conduct focused interviews with roadway data sources
4. Analyze and compare data sources against connected vehicle highway data needs.
5. Identify current data gaps and recommendations for closing those gaps

Connected Vehicle Highway Data Needs

- Initial list of roadway data items compiled from earlier research studies.
- Initial list was vetted among connected vehicle highway stakeholder groups

- State DOTS
- Local Transportation Agencies
- Transit Agencies
- USDOT Modal Agencies
- University Transportation Centers
- Automobile Manufacturers
- Motor Carrier Industry
- Traffic Signal Manufacturers
- Traffic Management Integrators
- Connected Vehicle Highway Integrators/Developers

Revised List of Roadway Data

Roadway Geometry

- Horizontal Alignment
  - Curve radius and length
- Grade
- Elevation
- Vertical Alignment
- Sight Distance
- Cross Slope/Superelevation

Roadway Inventory

- Roadway Characteristics
  - Number of Lanes
  - Surface Type
- Lane Characteristics
- Median
- Shoulder and Clear Zone
- Sidewalk
- Ramp
- Speed Zones
- Roadside Barriers/Guardrails

Revised List of Roadway Data

Intersection Characteristics

- Intersection Geometry
- Approach Configuration
  - Auxiliary Turn Lanes
  - Turn prohibitions
- Pavement Markings
- Traffic Control

Other Geospatial Features

- Railroad Crossings
- Bridges and Tunnels
- Transit Stops
- Commercial Vehicle Facilities
  - Truck Parking
  - Roadside Inspection Stations
- Coverage areas
  - GPS Signal
  - Weather Monitoring
  - Road Condition Monitoring
  - Traffic Monitoring

Sources of Roadway Data

- National Roadway Network Databases
  - ALK
  - DeLorme
  - Google
  - NAVTEQ
  - Tele Atlas
  - TIGER/Line
- National Roadway Inventory Databases
  - Highway Performance Monitoring System (HPMS)
  - National Bridge Inventory (NBI)
  - Highway-Rail Crossing Inventory (HRCI)

Sources of Roadway Data

- State DOT Roadway Inventory Data
- Local Roadway Inventory Data
  - County and municipal road agencies
  - Traffic Management Centers (TMCs)
- Public Transit Operators
- Innovative Data Collection Technologies
  - Interferometric Synthetic Aperture Radar (IFSAR)
  - Enhanced Videolog Feature Extraction
  - Mobile LIDAR

Trade Study Findings

Coverage

Geospatial roadway networks should provide nationwide coverage and include roadway geometry for all public roads

- Each of the six national roadway networks satisfy this requirement
- State roadway networks rarely extend beyond state borders, and often include only higher functional class roads
- Most local roadway agencies do not maintain their own roadway networks.

Trade Study Findings

Network Connectivity

Several connected vehicle highway attributes are best represented using a roadway database having network connectivity. This is also a prerequisite for vehicle routing and navigation

- Only the five commercial national roadway networks currently have complete network connectivity
- Very few State DOT roadway networks have network connectivity, and would require significant enhancement to meet this requirement

Trade Study Findings

Feature Resolution

Roadway networks should distinguish between individual travel lanes and provide lane-level attributes

- No national or state roadway database currently provides lane-level feature resolution
- Roads segments typically represent the centerline of the travel way
- NAVTEQ & Tele Atlas provide enhanced lane information for some road segments

Trade Study Findings

Positional Accuracy

Potential connected vehicle highway applications require a positional accuracy of 1 meter absolute error or better

- Current roadway networks have positional accuracies ranging from 3 to 15 meters.
- NAVTEQ and Tele Atlas are enhancing their networks to an a positional accuracy of 1 to 5 meters to support connected vehicle highway applications

Roadway Geometry

ATTRIBUTE	Current Data Sources	Using Emerging Technology
Horizontal Alignment	F	IFSAR
Grade	F	IFSAR
Elevation	F	IFSAR
Vertical Alignment	NA	IFSAR
Sight Distance	NA	LIDAR
Cross Slope	NA	LIDAR

Roadway Inventory

ATTRIBUTE	Current Data Sources	Using Emerging Technology
Number of Thru Lanes	A	A
Lane Characteristics	NA	LIDAR
Median Location	A	A
Median Characteristics	F	LIDAR
Shoulder Location, Type, Width	F	Videolog
Clear Zone Width	NA	LIDAR
Sidewalk Location	NA	Videolog
Ramp Location, Type, Lanes	A	A
Speed Zone Location	F	Videolog
Guard Rails	G	Videolog

Intersection Characteristics

ATTRIBUTE	Current Data Sources	Using Emerging Technology
Intersection Location	A	A
Type of Intersection	A	A
Intersection ID	NA	NA
Turn Prohibition	A	A
Lane Characteristics	G	Videolog
Paths through Intersection	NA	GPS Tracks
Pavement Markings	G	LIDAR
Traffic Signal Location	G	LIDAR
Traffic Signal Characteristics	NA	NA

Other Geospatial Features

ATTRIBUTE	Current Data Sources	Using Emerging Technology
Railroad Crossings	A	A
Bridges/Tunnels	A	A
Transit Stops	G	Videolog
Commercial Vehicle Facilities	F	Videolog
Truck Parking Facility Capacity	NA	NA
GPS Coverage Area	G	G
Weather Coverage Area	A	A
Road Condition Coverage Area	G	G
Traffic Coverage Area	G	G

Trade Study Findings

Data Format & Size

Data must be in a format that can be utilized by in-vehicle processors and efficiently communicated via wireless devices

- Most public domain data are stored and distributed using standard GIS formats
- Road inventory data stored using LRS requires additional processing to integrate, plus separate LRS maintenance
- NAVTEQ and Tele Atlas data are available in GDF format

Trade Study Findings

Updating Frequency & Methods

Attribute changes critical to vehicle safety must be transmitted to the roadway database in near real time.

- No existing database currently meets this requirement.
- Public databases are typically updated annually, but some data may reflect even longer update intervals.
- Commercial databases are updated continually, but published at intervals ranging from monthly to annually.

Trade Study Findings

Data Collection & Updating Technologies

- Data sources currently use similar collection methods
  - Airborne orthoimagery
  - Mobile data collection vehicles
- Emerging technologies can significantly increase positional accuracy and resolution.
  - IFSAR
  - Mobile LIDAR
- Cost and level of effort to process roadway data force data sources to prioritize what data is collected and its coverage.

Trade Study Findings

Work Flow Processes

Roadway data sources should have stable processes for data collection, updating, quality control and dissemination.

- Work flow processes are better defined and integrated for commercial data sources than for public agencies.
  - Dedicated staff for data collection, processing and verification
  - Established procedures and schedules for data updates
- Data collected by state DOTs are typically maintained in separate legacy databases, with few agencywide standards.

Federal databases are compiled from individual state DOTs, with little independent verification of data accuracy.

Trade Study Findings

Business Models

- Public agencies collect roadway data to satisfy internal business needs or to meet Federal reporting mandates.
- Commercial roadway databases are either the primary product or a key element of the product or service being marketed.
  - Data content and quality are tailored to the needs of the target market.
- NAVTEQ and Tele Atlas view connected vehicle highway applications as a promising new market, and are enhancing their current databases to support anticipated applications.

Conclusions and Recommendations

Refine and Standardize Connected Vehicle Highway Data Needs

- Need for clearer definition of connected vehicle highway data needs and development of data standards
- Standards development process needs to be collaborative and include data sources and application developers.
  - Standards development is time-consuming, highly technical, and iterative
- U.S. DOT should participate on several levels:
  - Connected vehicle highway stakeholder
  - Sponsor and facilitator of standards development meetings
  - Champion for adoption of standards that are developed

Conclusions and Recommendations

Options for Building a Roadway Database for Connected Vehicle Highway Applications

1. A public domain database managed by a Federal agency with authority to build and maintain the database.
2. A public domain database that is managed by a private sector contractor under Federal agency sponsorship.
3. A commercial database maintained by the private sector and marketed to connected vehicle highway application developers

Institutional Recommendations

1. Monitor and participate in ongoing national roadway data sharing initiatives (e.g., TFTN)
2. Consider local roadway data availability as a selection criterion for future connected vehicle highway demonstration grants

Research Recommendations

1. Evaluate the feasibility of using IFSAR to collect accurate 3-D roadway geometry, nationwide
2. Evaluate feasibility and costs of using mobile LIDAR to collect specific roadway geometry and inventory data
3. Coordinate connected vehicle highway data research with current highway safety data research (e.g., SHRP2)
4. Work with state DOTs to demonstrate benefits of collecting additional roadway data items in their business process
5. Expand current research to develop a data management and governance model for connected vehicle highway data.

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- Full Report can be found at:

  http://www.fhwa.dot.gov/publications/research/safety/10073