Beyond Base Mapping

Construction and Application of a Complete 3D Model of the Kansas Highway Network

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Outline

- Origin of Concept
- Spatially Enabled Applications
- Understanding GPS Accuracy
- Tenets of 3D Model
- Current Applications

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Origin ~ 1998

- Pavement Management Vans were augmented with GPS
- Video-log operations also were augmented with GPS
- Improve efficiency of data collection and use for later integration with GIS

GPS Augmented Data Collection

- GPS tags included in data stream, but not used in processing
- A more accurate model was needed to translate between Geodetic coordinates and LRS
- Data collection was not spatially enabled, only GPS augmented.

Spatially Enabled Applications

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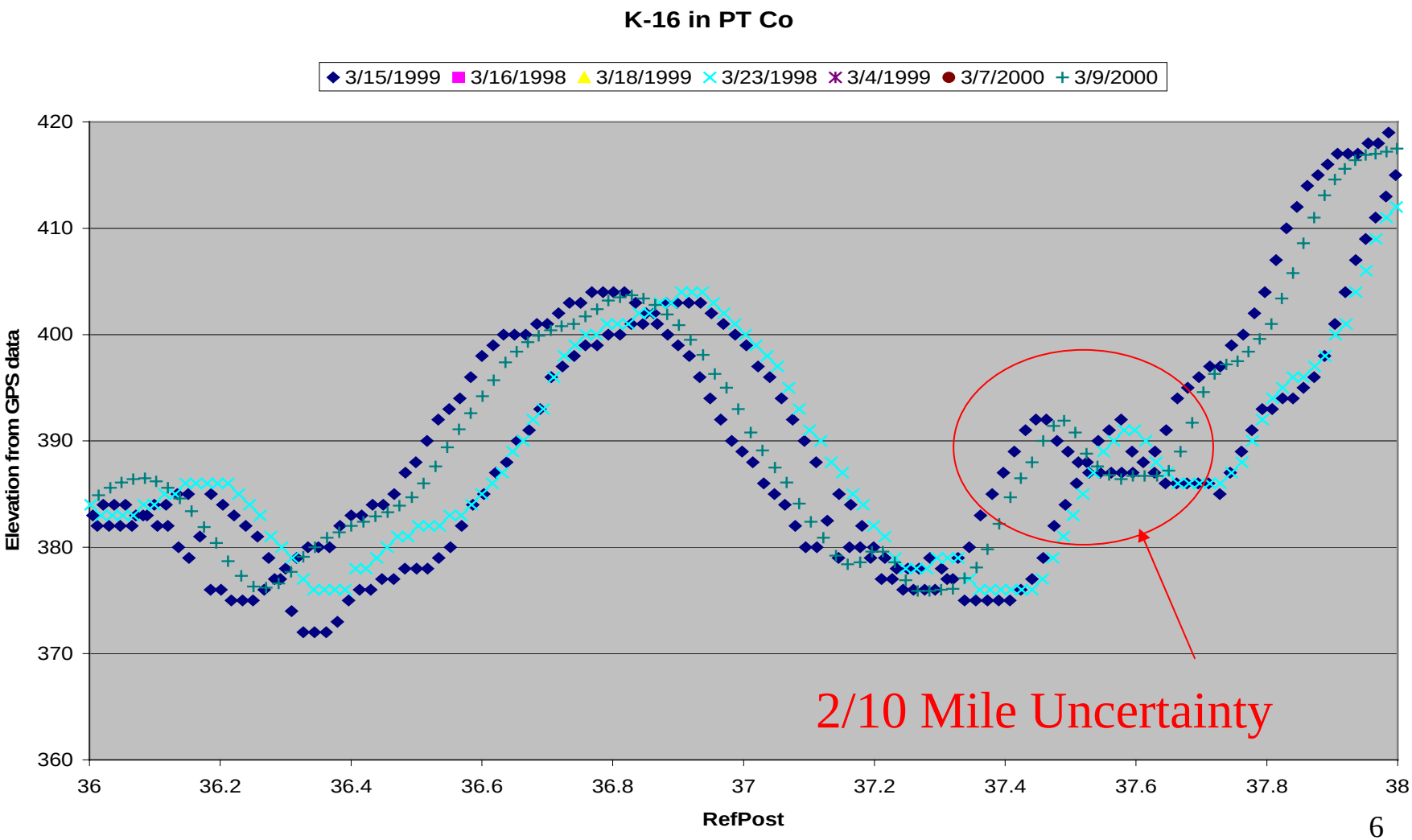
- Automated Data Collection
  - Geodetic coordinates were at the base of data collection
  - No manually entered LRS
  - Consistent location referencing
  - Immunity from human errors
  - Improved historical continuity of Data

Problems with LRS Reference



More Applications

- Geometric Analysis
  - Most assets have not only location, but form
  - “Form Data” are locked in design documents
- Data Linking
  - Integrate spatial data at the Geodetic Coordinate level, not the LRS level
  - Not all data is LRS centric
    - Bore Holes and Quarry Data

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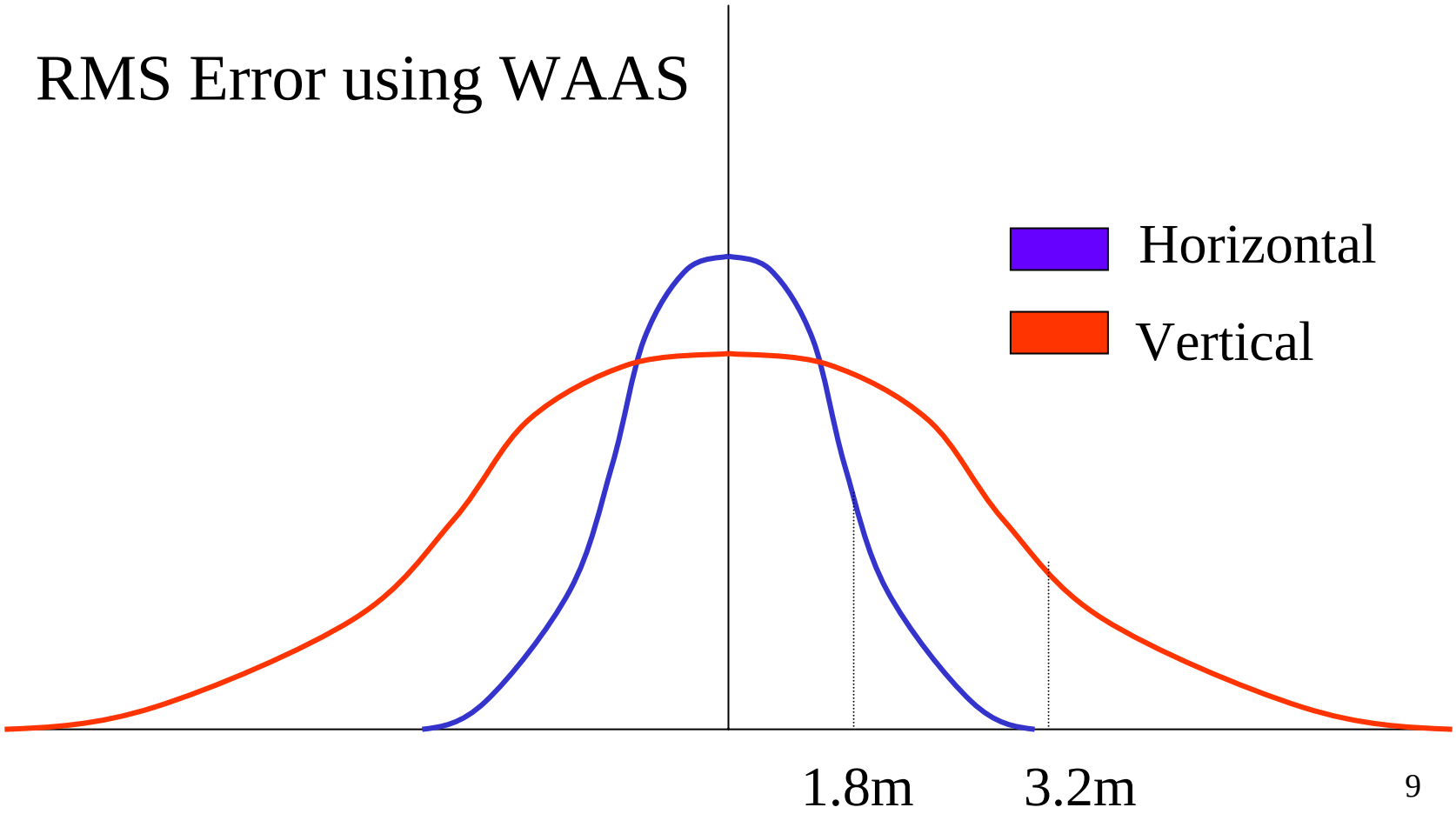
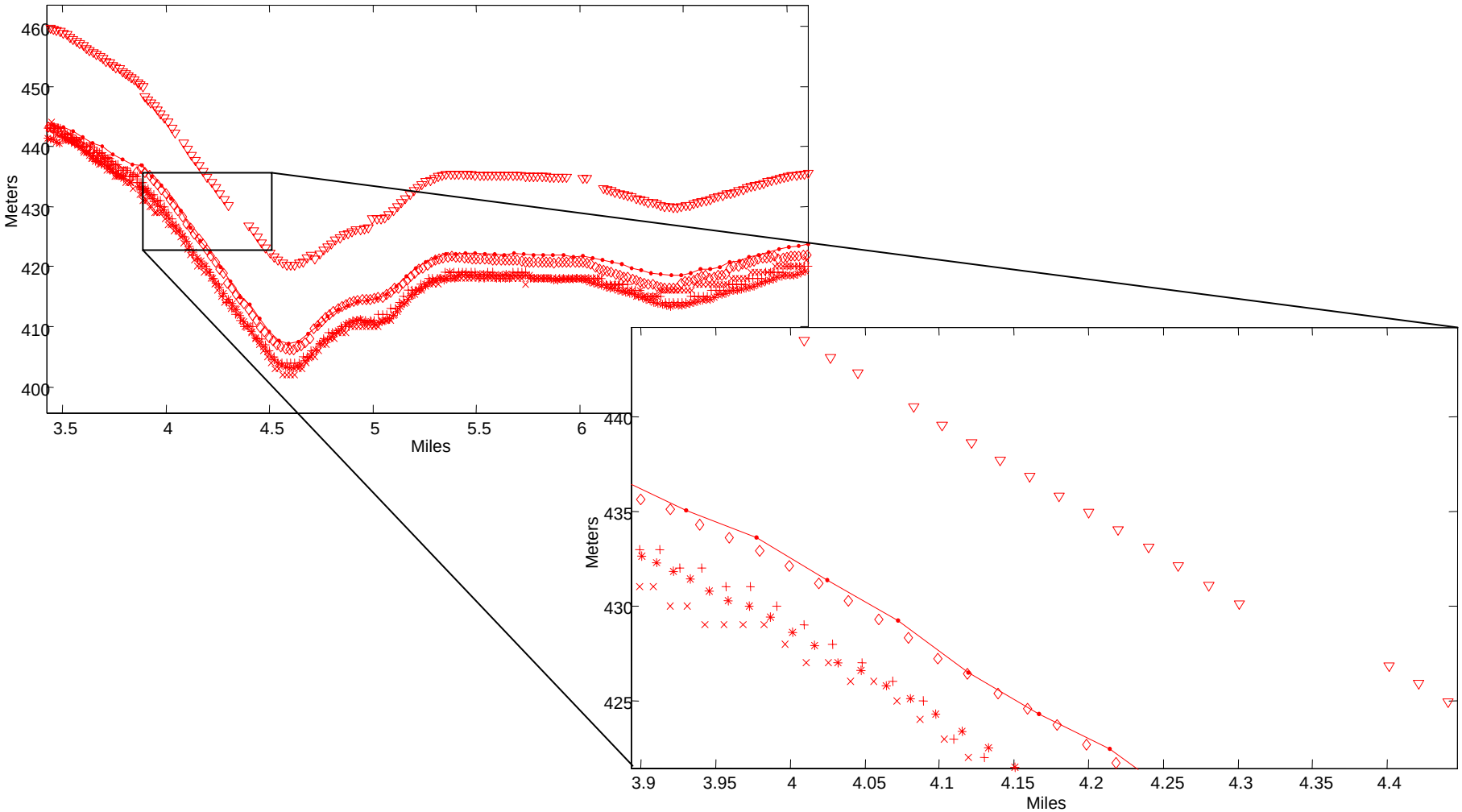
Error Tolerances

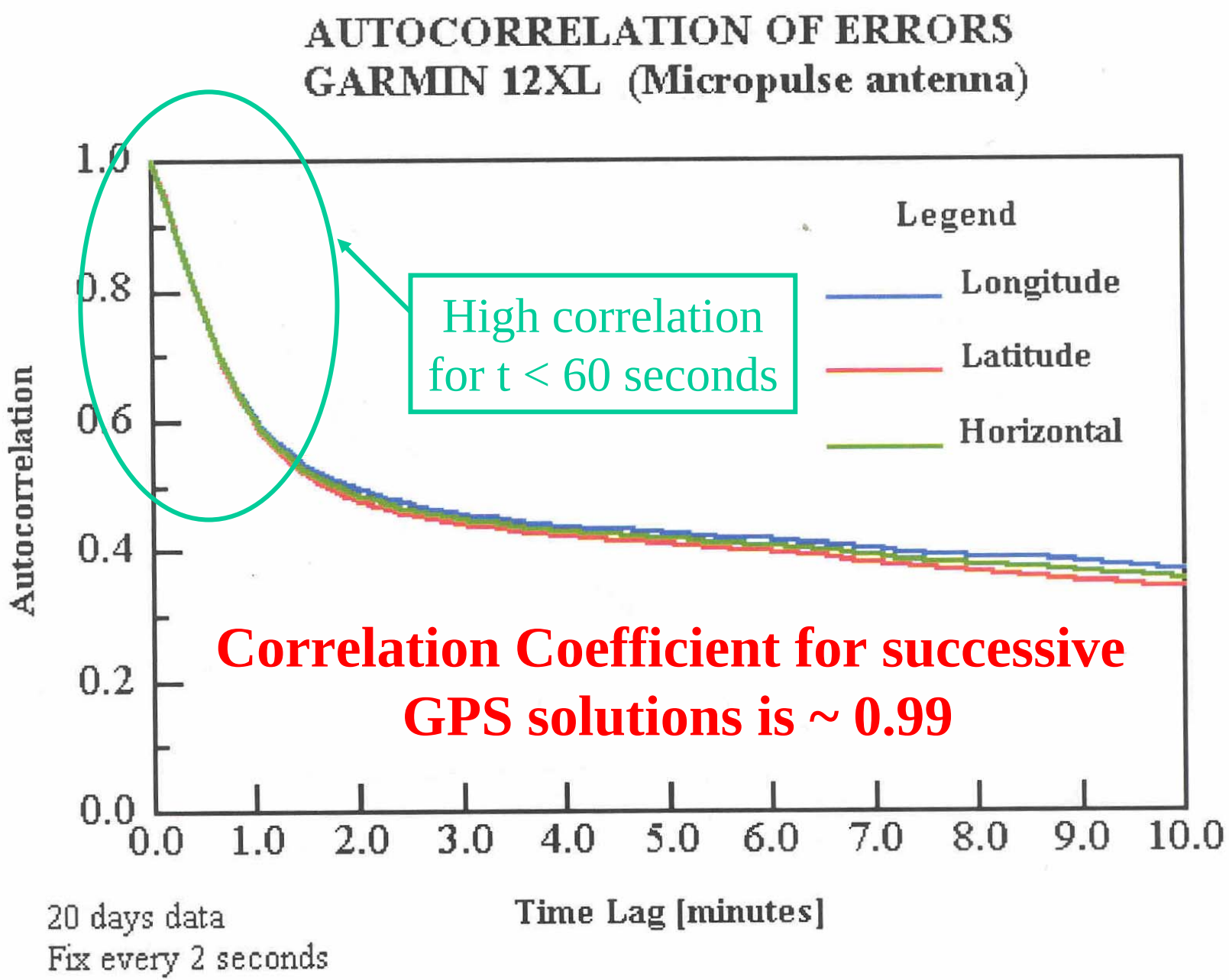
- Decision Mapping error tolerance
  - 10 meters to 1 KM
- Construction and surveying error tolerance
  - Realm of inches
- 3D model error
  - Bias error measured in vicinity of 1-3 feet
  - Relative geometric profile error within inches

Common GPS Error Characteristics



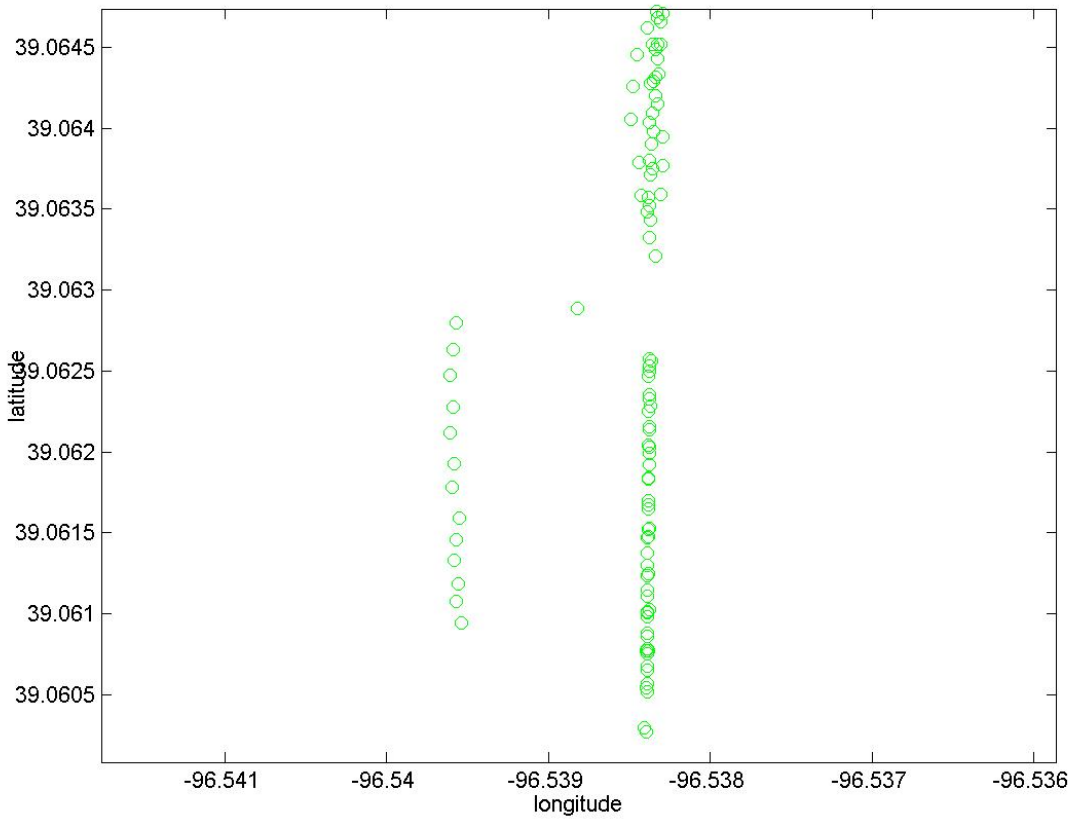
Vertical Data Sample
177 Riley



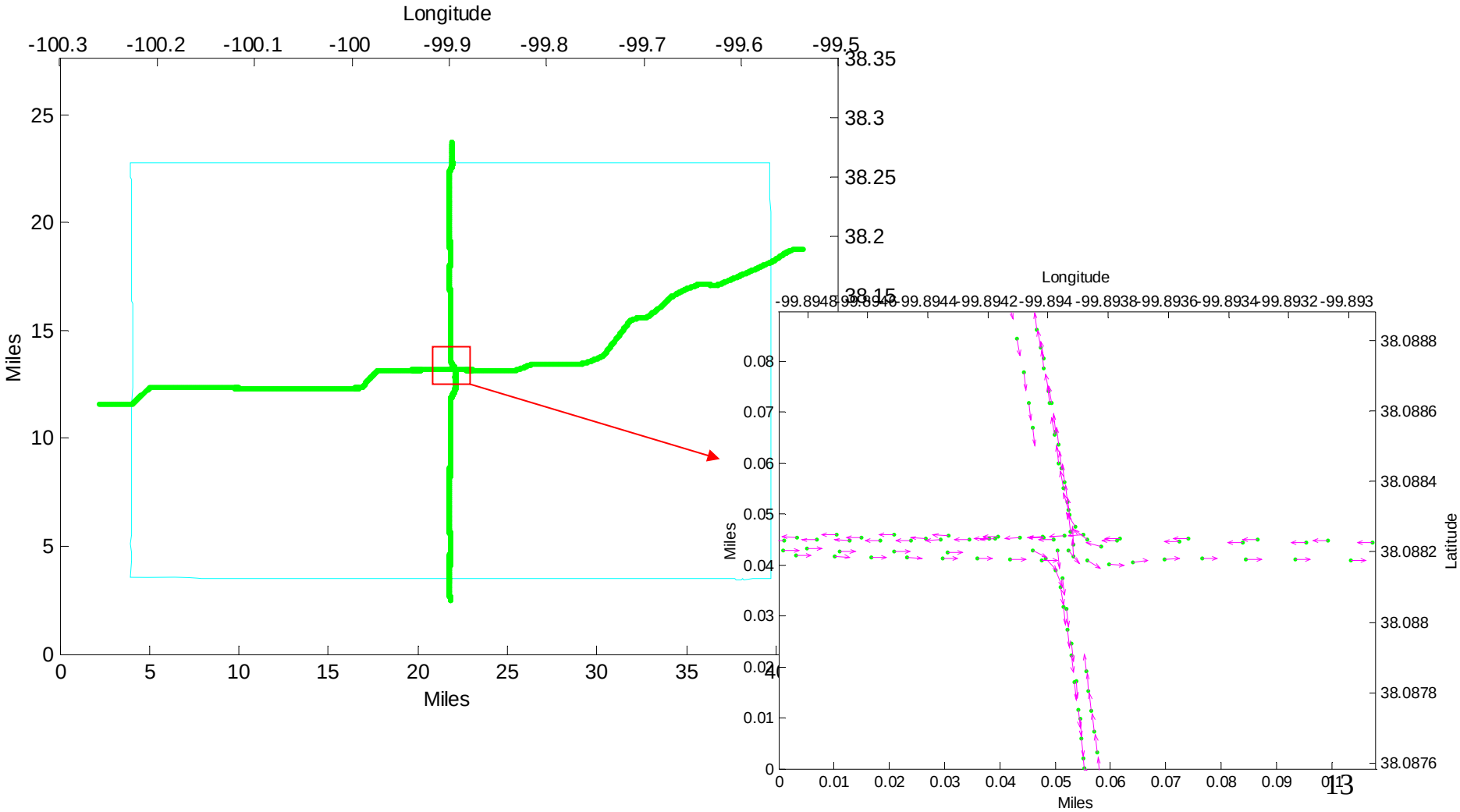

AUTOCORRELATION OF ERRORS
GARMIN 12XL (Micropulse antenna)
Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Time Lag [minutes]
Legend
Longitude
Latitude
Horizontal
High correlation
for t < 60 seconds
Correlation Coefficient for successive
GPS solutions is ~ 0.99
20 days data
Fix every 2 seconds

Example of Outliers

- Highway 177: Two dimensional view (longitude and latitude) (zoom in)



Sample Data - Hodgeman County, KS



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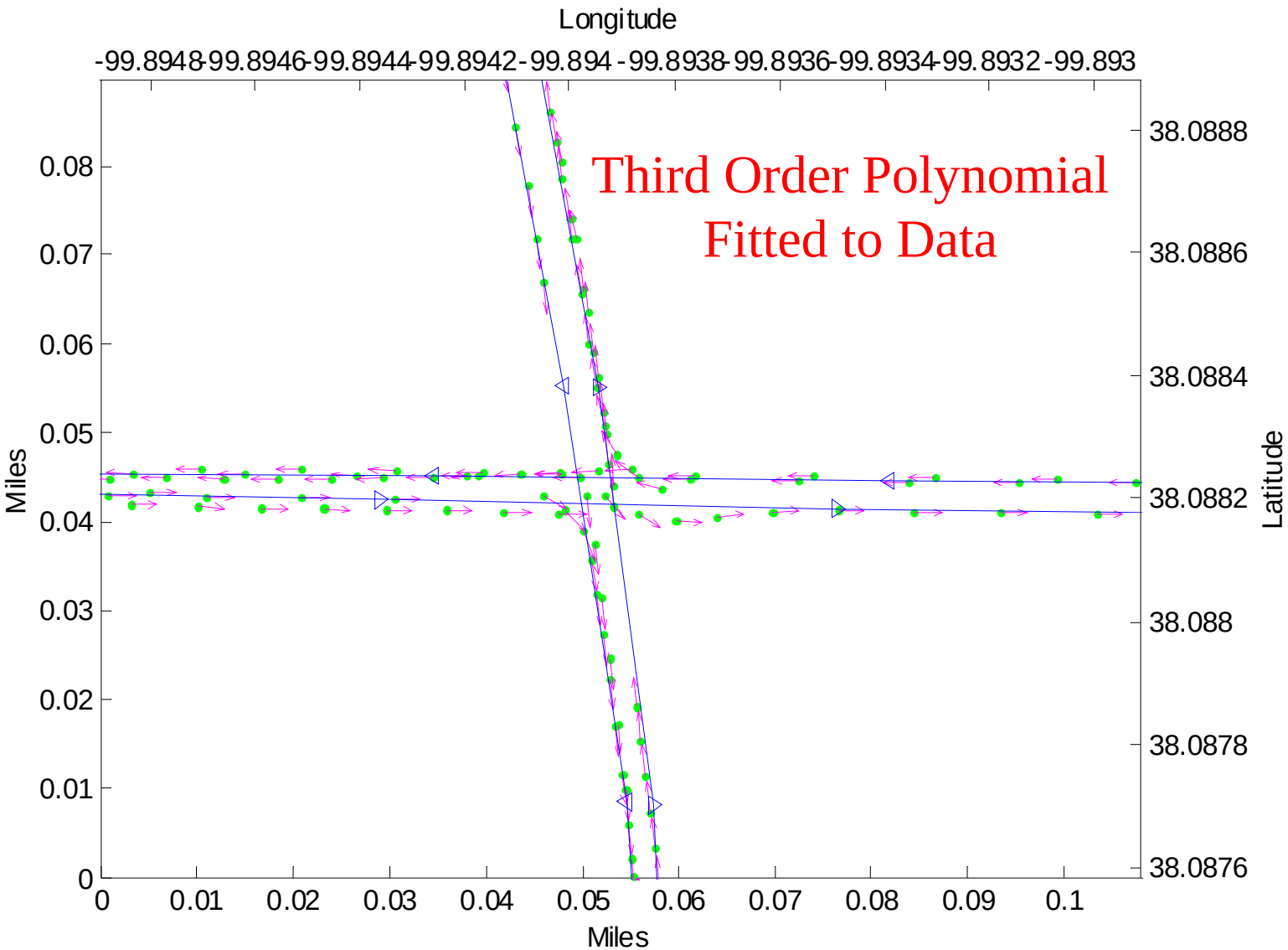
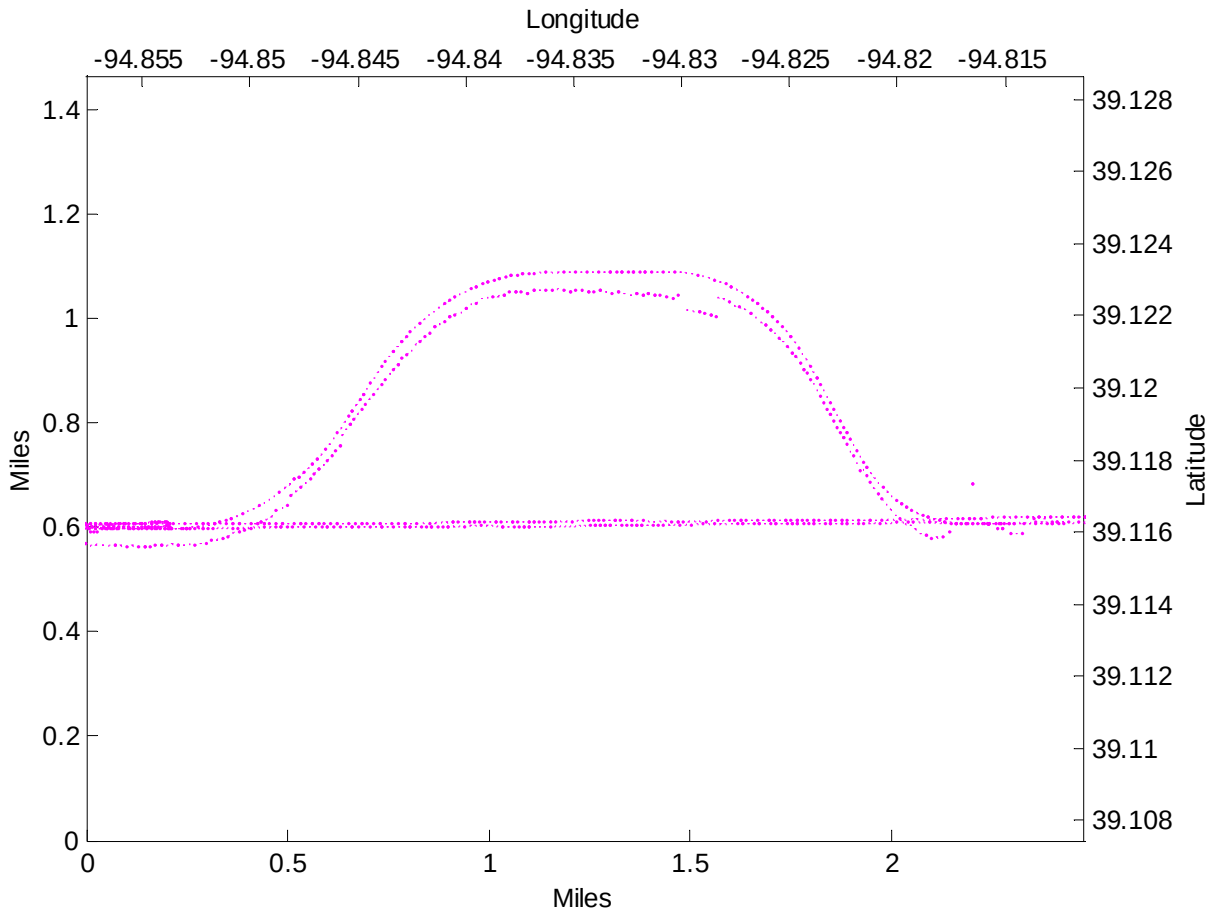


Sample Data – Need for 4D (Time)

- Highway 24 - Wyandotte County



Tenets of 3D Model

- Origin of Concept
- Spatially Enabled Applications
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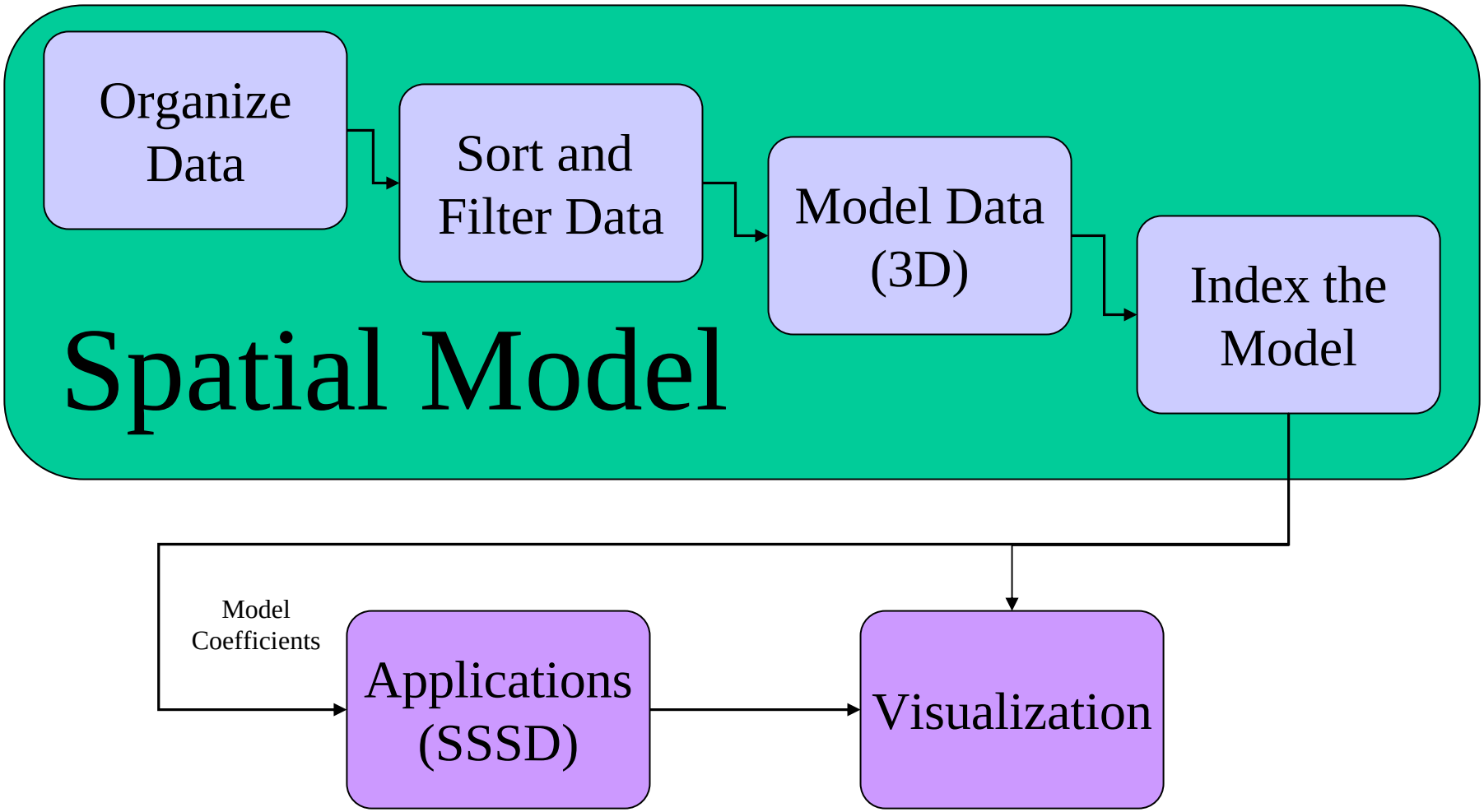
- Current Applications

- Geometric – position, direction, grade
- Maximize Spatial Accuracy
- Any source spatial data can be used
- Include time – a 4D model
- Characterize accuracy as part of the model
- Increased accuracy with more data

Methodology

- Automated Processing
- Use all historic GPS data
  - PMIS and Videolog
  - ~ 8 million point database
- Outlier detection and rejection
- Compare to available design profiles
- Independent of LRS

Project Flow



Elevation Profile : Comparison to design

Stopping Sight Distance Application

- Origin of Concept
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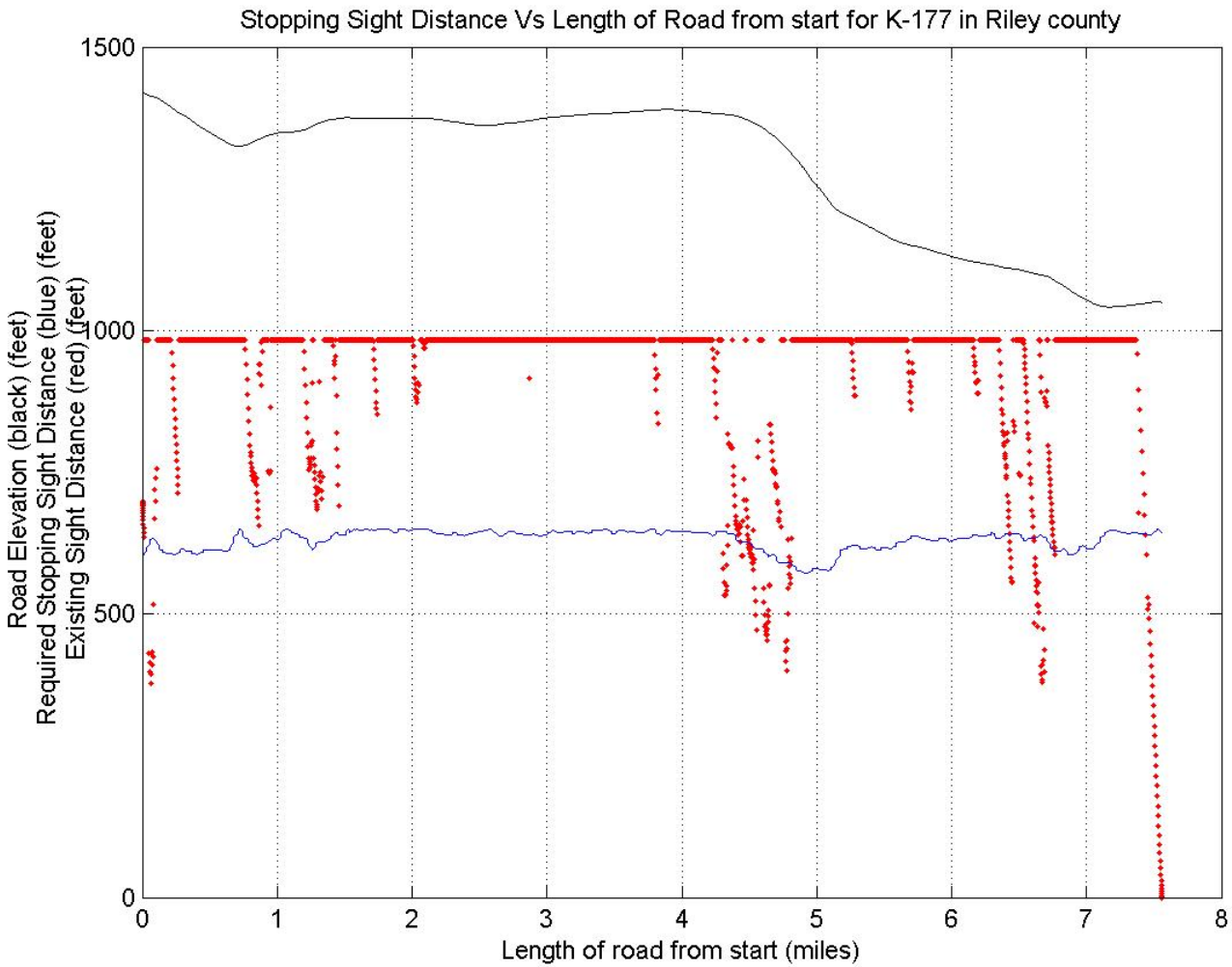
- Issues:
  - Network assessment used in priority formula
  - Validity of current inventory database is unknown
  - Which AASHTO standard?
- Objective:
  - Reassess entire 10000 miles of the state highway system, identifying location and intensity of SSSD
- Status:
  - Version 1.0 is complete, working through model and indexing problems

Elevation, SSD Vs Length of Road



Sample Database for K-177 in Riley County

X	Y	Z	Length of Road (miles)	Required SSD (feet)	Existing Sight Distance (feet)
1658.68	7516.01	410.98	4.653	776.83	834.48
1658.5	7520.72	410.82	4.656	777.11	834.02
1658.32	7525.43	410.66	4.659	777.4	833.55
1658.13	7530.14	410.5	4.662	777.69	818.02
1657.94	7534.84	410.35	4.665	777.97	802.49
1657.75	7539.55	410.19	4.668	778.26	786.95
1657.75	7539.55	410.19	4.668	781.14	786.95
1657.55	7544.27	410.04	4.671	781.33	771.39
1657.35	7549.03	409.88	4.674	781.32	755.67
1657.14	7553.89	409.72	4.677	781.1	754.69
1656.91	7558.89	409.56	4.68	780.7	753.43
1656.68	7564.07	409.38	4.683	780.11	751.94
1656.43	7569.49	409.18	4.687	779.35	750.29
1656.16	7575.19	408.97	4.69	778.45	748.56

Automated Location Referencing for Pavement Management

- Issues:
  - Equipment and processes based on LRS encoding
  - Uncertainty in mapping between coordinates and route
- Objective:
  - Develop code to map Geodetic coordinates to PMS LRS for processing of data
  - Solve any process/instrumentation issues
- Status:
  - Testing on single county complete, ready to move toward implementation in 2004

Other Applications

- Geometric
  - Horizontal Sight Distance
  - Sag vertical curve limitations
  - Grade limitations for heavy trucks
- Additional automated data collection
- Database linking, spatially enabled data

FAQ’s

- What software is used?
- What GIS or spatial data format is used?
- What is the accuracy of the model?
- How does this relate to the agency’s GIS effort / official base map?