Employing Spatial Data and GIS Tools to Support Transportation Safety Research

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University of Michigan
Transportation Research Institute

UMTRI UNIVERSITY OF MICHIGAN TRANSPORTATION RESEARCH INSTITUTE

Our Vision
Safe and Sustainable Transportation for a Global Society

Our Mission
Research Advancing Safe and Sustainable Transportation

- Interdisciplinary Transportation Safety Research
- Some $23M in annual funding from the government, foundations and industry
- 120 Full-time staff and students

Thanks to the NTSB for holding this meeting to discuss how GIS supports Transportation Safety

Presentation

Overview of UMTRI research supported by GIS
Short list of UMTRI generated and acquired spatial data
Experience and suggestions for employing a diverse set of spatial data to support transportation research
Q and A

UMTRI spatial data-naturalistic driving

- Safety Pilot Model Deployment
- Road Departure Crash Warning (RDCW)
- Integrated Vehicle Based Safety Systems (IVBSS)
- Teen Driving
- Alzheimer's Study

among other

Spatial Data provided to support UMTRI research

- HPMS national and state files that include: Michigan, New York, Ohio, Pennsylvania, Texas, and Washington State
- All Michigan public road intersections
- Several local agency, sign and signal locations, building footprints, and parcel data
- MDOT system sufficiency data
- High resolution aerial photography and Lidar data for several Michigan counties
- Michigan statewide crash data

UMTRI Transportation Research Projects Supported by GIS

TRB SO1 Development of Analysis Methods Using Recent Data: A Multivariate Analysis of Crash and Naturalistic Event Data in Relation to Highway Factors Using the GIS Framework, Nat'l Academy of Sciences. Investigator Gordon, T., UMTRI

- Driver Behavior
- Analytical application of naturalistic driving, crash & road data
- Map matching & data fusion (Michigan Data)
- Statistical analysis using data measures as surrogates

Ticketing Aggressive Cars and Trucks (TACT) project to support the Michigan Office of Highway Safety Planning submission to USDOT Federal Motor Carrier Safety Administration. Investigator Kostyniuk, L., UMTRI

- Law Enforcement/Driver Behavior
- Crash locations subset of aggressive driver behavior
- Map matching & data fusion (Michigan Data)
- Determination of concentrated enforcement & control sites (Michigan Data)

Center for the Management for Safe and Sustainable Transportation (CMISST)

Teen Driving Events, University of Michigan Injury Prevention Center, Nat'l Center for Injury Prevention and Control. Investigator, Bingham, R., UMTRI

- Teen Drivers/Public Health
- Map matching & data fusion (Michigan Data)
- Spatial Hierarchical modeling & statistics

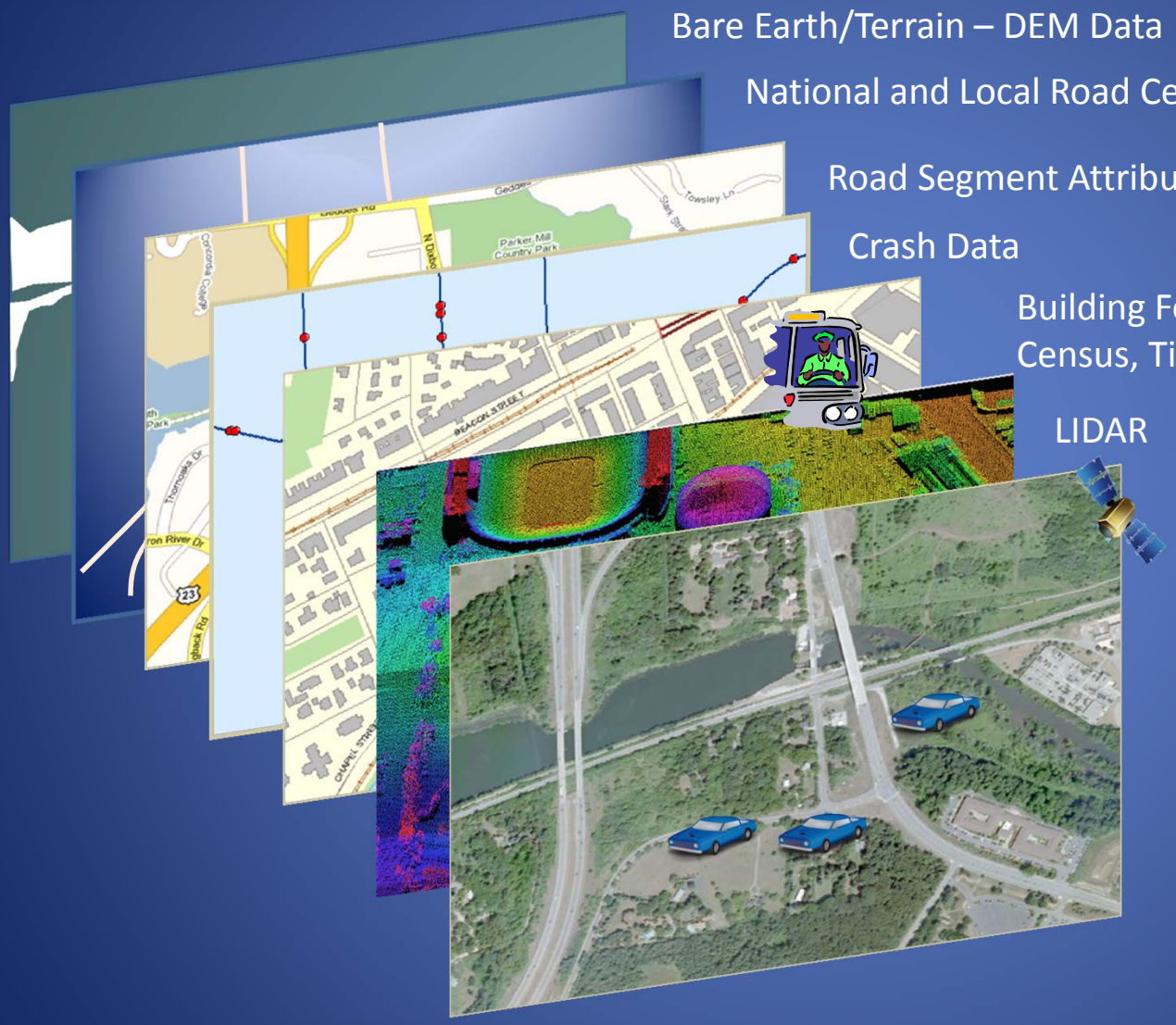
Safety Pilot Model Deployment, U.S. Department of Transportation, automobile, and industry partners. Investigator Sayer, J., UMTRI

- Vehicle Safety Device Evaluation-Vehicle to Vehicle and Vehicle to Roadside Communication
- Potential analysis includes: map matching between vehicles & roadside Dedicated Short Range Communication (DSRC) units (deployment route Ann Arbor, MI)
- Analysis of DSRC transmissions relative to path obstructions

Look Ahead Driver Feedback & Powertrain Management Systems, Eaton Corporation. Investigator LeBlanc, D., UMTRI

- Fleet/Driver Training & Performance
- Map matching, data fusion and digital elevation modeling (DEM) – multi-state road data
- Integrated Vehicle Based Safety System (IVBSS) FOT data mining – multi-state naturalistic driving data

Snapshot of spatial data sources used by UMTRI to support transportation research



Bare Earth/Terrain – DEM Data

National and Local Road Centerline – Polyline Data

Road Segment Attribute Data

Crash Data

Building Footprint, Transit Routes, Census, Time Zone, etc.

LIDAR

UMTRI Generated Spatial Data (GPS) via Data Acquisition Systems (DAS)
RDCW and IVBSS FOT
Naturalistic Driving Data (GPS)
Model Deployment
Teen Driving to name a few.

Ortho-Corrected Aerial Photo

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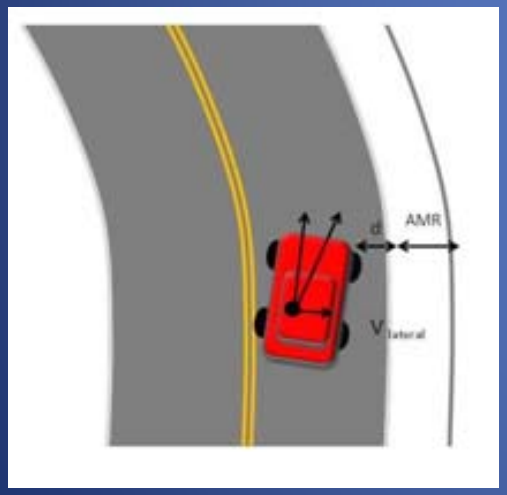
TRB SHRP II, SO1: Development of Analysis Methods Using Recent Data: A Multivariate Analysis of Crash and Naturalistic Event Data in Relation to Highway Factors Using the GIS Framework

Objective: To provide a validated quantitative link between detailed measurements from naturalistic driving behavior, road departure crashes, and road segment attributes. Then, if possible, identify common roadway elements that are associated with crash data and driver behavior as captured in the RDCW naturalistic driving data.



Time of edge crossing (TTEC)

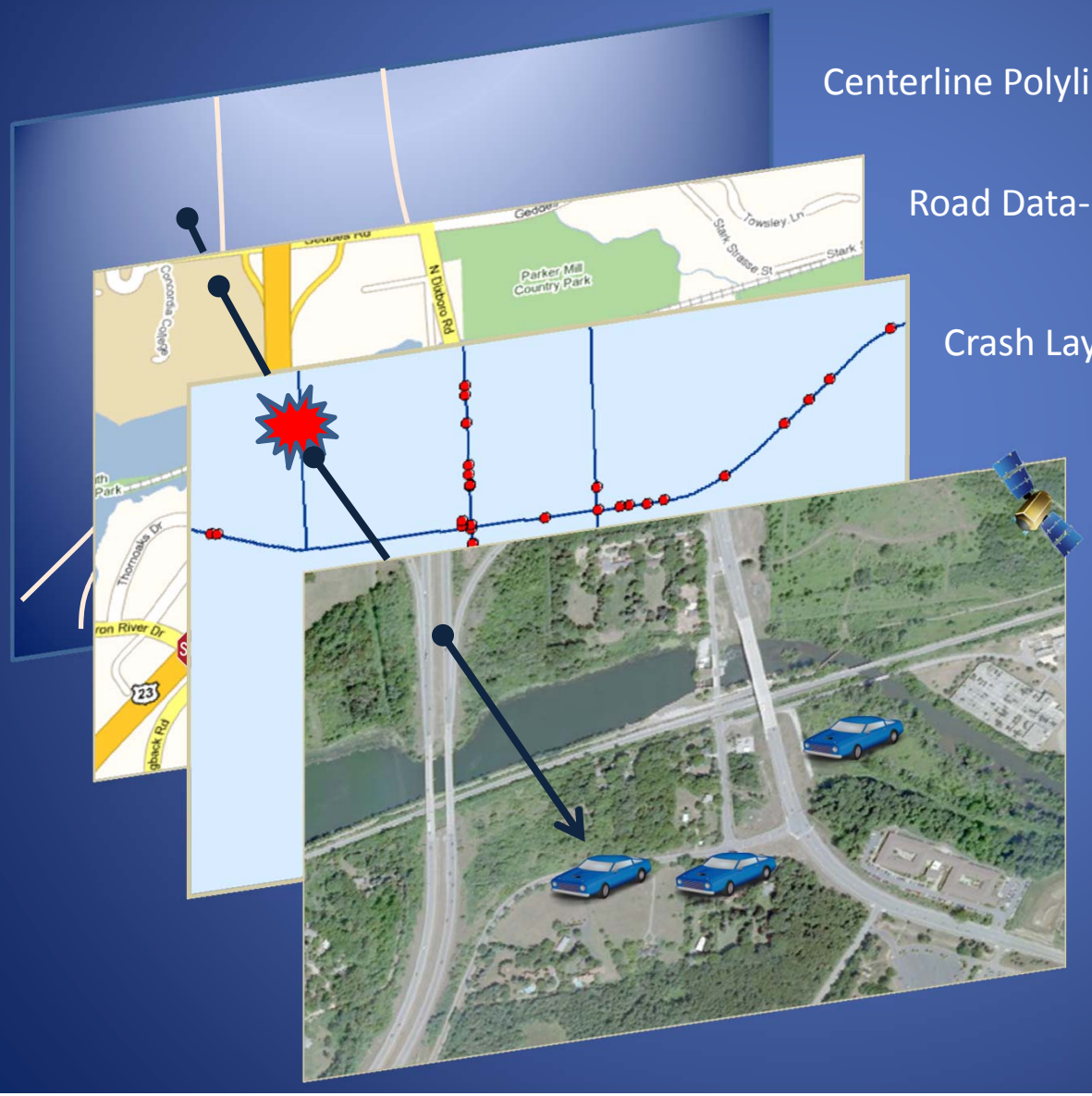
Research Questions:

Do naturalistic driving data contain measurable episodes of disturbed control?

Do objective measures of disturbed control from naturalistic driving data, integrated with on and off roadway geometrics and environmental factors satisfy criteria to act as crash surrogates for actual crashes?

TRB SHRP II, SO1

Spatial RDCW driving, road and crash data were fused to each HPMS road segment traversed.



Centerline Polyline File –HPMS Data

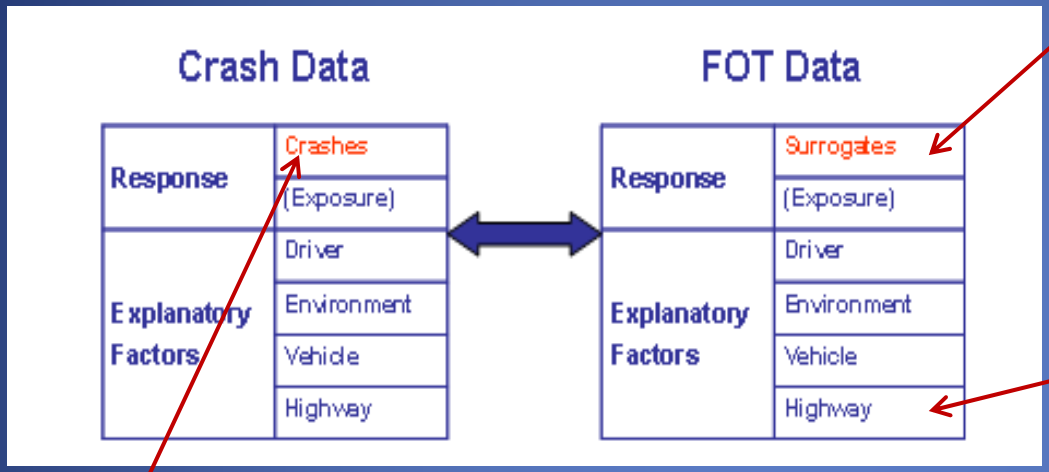
Road Data- Polyline Attribute Data

Crash Layer – Point/Event Data

Road Departure Crash Warning FOT Naturalistic Driving Data Alerts (GPS) /Aerial Photo

TRB SHRP SO1 - For each HPMS road segment that was traversed by an RDCW vehicle a variety of data were spatially joined to that segment. These records formed the multivariate data tables to support statistical analysis methods such as Extreme Value Theory and Seemingly Unrelated Regression

Analysis Model



Measures of Distributed Control Surrogates
Time to Edge Crossing
Lateral Drift Warning
Lane Deviation
Yaw Rate Error*

Highway Measures
Curves (via HPMS sample data)
Functional Class
Shoulder Type
Shoulder R/L Width
Through Lanes
Urban/Rural
Number of Traversals/Segment

Crash Measures
Crash ID
Road Departure Crash Count
(37K crashes, 2001-05)
Weather
Lighting
Road Condition
XY Coordinates
Direction
Time

Conclusion: The analyzes provided ample indication that episodes of disturbed control exist in the naturalistic driving data, and can be related to crashes via highway variables. The fusion/integration of spatial data sets make it possible to develop valid surrogates measures for behavioral outcomes.

SAFETYPILOT
GET CONNECTED

Research Vision

The vision of the Safety Pilot is to test connected vehicle safety applications in real-world driving scenarios to determine their effectiveness at reducing crashes and to ensure that the devices are safe and do not unnecessarily distract motorists or cause unintended consequences.

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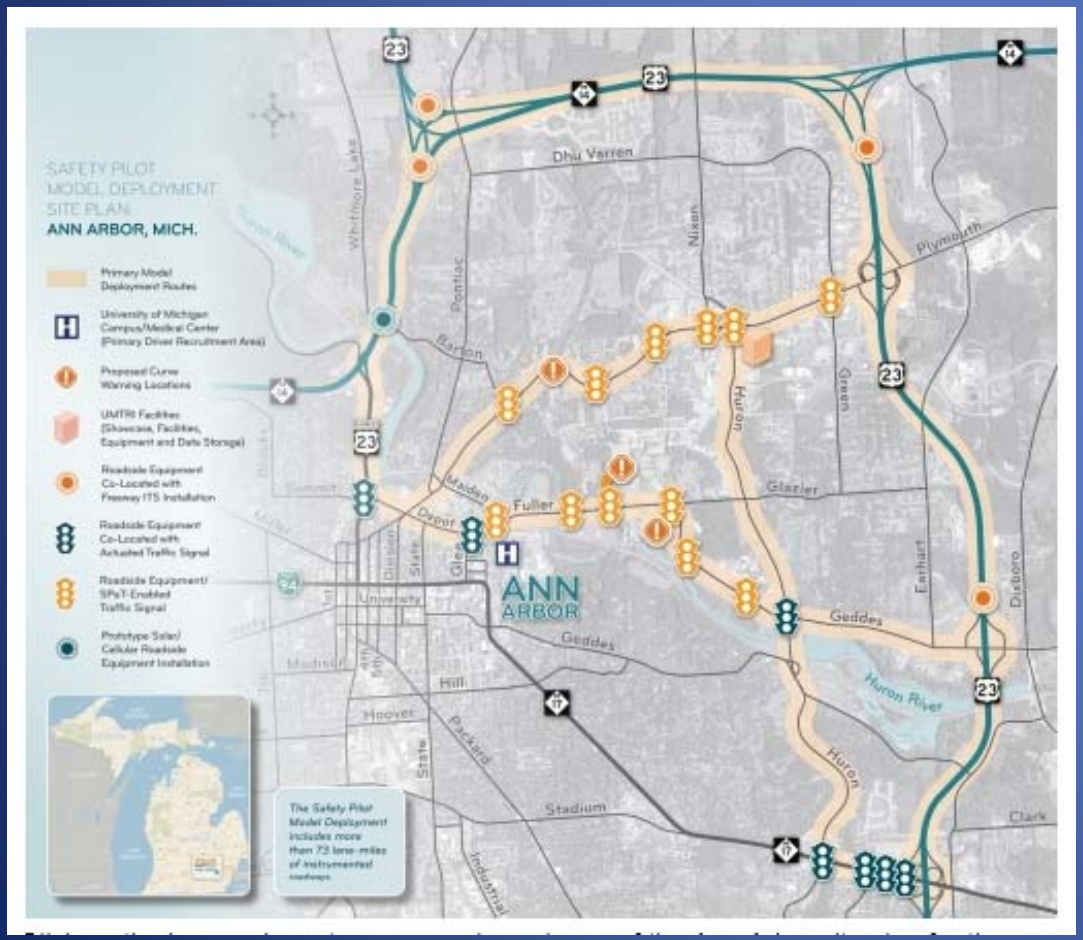


Safety Pilot Model Deployment: Approximately 2,836 vehicles will be equipped with wireless connected vehicle devices to test safety applications using DSRC between vehicles, while operating on public streets in an area highly concentrated with equipped vehicles.

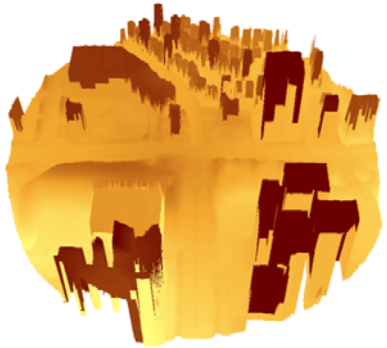
UMTRI envisions the Model Deployment project and its spatial data as a critical step to improving transportation safety.

Model Deployment Potential
Spatial Data Analysis

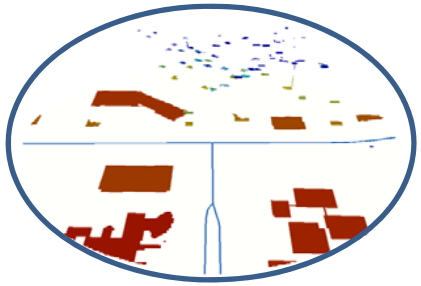
Aerial Photo draped and road draped over DEM

Ortho-Corrected Aerial Photo Clip

Digital Elevation Model (DEM) derived from LIDAR* data with extruded building footprints



Building Footprints



Omni-Directional Antenna Signal
Plymouth Rd @ Huron Parkway

The pink areas shown in the illustration above represent the extent of the omnidirectional antenna signal ** placed within the intersection. The surface of the earth and building footprints were used to model those features which may block or degrade the antenna signal.

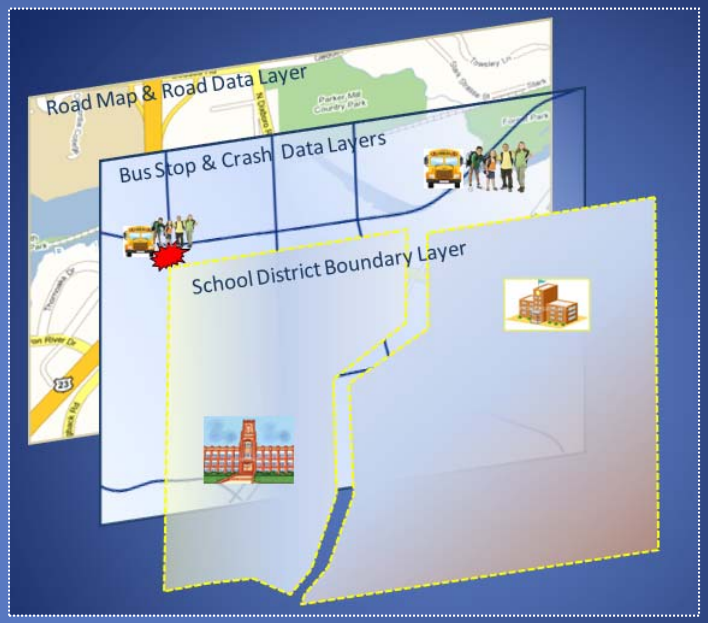
**Antenna
High Frequency Range (2.4 – 2.5 ghz)
Azimuth 3dB omnidirectional
Elevation Plan 50 degrees
Range modeled 300 meters

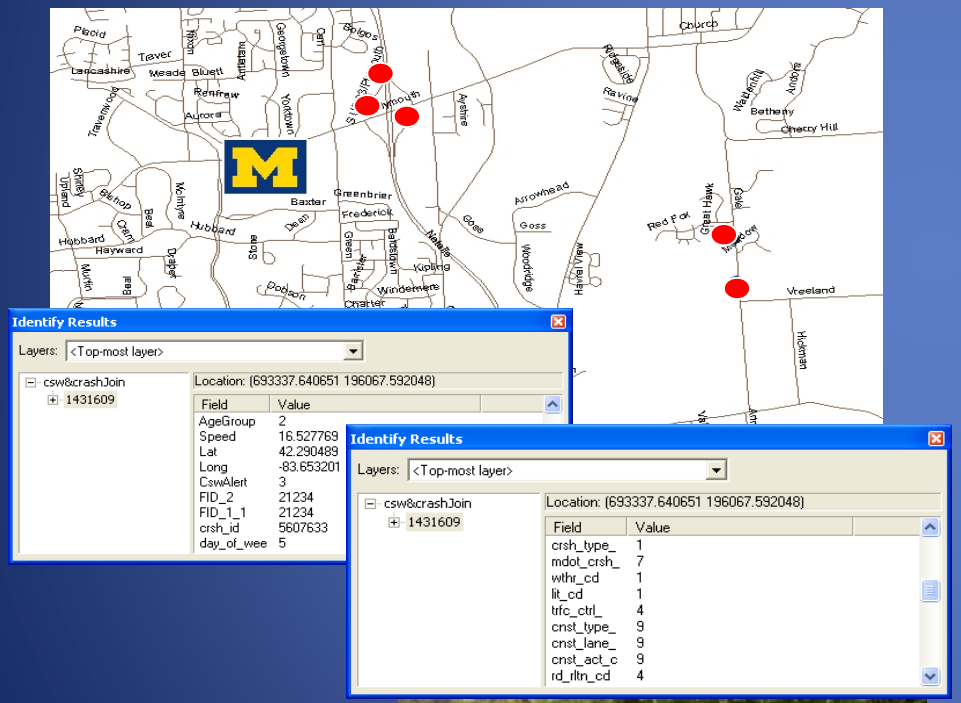
*LIDAR resolution – elevation 18 cm

Look Ahead Driver Feedback & Powertrain Management Systems

- Use of IVBSS naturalistic driving data
- Isolate scenarios of interest
- Eco-Driving Technology, automatic technology to reduce fuel use
- Driver Feedback/Behavior
- Fuel performance analysis by driver, trip, speed and mass. Fleet manager gets reports per driver
- Integrate roadway characteristics with driving data
- Explored grade/terrain impacts fuel usage

Transportation Data Center and Biosciences
STAR Database Proposal, Mapping of school bus crashes, bus stops, and districts.





Vehicle Safety Analysis
Plotting and Analysis of Large Truck and Car Crashes
Geo-Location of Large Truck Crashes: Sandia Nat'l Lab

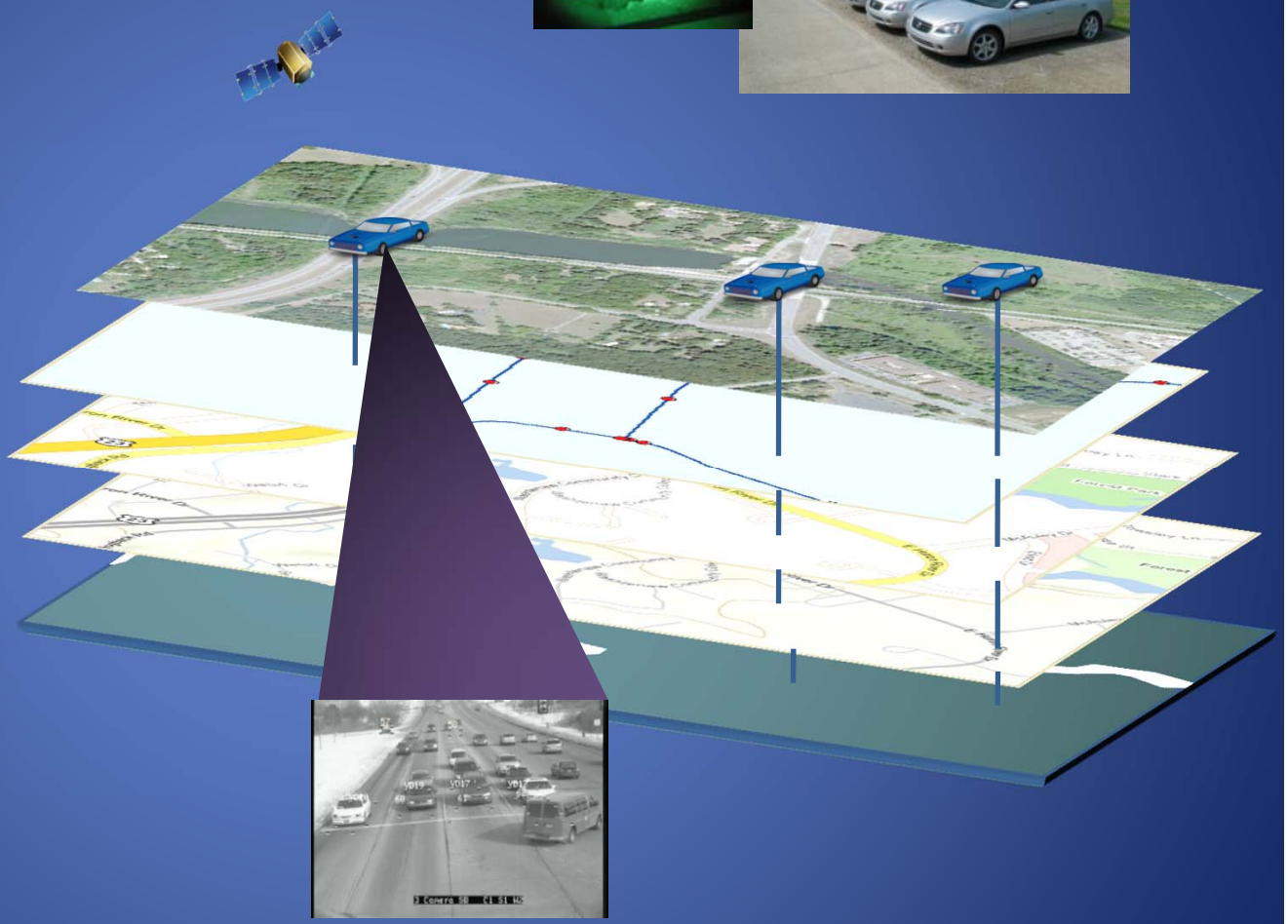
Road Departure Crash Warning (RCDW) Field Operational Test
UMTRI Vehicle Systems and Control
UMTRI Human Factors

Two areas were addressed: Safety-related changes in driver performance and driver acceptance of the RDCW system.

11 passenger sedans were equipped with RDCW and a data acquisition system that compiled numerical, video, and audio data.

78 unsupervised drivers used the vehicle for 4 weeks.

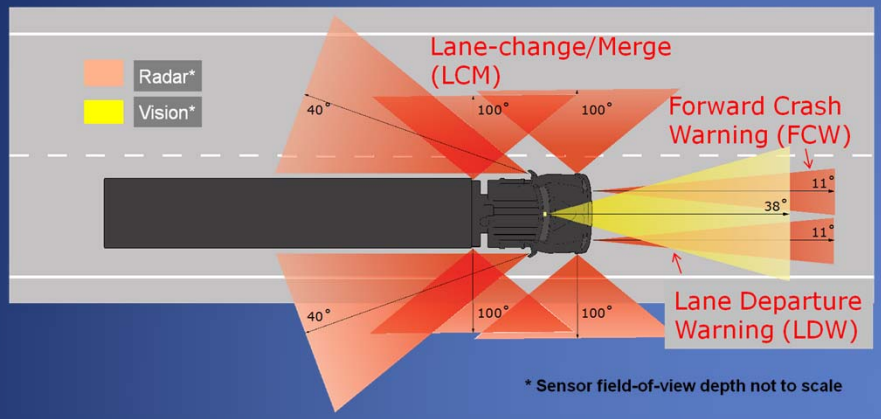
83,000 miles of driving were captured and 400+ signals captured at 10 Hz or faster.



Integrated Vehicle Based Safety System (IVBSS) FOT

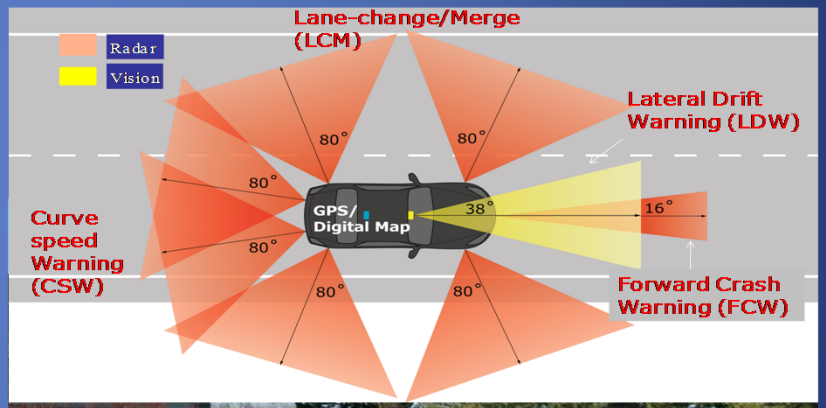
Commercial Fleet Con-way Freight
10 International tractors equipped
3 Warning Systems:
- Forward Crash
- Lane Drift
- Lane Change

1 year – 20 drivers – 600,000 miles
5 video, GPS, 500+ data signals @10-50Hz capture



Passenger Fleet, 16 vehicles
4 Warning Systems:
- Lateral Drift
- Forward Crash Warning
- Curve Speed Warning
- Lane Change Merge

108 drivers - 6 weeks -200,000 miles
7 radars, 5 video steams, GPS,
500+ data signals, @ 10-50Hz capture.



Practical experience, comments, suggestions in using GIS to support transportation safety research

Understand the differences between UMTRI generated spatial data and provided sources.

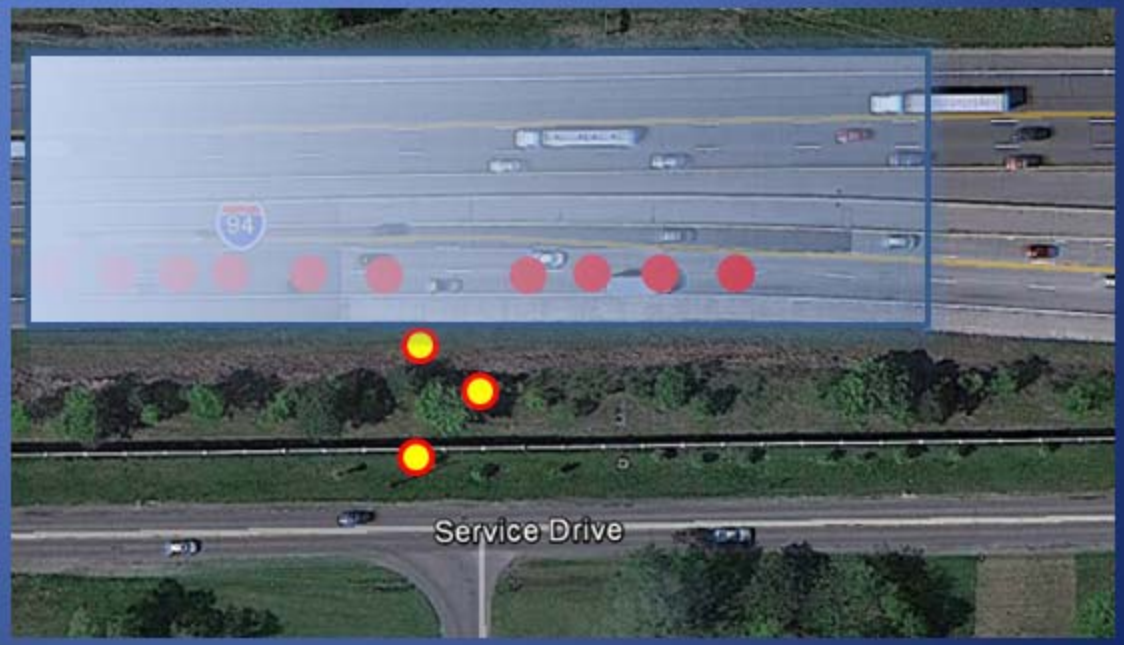
High density GPS trace data for a set of vehicles and experimental systems vs. multi-jurisdiction roadway asset data for maintenance and condition monitoring.

Understand the variance in resolution of data before integration and application to research.

Field Test GPS data 3 – 10m vs. High Resolution Lidar - sub meter

Validation of map matching for driver trips with a variety of spatial data sets. Integrating millions of points does not allow eye balling validation point by point.

Model the centerline data (polylines) as a polygon using the number of lanes and lane width.



UMTRI is highly regarded for field based geospatial data collection , analysis and integration of spatial data sources. UMTRI projects have involved a variety of platforms such as:

Commercial Truck Fleets,
Transit Bus and
Passenger Car Fleets.

GIS plays a key role to improving the safety of the nation's transportation system through the collection, mining and analysis of spatial data emerging from the Model Deployment project among others.

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Thank you for your interest in GIS to support UMTRI based transportation research

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- www.CMISST.org

cmisst
Center for the Management of Information for Safe and Sustainable Transportation
Safe Sustainable Transportation

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Understanding Driving Behavior and the Built Environment by Integrating GIS and GPS datasets, Special Issue Spatial Intelligence for Urban and Regional Analysis, International Journal of Applied Geospatial Research

A Comprehensive Speed Control Model for Human Drivers with Application to Intersection Left Turns, American Control Conference 2011.

Analysis of Crash Rates and Surrogate Events: Unified Approach, Transportation Research Board, Journal of the Transportation Research Board, forthcoming 2011.

Ticketing Aggressive Cars and Trucks (TACT) project to support the Michigan Office of Highway Safety Planning proposal to the USDOT Federal Motor Carrier Safety Administration

Teen Driving Events, The University of Michigan Injury Prevention Center Project, National Center for Injury Prevention and Control

Development of a Comprehensive Approach for Serious Traffic Crash Injury Measurement and Reporting Systems (FHWA)

Road Departure Crash Warning (RDCW) Field Operational Test

Integrated Vehicle Based Safety Systems (IVBSS) Field Operational Test

SO1 Development of Analysis Methods Using Recent Data: A Multivariate Analysis of Crash and Naturalistic Event Data in Relation to Highway Factors Using the GIS Framework (TRB)

SO9 Site-Based Video System Design and Development -Transportation Research Board (TRB)