PROCEEDINGS OF

1ST OUTSOURCED PROBE DATA SYMPOSIUM

JANUARY 15TH, 2015

COLLEGE PARK, MD
SUMMARY:

The National Transportation Center at Maryland (NTC @ Maryland) and the Center for Advanced Transportation Technology (CATT) held a symposium on 1/15/2015 to discuss emerging probe data products and applications of private sector data in planning, operations, and performance management. The first objective was to provide a venue for industry to discuss currently available data products in the areas of speed, travel time, O-D, freight, emissions, and volume. The second objective was to have a forum of leading state executives and managers discussing the critical data needs in their organizations, so that industry can hear and respond. In addition to 43 live attendees, online participants joined the event via live webcast.

The symposium opened with reviewing I-95 Corridor Coalition Vehicle Probe Project. The I-95 Vehicle Probe Project is a groundbreaking initiative providing comprehensive and continuous travel time information on freeways and arterials using probe technology. Then representatives from leading probe data industry including HERE, INRIX and TomTom presented their current and existing data products. After a short break panel members discussed their current applications for the probe data and their expectations from the industry. Panel was consisted of a diverse group of experts from Federal Highway Administration, State DOT and MPOs and academia.

This proceedings includes summary of the panel talking points, list of attendees and a compilation of the presentation slides. Recording of the event webcast is available for viewing at the following link:

http://vid.umd.edu/detsmediasite/Play/1a6294d88a824163b84ecd82a1c408551d

Masoud Hamedi, PhD
Symposium Organizer
Center for Advanced Transportation Technology
University of Maryland, College Park
masoud@umd.edu
SUMMARY OF THE PANEL TALKING POINTS

Panel members:

- Nicole Katsikides, Freight Performance Program Manager, Federal Highway Administration
- Glenn McLaughlin, Deputy Director, CHART, Maryland State Highway Administration
- Wenjing Pu, Transportation Engineer, Metropolitan Washington Council of Governments
- Debbie Bowden, Motor Carrier & Logistics Policy Advisor, Maryland DOT
- Subrat Mahapatra, Transportation Manager, Maryland State Highway Administration
- Stanley Young, Center for Advanced Transportation Technology, University of Maryland

GLENN MC LAUGHLIN, DEPUTY DIRECTOR, CHART, MARYLAND STATE HIGHWAY ADMINISTRATION

Current MDSHA/CHART Operational Uses for VPP Data

- Travel Times on Dynamic Message Signs
- Travel Times on Maryland 511
- Subjective Assessment of Incident Related Queues
- Basic View of Congestion Patterns
- Some Basic Indication of Incidents
- Post-Event Review of Traffic Impacts

Potential Operations Uses for VPP Data

- Incident Detection
- Congestion/Bottleneck Detection
- Evaluate Effectiveness of Traveler Information Strategies (e.g. TT vs. Caution Messages on DMS)
• Monitoring Queue Lengths and Impacts on Secondary Roads
• Assess Queue Recovery Times
• Run Predictive Simulations to Analyze Potential Incident Impacts in Real Time
• Assess Safety Relationships between Traffic Congestion and Frequency/Types of Collisions
• Data to Plan the Optimal Distribution of ITS Resources (e.g. ATMS, Traveler Information, etc.)
• Determine Network Impacts of Closures (Adjoining Freeways and Arterials)
• Signal Operations Optimization

Data Characteristics which Could Support Potential Uses

• Sub-TMC Resolution (Queue Monitoring, Building Travel Time Routes, Safety Assessments)
• Arterial Data (Network Impacts, Signal Operations)
• Minimal Latency (Incident Detection, Congestion Detection, Queue Recovery Times)
• Estimated Vehicle Volumes in Real-Time (Network Impacts, Predictive Simulation, Signals)
• Origin-Destination Estimates (Network Impacts)
• Improved Penetration on Nights, Weekends and During Severe Weather (All)

Challenges/Observations for Moving Forward

• Develop Applications to Utilize VPP Data in the Context of Real-Time Operational Processes and Protocols (Particularly in Light of the New Sub-TMC Capabilities)
• Bridge the Gap between VPP Data, and Traditional Simulation Models (Needing Volume Data?)
• Keep Improving on the Confidence in Arterial Data
• Create a “Latency Model” that Captures/Characterizes the Components of Latency (e.g.):
  o Event Occurs
  o Observable Congestion Builds
  o VPP Data Changes
  o Data Analysis Reflects Impacts
  o Traffic Conditions Compiled in System
  o Condition Displayed on User Interfaces
• Also note, there can be two types of latency: real-time and archived. Archived latency consists of time that elapses while congestion builds, data changes, and analysis is completed and consequently the data is archived with latency relative to the “ground truth” conditions.

WENJING PU, TRANSPORTATION ENGINEER, METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS

• **TMC availability and sub-TMC data.** We hope that the time lag between the opening of newly built highways or managed lanes and the availability of TMCs for those new highways/lanes could be shortened (the existing process takes about two years). All three vendors claimed that they offer sub-TMC level speed and travel time information to improve data granularity, but how or when we can access sub-TMC level data remains uncertain. The Vehicle Probe Project (VPP) Suite needs to be enhanced to handle such (bigger) data and additional funding is needed. Per the contracts between the Coalition and the vendors, vendors have to provide their own archive and made them accessible to users. We hope that such sub-TMC data can be accessed directly from vendors’ own archives.
- **Volume.** We hope that real-time estimation of vehicle volume become available in the future. INRIX’s existing method of integrating HPMS volume with speed could be used for historical annual average calculations, but may fall short for real-time operations, calculating seasonal variations or reliability measures.

- **Fuel use and emissions.** TomTom mentioned that they are testing the estimation of fuel use and emissions (including CO2, but not all of the criteria pollutants) based on probe speeds, classification of vehicles and other sources. This concept is particularly interesting for MPOs as it could provide another source for air quality information.

- **Managed lanes.** If new TMCs will be created for new managed lanes, we hope that the new TMC creation process could be shortened (as mentioned in 1.). For managed lanes without physical separation (i.e. no TMCs will be assigned to), we hope that future probe data could tell the difference between those managed lanes and general purpose lanes (such as conditions on I-66 and US-50 in the Washington region).

Debbie Bowden, Motor Carrier & Logistics Policy Advisor, Maryland DOT

**PROBE AND OTHER DATA NEEDS RELATED TO MULTIMODAL FREIGHT POLICIES AND NEEDS**

- **Highways**
  - Truck parking – need to identify demand on shoulders and ramps
  - Oversize / overweight loads, both permitted and illegal – could allow for comprehensive coverage of weight limits across the entire network
  - Last mile truck movements and intermodal (truck to rail, truck to water) – provides a complete look at truck movements on the supply chain
  - Value of transport and value of lanes – relates to commodity flow per truck.

- **Rail**
  - Commodities movement, e.g. crude oil – we would like to know the type of items are moving along the shared-use rail corridors
  - Freight and passenger shared use on the corridors – need more data regarding operations and safety

Subrat Mahapatra, Transportation Manager, Maryland State Highway Administration

- Look for opportunities for volume based metrics
- Trip based congestion and reliability metrics (Origin to Destination) for people and goods
- Tour based information on people and goods travel
- Multi-modal and multi-resolution networks that can meet both performance management, travel modeling and analysis needs
- Insights on markets and trips (Internal, Thru' and with one trip end in study area)
- Expansion factors to develop population O/Ds from the sample O/Ds
- Lane based performance metrics (HOV lane or, ETL running next to a general travel lane)
- Lane based usage (disproportional use of some lanes over others) to understand operations better
- Interfacing of navigation networks with state LRS
- Fusing datasets with other data sources like land use, traffic counts, detectors etc.
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<tr>
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AGENDA

08:45 AM – 09:30 AM  Registration & Breakfast

09:30 AM – 10:00 AM  Opening remarks and introduction to VPPII

10:00 AM – 11:30 AM  HERE, INRIX and TOMTOM presentations

11:30 AM – 11:45 AM  Break

11:45 AM – 12:45 PM  Data Forum

12:45 PM – 1:30 PM  Adjourn and lunch
I-95 CORRIDOR COALITION

Alliance of many transportation agencies along the East Coast

Facilitates coordination, consensus, collaboration, and communication across state lines

Pulled resource together on research projects

States had issues with getting travel time data across states lines to support regional initiatives
VEHICLE PROBE PROJECT (VPP1)

RFP released in April 2007 for travel time and speeds that could be used for:

- Traveler information (511, websites, DMS)
- Incident Management
- Transportation operations and planning
- Calculating regional performance measures

A contract vehicle for state DOT to purchase coverage

Contract awarded to INRIX in December 2007
VEHICLE PROBE PROJECT (VPP1)

FIRSTS

- First significant commercial deployment of probe data for public applications
- A specifications driven contract for travel time and speed
- On-going, transparent validation process to insure quality
- Introduction of ‘Confidence Metric’ for times when probe vehicle data not available
- Licensing allowed one purchase / all use
- Rapid adoption by states, first for operations, then followed by planning and performance measures
VPP SUITE/ RITIS

**Vehicle Probe Project Suite Dashboard**
Explore the relationships between bottlenecks and traffic events in real-time and in the past.

**Massive Raw Data Downloader**
Download raw probe data from our archive for offline analysis.

**Congestion Scan**
Analyze the rise and fall of congested conditions on a stretch of road.

**Trend Map**
Create animated maps of roadway conditions.

**Performance Charts**
Chart performance metrics over time.

**Performance Summaries**
Report on Buffer Time Index, Planning Time Index, and other performance metrics.

**Bottleneck Ranking**
Rank bottlenecks and discover which ones have the greatest impact.

**User Delay Cost Analysis**
Put a dollar amount on how much a road's performance impacts its users.

**FAQs**
Frequently asked questions and their answers.

**Tutorials**
Learn how to use each of the tools in the suite.
VPP II HIGHLIGHTS

Nothing left behind from VPP I

Added

- Multi-vendor marketplace
- Added tools to work with data
- More emphasis on non-freeway roadways
- Alternate segmentation methods
- Specifications and validation of latency
COVERAGE HAS GROWN

Initial Coverage (2008)
AND GROWN

September 2011
AND GROWN

I-95 Vehicle Probe Project Coverage – December 2013

December 2013
UNEXPECTED CONSEQUENCES

Acceptance and dependency of out-sourced data to drive DOT processes

- Travel time on signs
- **Performance** measures
- Mobility reports
- Work zone assessment
- Anticipation for use on Non-Freeway facilities
- Questions and expectations of what other out-sourced data may be available for DOT’s to leverage
TODAY'S TOPIC/S

Current and anticipated data products
  ▪ Presentations by HERE, INRIX, TomTom

User Data Needs
  ▪ Perspectives from Operations, Planning, Freight, MPO, Arterials

Open Discussion
  ▪ Can the two find middle ground
THE VALIDATION CHALLENGE

Validate the accuracy of the freeway received data within the context of the data quality specifications

- This grew to arterials as well about 2010

Perform continuous validation that is representative of the entire corridor

- Continuous from 2008 till present

Provide ad-hoc and supplemental analysis as requested

Adjust contractor payments to reflect data quality

Manage expectations of multiple parties

Remains the largest, most comprehensive validation of any type of traffic data

- EXTENDED TO THREE VENDORS IN 2014
TECHNICAL OVERVIEW

Frequency
- Initial validation July through October 2008
- Approximately monthly from 2009 till present (10 per year)
- All reports, data, and analysis open, available on website

Methodology
- Bluetooth Traffic Monitoring used as reference source
- Accommodates sophisticated filtering of outliers, and uncertainty in mean
- Segments selected based on propensity for congestion, picked in consultation with local jurisdiction

Metrics
- Average Absolute Speed Error (AASE) — measures deviation from reference source
- Speed Error Bias (SEB) — measures consistent high or low reading in data
- Analyzed in four speed bins, by segment, and overall
Through December 2014

- 11 states
- 49 evaluation reports
- 53 deployments, 829 days sensors on the road
- 1282 centerline mile (994 mile freeway, 288 mile arterial)
- 95,706 hour worth of ground truth data resulting from 11.7 million Bluetooth observations

### VALIDATION EFFORT

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VALIDATION TOOL
FEATURES

Internet accessible
Outlier filtering
Path data analysis
Evaluation report generator
Graph generator
Data Import and export (XML, CSV)
Bluetooth penetration rate analysis
Bluetooth OD analysis and report
Statistics report
TMC mapping
Data mining
Programming language C++, Database Microsoft SQL Server
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Agenda

- Traditional Probe Data Products
- Newly Introduced Products
- Emerging Products
## Flexible Options for End-to-End Deployment

### Data
- Navigable maps
- Truck maps
- ADAS maps
- Real-time traffic
- Predictive traffic
- Historic traffic
- Dynamic content (fuel prices, parking, EV, etc)
- Visual content (landmarks, 3D models, junctions)

### Platform APIs & SDKs
- Passenger Routing
- Traffic-enabled Routing
- Truck Routing
- Transit Routing
- Pedestrian Routing
- Matrix Routing
- Isoline Routing
- Geofencing
- Geocoding

### Applications
- HERE Traffic Viewer
- HERE Automotive Nav
- HERE Mobile Apps (Maps, Drive, LiveSight)
- HERE Web Apps
- Partner Apps (In-vehicle nav, PND, web, mobile)
HERE Maps

- **214** Countries and territories mapped
- **2.7M** Changes per day
- **75,600** Buildings with indoor maps
- **96** Countries with voice-guidance
- **41** Countries with live traffic service
- **80,000** External sources help to create our maps
- **805** Cities with public transport
- **52** Languages
HERE Location Platform APIs

Multi-modal routing APIs and SDKs for routing and visualization

**Truck Routing**
Optimized routing based on the truck attributes data set

**Traffic-enabled Routing**
Optimized routing with real-time traffic data and/or Historical traffic data

**Isoline Routing**
Route calculation based on areas of reach within a particular time or distance

**Matrix Routing**
Route calculation for multiple destinations

**Pedestrian Routing**
Optimized routing using pedestrian specific walk ways and virtual connections

**Public Transit Routing**
Estimated routing using frequency-based schedules
Timetable routing using dynamic up-to-date frequency-based schedules
HERE & Partner Applications & Devices

Multi-modal traveler applications for driving, public transit, pedestrian

HERE both creates applications and powers 3rd party applications for in-vehicle, PND, mobile devices and across operating platforms.
HERE TRAFFIC
Big Data turned into Useful Information: HERE Traffic

HERE Real Time Traffic
Continuous Dynamic Traffic Information, providing up to the minute data for 44 countries
- Real-time speeds and travel times
- Real-time incidents (accidents, construction)

HERE Advanced Analytics
Traffic Analytics
- A rich dataset of daily historical traffic speed and statistical information
- Sliced and diced on demand

NPMRDS
- Un-modeled research data set

Traffic Patterns
- Typical speeds & travel times by day/time based on historical data

HERE Predictive Traffic
Modeled real-time traffic forecasts for future time slots to help drivers, fleets, and road network operators make better decisions.
- Forecasted speeds and travel times
- 12 hours into the future
Halo: Real-Time Data Processing Engine

Data Inputs
- GPS-Probe Data
- Sensor Data
- Incident Data
- Historical Data

Processing
- Real-Time Engine
- Learning Platform
  - Model Historical Data
  - Collect Influencers
  - Predict Future

Outputs
- REAL-TIME TRAFFIC (Now)
- REAL-TIME INCIDENTS (Past)
- HISTORIC TRAFFIC (Future)
- PREDICTIVE TRAFFIC

Real-time Data is published every minute
Granular Conditions

Micro-Traffic enables HERE Traffic to be reported at a sub-TMC level

Captures the natural breaking of traffic speeds based upon real world conditions
## Evolution of Archived Data Products

<table>
<thead>
<tr>
<th>Traffic Patterns</th>
<th>Analytic Traffic Patterns</th>
<th>National Performance Dataset</th>
<th>Traffic Analytics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suited for route planning, arrival time estimation</td>
<td>Suited for analysis of monthly and season trends</td>
<td>Unmolded raw speed data operations research and analysis</td>
<td>User defined, customizable data sets built on-the-fly</td>
</tr>
</tbody>
</table>
Traffic Analytics

Tell your story using a data driven approach

Show and prioritize where investment is needed

Quantify and measure network performance

• A rich dataset of daily historical traffic speed and statistical information
• Sliced and diced on demand
Traffic Analytics

User defined historical data sets for performance measurement

A rich dataset of daily historical traffic speed and statistical information

Slice and dice on demand by user preferences (date/time, location, resolution, modeling)

Includes analytical details
Traffic Analytics: Benefits over existing options

- Consistency over Time
- Granularity: Smallest road segments.
- Flexibility: Data constructed by user preferences.
- Usability: Manageable and customizable data sets.
Real-Time Predictive Traffic

Modeled real-time traffic forecasts for future time slots
- Forecasted speeds and travel times
- 12 hours into the future

1. Improves planning and alerting capabilities
2. Anticipate the best routes and reduce the number of re-routes during a journey
3. Improves arrival time estimates for longer routes
Planning and Alerting
Manage expectations

Transportation Agency.
Alert travelers so they know what to expect and have alternate choices.
Planning and Alerting
Complex journeys

Fleet routing.
Optimize route planning and timing for multi-stop journeys.
Know when the truck will arrive.
More accurate arrival time estimates for long journeys
Routes more than 30 minutes

Friday drive to the beach

Hitting the slopes for the weekend
Data Analytics: Aggregated Braking Patterns

Initial Speed 50-59kph

Points of first brake application

Last second braking

Behavior in sharp curve
Real-Time Traffic Volume Estimation
Connected Traffic Signals

HERE Traffic Engine and SWARCO MISTIC Platform

• The use of Signal Phase and Timing (SPaT) data along with HERE to deliver enhanced traffic flow, prediction accuracy and real time mobility status

• For road authorities the combination can improve congestion management, vehicle efficiency and reduce carbon emissions.

• Demonstrated at ITS World Congress in Detroit
Other Trends and Initiatives
Nokia is investing and HERE is implementing connected and automated vehicle technology

Nokia announces $100M fund to accelerate connected car technology

Nov 2013
HERE has teamed up with Mercedes Benz to jointly develop smart maps for connected cars and ultimately, self driving cars.

Jan 2014
North American Auto Show 2014: Continental and HERE team up to map out the future of vehicle connectivity using HERE maps and Electronic Horizon.

Oct 2014
HERE receives BMW Supplier Innovation Award in the area of Connected Driving.
Nokia’s HERE Maps arrive on Google Play, coming to iOS in early 2015
Thank you!
1st Outsourced Probe Data Symposium

Rick Schuman, Ted Trepanier
January 15, 2015
INRIX Overview

Leading Global Provider of Traffic Information, Analytics & Connected Car Services

- **World’s largest driver network**
  - 175M real-time vehicles & devices; Hundreds of distinct data sources

- **Across 40 countries**
  - Covering 4M+ miles; Expanding across South America, the Middle East and Asia

- **Delivering breakthrough Connected Car services & transportation analytics**
  - Traffic, Fuel, Parking, EV, Multi-Modal; Transportation & Population Analytics

- **Serving 300+ B2B customers worldwide**

<table>
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<th>Automotive</th>
<th>Mobile/Internet</th>
<th>Public Sector</th>
<th>Enterprise</th>
<th>Media</th>
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<td>Transport for Landon</td>
<td>Atkins</td>
<td>The Weather Channel</td>
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<tr>
<td>Ford</td>
<td>TELENAV</td>
<td>Transport for Greater Manchester</td>
<td>CDUniverse</td>
<td>Comcast</td>
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<td>BMW</td>
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<td>TELNET</td>
<td>TELVENT</td>
<td>BBC</td>
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<td>Mercedes</td>
<td>SPARROW</td>
<td>Mouschei</td>
<td>Gannett</td>
<td>WSI</td>
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<td>Toyota</td>
<td>RAC</td>
<td>The University of Manchester</td>
<td>Better Homes</td>
<td>Pelmorex Media Inc.</td>
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<td>BOSCH</td>
<td>Mapbox</td>
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<td>Telenz</td>
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<td>NAVIGON</td>
<td>Mapbox</td>
<td>Purdue</td>
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<td>RENAULT</td>
<td>TCS</td>
<td>Microsoft</td>
<td>Partners</td>
<td>Gannett</td>
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<td>TELNET</td>
<td>Microsoft</td>
<td>MIT</td>
<td>Gannett</td>
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<td>DENSO</td>
<td>OXYGEN8</td>
<td>Google</td>
<td>IBM</td>
<td>Gannett</td>
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<td>Clarion</td>
<td>Orange</td>
<td>Adobe</td>
<td>Siemens</td>
<td>Gannett</td>
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<tr>
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<tr>
<td>Mercedes-Benz</td>
<td>HTC</td>
<td>Amazon</td>
<td>Accenture</td>
<td>Gannett</td>
</tr>
</tbody>
</table>
Keys to Useful Probe Data

• Sufficient Raw Source Data
• Fusion and Algorithms
• Reliability and Scalability
• Matching Products to Use Cases
• Ease of Use/Integration
Incoming Data – April 2009
Incoming Data – April 2014
Robust Probe Data Managed as a Portfolio

Top 5 Data Sources by Time of Day (DC Area Avg Weekday - Spring 2013)
INRIX Processing Steps

**Normalize**
- GPS Vehicle Probe
- Mobile Probe
- Driver Generated Report
- Road Sensor
- Traffic Camera
- Incidents

**Map Matching**

**Speed Estimation**

**Statistical Refinement**

**Provider Health Processing**

**Fusion Engine**

**Aggregate speed data from probes and sensors**
- Collect data from over 400 sources
- Monitor to ensure proper data point – timely and valid
- Place valid data points on a specific road
- Sensor and Provider Health Processing

**Snap probe data to road network**
- Filter points based on location, heading, speed
- Locate points within a road segment

**Compute speed value based on data collected over 15 minutes**
- Outlier detection to remove statistical anomalies
- Weight data based on source and latency
- Apply “Adaptive Spatial Resolution” to optimize accuracy and relevance

**Enhance precision of result and calculate confidence factor**
- Leverage real-time where possible
- Enhance data to leverage road closures
- Process less than ideal real-time estimates with typical and predictive forecasts
VPP1 Freeway Validation Results

- Subject to world’s most rigorous testing in VPP1 since 2008
- Agreed to Payment Penalty Formula in VPP1 – never penalized
- Significant accuracy during VPP1
- Agreed to 7MPH AASE rqmt in VPPII vs. 10 MPH in VPP1
INRIX XD Segments (More Roads, Precision)

- Introduced late 2013 – Purpose built for dynamic traffic reporting
- Function precisely like TMC segments
  - Fixed segments, fully populated data, updated every minute
- Key Benefits of XD Segments
  - ~40% More Coverage nationally – large increases in ramps and arterials
  - Better segment granularity – typical segment length ~1 mile (1.7 mile max)
  - Eliminate gaps and overlaps endemic in TMC segments
  - Not dependent upon TMC Consortium for codes
  - Sub-segment granularity optional – data and tiles
Queue Monitoring – TMC Segments

T-75 @ US-25/Exit 62

- TMC Id: 121-0-764 (External)
- Time: Wed Oct 8 2014 5:01 PM (EDT)
- Direction: Southbound
- Length: 13.05 miles
- Speed: 7 mph
- Hist. Average: 65 mph
- Free Flow: 65 mph
- Score: 30
- Travel Time: 1 hour 51 minutes 53 seconds
Queue Monitoring – XD Segments
Available Road Coverage

TMC Segments – 133K miles

INRIX XD Segments – 187K miles
Available Interchange Coverage

TMC Segments

INRIX XD Segments
This is Big Data...

- INRIX Data Updates every minute...so...

### TMC Segments vs. XD Segments

<table>
<thead>
<tr>
<th>TMC Segments</th>
<th>XD Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>22,624</td>
<td>55,860</td>
</tr>
<tr>
<td>32.5M+</td>
<td>81.8M+</td>
</tr>
<tr>
<td>~11.9B</td>
<td>~29.9B</td>
</tr>
</tbody>
</table>

- In other words, 30 BILLION of these each year...

```
<table>
<thead>
<tr>
<th>tmc_code</th>
<th>measurement_tstamp</th>
<th>speed</th>
<th>average_speed</th>
<th>reference_speed</th>
<th>travel_time_minutes</th>
<th>confidence_score</th>
<th>cvalue</th>
</tr>
</thead>
<tbody>
<tr>
<td>103N04275</td>
<td>12/11/2014 12:00</td>
<td>46</td>
<td>42</td>
<td>52</td>
<td>0.85</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>
```
INRIX Public Sector Suite
A traffic platform for planning, analysis and operations of road networks

Real Time Traffic
*Effectively manage daily roadway traffic*

- Traffic Speeds, Travel Times
- Traffic Tiles (Maps)
- Traffic Incidents
- Traffic Cameras
- Drive Time Polygons
- XD Monitoring

Historical Traffic
*Determine how to best leverage infrastructure investments to optimize long term flow*

- Traffic/Freight Profiles
- Traffic Data Archive
- OD: Trip Records, Matrices

Analytics
*Assessing performance of roadways and impact of investments in infrastructure*

- Traffic Monitoring Dashboard
- Bottleneck & Congestion Analysis
- Historical Traffic Analysis
## Features Compared to Typical Applications

<table>
<thead>
<tr>
<th>Segment Speed/Travel Time Data API</th>
<th>Application</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>XD Segments</td>
<td></td>
<td>Best API in general - works for all use cases</td>
</tr>
<tr>
<td>XD Subsegments Option</td>
<td></td>
<td>Provides more detail than XD Segments, slightly harder to integrate</td>
</tr>
<tr>
<td>TMC Segments</td>
<td></td>
<td>Core API of Vehicle Probe Project 1</td>
</tr>
<tr>
<td>TMC Subsegments Option</td>
<td></td>
<td>Provides more detail than TMC Segments, slightly harder to integrate</td>
</tr>
</tbody>
</table>

### Traffic Tile API

| XD Segments                       |             | Increased resolution over TMC, 40% more roads, 7x more interchanges |
| XD Subsegments Option             |             | Optimal resolution option |
| TMC Segments                      |             | Core API of Vehicle Probe Project 1 |
| TMC Subsegments Option            |             | Improved resolution over TMC Segments |

### Other APIs

| RTSMIP Alert API                  |             | Translate slowdowns, accidents, work zones into formatted messages |
| Route Travel Time API              |             | Designed to provide point-to-point travel times, made for DMS Use Case |
| Virtual Sensor ("Speed at a point") API |         | An option for ATMS software integration to mimic roadside detectors |

### j95.inrix.com Monitoring Site

| Site with TMC Segment Maps        |             | Core Monitoring Site of Vehicle Probe Project 1 |
| Site with TMC, XD and Sub-segment Maps |             | Enhanced coverage and precision; available for full coverage states only |

### UMD VPP Suite

| Full Statewide TMC Coverage       |             | Purpose built for performance measurement, all contracted data included |

All features available in base fee for contracted coverage
Monitoring Sites – Multi-Dimensional, Easy Access Situational Awareness
Interface Guide Simplifies Integration

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19 States with Agencies/ Services Accessing INRIX APIs
Incident Detection Application

Explanation

Delta Speed: Difference in speed from an initial segment to the adjacent segment downstream.

This is where we as an industry need to focus our attention. High speed to low speed indicates the back of a queue.

Real Time Data (every minute)

Segment 1: 70 MPH
Segment 2: 68 MPH
Segment 3: 35 MPH

Delta Speed:
- Segment 1 to Segment 2: -2 mph
- Segment 2 to Segment 3: -33 mph
XD Segments Supporting Queue Detection (Indiana DOT/Purdue) – “Game Changing Fidelity”

http://tinyurl.com/purdue-indot-queue-warning

http://youtu.be/5eFwSBGZkqI
Types of 511 Services Supported

- Web Sites
  - Traffic Maps
  - Drive Times
  - Congestion Events
- Phone IVR
  - Congestion Events
  - Average Travel Times
- Mobile Apps
  - Congestion Ahead
- Text/Email Alerts
Examples: Maps
Examples: Drive Times/Congestion Events

- Drive Times/Congestion
- Events
Examples of Analytics/Archived Data Uses

• Statewide Reports
  • “Texas 100 Most Congested Corridors” – TTI/TxDOT
    • http://www.txdot.gov/inside-txdot/projects/100-congested-roadways.html
  • Indiana Mobility Report – Purdue/INDOT
    • http://docs.lib.purdue.edu/imr/
  • Maryland Mobility Report – MDDOT/MDSHA/UMD
    • http://sha.maryland.gov/OPPEN/2013_Maryland__Mobility.pdf
  • Bottlenecks on the Florida SIS – FDOT/CDM Smith
    • 2014 ITE Transportation Planning Council Best Project Award winner

• Metropolitan Area Reports
  • DC Congestion Management Process (MWCOG)
    • www.mwcog.org/cmp/
  • Baltimore Quarterly Congestion Analysis Report (BMC)
  • Philadelphia Area “Using Operations Data for Planning in the Delaware Valley: First Steps” (DVRPC)
    • http://www.dvrpc.org/reports/11049.pdf
Arterial Retiming Cost – Benefit Analysis using Crowd Sourced Data

**Legend**
- **Week 13 (Before)**
- **Week 16 (After)**

**March 2012**
- **Before Retiming**
  - Week 13: 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

**April 2012**
- **Retiming**
  - Week 15: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
  - Week 16: 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30
Arterial Retiming Cost – Benefit Analysis using Crowd Sourced Data

Using TTI Travel Time Savings Calculations: Expected Yearly Savings are $2.7 Million
Free Tools and Trials

- Free tools
  - INRIXTraffic! Mobile App
  - INRIXTraffic.us Monitoring Site
    - For Transportation Agencies
  - I95.inrix.com Monitoring Site
    - For I-95 Corridor Coalition Members

- Trials
  - XD Monitoring
  - INRIX Analytics
  - Both trials available via INRIXTraffic.us
Analytics for the Public Sector

*Turning Data into Information*

- Real-Time Bottlenecks Identification
- Historical Traffic Download for Custom Analysis
- Congestion Tracking Analysis
- Congestion Trends
- Bottleneck Ranking & Movement

Data from January 2011 to the present

**Free Trial Access**
## INRIX VOLUMES

### Dataset Details

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMC_Code</td>
<td>TMC in 9 digit format. Delineates road segment specified in the TMC reference file attributes for each TMC Code.</td>
</tr>
<tr>
<td>MarketID</td>
<td>Unique identifier for the market in which the TMC code resides</td>
</tr>
<tr>
<td>FRC</td>
<td>Functional Road Class of the TMC segment</td>
</tr>
<tr>
<td>CBSAName</td>
<td>Core Based Statistical Area name where TMC Segment resides</td>
</tr>
<tr>
<td>CSAName</td>
<td>Combined Statistical Area name where the TMC Segment resides</td>
</tr>
<tr>
<td>FHWA FRC</td>
<td>FHWA designated Functional Classification System</td>
</tr>
<tr>
<td>NumberofLanes</td>
<td>Average number of lanes</td>
</tr>
<tr>
<td>speed</td>
<td>Average speed, in MPH, for the time of day and day of week</td>
</tr>
<tr>
<td>TimeofDayBinID</td>
<td>Time of day expressed as a number from 0 -95 with each number representing a 15 minute time bin, counted from midnight where 0=midnight, 95=11:45pm.</td>
</tr>
<tr>
<td>DayOfWeek</td>
<td>Day of the week in 3 letter abbreviation. SUN=Sunday, MON=Monday, TUE=Tuesday, WED=Wednesday, THU=Thursday, FRI=Friday, SAT=Saturday</td>
</tr>
<tr>
<td>AADTByDay</td>
<td>Annual Average Daily Volume in number of cars per day</td>
</tr>
<tr>
<td>VehicleVolume</td>
<td>Average estimated volume of vehicles for the specified day of week and 15 minute time bin</td>
</tr>
</tbody>
</table>
### INRIX VOLUMES

#### Metrics Supported

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Volume</strong></td>
<td>A measure of the number of vehicles which traversed a specified segment/route in a specified time.</td>
</tr>
<tr>
<td><strong>Vehicle Miles Travelled (VMT)</strong></td>
<td>The number of miles travelled by all vehicles over a specified segment/route in a specified time frame</td>
</tr>
<tr>
<td><strong>% Arrival on Green (Arterial Signal Timing)</strong></td>
<td>The percent of vehicles that arrive at a signal while the signal is green.</td>
</tr>
<tr>
<td><strong>Turning Maneuver Percentile</strong></td>
<td>The percent of traffic making each possible type of turning maneuver at a traffic control device</td>
</tr>
<tr>
<td><strong>Emissions</strong></td>
<td>Use of Volume, Congestion, and Travel Time to estimate pollution from vehicle emissions</td>
</tr>
</tbody>
</table>
INRIX VOLUMES

Use Cases Supported

Capacity Planning
How much capacity does my road network have?

Model Calibration
How reflective is my demand model to current ground truth?

Advertising Measurement
How many targeted impressions did my ad receive?

Cost of Delay
What is the cost of congestion by hour and day?
Insights Into the Movement of People

*Population Analytics from INRIX is designed to answer the most pressing and valuable questions about how people move through our world*

- How many people are here right now?
- What is the mix of vehicles which got them here?
- What is the relative density of people in this area?
- How many people saw my ad?
- Where did the people originate?
INRIX Population Analytics
The Movement of People Regardless of Mode

Population Analytics from INRIX is designed to answer the most pressing and valuable questions about how we move through our world

Understand the Travel and Population Growth Patterns of Large Populations
- Volumes of anonymized data with sample sizes correlate statistically with real-world population volumes

Accurate population movement analysis provides valuable location insights
- Understand trip details, density, and routes to better model and plan for the future

Data + Analytics to Improve Your Planning and Prediction
- Make better investment decisions, choose the right retail site, model the smart city of the future

What is the relative density of people in this area?
Population Density

*Summer 2014 Release Key Features*

- **Population Heat Map**
  - View relative population density and movement in time and space

- **Historical Population Slider**
  - Compare population density intra-day and between days

- **Population Detail View**
  - View detailed statistics of population types at a particular date, time, and space

- **Data Type Filter**
  - Customize the heat map to match your analytics needs by data type

- **Auto Scroll**
  - View automated population density movement over a 24 hour period
Population Heat Map

- View relative population density in time and space
- High granularity analysis with Interval Selection
- Customize heat map view with Density Scale
Historical Population Slider

- View density for past days and times
- Quickly compare intra day trends such as morning and evening rush hour
- Compare a specific time of day between different days of week
Quickly understand the mix of different device types to better target your analysis

Data split by Freight (truck/taxi fleets), Consumer cars (eg BMW, Audi, Toyota), and Mobile Apps (eg INRIX, Mapquest)

Use in combination with Historical Slider to compare across times and days
Target your analysis by device type for faster insights
Combine with Density Scale to understand where to focus
Use together with Historical Slider to compare targeted density analysis between days or within a day
Auto Scroll

- Auto Play population density over time
- Play through up to 24 consecutive hours
- Pause, Rewind and skip forward density auto play
2012 Summer Games Traffic & Travel

INRIX Selected by Olympic Development Authority

- Official Spectator Journey Planner website and mobile app powered by INRIX Traffic
- INRIX traffic analysts embedded in Games Travel Demand Management centre
- INRIX incident processing systems upgraded to support venue and spectator specific advice management INRIX disseminated traffic & travel data through INRIX media and online channels (40 million weekly consumer reach in UK) and through Spectator Journey Planner
INRIX Population Analytics

*Origin/Destination and Trip Analysis*

**Visual Trip Exploration**
Explore Trip data visually overlaid with a map
View trips in a heatmap or connecting lines overlay

**Customized Analysis**
Define custom polygons to pinpoint spatial analysis
Filter trips on Mode (Walk, Vehicle, Rail)
Filter Analysis on origins, destinations, or start/end date/time

**CSV Download**
Download Trip Data in CSV format for offline analysis
Use Visual Trip Explorer to configure download
Types of Historical Freight Data

• Origin/Destination (OD)
  • Option 1: “Trip Record” – start and end location and time of trip
  • Option 2: “Trip Record + Waypoints” – adds waypoints to option 1
  • Option 3: OD Matrix (count and/or %) – based on customer zone definition

• Freight Profile
  • Calculated speeds and percentiles which represent historical profiles for a given location
  • Speed by day of week/time of day (15 minute bins)
  • Holidays reported as separate “day types”
  • In TMC Segment or XD segment formats
Chicago Freight Study

- Study Area:
  - Greater Chicagoland Area, and beyond
  - 154 zones
- Study Period:
  - July – Sept 2013 (3 months)
- Total Data Points Analyzed:
  - ~1.5 billion
- Freights Trips Identified:
  - 4.8 million
- Results provided as OD Matrix
INRIX Drive Time – Accessibility Metric
New Product – INRIX RoadWatch™
Questions

rick@inrix.com
Why we are all here
**Product:**
TomTom Traffic Flow Data

**Requirements:**
Provide accurate, real-time speed and travel time information to Coalition members.

**Solution:**
TomTom and the I-95 Corridor Coalition announced a partnership agreement to offer real-time traffic content to enhance transportation mobility, safety and efficiency.
TomTom I-95 Team

Customer Facing
• Harriet Chen: Project Manager – Technical
• Mark Dykstra: Senior Account Manager – Programmatic
• Nick Cohn: Senior Advisor – Technical
• Ken Clay: Project Manager – Programmatic
• Bart DeWolf – Senior Solutions Architect, Customer Program Management

Back-end Support
• Stefan Lorkowski – Director Real-Time Traffic
• Peter Mieth – Director Historical Traffic
• Jeroen Brouwer – Product Manager + Traffic Stats Web Portal
• Mike Dannehy – Training & Support
• Barry Tremeer – Director, Product Management, Traffic & Travel Time Product Unit
WORLD LEADER IN LOCATION AND NAVIGATION PRODUCTS AND SERVICES

4,000 EMPLOYEES WORLDWIDE

HEADQUARTERS: AMSTERDAM
NORTH AMERICA: LEBANON, NH
Business structure

B2C

Consumer

Drive - PND’s Sports – GPS Sports Watches

Connected Car

Car manufacturers and direct vendors Connected services

B2B

Fleet

Fleet telematics and commercial fleet owners

Government

Tools for Traffic Management, Planning, Model Development, Policy Evaluation

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Global Presence & Local Knowledge

**Americas**
- Burlington, MA
- Lebanon, NH
- Mexico City, Mexico
- San Jose, CA
- Sao Paulo, Brazil
- Southfield, MI

**Europe**
- Amsterdam
- Berlin
- Budapest
- Calne
- Copenhagen
- Edinburgh
- Eindhoven
- Ghent
- Harsum
- Helsinki
- Istanbul
- Leipzig
- Lisbon
- Lodz
- London
- Madrid
- Milan
- Moscow
- Munich
- Paris
- Prague
- Stockholm
- Warsaw
- Zurich

**APAC**
- Bangkok
- Irene
- Jakarta
- Kuala Lumpur
- Pune
- Seoul
- Shanghai
- Singapore
- Sydney
- Tokyo
- Taipei

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TomTom Traffic

Data from these sources is used to provide Real-Time traffic services in 46 countries

- Over 400 million connected GPS devices
- Thousands of journalists collecting incident data
TomTom Traffic Portfolio

HISTORICAL TRAFFIC

Speed Profiles

Custom Area Analysis

Custom Travel Times

REAL TIME TRAFFIC

TomTom Traffic

TomTom Traffic Flow

TomTom Route Times

- > 10 trillion anonymous GPS measurements since 2007
- > 7 billion new GPS measurements per day
- Many roads with >100,000 measurements
- > 175 billion miles driven
- > 700,000 years of actual driven GPS journey data
TOMTOM DATA IS EVERYWHERE
Selected New Products and R&D

Real-time services:
• Weather and its influence on Traffic
• Traffic Prediction
• Jam-ahead warnings
• Detection of Road Closures

Traffic Management Tools
• Moderation

Analytical tools:
• Performance Reporting
• Origin-Destination

• Fuel Use and Emissions Prediction
• Content and Services for Highly Automated Driving
Advanced Weather Services
Advanced Weather Services
Advanced Weather Services
Advanced Weather Services

- Bad weather that impacts traffic such as heavy rain, snow or hail is displayed by using weather data in our fusion engine.
- Weather information will be used for improving traffic prediction.
Key Features & Options

<table>
<thead>
<tr>
<th>Location Referencing</th>
<th>Optional Content Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>OpenLR: extended road network – average approx. 40% more messages</td>
<td>Jam Tendency getting worse/better - and / or - Jam Lifetime minutes until freeflow - and / or - Jam Ahead Warning safety - significant speed difference ahead</td>
</tr>
<tr>
<td>TMC: limited road network</td>
<td>Predictive Flow 15/30/45 minutes ahead</td>
</tr>
</tbody>
</table>
Flow Prediction, Jam Tendency and Jam Lifetime

Now

+15 min.

+30 min.

+45 min.

Tendency:
- Increasing
- Increasing Fast
- Decreasing
- Decreasing Fast
- Stable

Incidents
• Over 35% of drivers have admitted to experiencing an accident caused by sudden or unexpected traffic holdups
• Jam ahead warning messages in traffic output can be used to create these safety messages with great accuracy
Automatic detection of & correction of closures

3rd party road closure report

Corrected by HD Traffic Fusion

Corrected by LIVE data input

Automatic detection of road and slip-roads (ramp) closures

- Monitoring flow – roads with normally high volume of observations dropping to nothing
Traffic Incident Moderation

- Moderation tool by TomTom
- Available 24/7
- Access over a Traffic Moderation Tool to modify traffic incidents
- Access to Probe Data, Analyzing Tools and the Map Share Contributions

Example of the effort from the moderation team; closed all involved roads in Taiwan after the gas explosion.
Performance Reporting

1. Travel Time Index
2. Traffic Jam Statistics
3. Traffic Index

- By route
- By road segment
- By road class
- By road name
- By network
- By year, season, day
- By time
Analytical Tools
Origin Destination Applications in the field

Table 4: TomTom O-D Data – Monday Peak Period (6:00 AM to 9:00 AM)

<table>
<thead>
<tr>
<th>Destinations</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>A – 1-95 West of Staples-McIntyre</td>
<td>68.66%</td>
<td>31.34%</td>
<td>2.80%</td>
<td>5.60%</td>
<td>1.40%</td>
<td>1.00%</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
<tr>
<td>B – 1-95 North of 155/54</td>
<td>53.59%</td>
<td>46.41%</td>
<td>5.41%</td>
<td>0.41%</td>
<td>0.25%</td>
<td>0.25%</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
<tr>
<td>C – 1-95 South of 155/54</td>
<td>13.33%</td>
<td>86.67%</td>
<td>2.80%</td>
<td>5.60%</td>
<td>1.40%</td>
<td>1.00%</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
<tr>
<td>D – 1-95 East of Shockoe Bottom Bridge</td>
<td>28.94%</td>
<td>71.06%</td>
<td>2.80%</td>
<td>5.60%</td>
<td>1.40%</td>
<td>1.00%</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
<tr>
<td>E – 1-95 West of 155</td>
<td>0.62%</td>
<td>0.38%</td>
<td>0.38%</td>
<td>0.38%</td>
<td>0.38%</td>
<td>0.38%</td>
<td>0.38%</td>
<td>0.38%</td>
</tr>
<tr>
<td>F – 1-95 South of 1-15</td>
<td>23.22%</td>
<td>80.57%</td>
<td>2.80%</td>
<td>5.60%</td>
<td>1.40%</td>
<td>1.00%</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
<tr>
<td>G – Battlecreek Street North of 155/54</td>
<td>9.95%</td>
<td>90.05%</td>
<td>2.80%</td>
<td>5.60%</td>
<td>1.40%</td>
<td>1.00%</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
<tr>
<td>H – Battlecreek Street South of 155/54</td>
<td>3.98%</td>
<td>96.02%</td>
<td>2.80%</td>
<td>5.60%</td>
<td>1.40%</td>
<td>1.00%</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
</tbody>
</table>

Number of Measurements: 6,608

Table 5: TomTom O-D Data – Midday Peak Period (11:00 AM to 2:00 PM)

<table>
<thead>
<tr>
<th>Destinations</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>A – 1-95 West of Staples-McIntyre</td>
<td>13.20%</td>
<td>25.79%</td>
<td>2.78%</td>
<td>5.60%</td>
<td>1.40%</td>
<td>1.00%</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
<tr>
<td>B – 1-95 North of 155/54</td>
<td>45.96%</td>
<td>54.04%</td>
<td>2.78%</td>
<td>5.60%</td>
<td>1.40%</td>
<td>1.00%</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
<tr>
<td>C – 1-95 South of 155/54</td>
<td>13.33%</td>
<td>86.67%</td>
<td>2.78%</td>
<td>5.60%</td>
<td>1.40%</td>
<td>1.00%</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
<tr>
<td>D – 1-95 East of Shockoe Bottom Bridge</td>
<td>28.94%</td>
<td>71.06%</td>
<td>2.78%</td>
<td>5.60%</td>
<td>1.40%</td>
<td>1.00%</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
<tr>
<td>E – 1-95 West of 155</td>
<td>0.62%</td>
<td>0.38%</td>
<td>0.38%</td>
<td>0.38%</td>
<td>0.38%</td>
<td>0.38%</td>
<td>0.38%</td>
<td>0.38%</td>
</tr>
<tr>
<td>F – 1-95 South of 1-15</td>
<td>23.22%</td>
<td>80.57%</td>
<td>2.78%</td>
<td>5.60%</td>
<td>1.40%</td>
<td>1.00%</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
<tr>
<td>G – Battlecreek Street North of 155/54</td>
<td>9.95%</td>
<td>90.05%</td>
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<td>5.60%</td>
<td>1.40%</td>
<td>1.00%</td>
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<td>0.50%</td>
</tr>
<tr>
<td>H – Battlecreek Street South of 155/54</td>
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<td>96.02%</td>
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<td>1.40%</td>
<td>1.00%</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
</tbody>
</table>

Number of Measurements: 6,608
High-Precision Fuel Use & Emissions Prediction

- Creating ‘Fuel Use Profiles’
- Creating ‘Estimated Route Fuel Use’ taking real-time traffic situation into account
- Routing based on minimizing fuel use
- Identifying worst road segments for emissions
- Validated by vehicle type
Highly Automated Driving: New Safety Services
Traffic Management: Traditional Situation

Road authorities vs service providers

Inform Driver

Measure

Influence Traffic

Inform Driver

Measure

Guide Driver
Integrated Traffic Management