Research Connection Presentation

Hosted by Division of Research, Innovation and System Information (DRISI)

Hybrid Data Implementation

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What is the need for this research?

- Caltrans had 40,000 individual vehicle detection zones
- Gigabytes of data is collected every day
- Caltrans programmed over $150 million of SHOPP funds for failed or failing detection stations

Pavement failure near installation

Copper wire theft

Rural area with no detection

Benefits of Third-Party Data

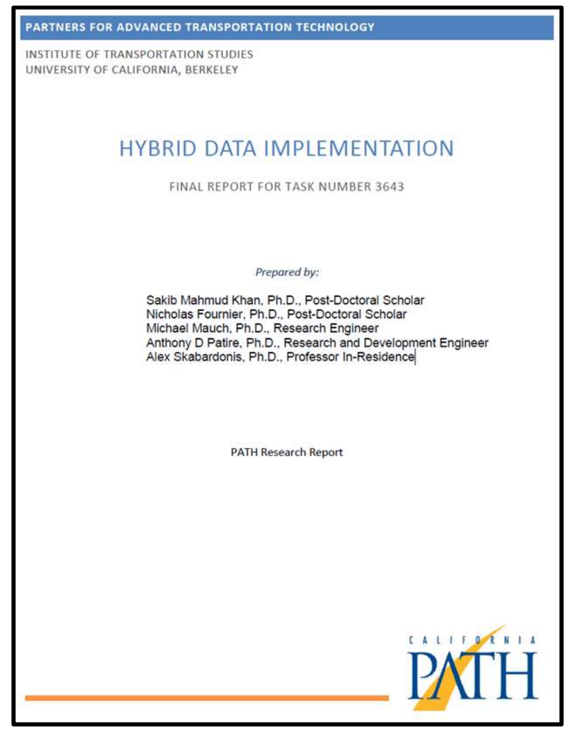
- Reduce the use of traditional vehicle detection
- Reduce maintenance cost
- Limit exposure of construction, maintenance, and operations personnel to live traffic
- Provide broader coverage of the state routes to include those areas not currently monitored (Arterials, Rural)

Presentation Highlights

- New methodologies for using third party data
- Benefits to Caltrans for using third party data in established performance measurement, including reduced costs and increased coverage
- Impacts that data sources have on performance measurement

Acknowledgements

Sakib Mahmud Khan, Ph.D., Post-Doctoral Scholar
Nicholas Fournier, Ph.D., Post-Doctoral Scholar
Michael Mauch, Ph.D., Research Engineer
Alex Skabardonis, Ph.D., Professor In-Residence



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HYBRID DATA IMPLEMENTATION

FINAL REPORT FOR TASK NUMBER 3643

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PATH Research Report

Outline

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- Introduction
- Methodology for delay calculation
- Challenges
- Evaluation of methods
- Goals and next steps

Hybrid Data Question

- **Is it possible use third-party traffic data to augment or replace existing infrastructure for collecting point-based traffic data?**

Here & Now
Point-based sensors
(loops)

Transition

Future
Hybrid data
Leverages private sector

Summary Answer

- **Yes. Third-party travel time data are useful and complementary to data from point-detectors**
- **Point-detector data should focus on <u>quality</u> over quantity**
  - Lane specific
  - Obtains complete cross-section of flow
- **This evaluation pertains strictly to the measurement of delay**
  - Third-party data can compensate for loss of point-based sensors
  - Third-party data can be used to **<u>roughly</u>** estimate delay with limited instrumentation
- **Must overcome challenges related to legacy PeMS meta information (configuration information)**

Comparison of Data Vendors

	FHWA NPMRDS	HERE	TOMTOM	INRIX	STREETLIGHT	CITILABS
Data Sources	HERE Data	CELL, GPS, CV - MANY	GPS	GPS, some CV - MANY	GPS, CELL	Multiple (GPS, CELL, Traffic Counts)
Data Collection Method(s)	HERE Method	Purchased from App providers, OEM vehicles	INTERNAL GPS DEVICES	CV, INRIX APP	INRIX METHOD	Proprietary process combining multiple data types and sources
Main Product	Auto and Truck Speeds and TT	SPEED	SPEED	SPEED VOLUME	O-D VOLUME	SPEED VOLUME O-D
Real-time Delivery Capability	NO	Yes, Real-time and predictive	Yes, Real-time and predictive	Yes, Real-time and predictive	NO	NO
Historical Delivery Capability	Historic, delivered monthly	Historic, delivered daily	Historic	Historic, delivered daily	Historic, delivered daily	Historic
Data validation reports?	YES	YES	?	YES	YES	YES
Mapping Capability	HERE mapping	have a map product	have a map product	Previously using OSM and TomTom, migrating to HERE	NO	?

In general, they have different maps

Grid of Data Types

	3rd	PeMS
Real		
Simulated		

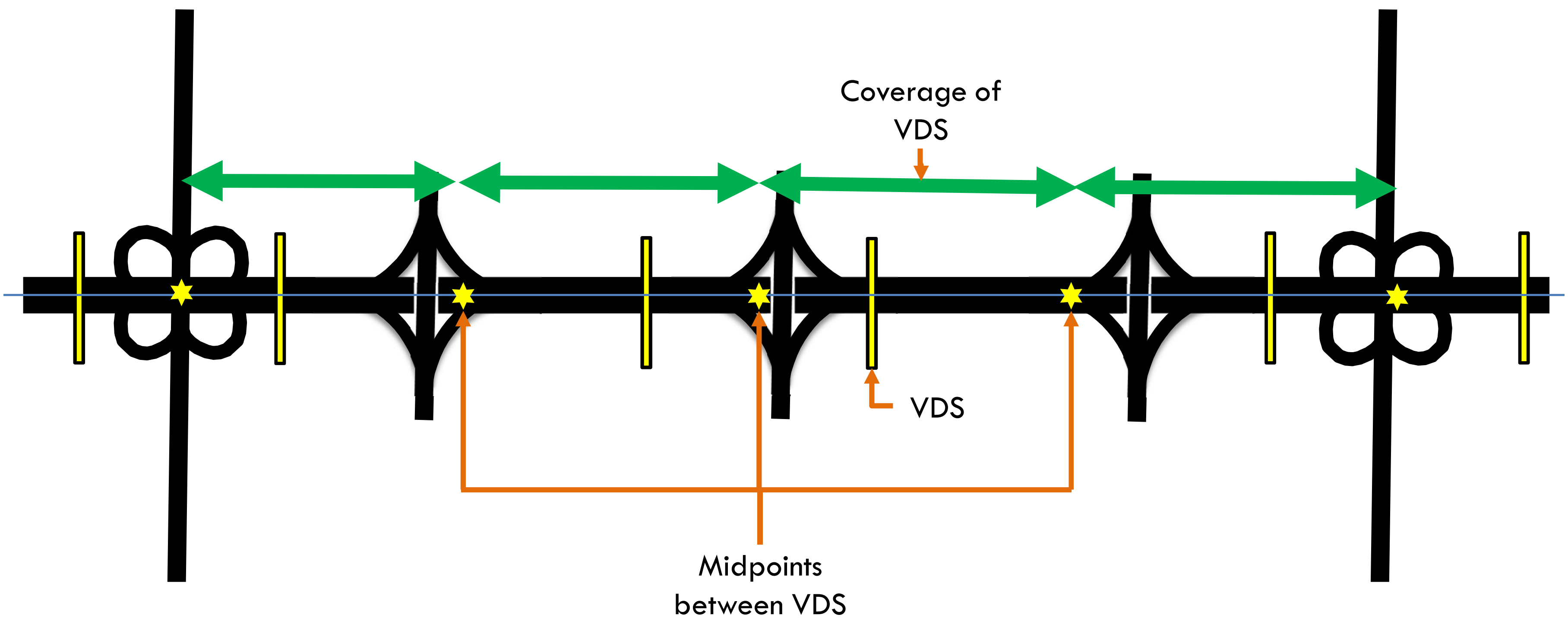
	Third-party Data	Caltrans Field Data
Real World	Raw GPS Points Link travel times / speeds	Vehicle Detector Station (VDS) Flow, Occupancy, Speed Annual Average Daily Traffic (AADT)
Simulated	Synthesized Data Link travel times / speeds	Synthesized Data Flow, Occupancy, Speed

Methodology for DVHD

Calculation of Daily Vehicle Hours of Delay (DVHD)

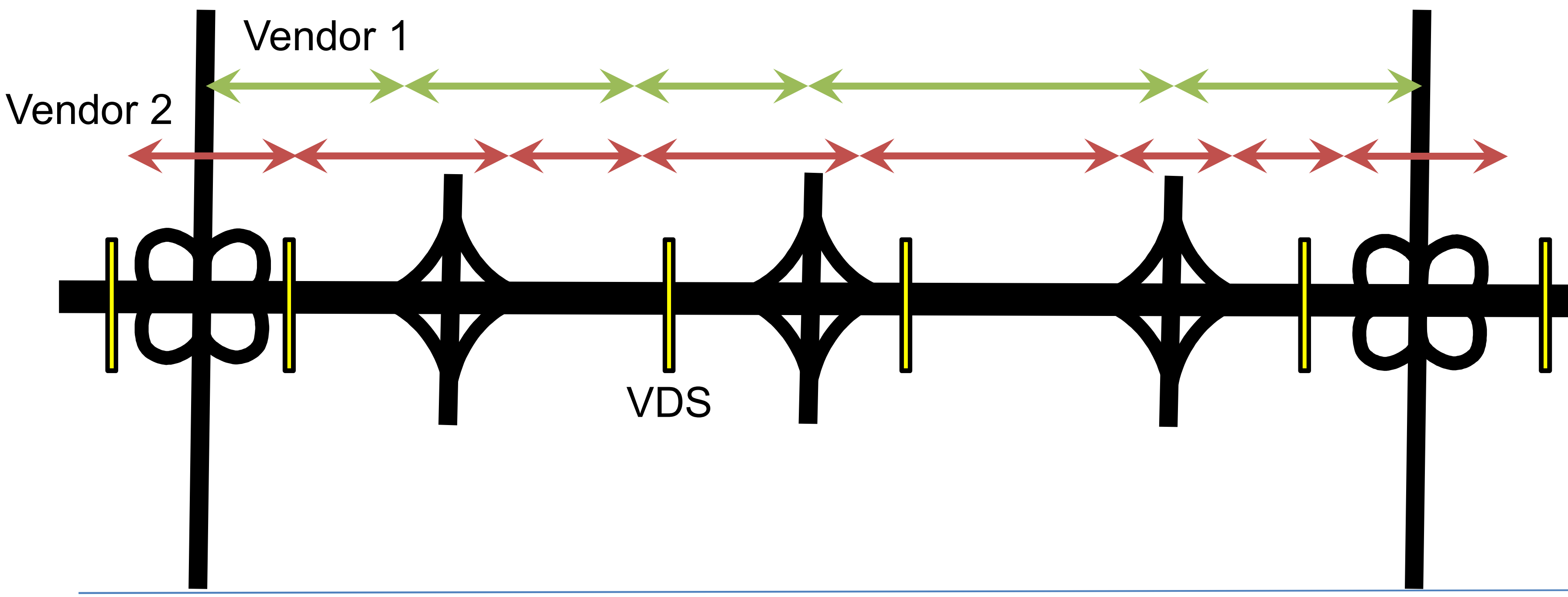
Mobility Performance Report (MPR)

- The existing MPR uses data from fixed point-sensors called Vehicle Detection Stations (VDS)
- The pavement covered by each VDS extends from upstream midpoint to downstream midpoint



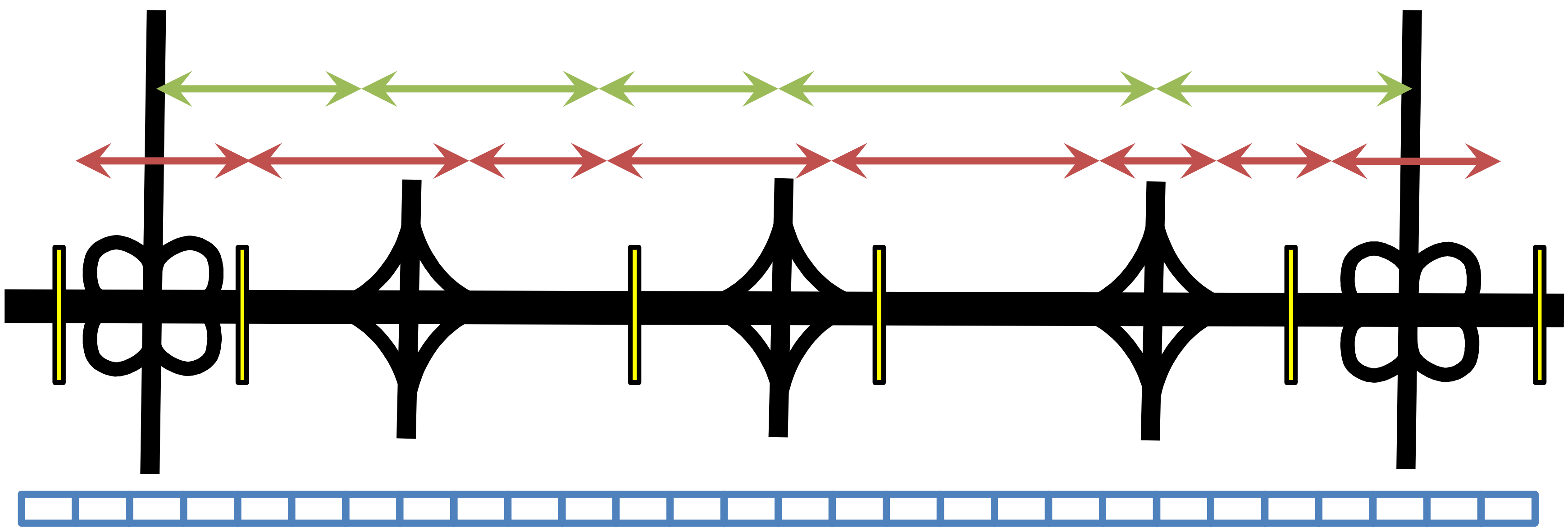
Hybrid Calculation: Overview

- Use flow and density measurements from VDS
- Use travel time measurements from 3rd party vendors
- Different vendors may have different maps



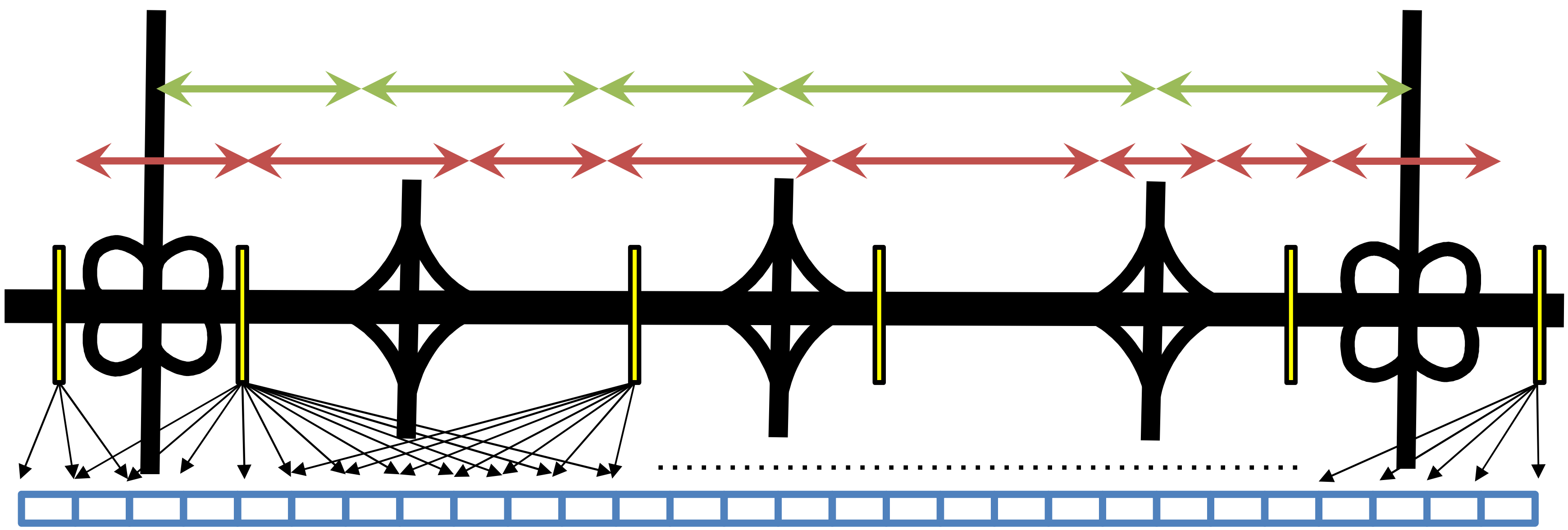
Hybrid Calculation: Domain of Analysis

- Create evenly spaced grid



Hybrid Calculation: Data Projection

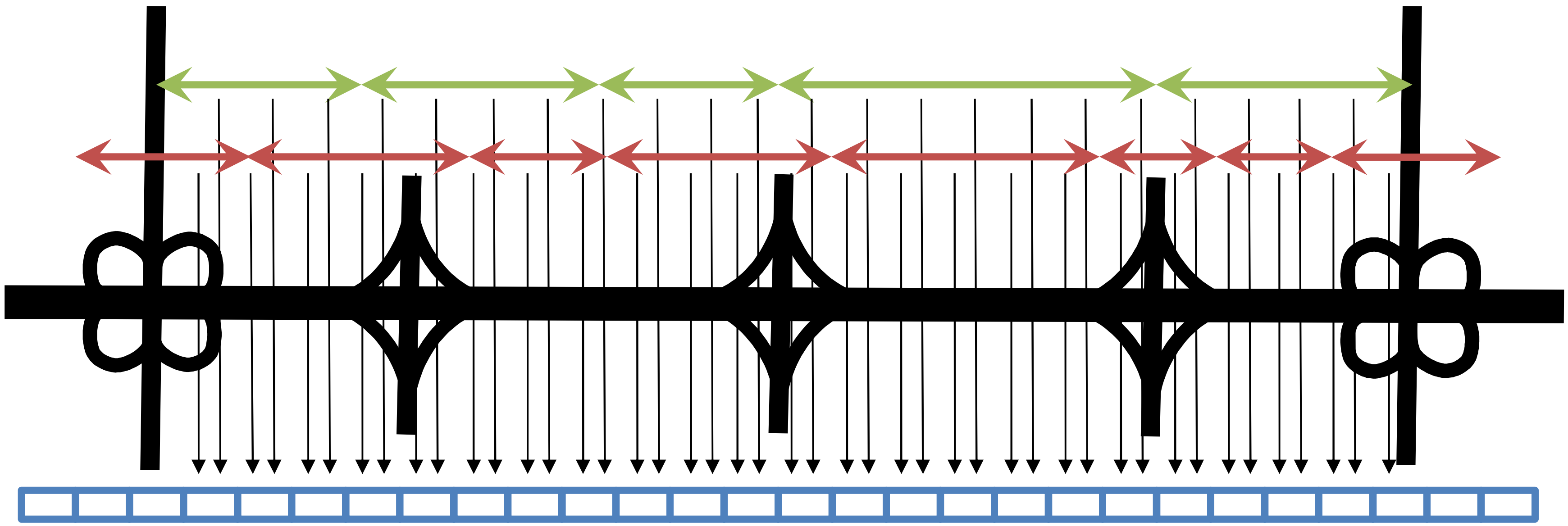
- **Fill in the blanks using VDS**
  - Populate grid with flow and density data
  - Confined Generalized Adaptive Smoothing Method (C-GASM)*



*Khan, S. M., and Patire, A. D., (2021) "Is Third-Party Provided Travel Time Helpful to Estimate Freeway Performance Measures?" Proceeding of the 100th TRB Annual Meeting, Washington, D.C., and under-review by TRR.

Hybrid Calculation: Use 3rd Party Data

- Conflate third party travel time information onto the grid
- Calculate desired metrics



Challenges

What challenges impede a hybrid data approach?

PeMS meta-information

- **Existing PeMS meta-information**
  - Provides enough sensor location information for maintenance
  - Does not provide adequate sensor location information for an algorithm to automatically conflate third-party data with PeMS data
  - The location information in PeMS corresponds to the location of the controller instead of the location of the pavement being monitored

Interpretation of Meta Information

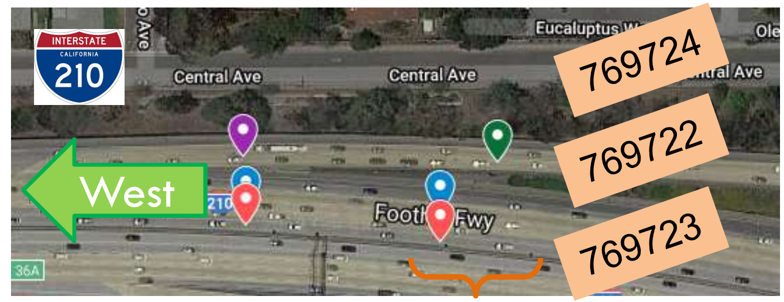
Name: Closest cross- street or feature

Abs PM: Absolute postmile of sensor's controller

Fwy: Physical freeway associated with the sensor's controller

Type: Relationship of sensor to physical freeway

Abs PM	ID	Name	Fwy	Type
36.29	769723	NB 605 TO WB 210 CON	I210-W	HOV
36.29	769722	NB 605 TO WB 210 CON	I210-W	Mainline
36.29	769724	NB 605 TO WB 210 CON	I210-W	On Ramp
36.89	773204	NB 605 TO MT. OLIVE	I210-W	Fwy-Fwy
36.89	773205	EB 210 TO MT. OLIVE	I210-W	Fwy-Fwy
36.89	773206	SB 605 FROM WB 210	I210-W	Fwy-Fwy
36.89	773207	NB 605 TO EB 210	I210-W	Fwy-Fwy
36.89	775795	NB 605 TO WB 210	I210-W	Mainline
36.90	775796	EB 210 TO SB 605	I210-W	Fwy-Fwy
27.95	774264	NB 605 TO MT OLIVE	I605-S	Fwy-Fwy
27.95	774261	EB 210 TO MT OLIVE	I605-S	Fwy-Fwy
27.95	774262	WB 210 TO MT OLIVE	I605-S	Off Ramp
27.95	774263	MT OLIVE TO WB 210	I605-S	On Ramp
27.95	774258	MT OLIVE TO EB 210	I605-S	On Ramp
27.95	774260	MT OLIVE TO SB 605	I605-S	On Ramp



- **VDS inherit their Abs PM and freeway (Fwy) association from the controller they are connected to**
- **This works well for maintenance purposes**
- **But has confusing consequences at freeway interchanges**

Meta Information at Interchanges

- One single control box may handle multiple freeways at an interchange, but it can only be associated with one freeway

- The description of freeway location, connectivity and type get condensed into the name

Abs PM	ID	Name	Fwy	Type
36.29	769723	NB 605 TO WB 210 CON	I210-W	HOV
36.29	769722	NB 605 TO WB 210 CON	I210-W	Mainline
36.29	769724	NB 605 TO WB 210 CON	I210-W	On Ramp
36.89	773204	NB 605 TO MT. OLIVE	I210-W	Fwy-Fwy
36.89	773205	EB 210 TO MT. OLIVE	I210-W	Fwy-Fwy
36.89	773206	SB 605 FROM WB 210	I210-W	Fwy-Fwy
36.89	773207	NB 605 TO EB 210	I210-W	Fwy-Fwy
36.89	775795	NB 605 TO WB 210	I210-W	Mainline
36.89	775796	EB 210 TO SB 605	I210-W	Fwy-Fwy
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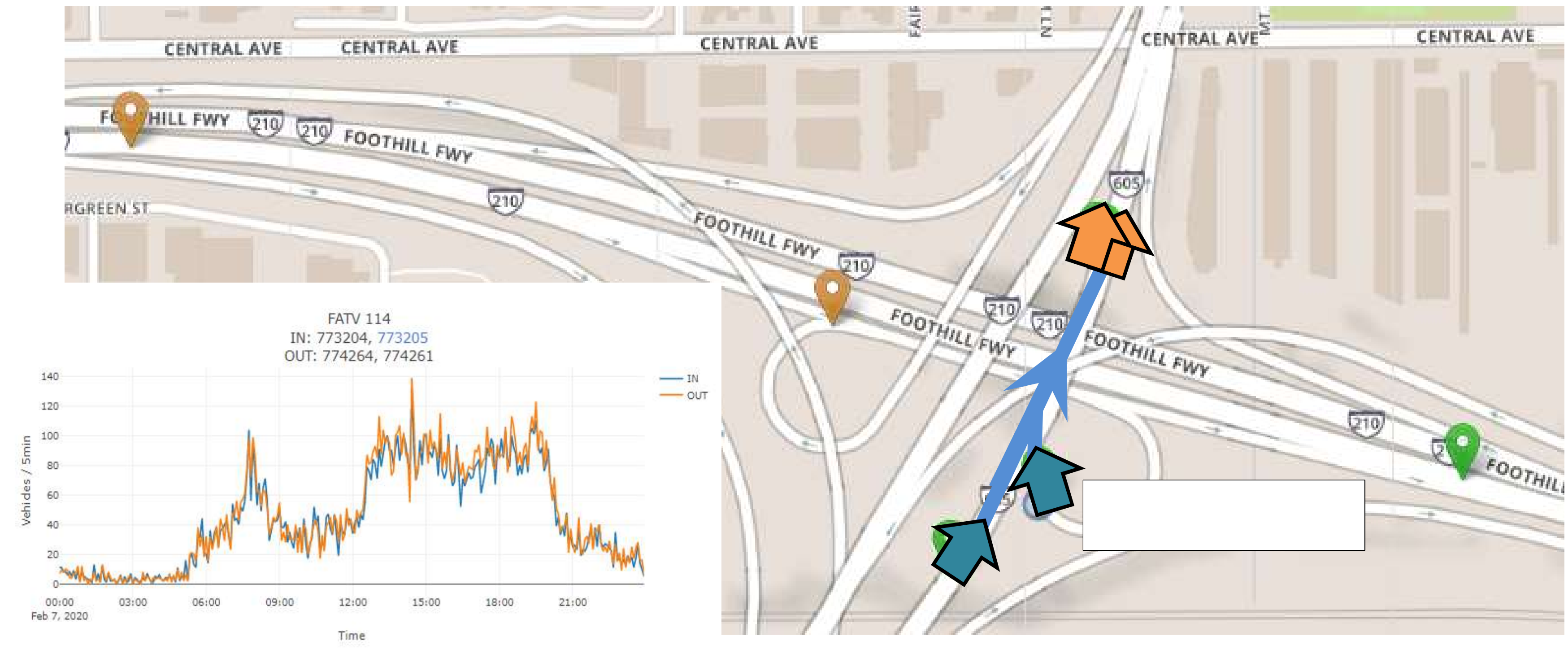
Proposed Solution

- **Question: How could configuration meta-data be improved at major junctions?**
- **Best answer: Associate sensors on the pavement with a network map to show exact locations**
- **Minimal answer: Add additional information**
  - Each sensor (pavement location) should get its own latitude and longitude coordinates
  - Add one additional table to PeMS to organize VDS around fully accounted traffic volumes (FATVs)

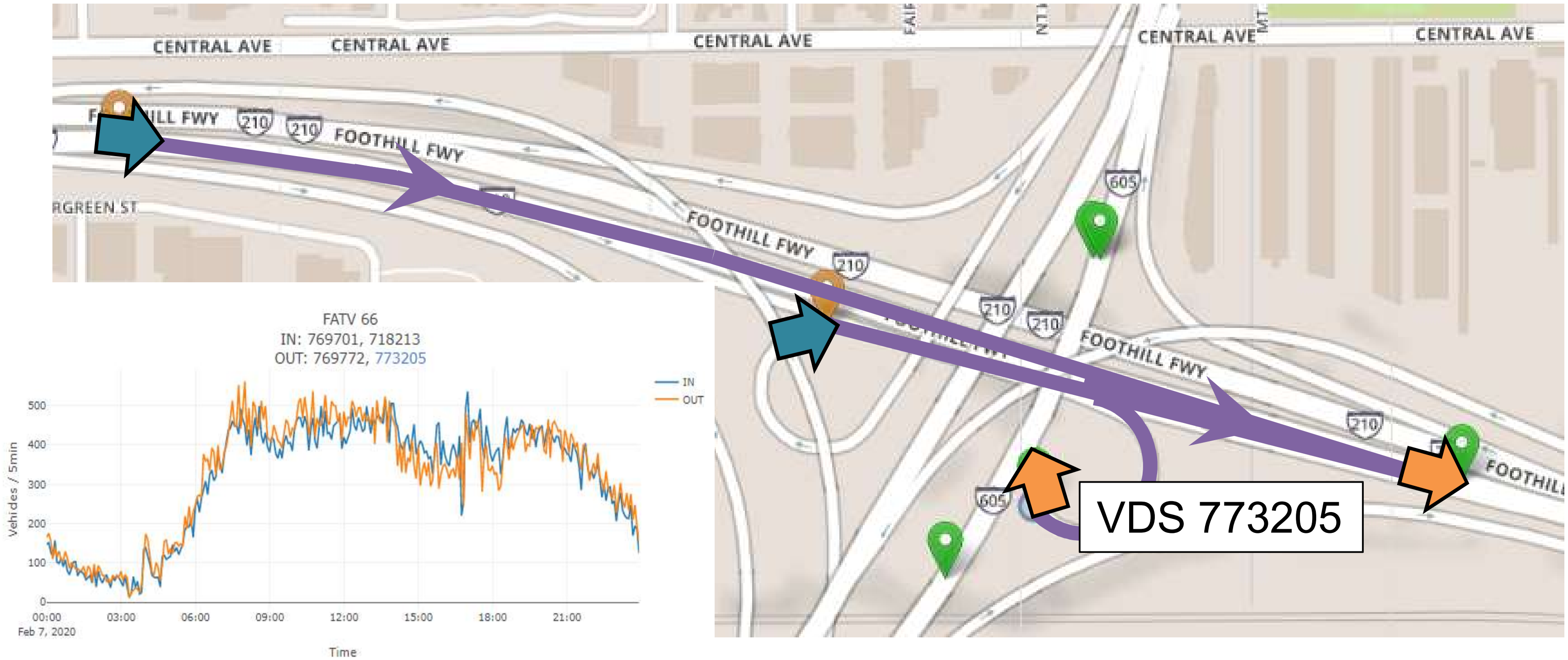
Fully Accounted Traffic Volume (FATV)

- FATV with VDS 773205 as an input flow sensor



Fully Accounted Traffic Volume (FATV)

- **FATV with VDS 773205 as an output flow sensor**



Advantages of FATV approach

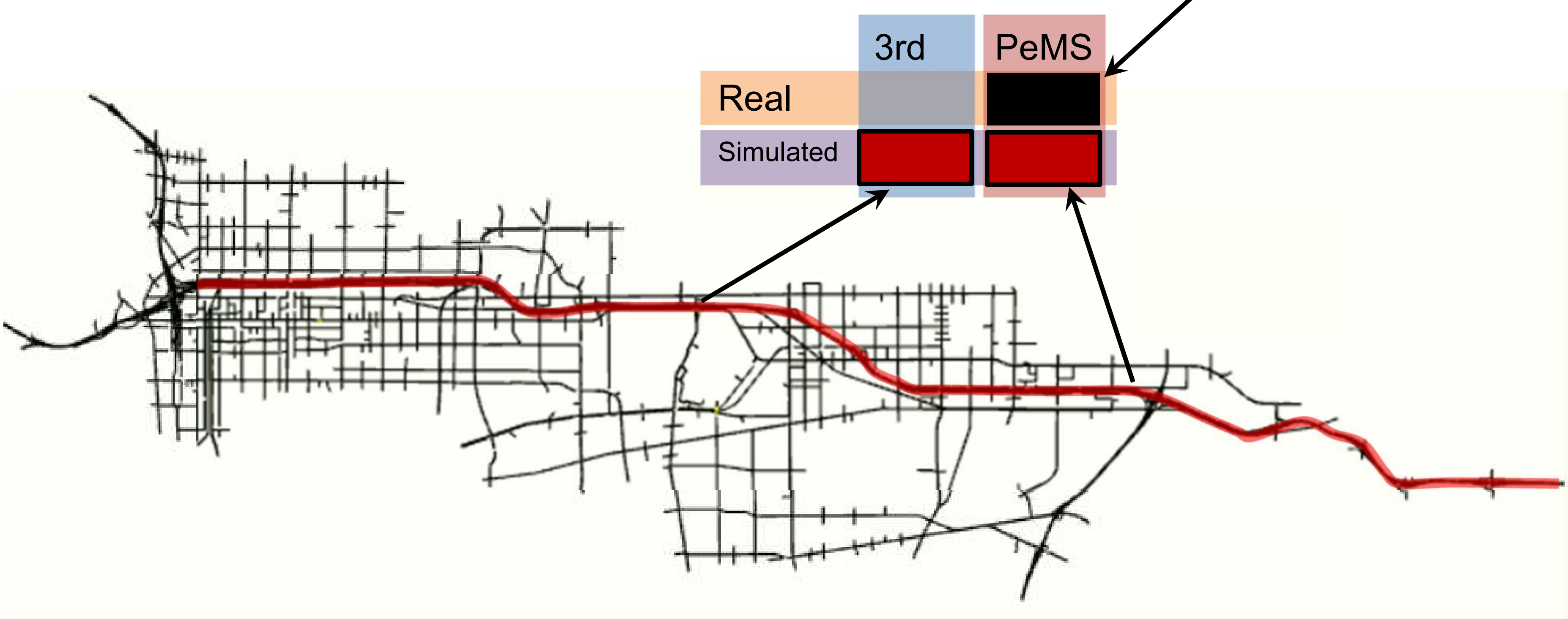
- **FATVs would help clarify locations of VDS**
  - Everywhere along a freeway
  - Especially useful at major junctions
- **Over the course of one day, input flow should roughly equal output flow**
  - Enables automated checking of configuration
  - Enables automated checking of data integrity
- **FATVs would improve ability to fill in missing data**
- **Partially accounted traffic volumes (PATVs) are also useful to know what kind of data to expect**

Evaluation of Methods

Microsimulation

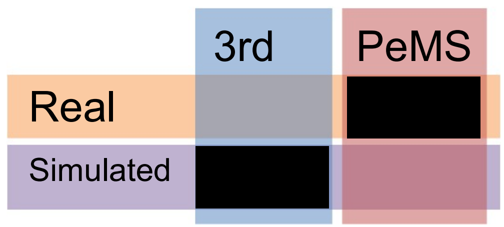
Study Corridor: 16 miles of I-210 WB

Data taken from outside the geographic boundaries of the model

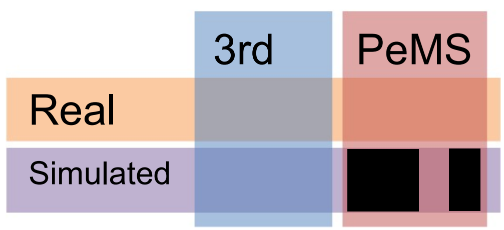


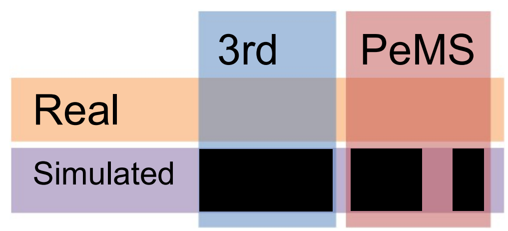
Simulated Scenarios

- **Selection of four time periods**
  - Before AM Peak
  - AM Peak
  - Noon
  - PM Peak
- **Approximate flow: no instrumentation within model geography**



- **Reduced instrumentation, removing VDS pairs**

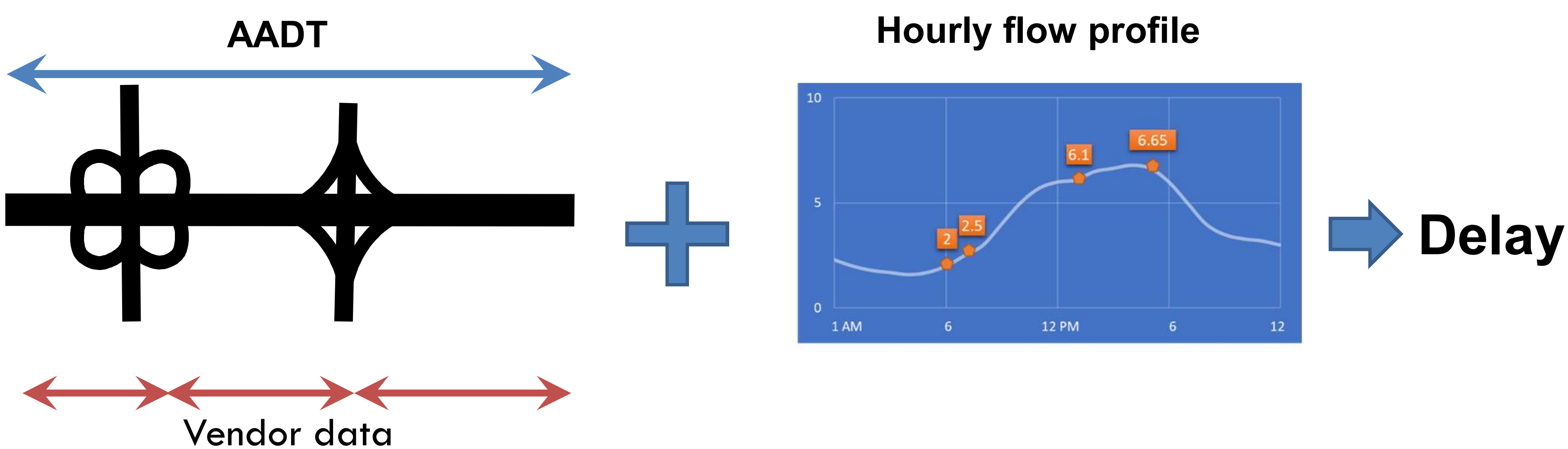




Approximate flow

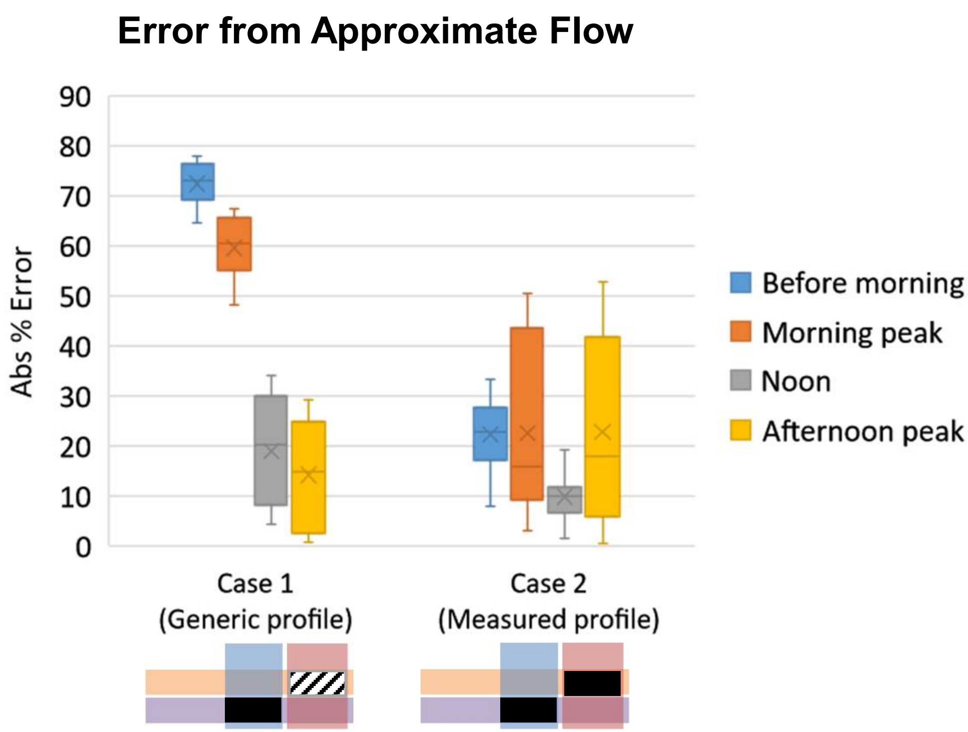
	3rd	PeMS
Real		
Simulated		

- **Available information**
  - Travel times from third party data
  - Annual Ave Daily Traffic (AADT)
- **Convert AADT to hourly flow:**
  - Case 1: Generic flow profile
  - Case 2: Measured flow profile from nearby sensors



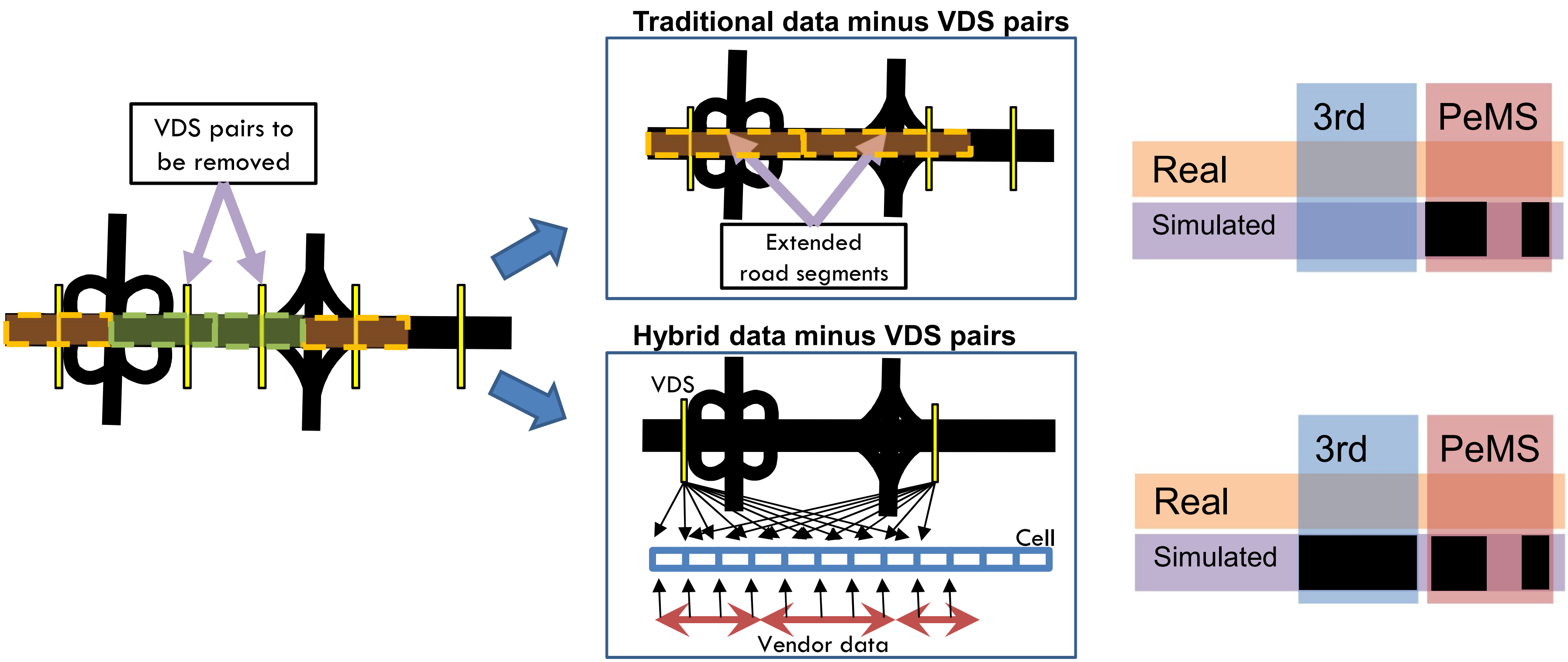
Delay Estimation Error Distribution

- Error distribution of segmented by time of day



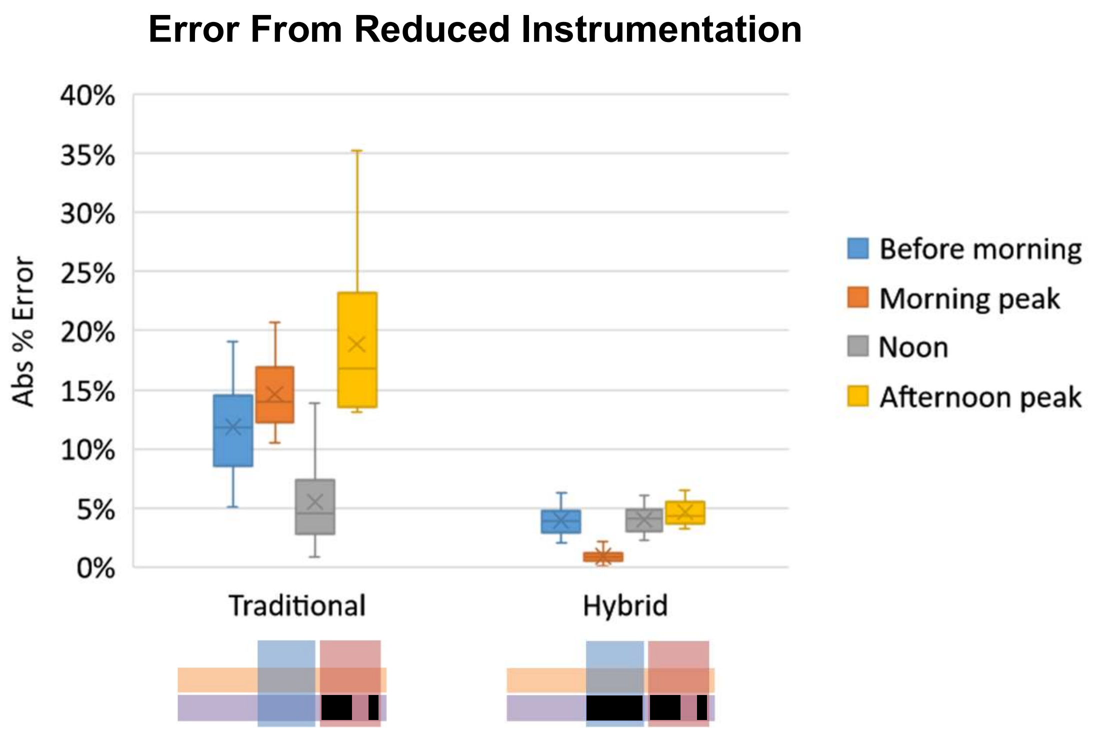
Reduced Instrumentation (Sensor Removal)

- Systematically remove sensors along corridor
- Repeat for all pairs of VDS



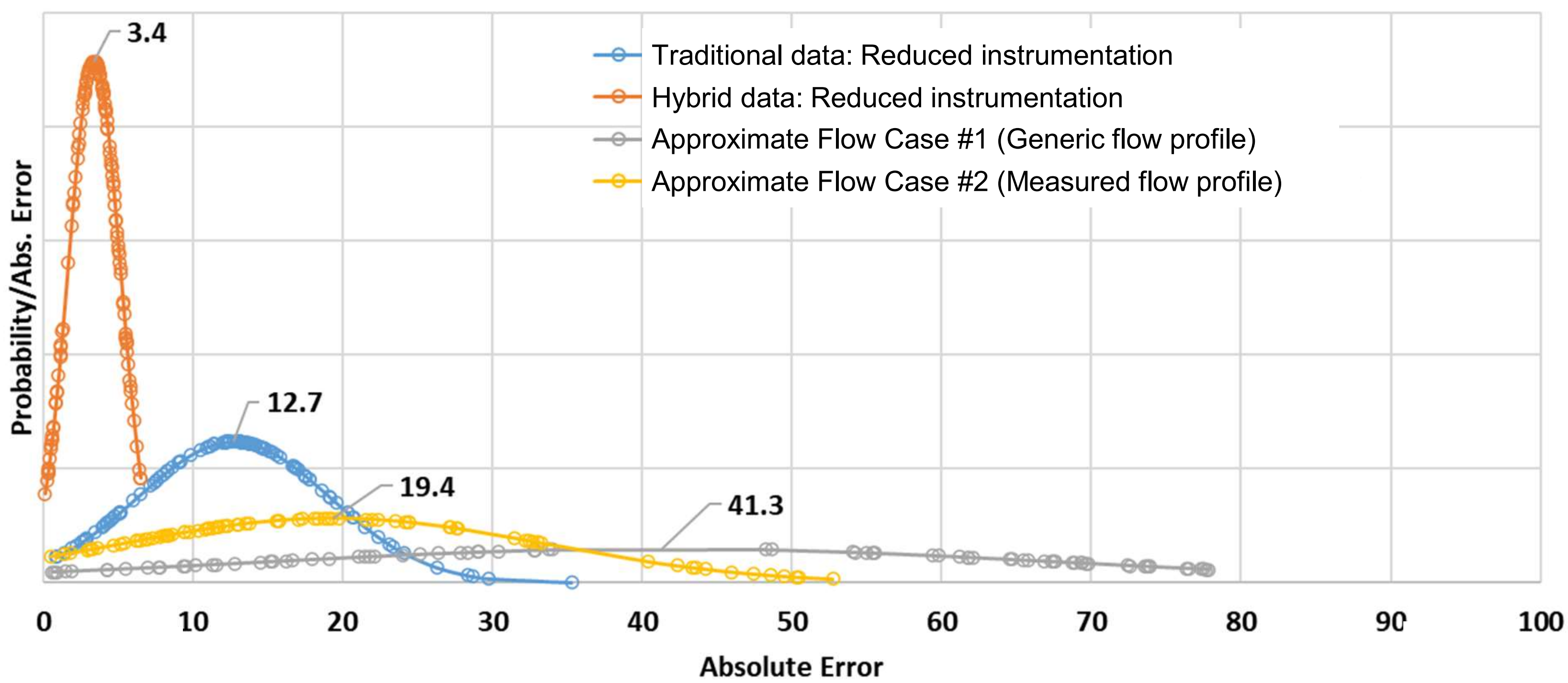
Delay Estimation Error Distribution

- Error distribution segmented by time of day



Error Distribution

- Error distribution of all evaluation scenarios



Summary Results

- **The ability to leverage third-party data to calculate delay depends on the <u>quality</u> of the point-detector data, not the quantity**
- **Point-detectors are needed where lane specific information is required, such as HOV lanes**
- **Must overcome challenges related to legacy PeMS meta information (configuration information)**
- **This evaluation pertains strictly to the measurement of delay**
  - Third-party data can compensate for loss of point-based sensors
  - Third-party data can be used to **<u>roughly</u>** estimate delay with limited instrumentation

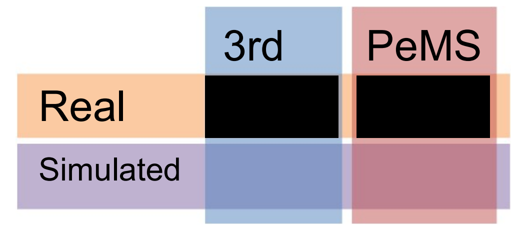
Recommendations for Delay Calculations

Calculation Methods	Mainline	HOV
Traditional data and calculation		3rd party data not widely available
Hybrid calculation	Obtained best performance	Potential for the future

- **Adjustments for limited instrumentation**
  - Applicable where data is limited
  - Appropriate where high fidelity is not required

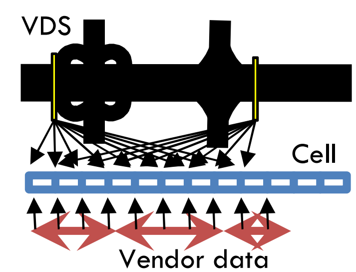
Goals and Next Steps

Implementation Roadmap



- **Step 1: Limited pilot**
  - Select well-studied freeways with excellent data
  - Use the pilot period to
    - Determine accuracy with real-world data, not simulation
    - Compare data quality of alternative 3rd parties

- **Step 2: Full-scale pilot in selected district**
  - Assess cost and difficulty of data integration over a limited geographical region
  - Assess value of hybrid, integrated traffic information
    - Delay and other performance measures
    - Situational awareness for TMC operators
    - Traffic management applications



Next steps

- **The future of point-detector data should focus on <u>quality</u> over quantity**
- **Key research related tasks that could inform pilot**
  - Create an initial set of freeways with high quality and reliable data.
  - Pre-select sites for an initial pilot
  - Perform an initial FATV assessment
  - Obtain precise location information at freeway-freeway connectors
  - Redundancy analysis to prioritize existing sensors

Questions?

Contact DRISI to discuss any research needs

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