Arterial Performance Measures, Data Sources and Application

September 12, 2016

ITS Carolinas Annual Meeting

Work Shop Order

Collecting Arterial Performance Data

- Outsourced Probe Data
- Re-identification Data
- High Resolution Controller Data

Arterial Performance Measures

- Quality of Flow – signal coordination
- Capacity utilization – cycle/phase failures
- Travel time and travel time reliability

Outsourced Probe Data Recommendations

(Jan 2015)

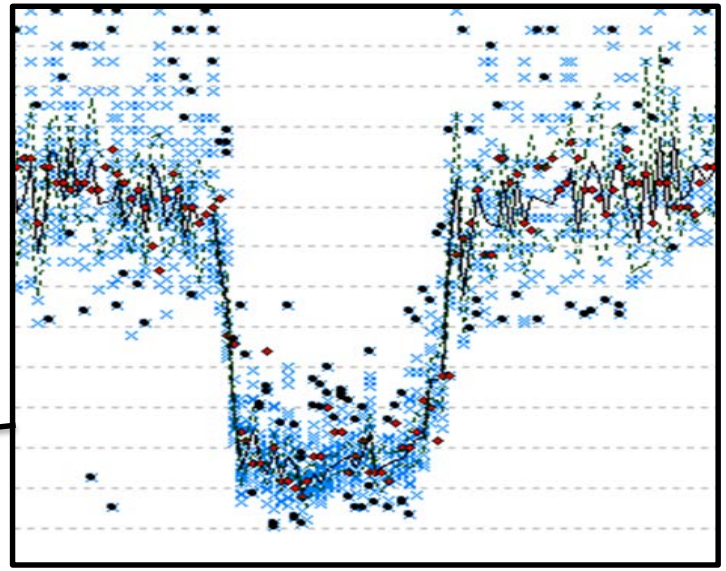
✓ RECOMMENDED	SHOULD BE TESTED	✖ NOT RECOMMENDED
● <= 1 signal per mile	● 1 to 2 signals per mile	● >= 2 signals per mile
● AADT > 40,000 vpd (2-way)	● AADT 20K to 40K vpd (2-way)	● AADT < 20K (2-way) - low volume
● Limited curb cuts	● Moderate number of curb cuts	● Substantial number of curb cuts
Principal Arterials	Minor Arterials	Major Collectors
Likely to be accurate…	Possibly accurate, test …	Unlikely to be accurate…

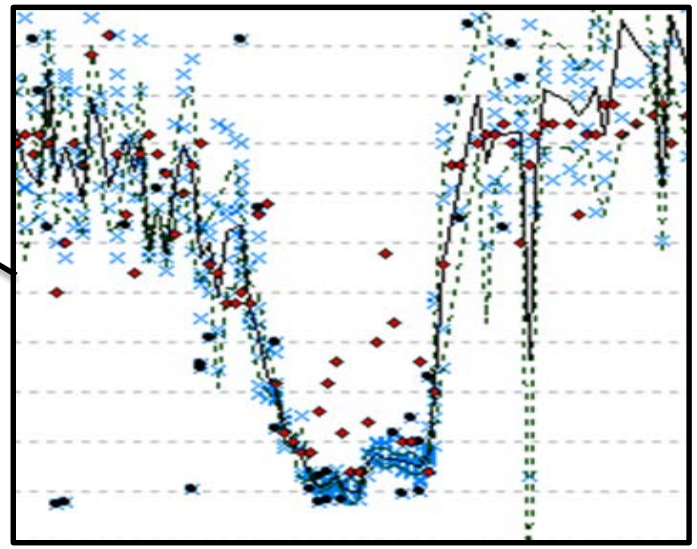
- **Data quality most correlated to signal density**
- **Consistently over-reports speed during congestion**
  - As probe data improves, delay will increase
- Other issues / challenges:
  - Challenged by queuing, multi-cycle failures
  - Follows faster mode in bi-modal traffic
  - Insensitive to signal timing changes
- Improvement anticipated …

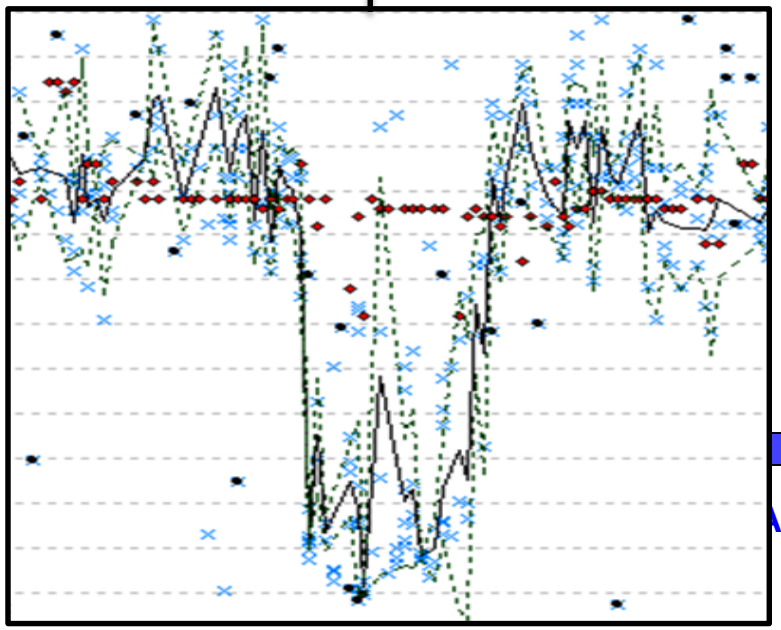
Full Report posted to the
I-95 Corridor Coalition Website

Slowdown Analysis

- Slowdowns identified
  - Major : >15 mph in speed, > 1 hour
  - Minor : > 10 mph in speed, > 30 minutes
- For each slowdown rate as:
  - Fully Captured
  - Partially Captured
  - Failed to Capture

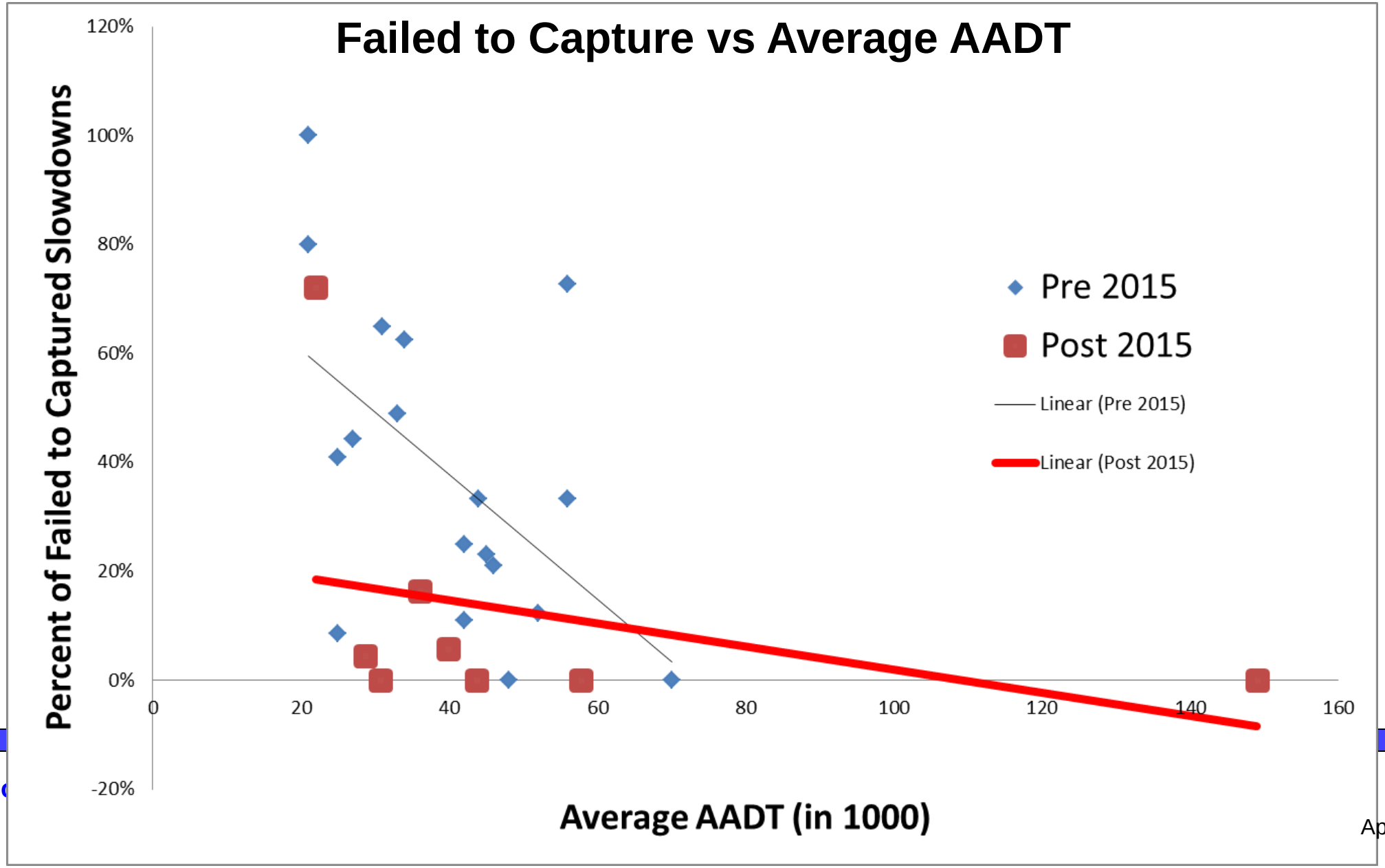




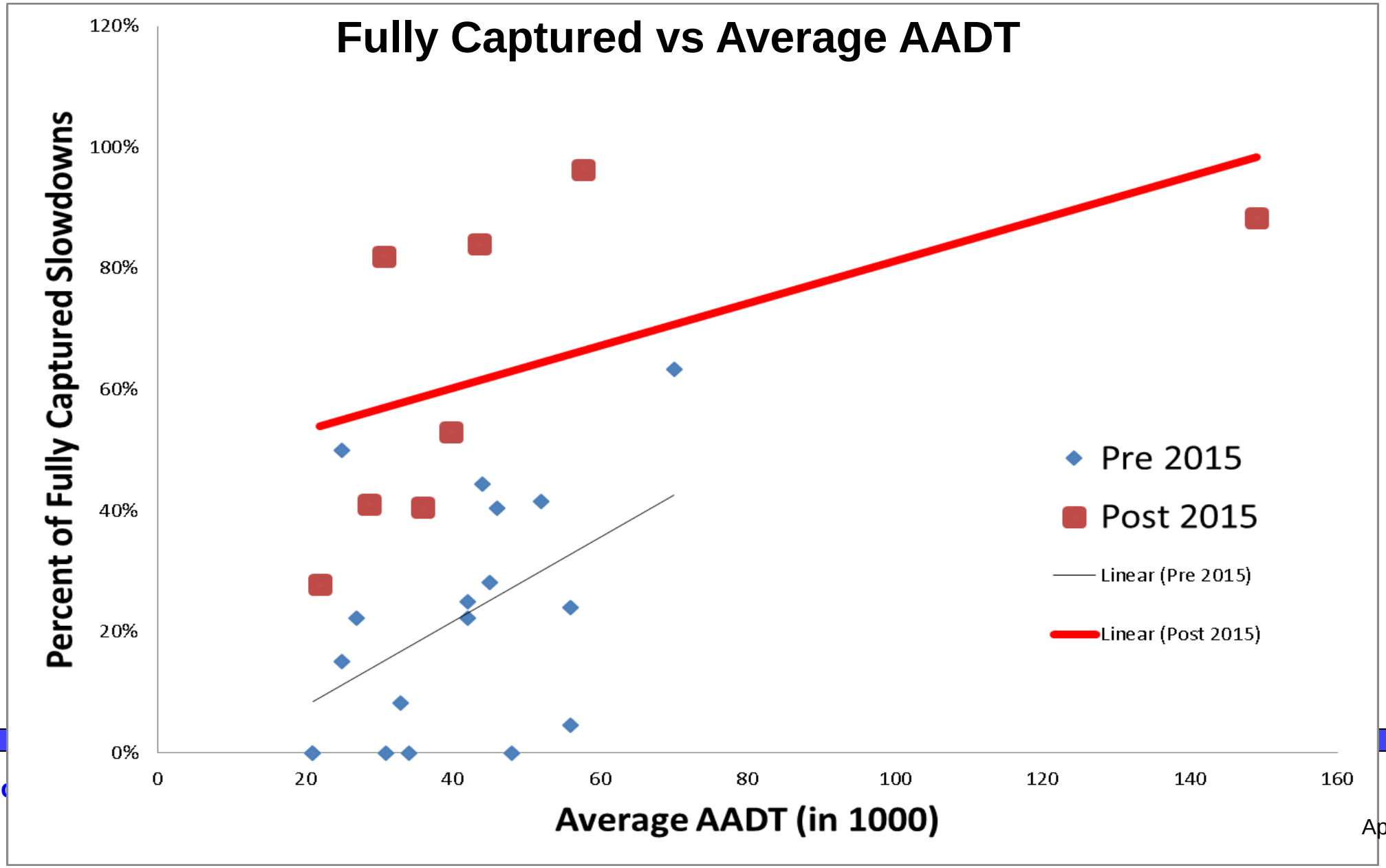


	Total	Fully	Partially	Failed
Major	45	11	25	9
Minor	33	11	13	9

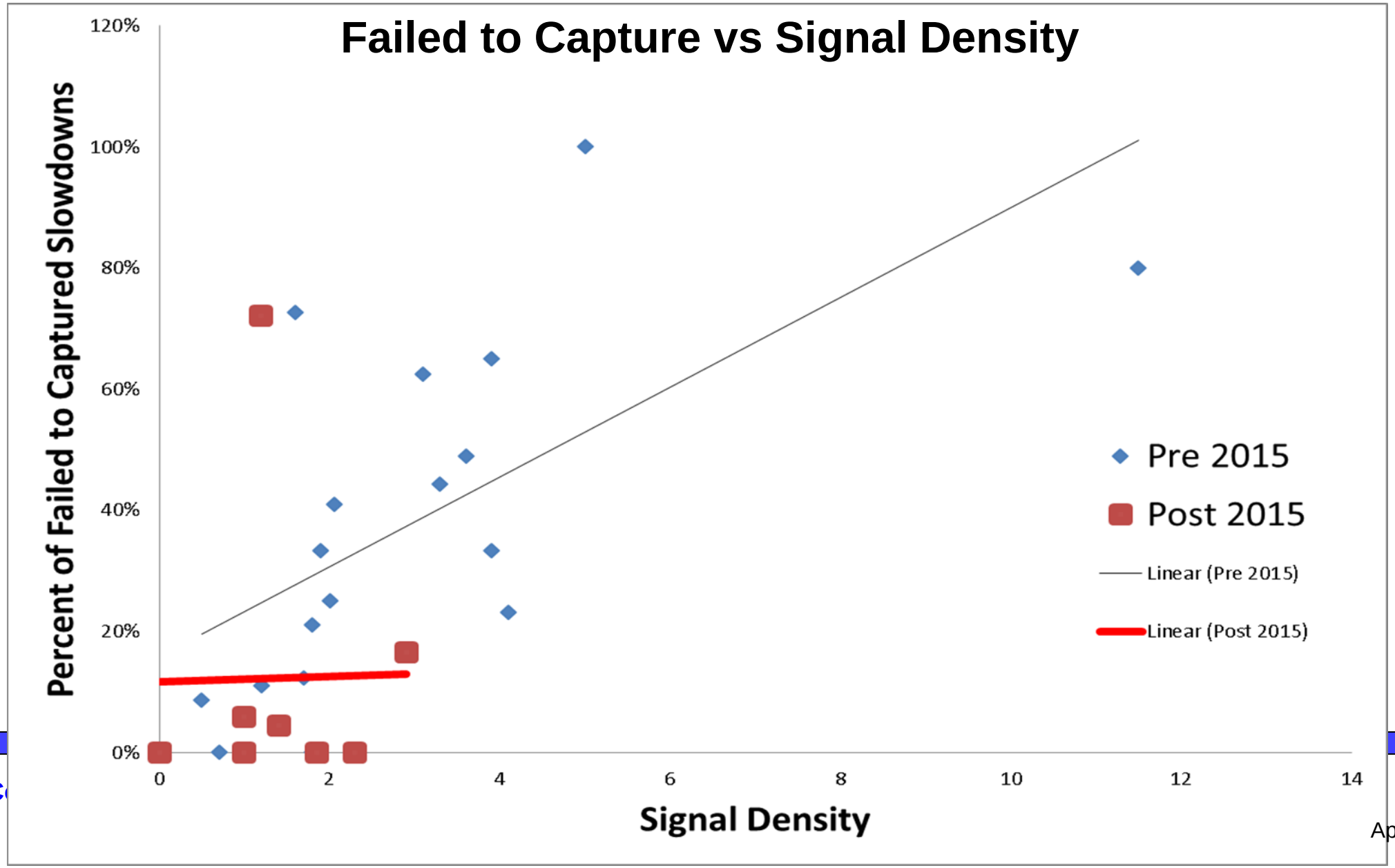
Results since 2015 (1/4)



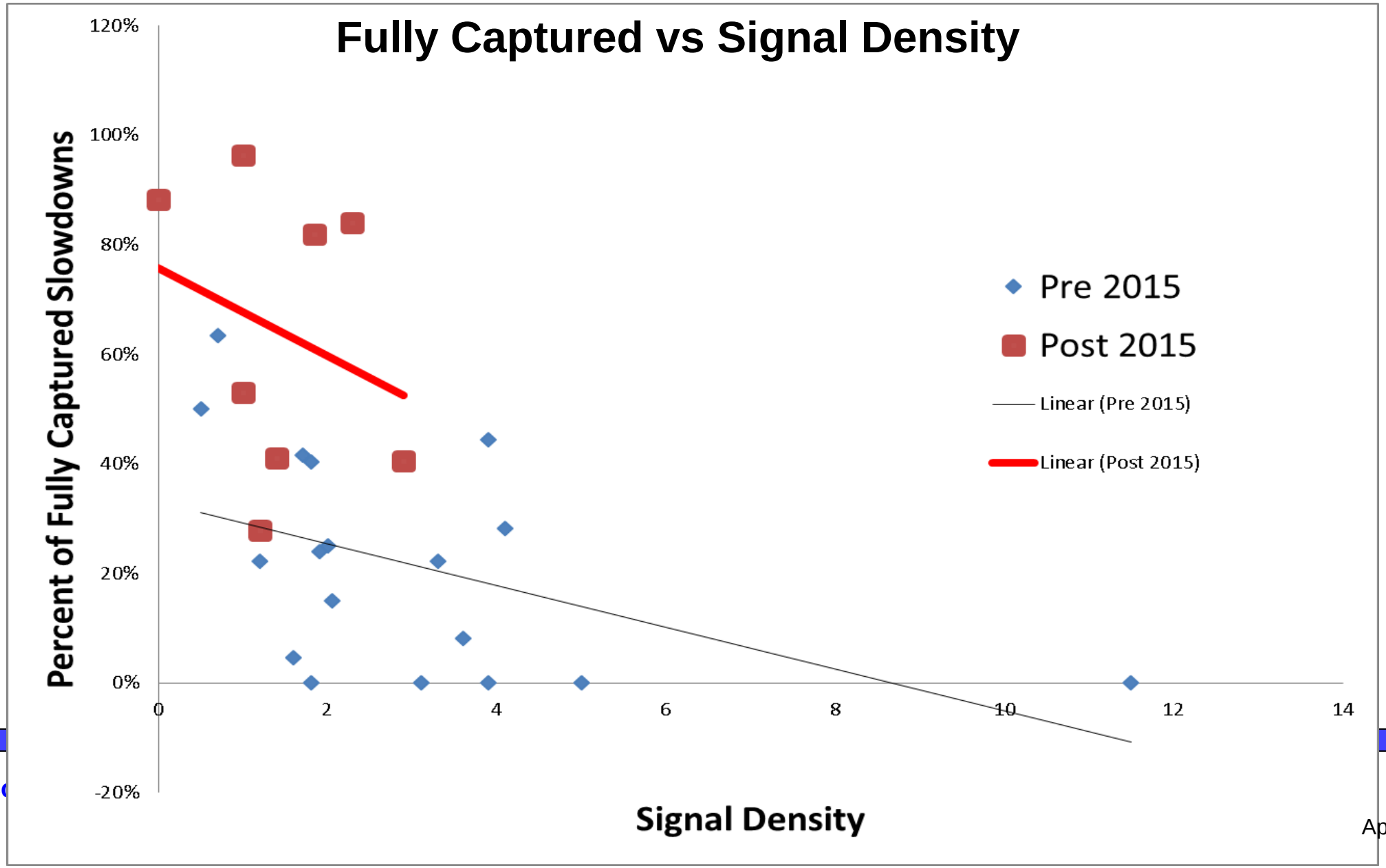
Results since 2015 (3/4)



Results since 2015 (2/4)



Results since 2015 (4/4)



Vehicle Probe Arterial Data Quality

- Statistically significant movement since 2015
- Anticipate updated report later in 2016
  - Contacts Masoud Hamedi and Elham Sharifi
- ‘Slowdown Analysis’ to become part of standard VPP reporting

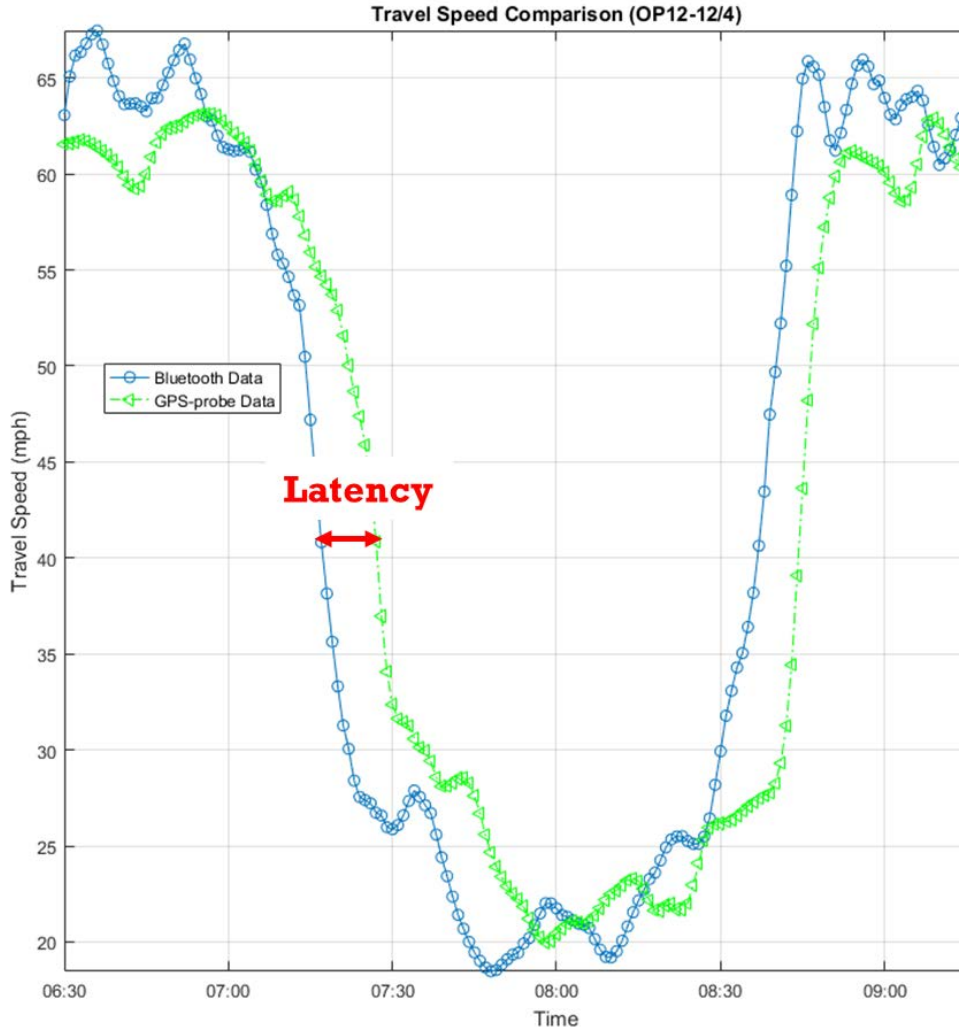
VPPII Data Validation

- Three data vendors, HERE, INRIX and TomTom
- Data Collection:
  - Validation balanced, but emphasized arterials
  - Approximately monthly
  - Moving toward Bluetooth + WiFi
- Individual validation reports are produced for each state & each vendor
- Assessing additional quality metrics

SEQUAL 2016

VPPII Data Validation

- Additional performance measures are monitored including:
  - **Data availability:** to check for time lapses in the data
  - **Real-time share:** indicating the proportion of real-time data according to the criteria set by each vendor
  - **Latency:** the time offset between the time that a change in traffic pattern occurs, and the time that it is reported by probe data.
    - The current latency measurement method is only applicable to freeways

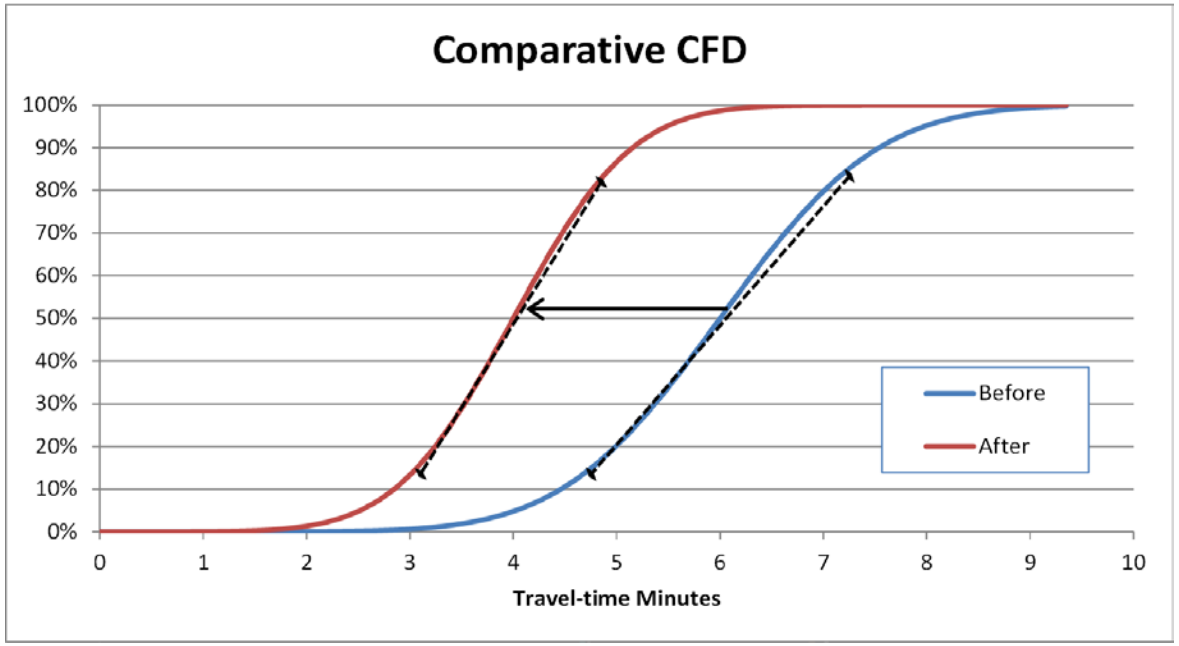


Other VPP and Probe Initiatives

- **Real-time Volume and Turning Movement from Probe Data**
  - UMD CATT / NREL / INRIX / HERE / TomTom
  - Calibration Network from I95 Coalition members count stations
  - Serves as ‘Base Stations’ to estimate network wide volumes
- **TMC White Paper –** 2016, webinar May 11

Outsourced Probe Data & APM Framework

- **Proposed Top Level Arterial Performance Measures**



Roadmap for Arterial Management Systems

- Arterials perform fundamentally different than Freeways
- THEN, continuous monitoring/measurement was infeasible
  - Performance had to be modeled or periodically sampled.
- NOW, technology-enabled continuous, ubiquitous performance assessment
  - Vehicle probe, Re-identification, High-Resolution Controller data
- DATA perspective, we are NOW (2016) with arterials, where we were in 2008/9 with freeways
- Significant opportunity – significant challenge
  - Common language, lexicon, tools, performance measures
  - Bridge culture divide between traffic, planning and operations
  - Legacy thinking and approaches

Technologies Enabling Arterial Management Systems

Re-identification

- Direct samples vehicle travel time (5% - 20% BT & WiFi)
- Works best at corridor level
- Independent of Signal System
- Provides top-level user experience information

High-Res Signal Data

- Logs ***all*** actuation and phasing information
- Works at intersection level
- Integrated with Signal System
- Provides detailed intersection analysis and data for optimizing signal system

Both enabled by consumer wireless communication and big data processing.
Available Now – Multiple Vendors - Cost Effective

Not one or the other… but both!

Emerging Arterial Performance Measures

- **Travel Time & Travel Time Reliability – based on sampled travel time sources**
  - Enabled by re-identification data
  - Fundamentally linked to statistical distribution of travel time
- **Quality of progression - Percent Arrivals on Green**
  - Supported by Purdue Coordination Diagram tools
- **Split Failures (frequency of occurrences)**
  - Reflects capacity constraints
  - Related to GOR / ROR

Arterial Performance Measures

THEN	NOW
Both fundamentally based on delay	

- TEMPORAL:
  - Sampled yearly – ‘typical day in May’
  - Weekday peak peroid
- DATA: Travel time runs, and counts
  - Manually collected
- Intersection & corridor
- MEASURES:
  - HCMLOS based on Delay
  - User complaints
- Annual Performance Measures

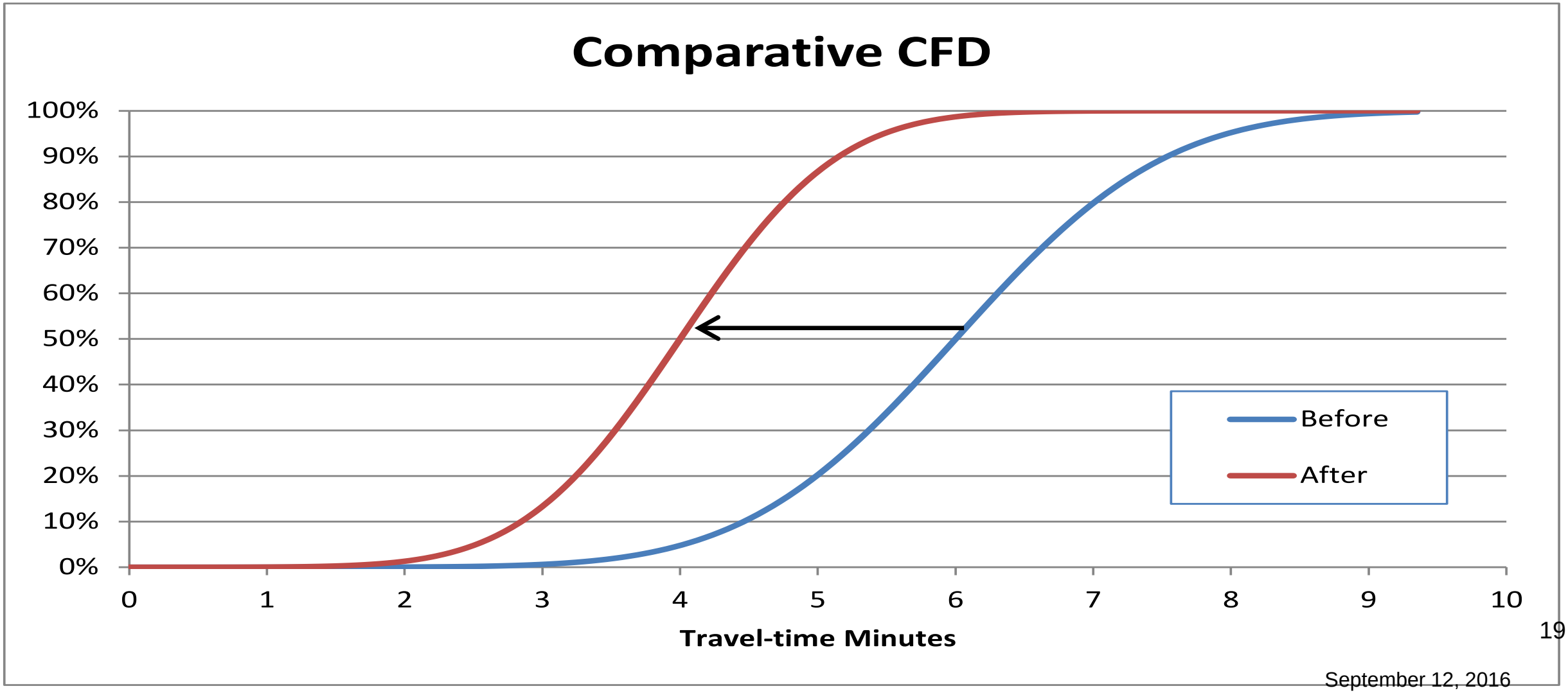
- TEMPORAL
  - Continuous – ubiquitous coverage
  - All Days, every signal cycle
- DATA: Probe, Re-ID, & HRCD
  - Automated
  - Integrated with Signal System
- Intersection, corridor, & network
- MEASURES: Emerging
  - Travel Time & Reliability
  - Corridor Progression Quality
  - Capacity Utilization
- Supports maintenance, operations, and annual performance measures

Moving to Real-time Dynamic Feedback!

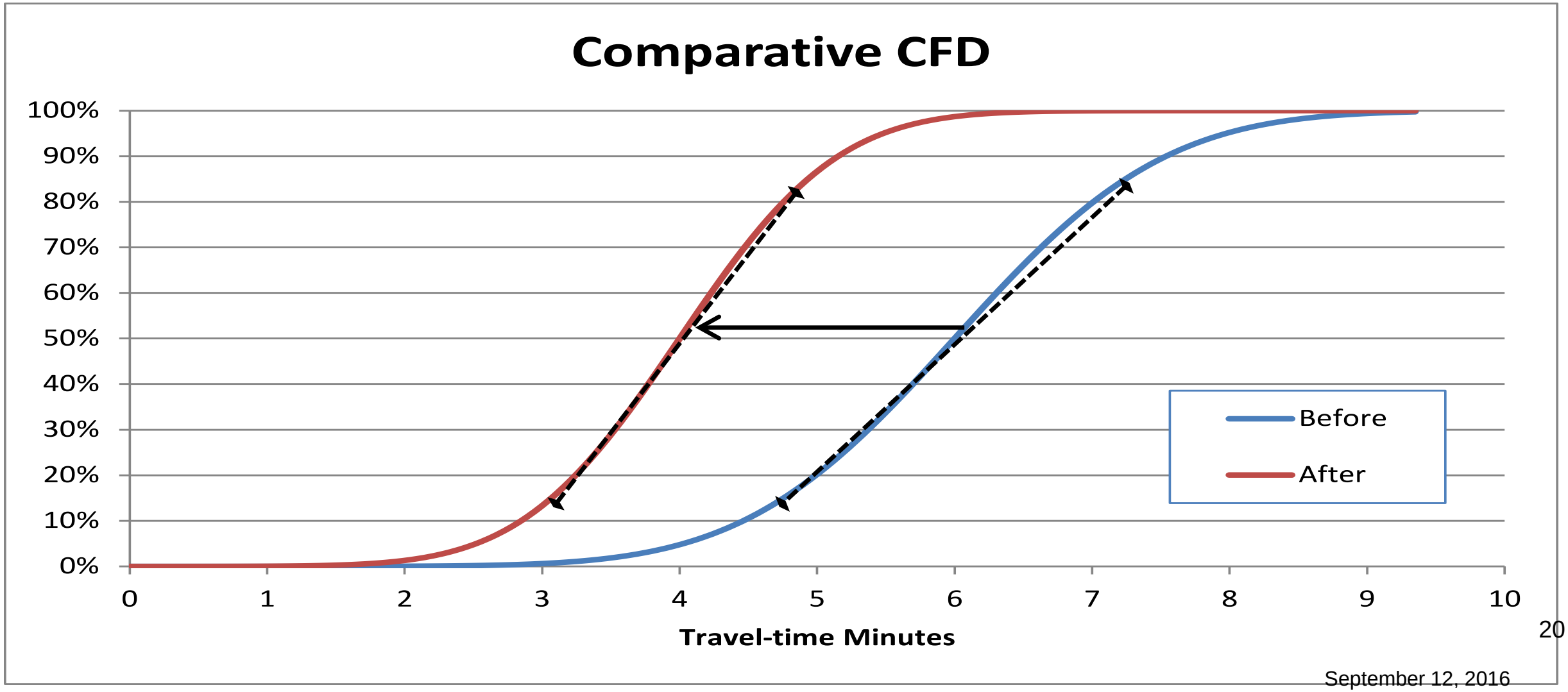
Travel Time and Travel Time Reliability

- Based on directly sampled travel time measurements
- Directly reflects concerns of the traveling public
  - Efficient and predictable travel
- Measures can be applicable to other modes of travel
  - Freeway, transit, air, etc.

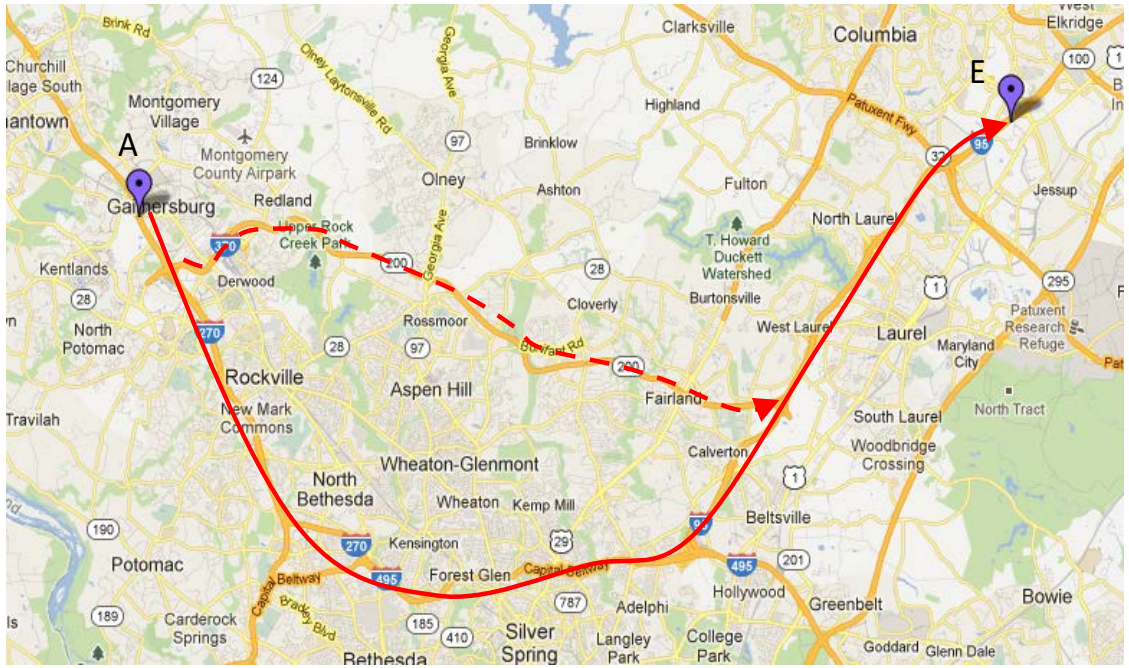
Travel Time

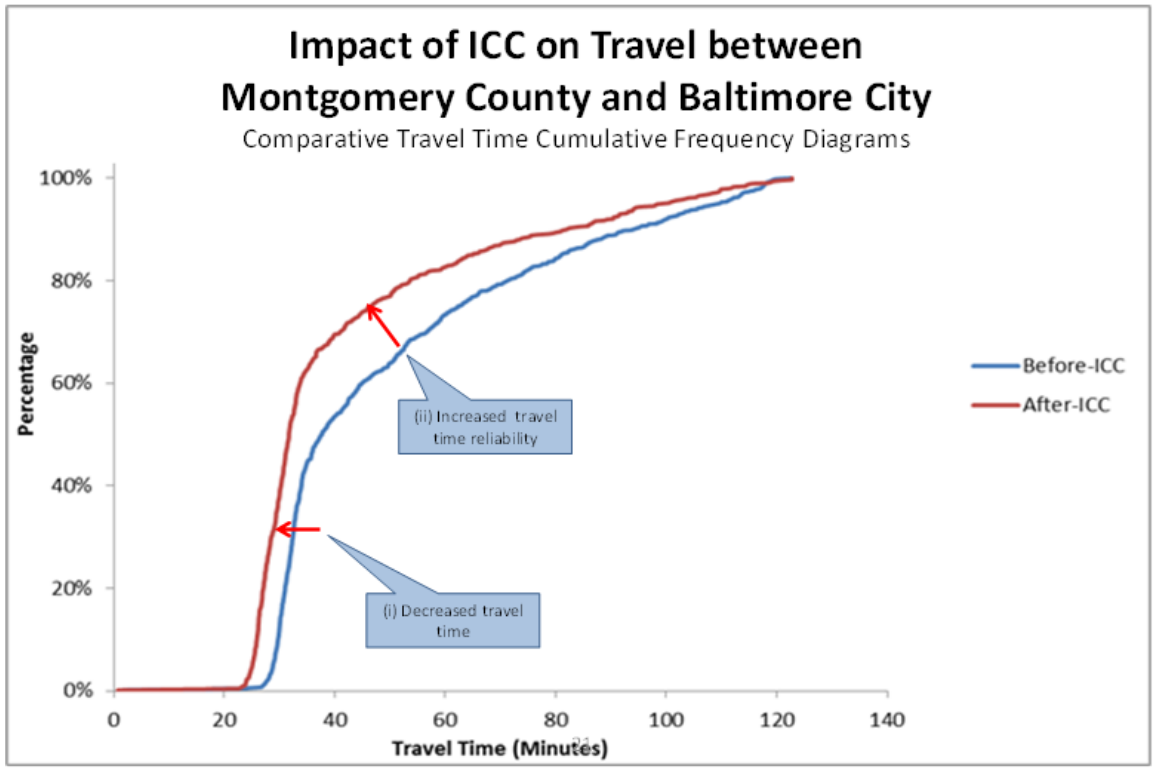

Comparative CFD
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
6
7
8
9
10
Travel-time Minutes
Before
After

Travel Time Reliability

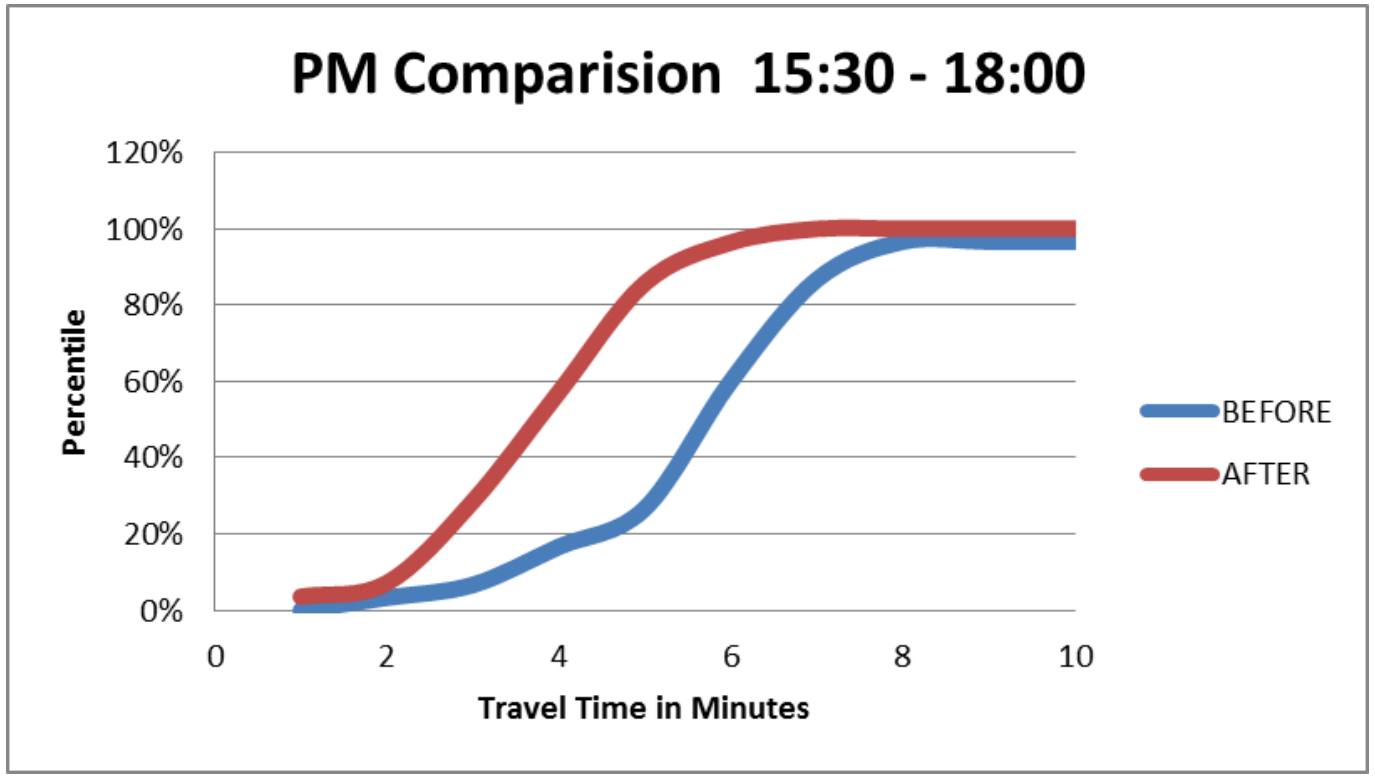


Travel time impact of the Inter-County Connect (ICC)(MD-200) in Maryland



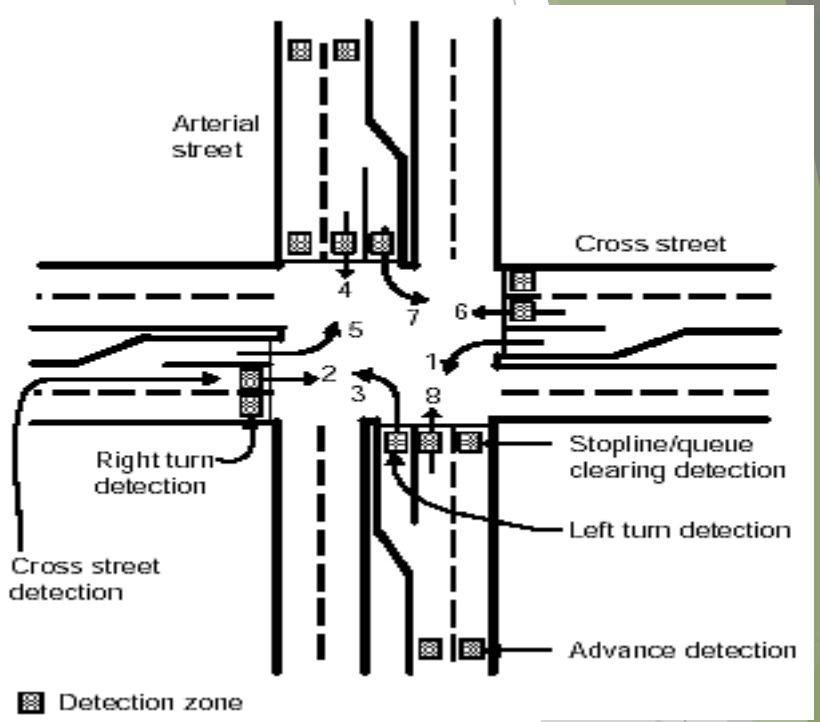


Before / After Maryland Route 24 Signal Timing Plan



High Resolution Signal Data

- Logging of sensor and phase information
- Data forwarded periodically to central server
- Applications
  - Purdue Coordination Diagram
  - Red-Occupancy Ration / Green Occupancy Ratio
  - Volume / Demand Analysis (per movement)
  - Streamlined Maintenance



Picture Source: FHWA

THIS IS CONNECTED INFRASTRUCTURE!!!!!

Percent Arrival on Green (PAG) and Split Failures

- **P**ercent **A**rrivals on **G**reen
  - Measure on how effectively signals are coordinated, moving vehicles **through** the system
  - The higher the PAG, …
    - Less stops, happier customers
    - Higher corridor speed , better fuel economy, less emissions
    - Direct indicator of signal system performance
- Split Failures (i.e. Capacity Constraint)
  - Measures percent of system (time and space) suffering from lack of capacity
  - The ‘need more capacity’ metric, or ‘get off my back’ metric, its ‘time to spread the pain’ metric …
  - Something more than signal optimization required – capacity/demands need to be addressed

Products of SBIR Initiative

- Arterials Performance Measures Framework – Main
- Two Case Studies
- Technical Reports
  - Real-time Measures
  - Graphics Report
  - Network Performance Measures
  - Measuring how arterials are used
- Software Tools
  - Standard data format and reference implementations

Conclusions – Final Thoughts

- Vehicle Probe Data Validation
  - Arterial Data Accuracy is Improving
  - Anticipate updated report in 2016
  - Expand to data availability, real-time perf., latency
- Arterial Performance Measures Framework
  - Travel time and travel time reliability with re-id
  - Quality of progression and capacity analysis with HRCD
  - Next generation of Arterial Performance Management