Monitoring and Assessing Arterial Traffic Performance

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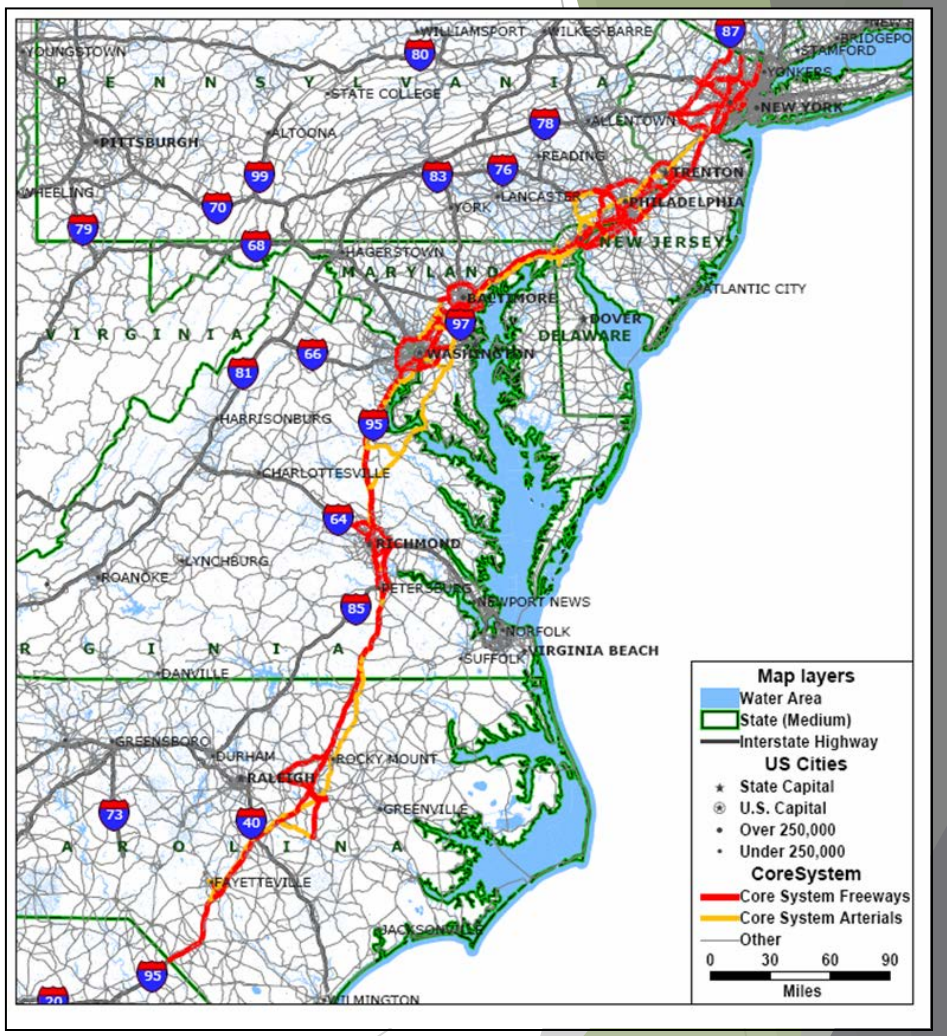
Outline

- Traffic Data Fidelity of Outsource Probe Data
  - Where we have been, where we are now ….
- Completing the Picture … Arterial Performance Measures
  - Bringing in Volume Data – State Wide
  - Extending Real-Time to Arterial Networks
  - Its time for Arterial Management Systems …

I-95 Vehicle Probe Project

- Phase I (2008-2014)
  - First Probe-based Traffic System
  - Specifications-based, validated
  - Licensing - one buys, all share
  - Began 2.5K miles, grew to 40K
  - Travel time on signs, 511 systems, operational awareness, performance measures
- Phase II (2014 forward)
  - All of the above
  - Better quality, less cost
  - Data market place (Multiple-vendors)
  - Emphasis on arterials and latency
  - 42.5K and growing
  - Map-21 Performance Measures



Vehicle Probe Project

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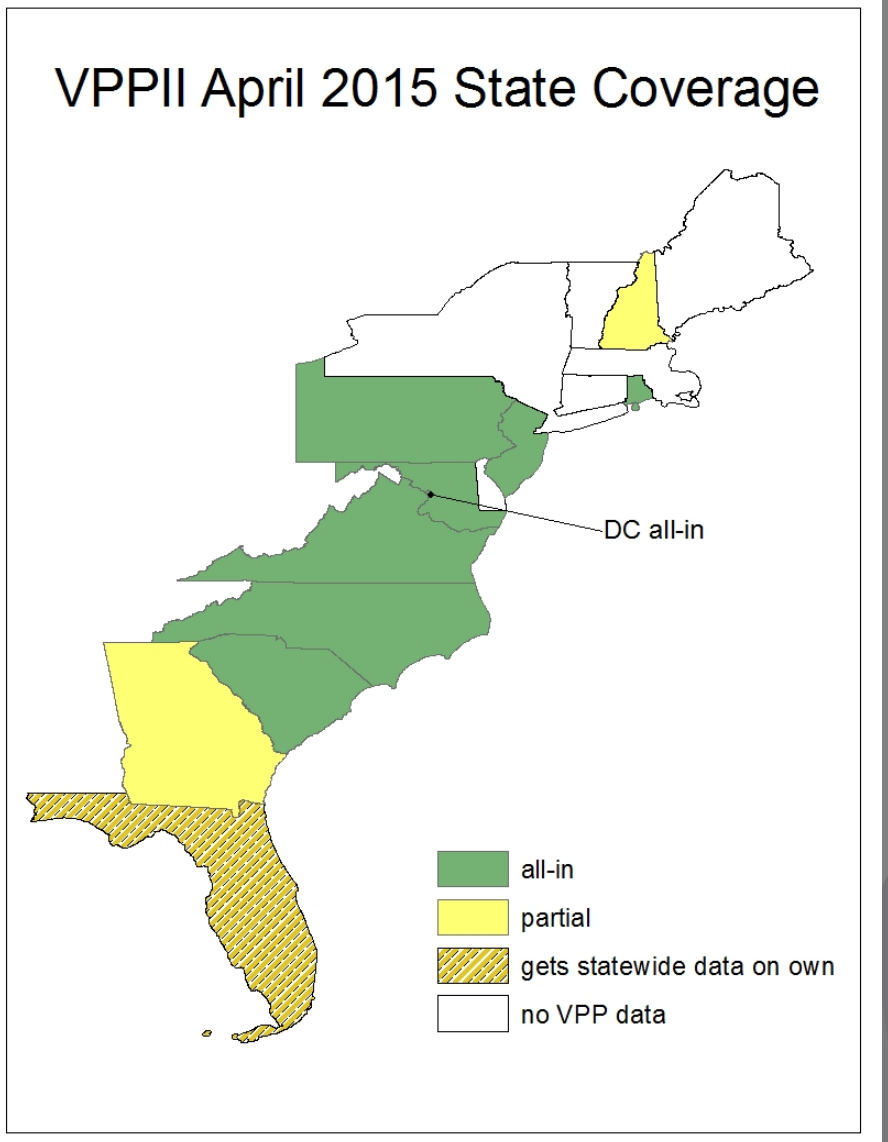
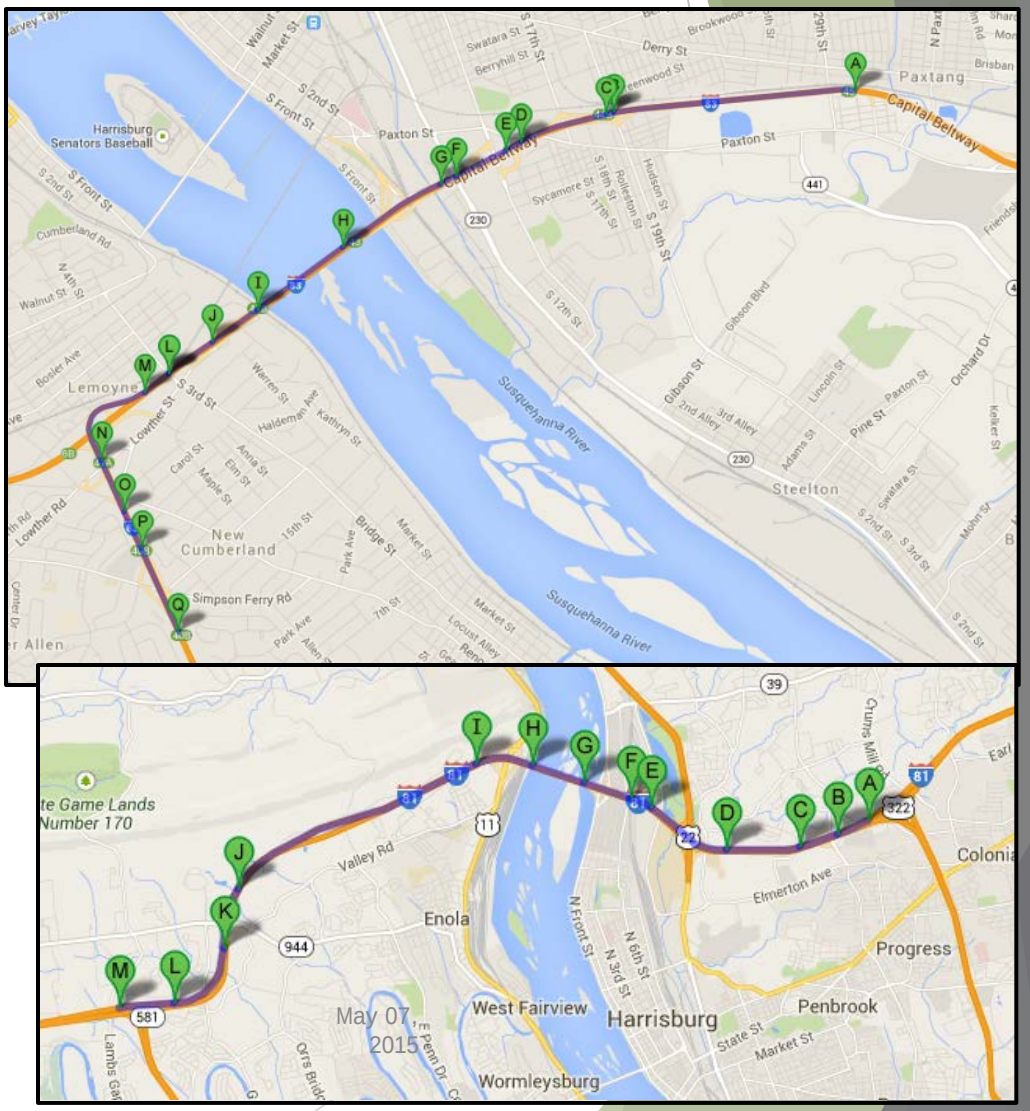
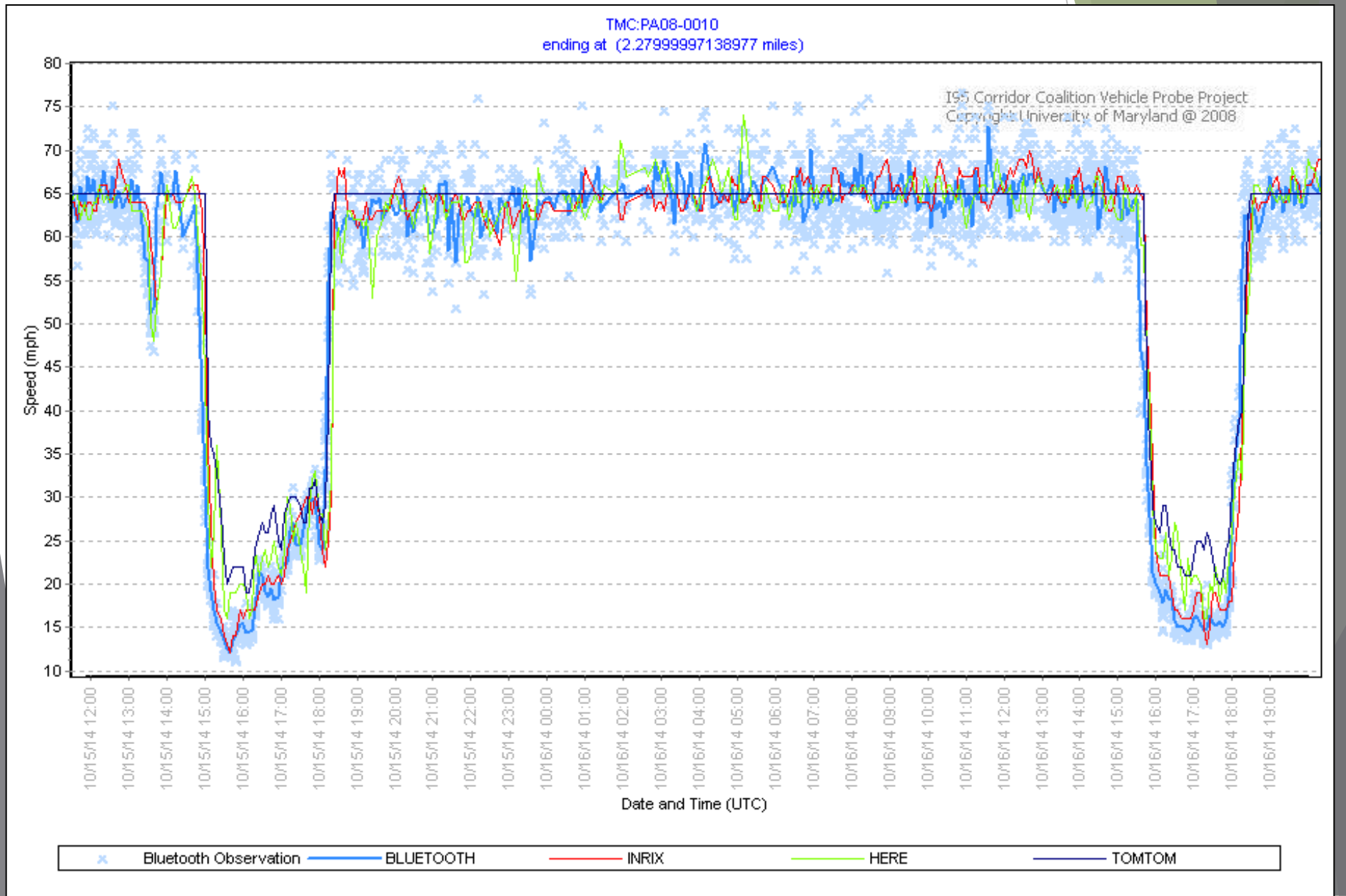


First Multi-Vendor Freeway Validation
I-83 & I-81 Harrisburg, Oct 2014

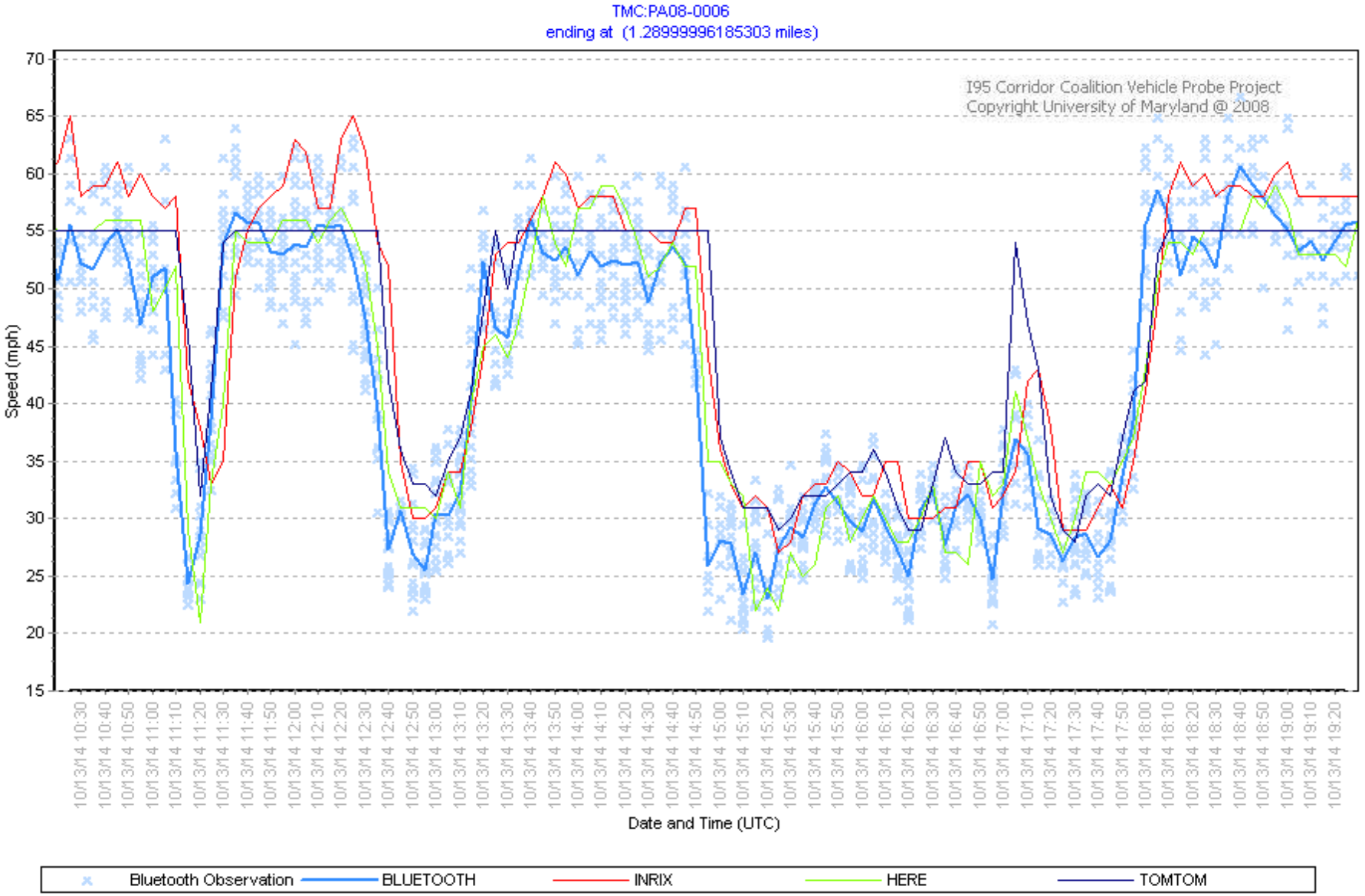
- PA-08
  - 14 Segments
  - 31.3 miles
- Data collection
  - 2300 to 2555 total hrs
  - 71 to 80 hrs [0-30]
  - 53 to 66 hrs [30-45]
- AASE
  - 2.1 to 4.1 mph [0-30]
  - 3.1 to 5.8 mph [30-45]



PM Peak Hour (Oct 15-16, 2014)



Non-recurring Congestion
Oct 13, 2014 10 AM to 7 PM



Arterial Probe Data Quality Study 2013 – mid 2014

State / Set ID	Road Number	Road Name	Validation Date Span	# of Segments	# of Through Lanes	AADT Range (in 1000s)	Length* (mile)	# Signals / Density	# of Access Points	Median Barrier	Speed Limit (mph)
NJ-11	US-1	Trenton Fwy, Brunswick Pike	Sep 10 - 24, 2013	10	2-4	33 - 90	14.2	10 / 0.7	112	Yes	55
	NJ-42	Black Horse Pike		8	2	25-54	12.5	23 / 1.8	260	Yes	45-50
	US-130	Burlington Pike		10	3	42	14.3	28 / 2.0	229	Yes	50
NJ-12	NJ-38	Kaighn Ave.	Nov 5-19, 2013	16	2-4	32-80	24.5	44 / 1.8	235	Yes	50
	NJ-73	Palmyra Bridge Rd.		18	2-4	33-74	23.9	41 / 1.7	236	Yes	45-55
PA-05	US-1	Lincoln Highway	Dec 3 - 14, 2013	28	2 - 3+3	21 - 100	30.62	107 / 3.5	178	Yes	40 - 50
	US-322	Conchester Highway		6	1-2	22 - 34	14.28	7 / 0.5	48	No	35 - 45
PA-06	PA-611	Easton Rd	Jan 9 - 22, 2014	10	2-4	18-31	6.7	21/ 3.13	98	NO	40-45
	PA-611	Old York Rd		8	1-2						
	PA-611	N Broad St		16	2-4						
VA-07	VA-7	Leesburg Pike and Harry Byrd Hwy	April 5-16, 2014	30	2-4						
	US-29	Lee Hwy (S Washington St)		4	2						
VA-08	US-29	Lee Hwy	May 8-19, 2014	26	2-4						
MD-08	MD-140	Reistertown Rd	June 5-14, 2014	12	1 - 3						
		Baltimore Blvd		6	2 - 4						

- 9 Case Studies from 2013-14
- Spans NJ through NC
- Test extent of probe data
  - 15K AADT to 100K
  - 2 – 12 lanes
  - 0.5 to 10+ signals per mile
- Objective: Reference case studies

Arterial Probe Data Recommendations

Likely to have usable probe data	Possibly usable probe data	Likely not usable probe data
• **<= 1 signals per mile** • AADT > 40000 • Fully or Partially captures >75% slowdowns	• **<= 2 signals per mile** • AADT 20K to 40K • May Fail to capture > 25% of slowdowns • Should be tested	• **>=2 signals per mile** • Not recommended

- **2013/14 Data not ready for Prime Time**
- **Probe data quality most correlated to signal density**
- **Consistent positive bias at low speeds**
  - As probe data improves, delay will increase
- Other challenges include:
  - Severe queuing, multi-cycle failures,
  - Optimistic bias in bi-modal traffic
  - Insensitive to signal timing changes

Roadmap for Arterial Management Systems

- Arterial Performance Measures are fundamentally different than Freeway Performance Measures
- Until recently (2014), performance assessment has been too costly for broad based monitoring and performance measures
- New technology developments have enabled first generation large scale performance assessment
  - Include Re-identification data, High-Resolution Controller data
- We are NOW (2015) with arterials, where we were in 2008/9 with freeways

Technologies Enabling Arterial Management Systems

Re-identification

- Direct samples vehicle travel time (5% for BT)
- 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

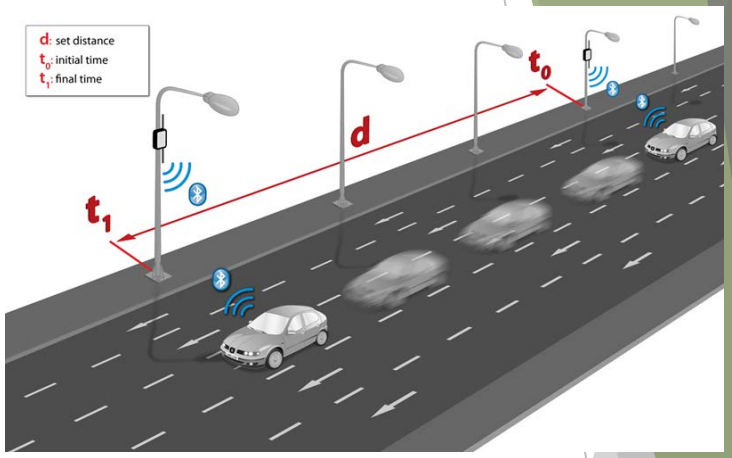
Not one or the other… but both!

Emerging Arterial Performance Measures

- **Travel Time and Travel Time Reliability – based on sampled travel time sources**
  - Enabled by re-identification data, later outsourced probe data and connected vehicle data as it matures
  - Fundamentally linked to the statistical distribution of travel time
- **Percent Arrivals on Green – reflects quality progression**
  - Supported by methods such as Purdue Coordination Diagram tools
- **Split Failures (frequency of occurrences)**
  - Reflects capacity constraints
  - Related to GOR / ROR

Re-Identification Data (Bluetooth)

- Uses a ID unique to a vehicle (MAC ID of a Bluetooth device inside vehicle)
- An initial detector identifies when a vehicle enters a corridor by the vehicle's ID
- Another detector *re-identifies* the vehicle at the end of the corridor
- Travel time/ speed can be directly calculated from the entry and exit time



Car	MAC address	Entry Time hh:mm:ss	Exit Time hh:mm:ss
1	12-34-56-78-9A-BC	13:10:05	13:15:37
2	48-2C-6A-1E-59-3D	13:10:10	13:15:25

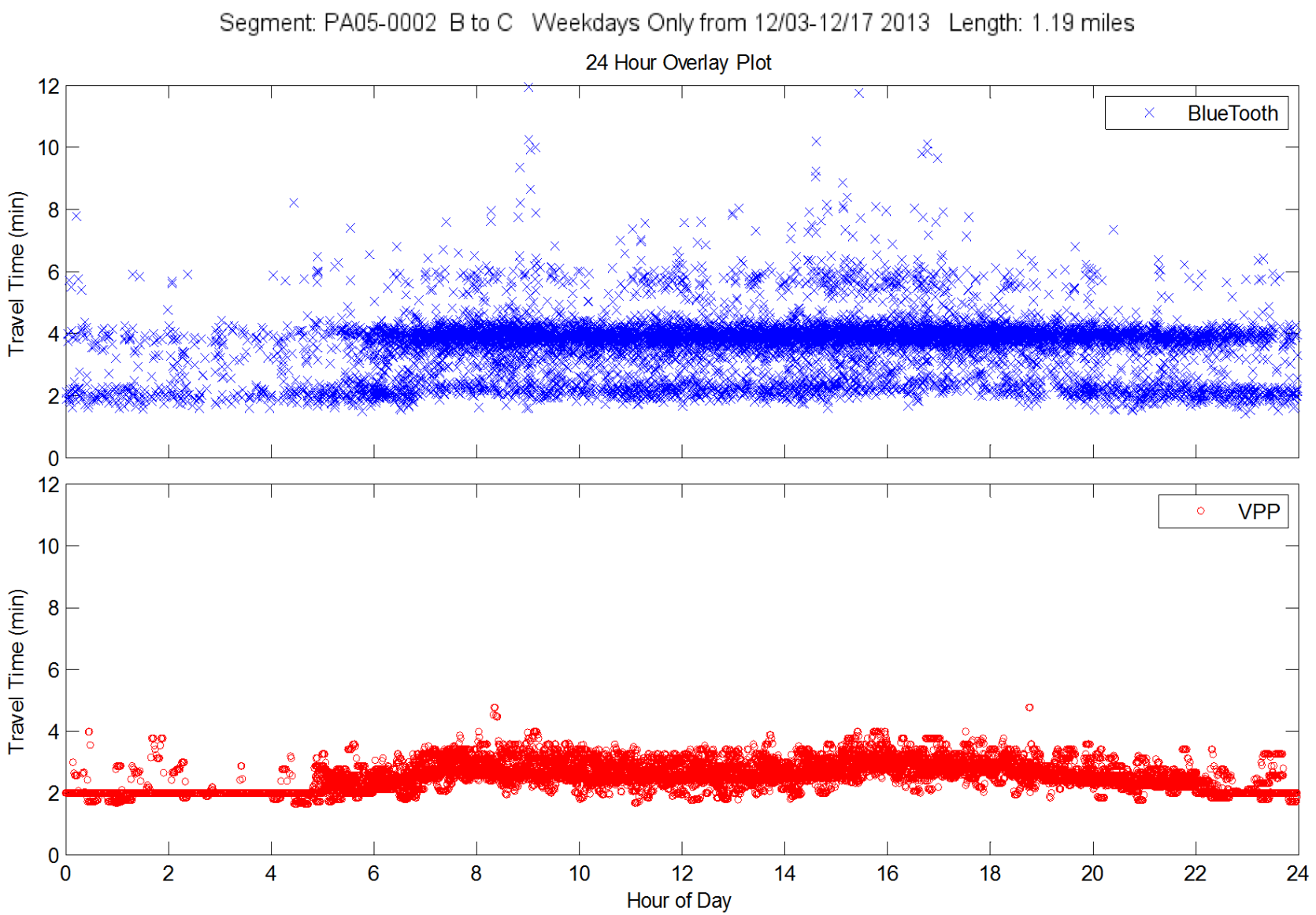
Direct samples of Travel Time

Picture source: libelium.com

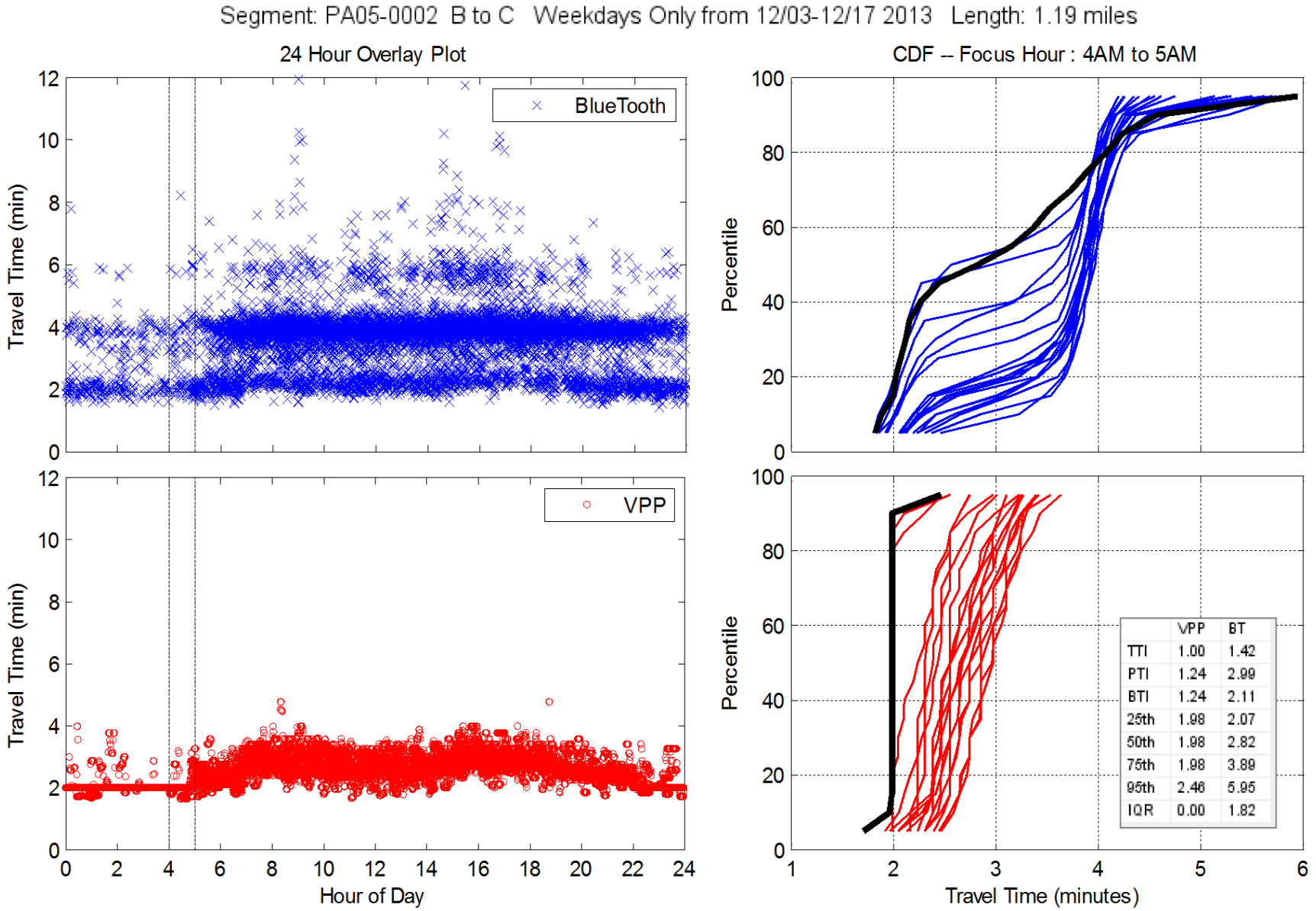
Travel Time and Travel Time Reliability

- Based on directly sampled travel time measurements
- For arterials, can be applied ….
  - Intersection to intersection
  - **Corridor based**
  - Network level, origin to destination
- Directly reflects concerns of the traveling public
  - Efficient and predictable travel
- Measures can be applicable to other modes of travel
  - Freeway, transit, air, etc.

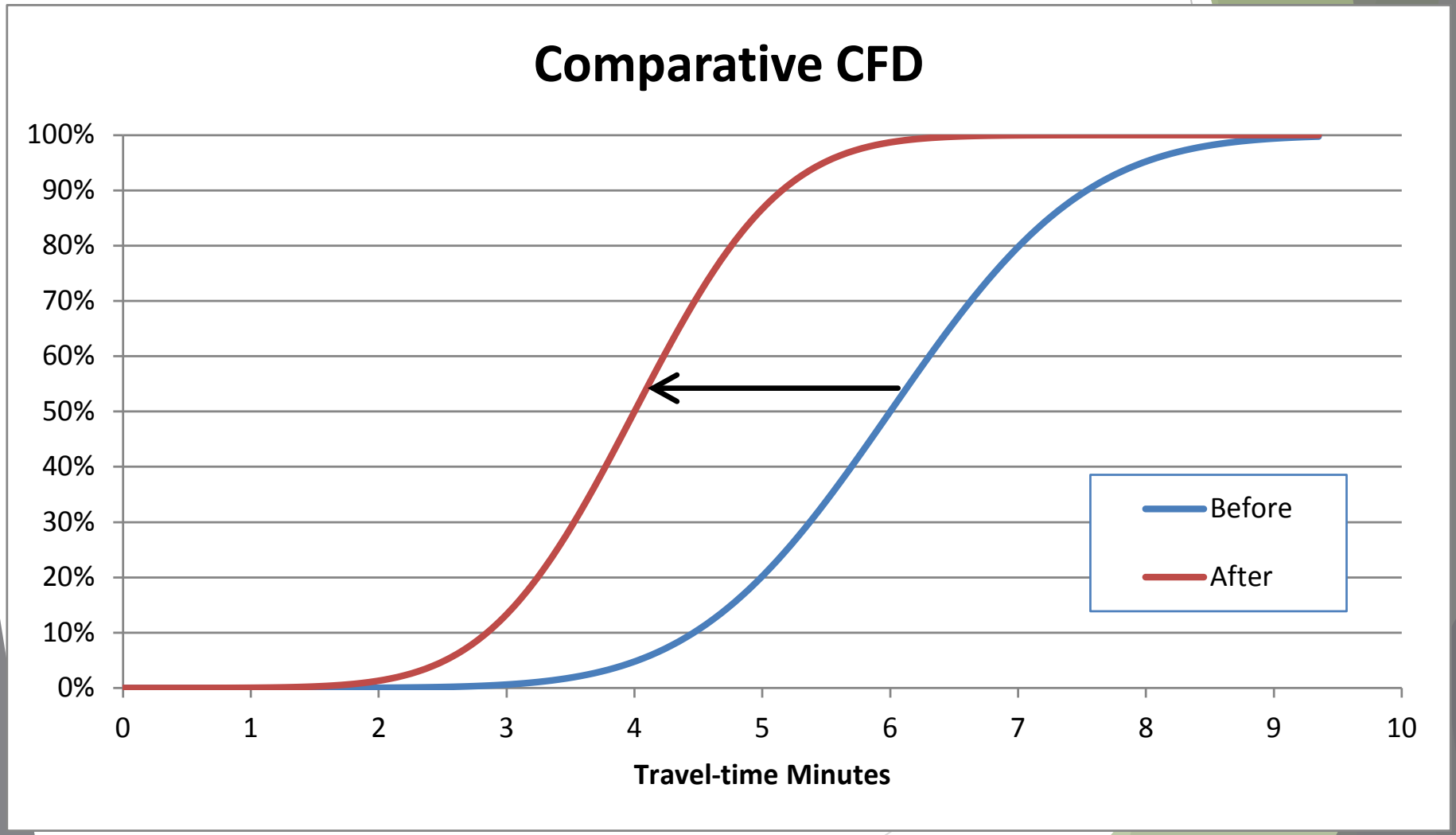
Re-id Travel Time Data Fidelity



CFD Statistical Performance Measures



CFDs to Contrast Performance



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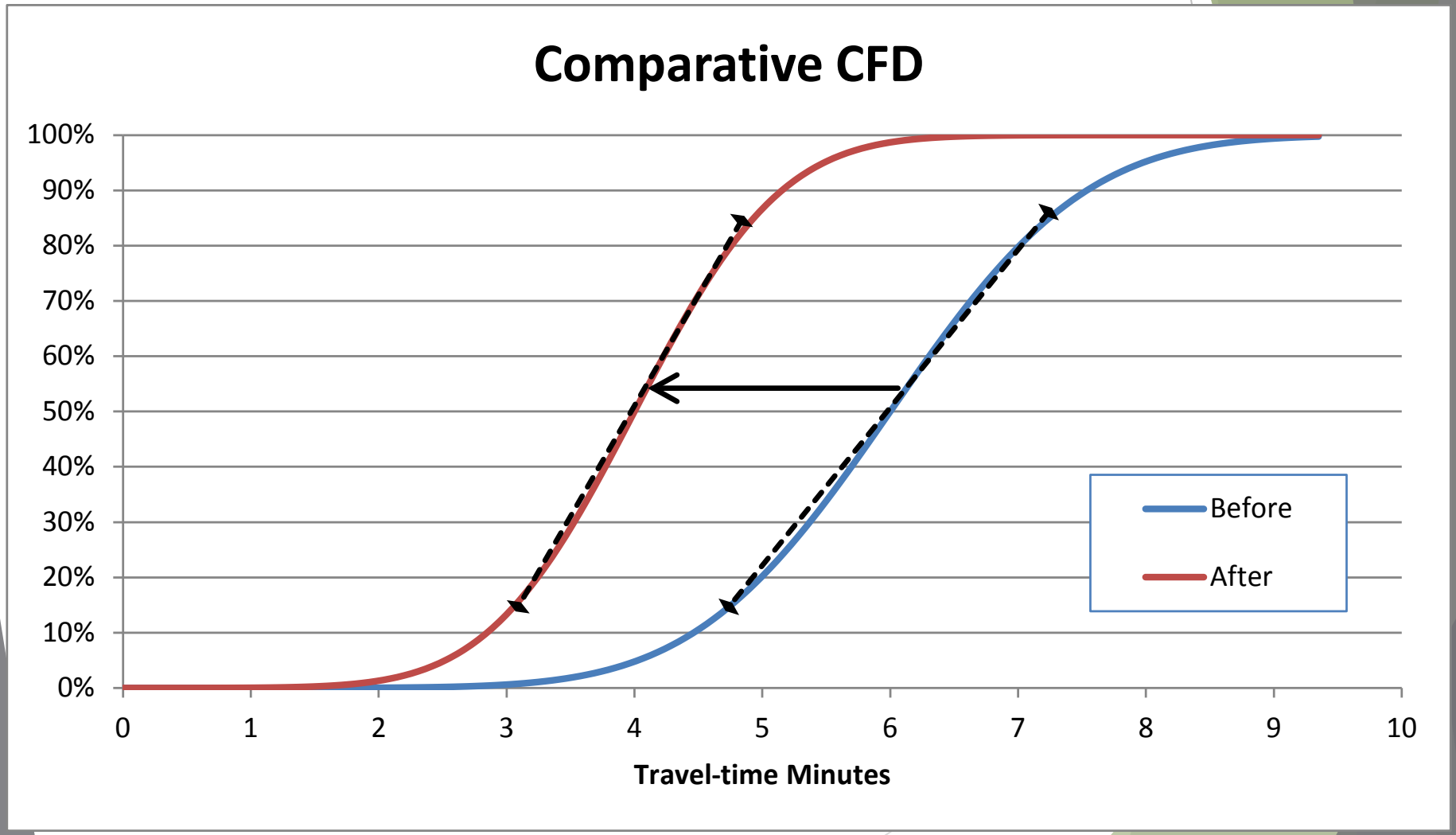
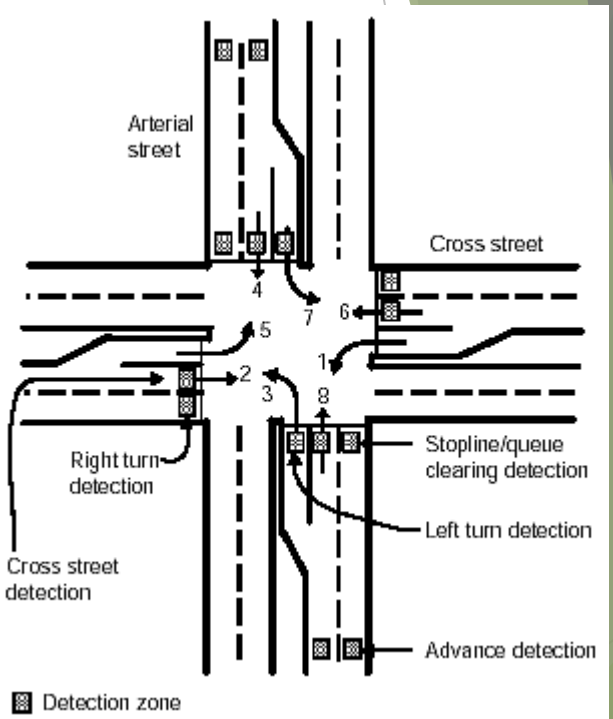


Percent Arrival on Green and Split Failures

- **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

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

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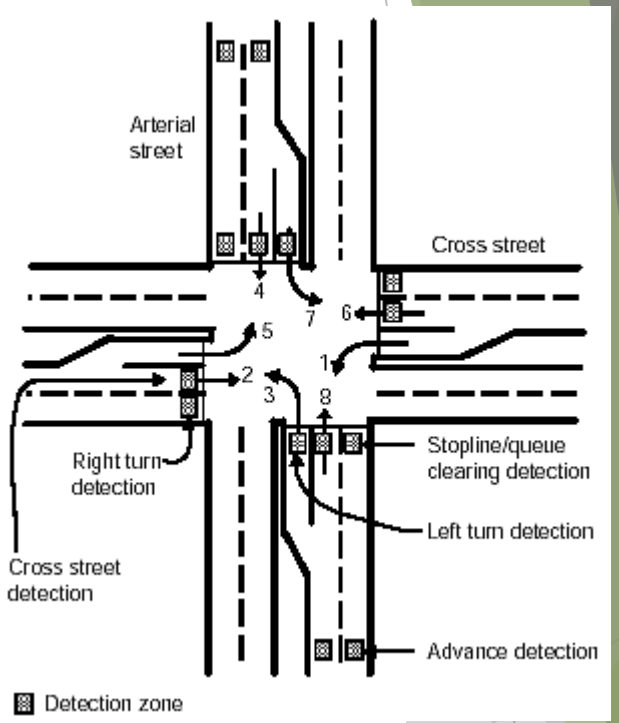
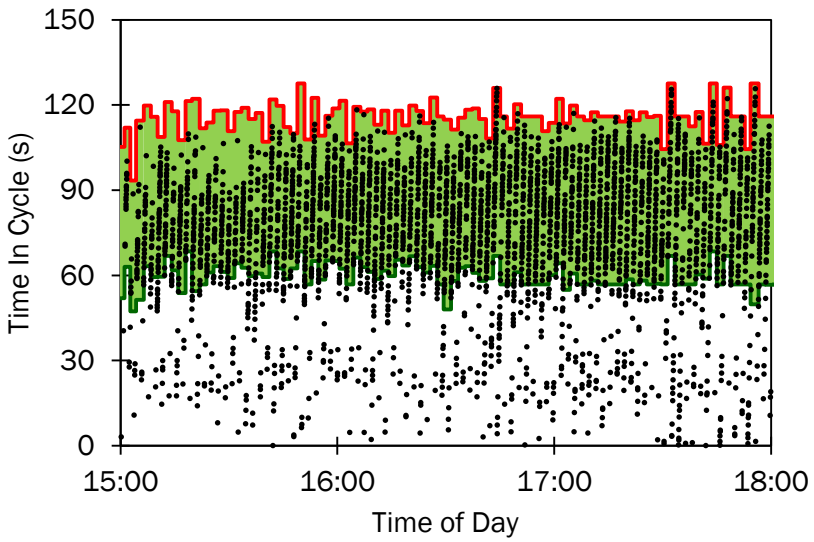


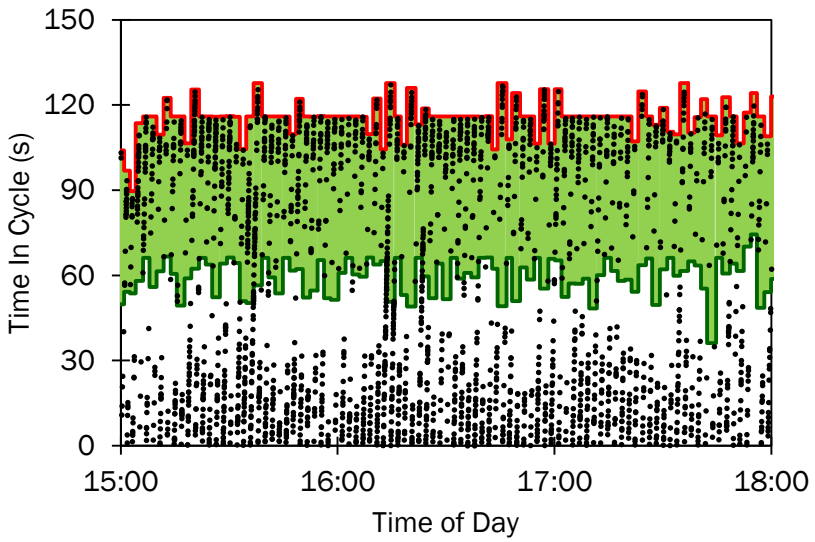
Picture Source: FHWA

THIS IS CONNECTED INFRASTRUCTURE!!!!!

Sample Metric - PAGs

Purdue Coordination Diagram





PAG in the news!

Salt Lake City 53 °
Traffic

The Salt Lake Tribune

WWW.SLTRIB.COM MAY 21, 2015

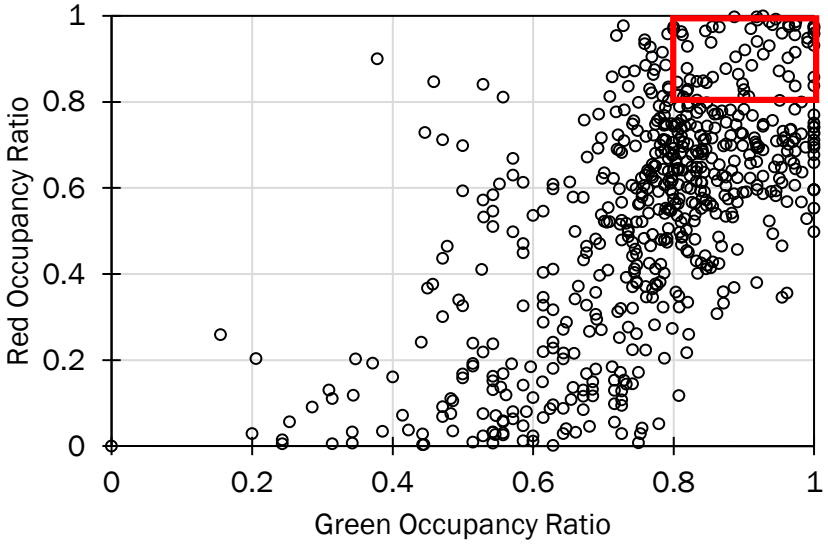
Odds of hitting a red light in Utah? Just 1-in-4

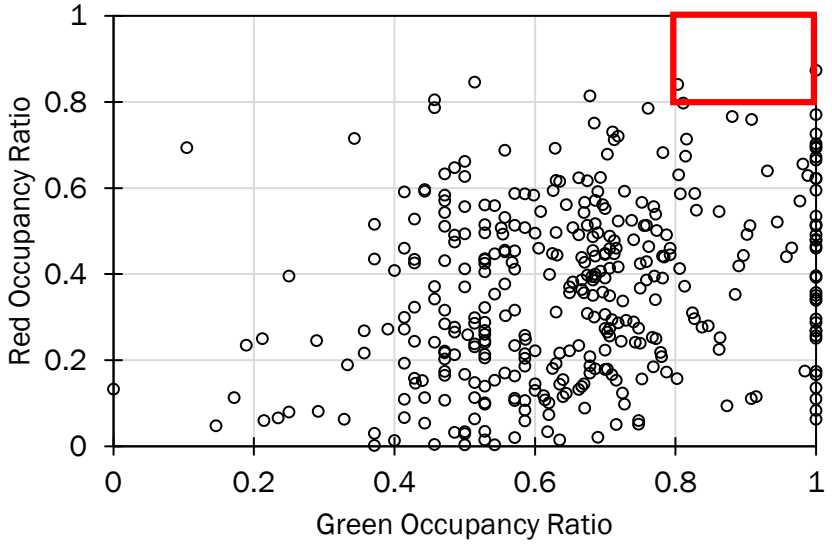
By Lee Davidson The Salt Lake Tribune

Published December 23, 2013 10:04 pm

Sample Metric - Intersection

Movement Capacity Analysis (ROR – GOR)

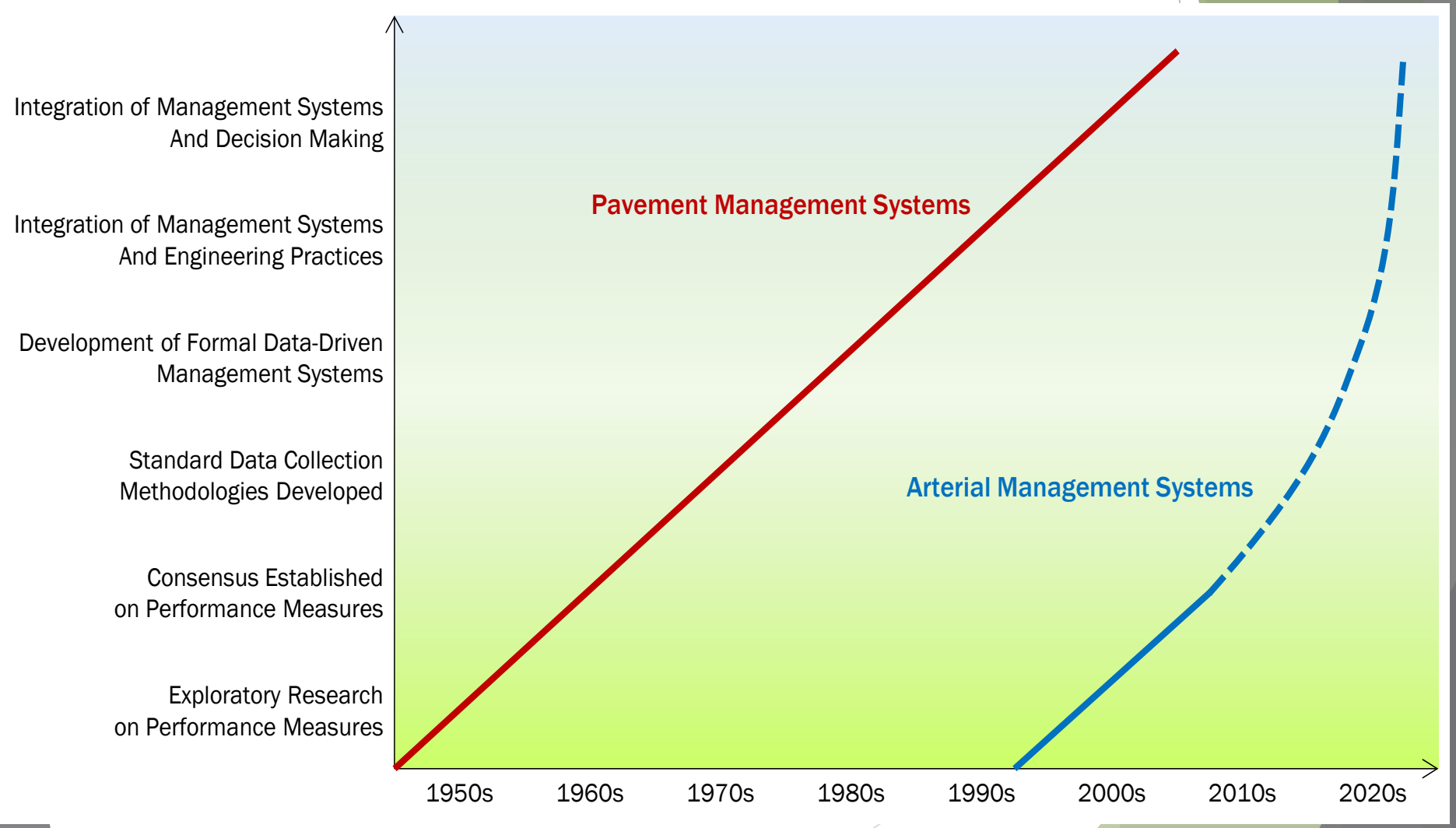




Frequency of Split Failures

- Indicator of oversaturation
  - When demand overruns capacity
- Indicates when additional capacity or demand management is required
- Also known as the metric for ….
  - ‘Get off my back, nothing left to do’
  - ‘Time to share the pain’
  - ‘Give me another lane if you want this solved’

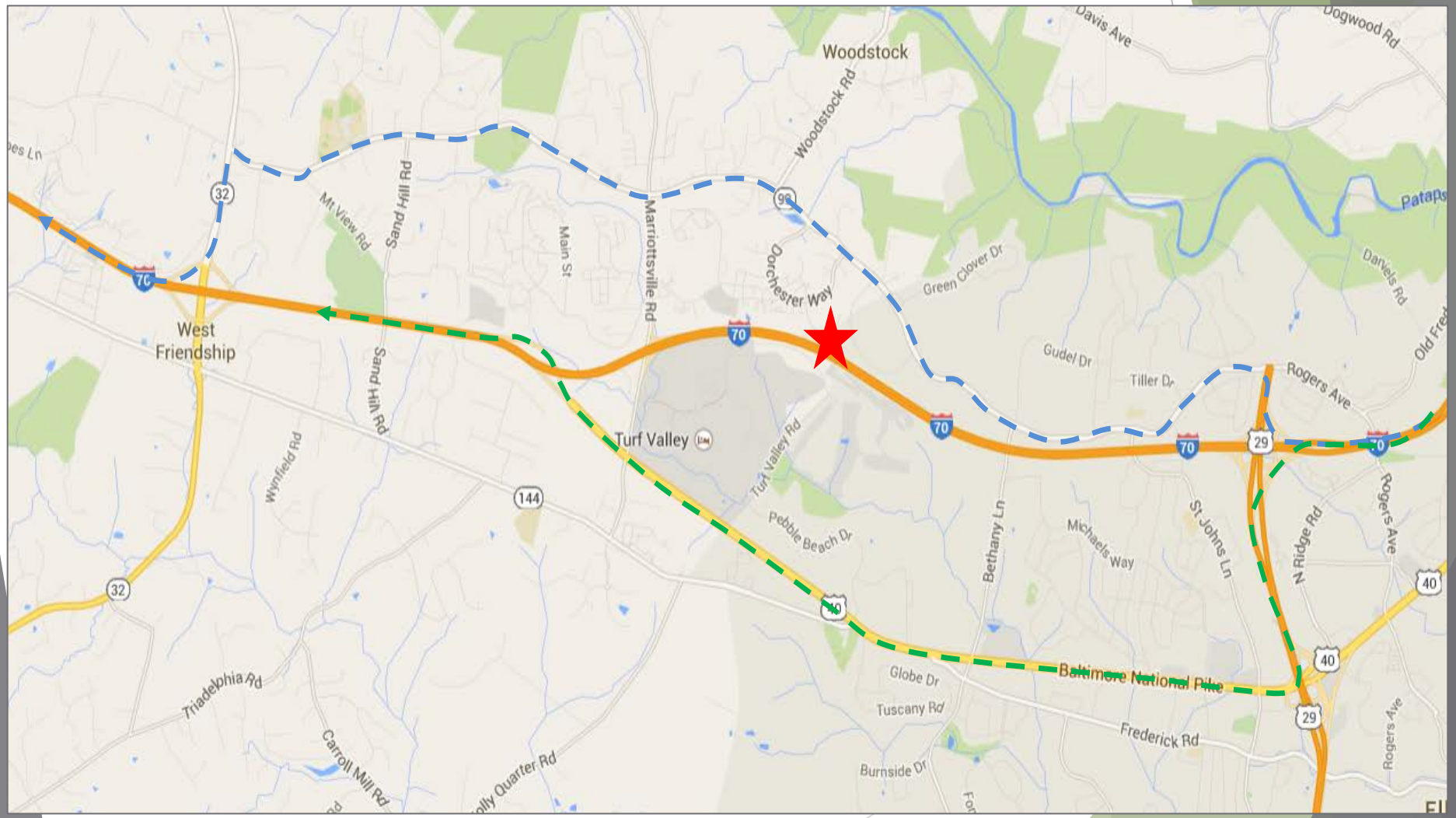
Current State of Arterial Management Systems (AMS)



Challenges / Benefits to Arterial Performance Measures

- Created a common lexicon/language
  - Between Traffic, Ops, Planning
  - Define Performance Levels (Good, Mediocre, and Ugly)
  - Effective communication with management and public
- Systematic approach
  - Link performance to budget/funding
  - Long term performance tracking
  - Predictable return on investment
- Linking to other Priorities
  - Operations during freeway incidents
  - Energy efficiency, dGlobal warming (GHG emissions)

Real-Time Arterial Performance



Conclusions – Final Thoughts

- Arterial Performance Fundamentally Different than Freeways
- Re-identification and Hi-Res Data enable full observability
- Key Measures Include
  - Travel time and travel-time reliability
  - Quality of progression
  - Degree of capacity saturation
- These Enable **Performance Management** of Arterials

Thank You!

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