Monitoring and Assessing Arterial Traffic Performance

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Outline

▶ Outsource Probe Data Quality

  ▶ Multi-Vendor, Freeways, & Arterials

▶ Completing the Picture … Arterial Performance Measures

  ▶ Possible to measure – not model

  ▶ Re-identification and High-Res technologies

  ▶ FOUR key measures to bank on

▶ And Beyond …
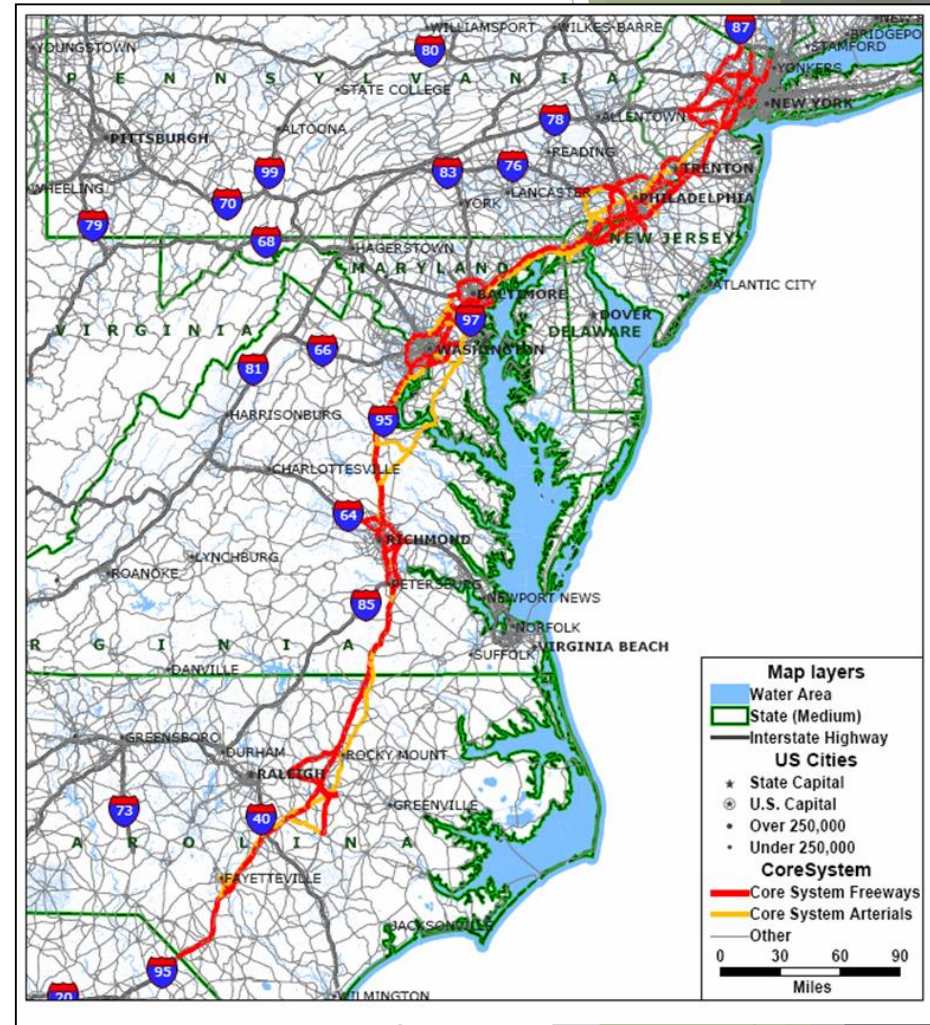
I-95 Vehicle Probe Project

► ## 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
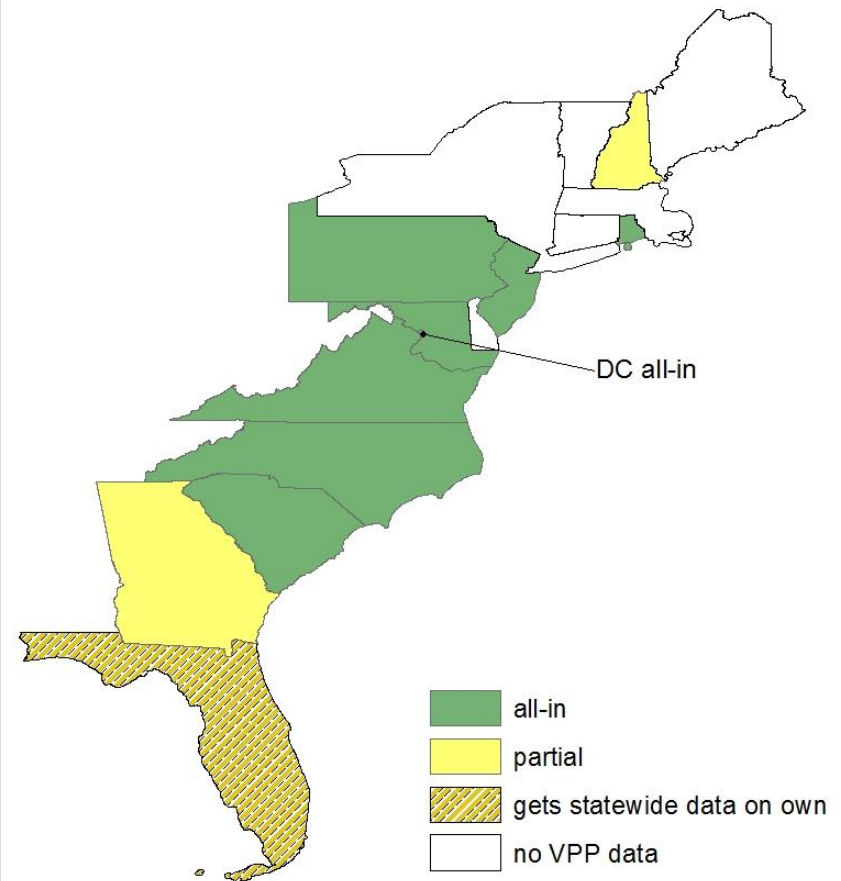- ► 42.5K miles and growing
- ► Map-21 Performance Measures

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VPPII April 2015 State Coverage

DC all-in

all-in

partial

gets statewide data on own
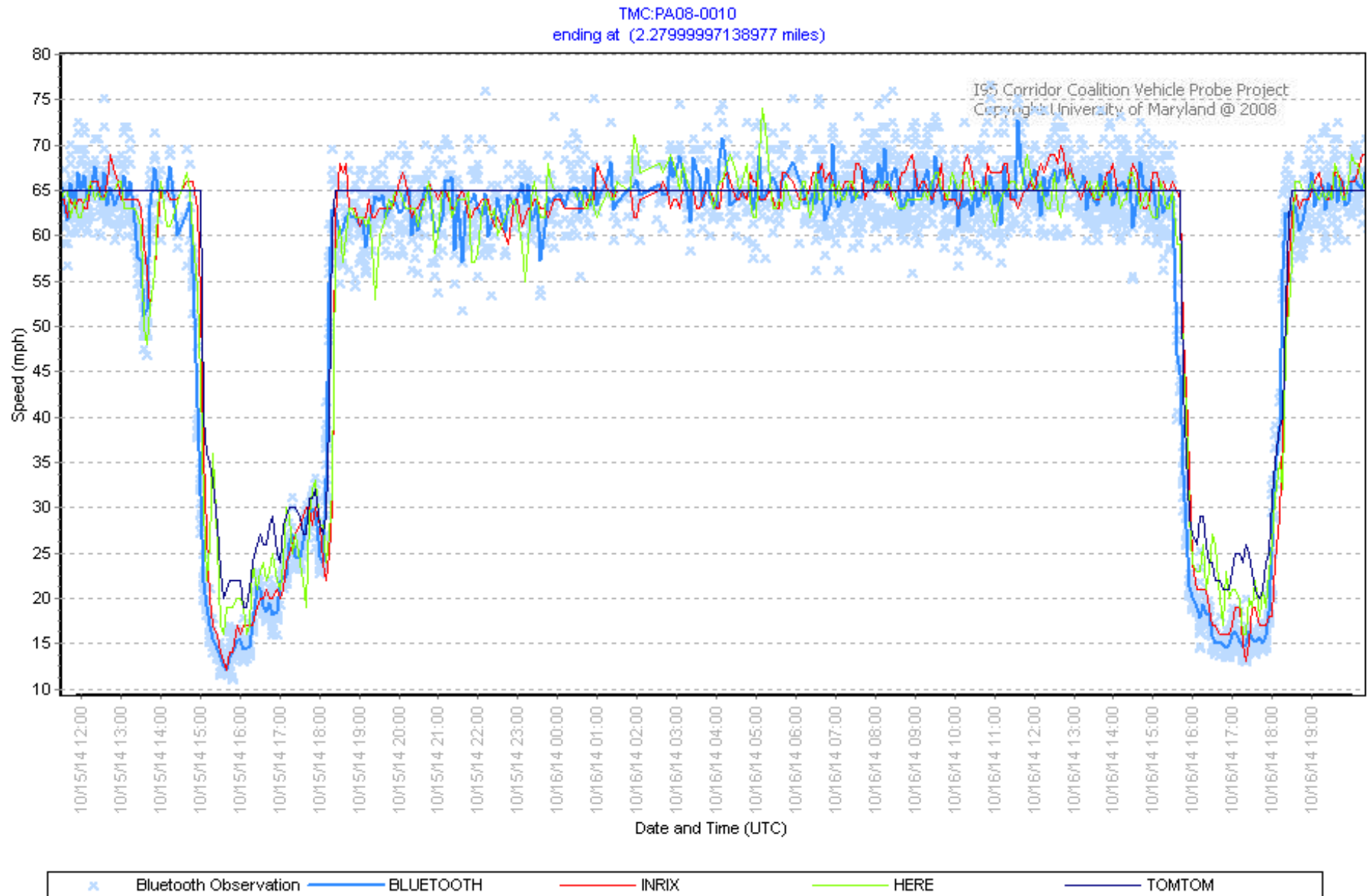
no VPP data

First Multi-Vendor Freeway Validation I-83 & I-81 Harrisburg, Oct 2014
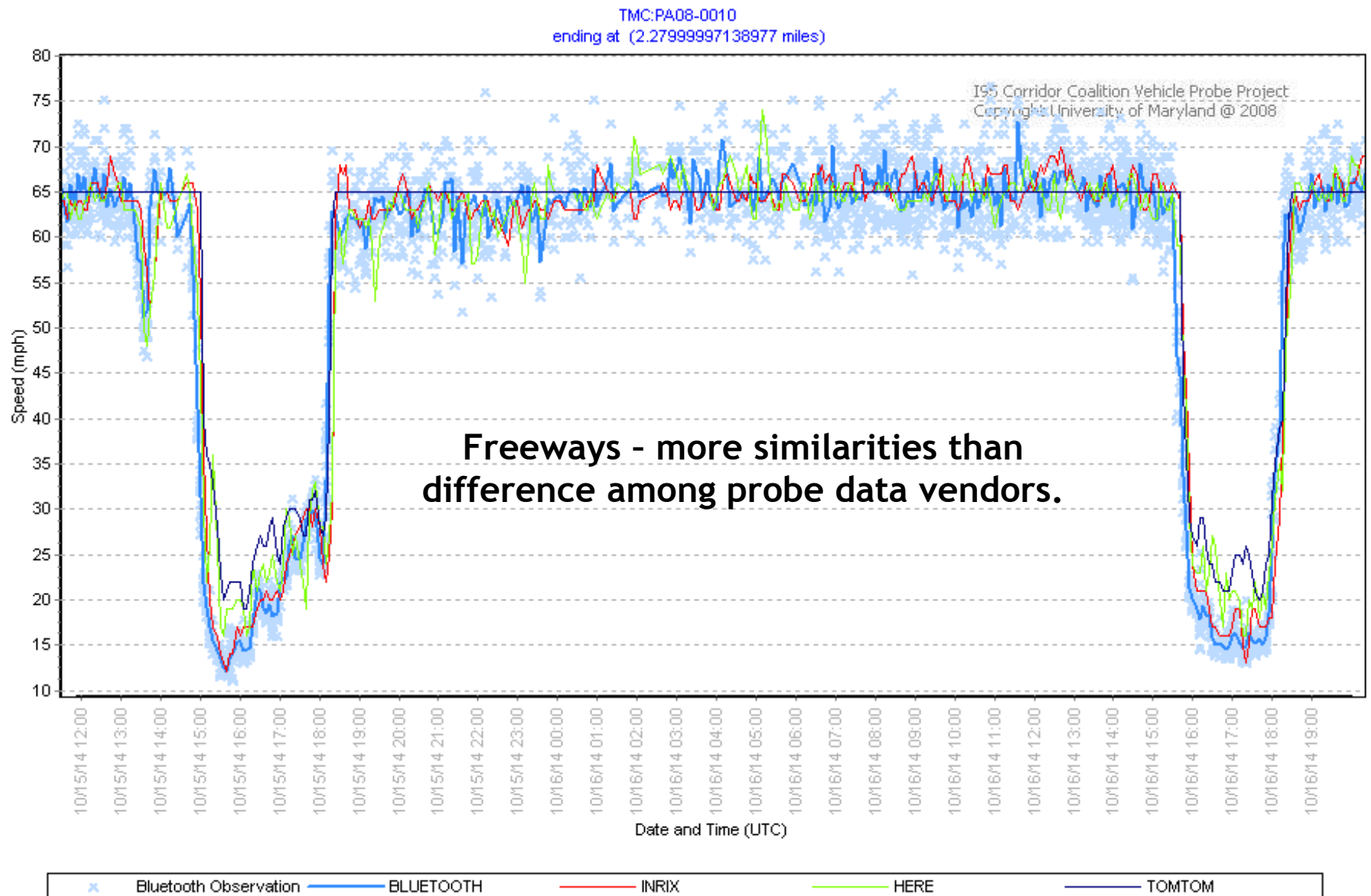
- ▶ PA-08
  - ▶ 14 Segments
  - ▶ 31.3 miles
- ▶ Data collection
  - ▶ 2300 to 2555 total hrs
  - ▶ 71 to 80 hrs [0-30]
  - ▶ 53 to 66 hrs [30-45]
- ▶ AASE
  - ▶ 2.1 to 4.1 mph [0-30]
  - ▶ 3.1 to 5.8 mph [30-45]
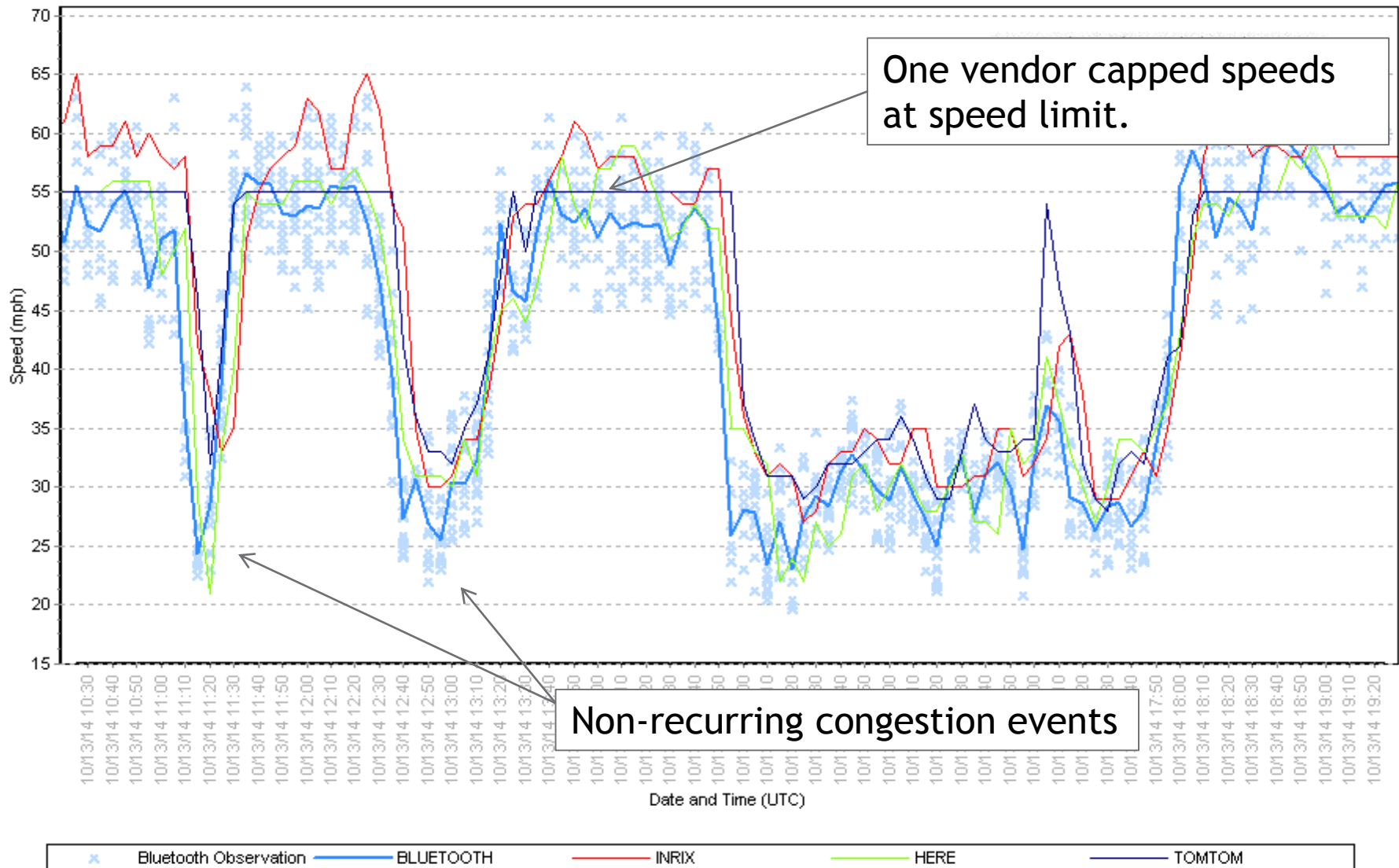
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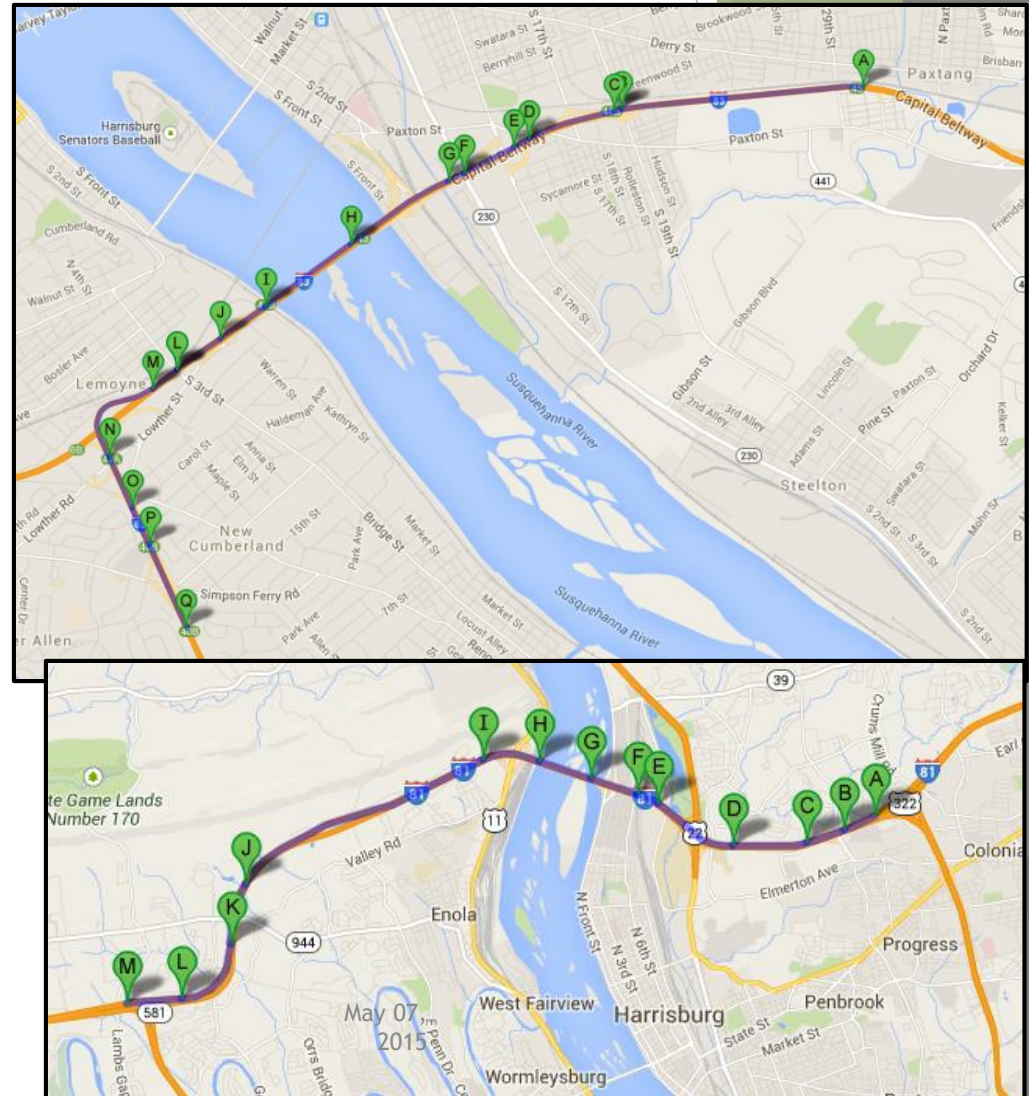
PM Peak Hour (Oct 15-16, 2014)

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Freeways – more similarities than difference among probe data vendors.

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

TMC:PA08-0006
ending at (1.28999996185303 miles)

One vendor capped speeds at speed limit.

Non-recurring congestion events

Speed (mph)

Date and Time (UTC)

Bluetooth Observation ╳ BLUETOOTH INRIX HERE TOMTOM

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	21-30	7.3	26 / 3.56	105	Partial	45-49
	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
  - 20K AADT to 50K AADT
  - 4 – 6 lanes
  - 0.5 to 4 signals per mile
- Objective: Reference case studies

Arterial Probe Data Recommendations

✓ 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**
- **Consistent over-reporting speed in 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
- Anticipated improvement …
  - Increased probe density
  - Point pair processing (true travel time sampling)

Shifting Gears –
Measuring Arterial Performance

Roadmap for Arterial Management Systems

- ▶ Fundamentally different than Freeways
- ▶ Until now, ... too costly to measure, had to be modeled
- ▶ Technology has enabled first generation system wide measurement
  - ▶ Re-identification data, High-Resolution Controller data
- ▶ Significant opportunity – significant challenges
  - ▶ Common language, lexicon, tools
  - ▶ Bridge culture divide between traffic, planning and operations

Technologies Enabling Arterial Management Systems

Re-identification

High-Res Signal Data

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

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

- Works best at corridor level

- Independent of Signal System

- Provides top-level user experience information

- Logs *all* actuation and phasing information

- Works at intersection level

- Integrated with Signal System

- Provides detailed intersection analysis and data for optimizing signal system

Not one or the other… but both!

Emerging Arterial Measures

- **Travel Time & Travel Time Reliability – based on sampled travel time sources**
  - Based on sampled travel time from re-identification data
  - Future may include outsourced probe data and connected vehicles
  - Based on the statistical distribution of travel time
- **Percent Arrivals on Green – reflects quality progression**
  - Based on High-Res Data
  - Purdue Coordination Diagram tools
- **Split Failures / Phase Failures (frequency of occurrences)**
  - Based on High-Res Data
  - Reflects capacity constraints
  - Based Green Occupancy Ratio / Red Occupancy Ratio

Travel Time and Travel Time Reliability

► **Based on direct measures of travel time**

► Emphasized quality of corridors

► Directly reflects traveling public

  ► Measures efficiency & travel predictability

► Can be applicable to other modes of travel

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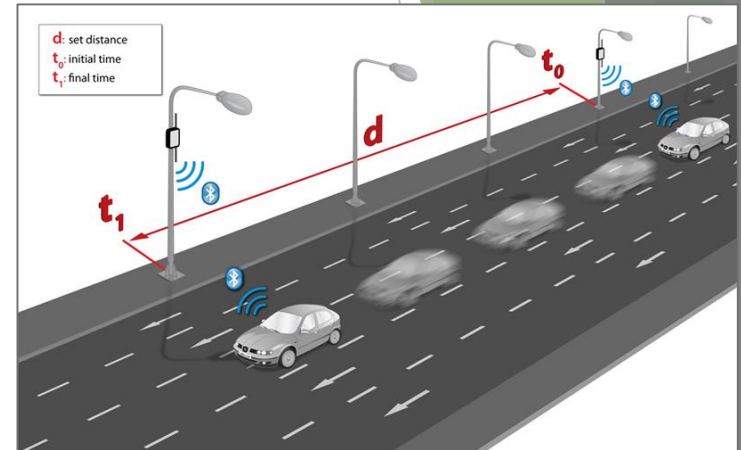
Car	MAC address	Entry Time hh:mm:ss	Exit Time hh:mm:ss
1	12-34-56-78-9A-BC	13:10:05	13:15:37
2	48-2C-6A-1E-59-3D	13:10:10	13:15:25

Re-id Travel Time Data Fidelity

Segment: PA05-0002 B to C Weekdays Only from 12/03-12/17 2013 Length: 1.19 miles

24 Hour Overlay Plot
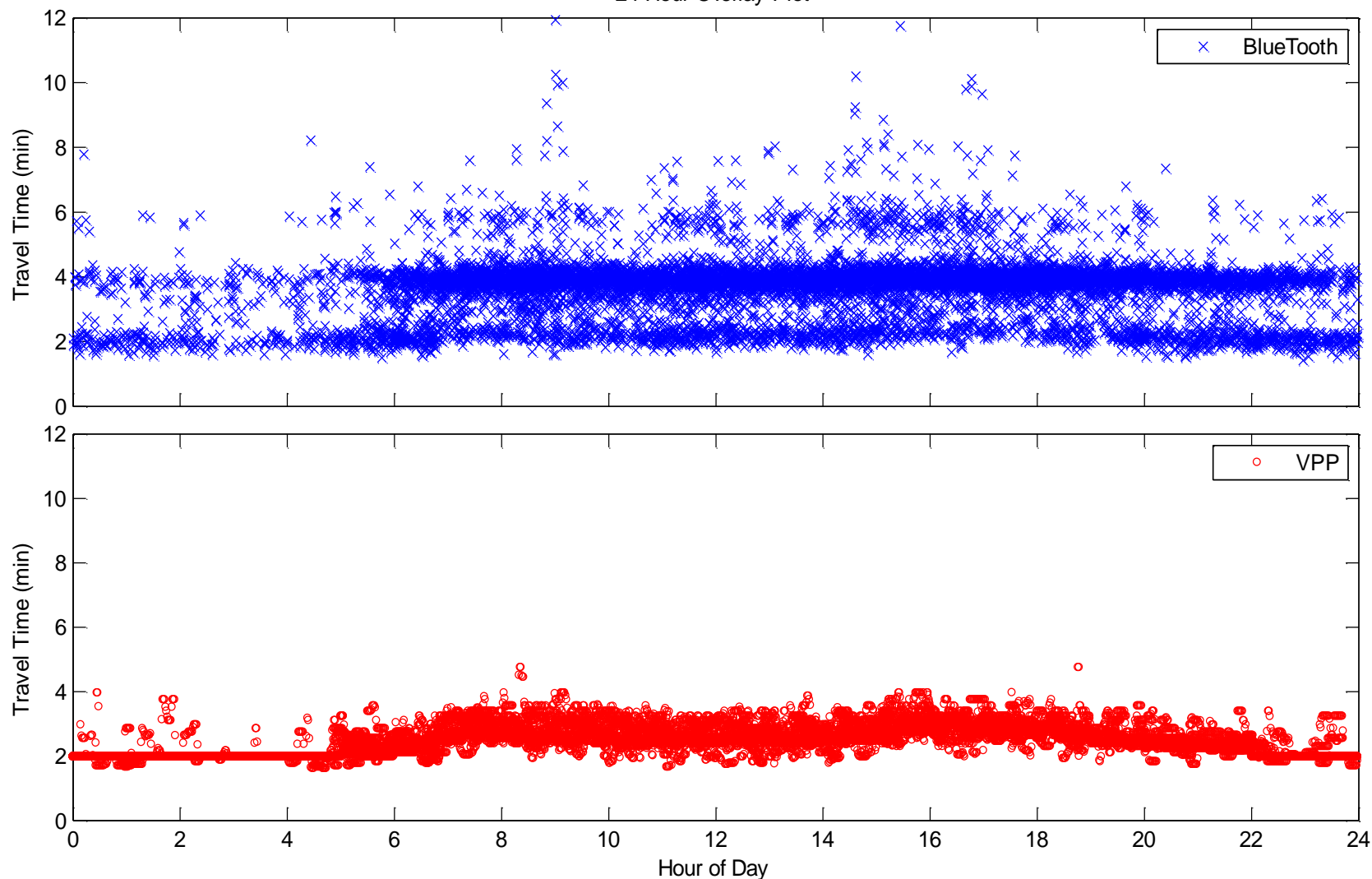
CFD Statistical Performance Measures

Segment: PA05-0002 B to C   Weekdays Only from 12/03-12/17 2013   Length: 1.19 miles

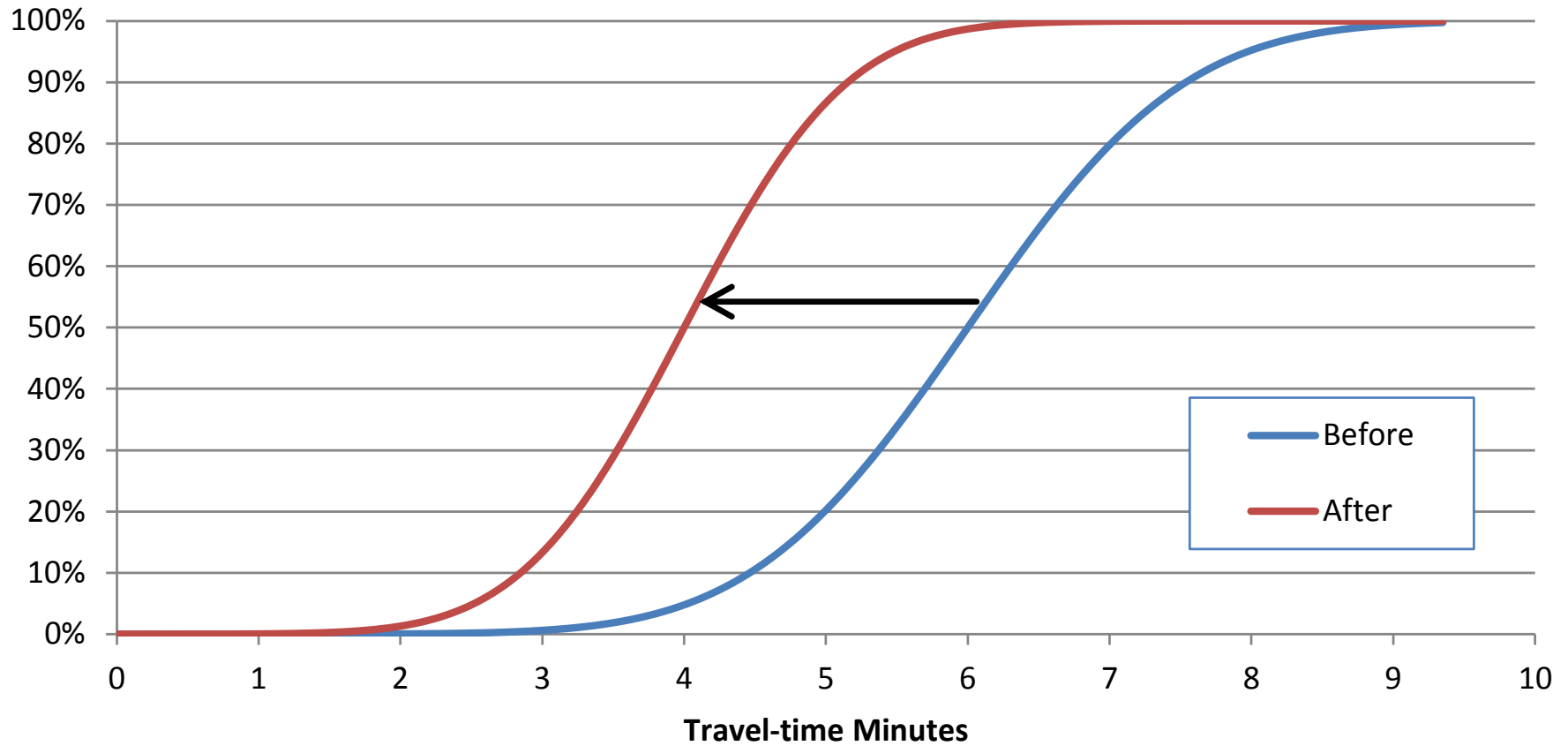|	VPP	BT
TTI	1.00	1.42
PTI	1.24	2.99
BTI	1.24	2.11
25th	1.98	2.07
50th	1.98	2.82
75th	1.98	3.89
95th	2.46	5.95
IQR	0.00	1.82
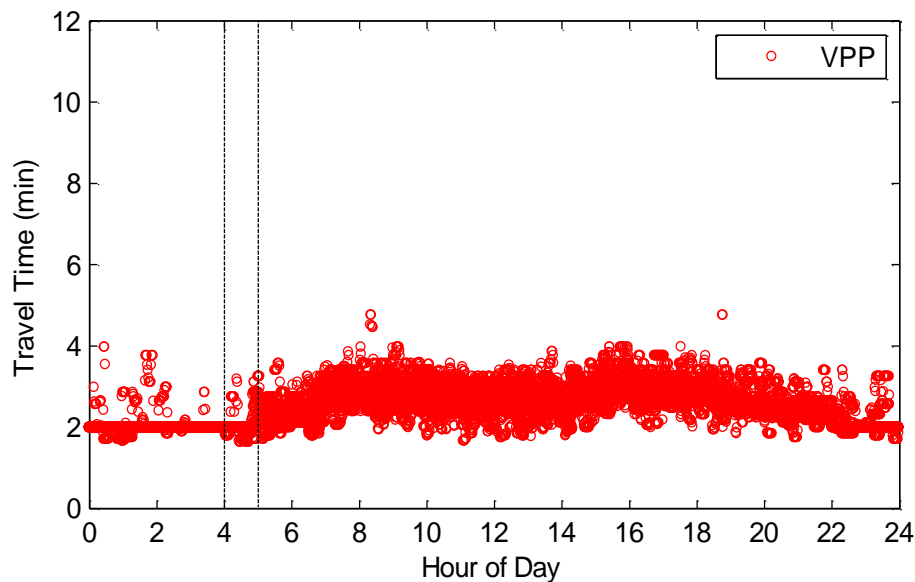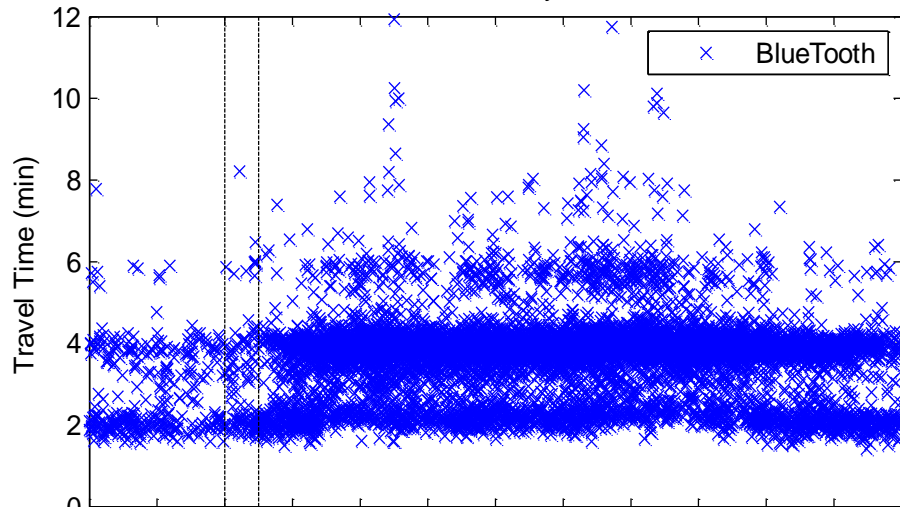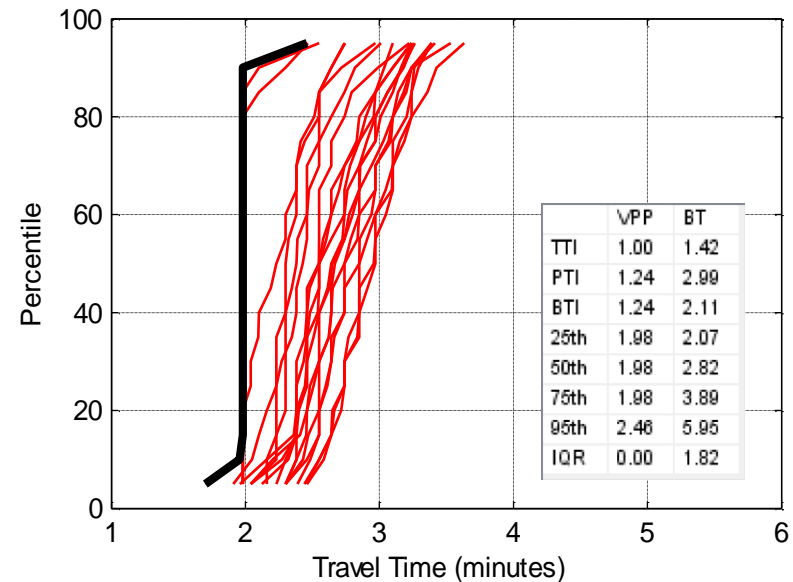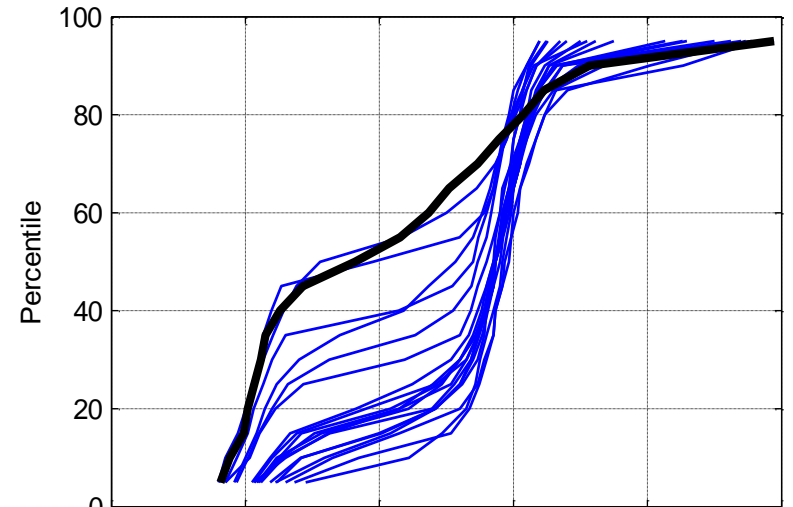
Travel Time

Comparative CFD

Travel Time Reliability

Comparative CFD
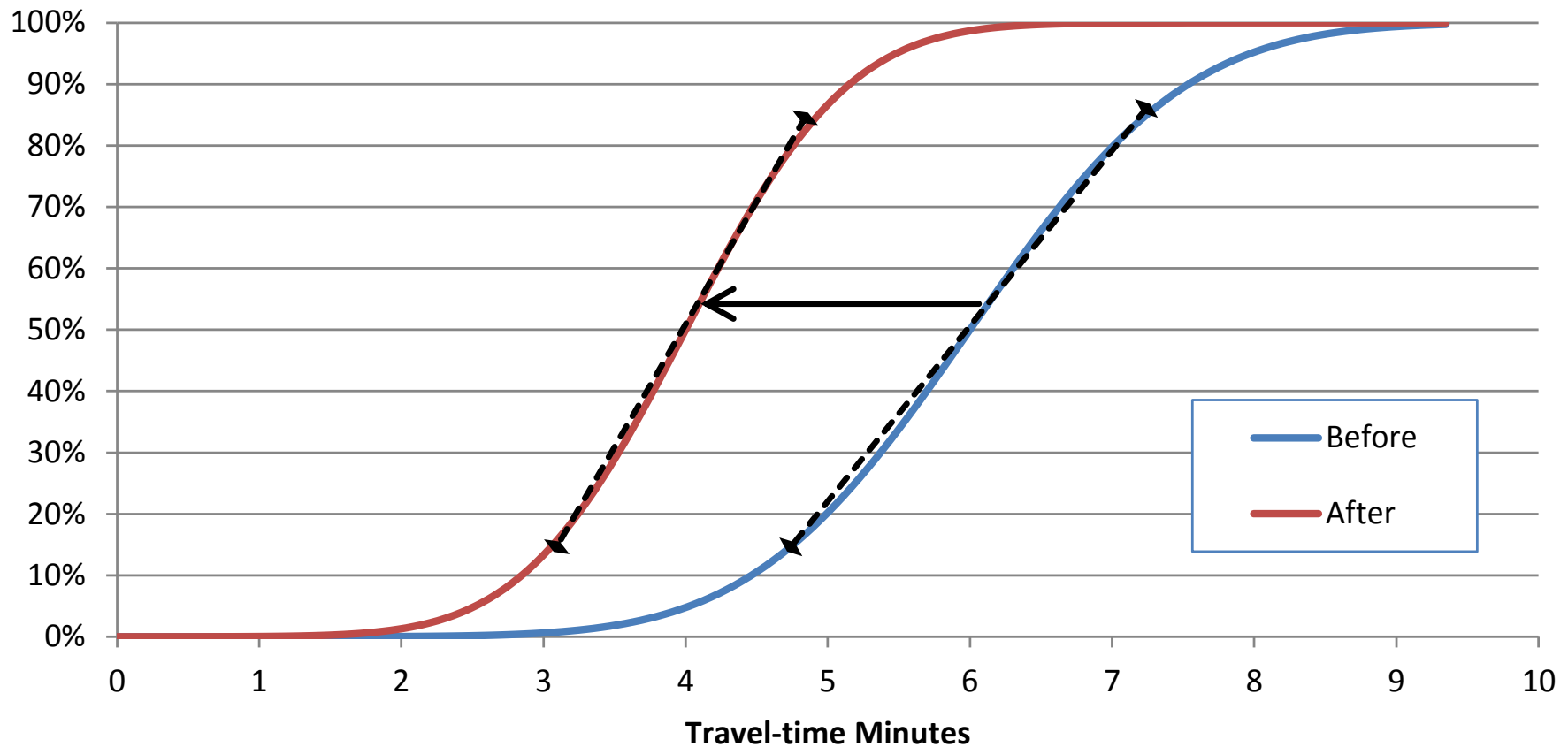
High Resolution Signal Data

- ▶ 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
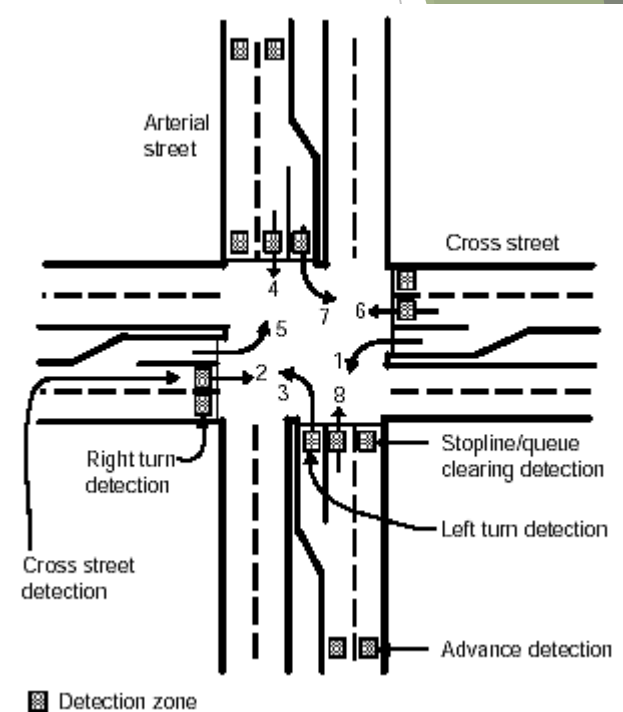
Picture Source: FHWA

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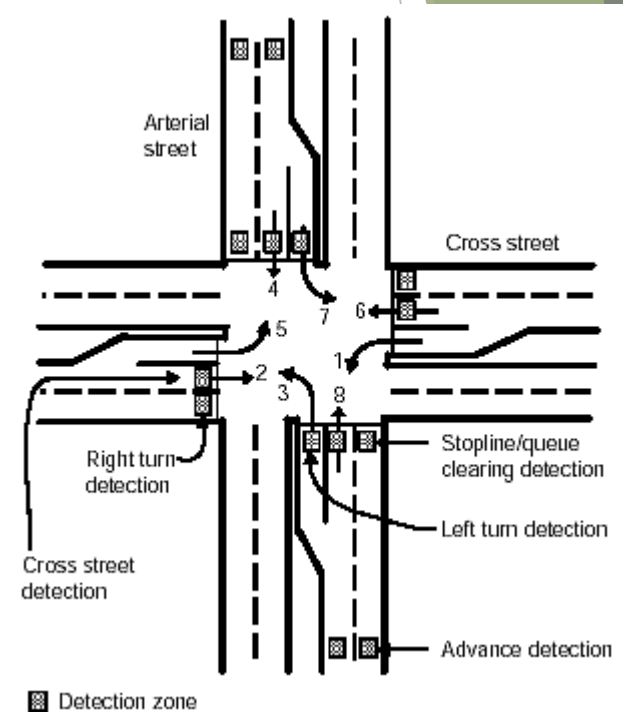
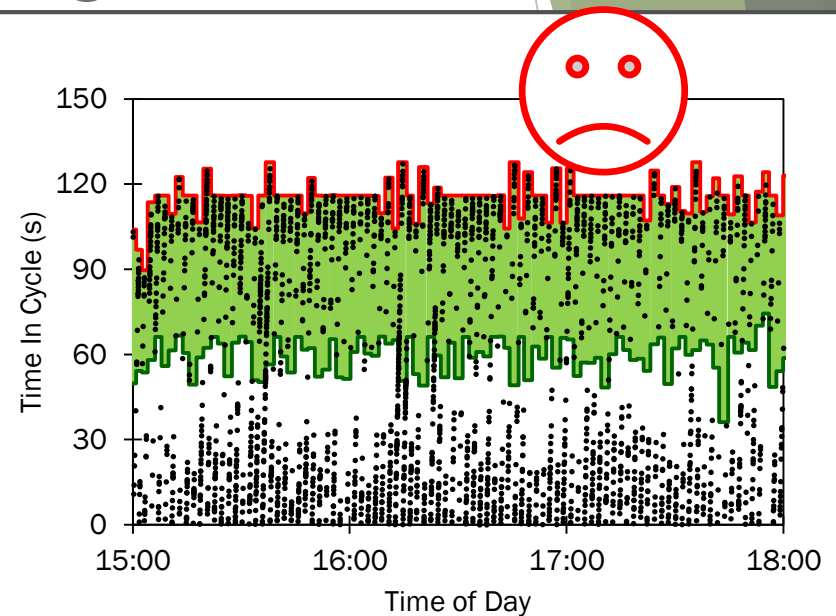Picture Source: FHWA
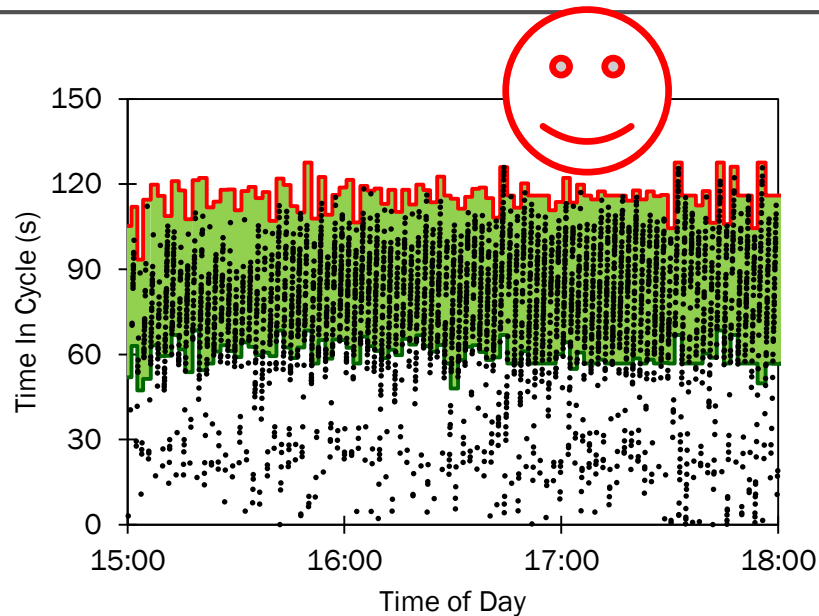
THIS IS CONNECTED INFRASTRUCTURE!!!!!

Percent Arrivals on Green
Purdue Coordination Diagram

Purdue Univ.

Percent Arrivals on Green
Purdue Coordination Diagram

Purdue Univ.
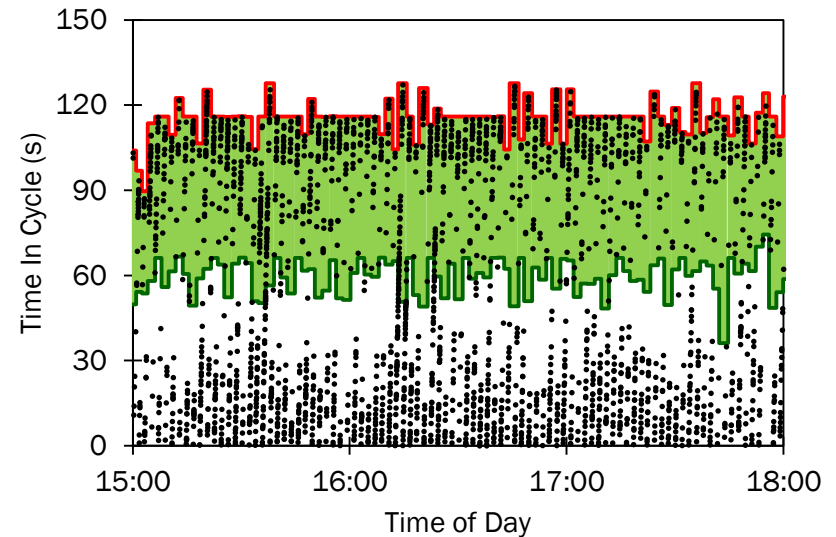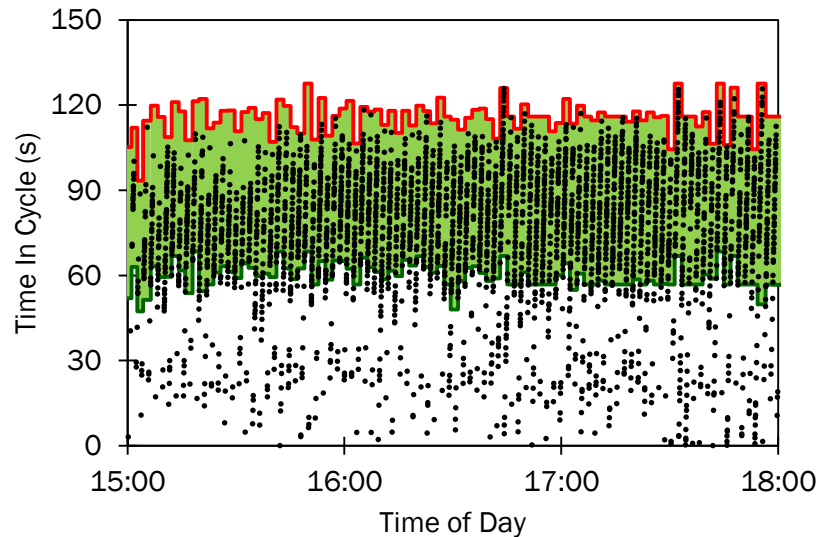
Percent Arrivals on Green in the news!

Salt Lake City 53 °
Traffic

The Salt Lake Tribune
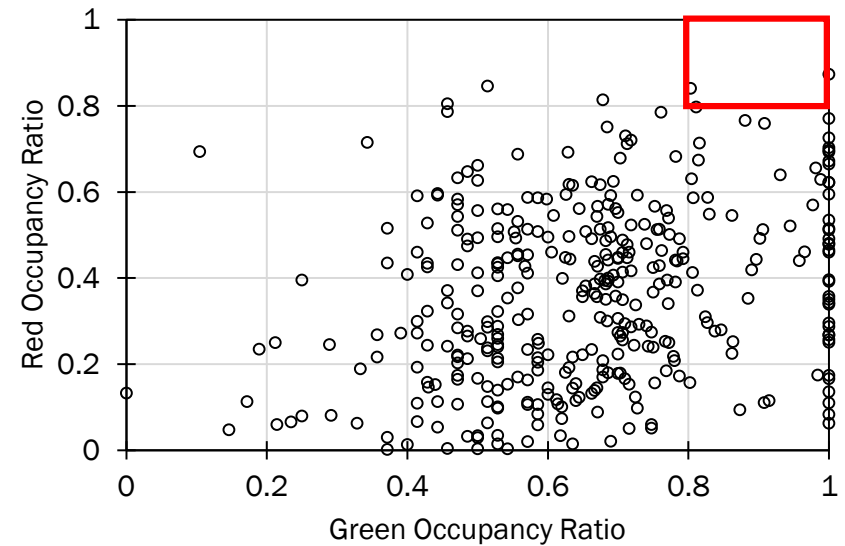
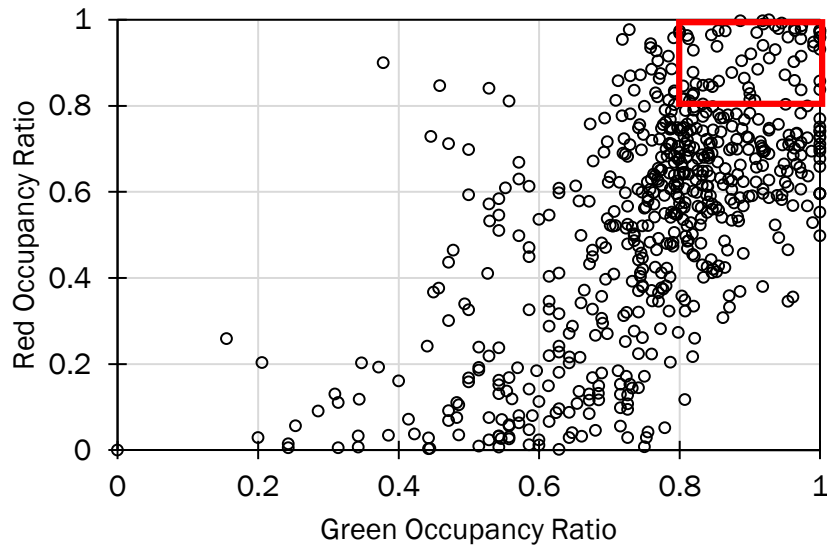WWW.SLTRIB.COM   MAY 21, 2015

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

By Lee Davidson The Salt Lake Tribune

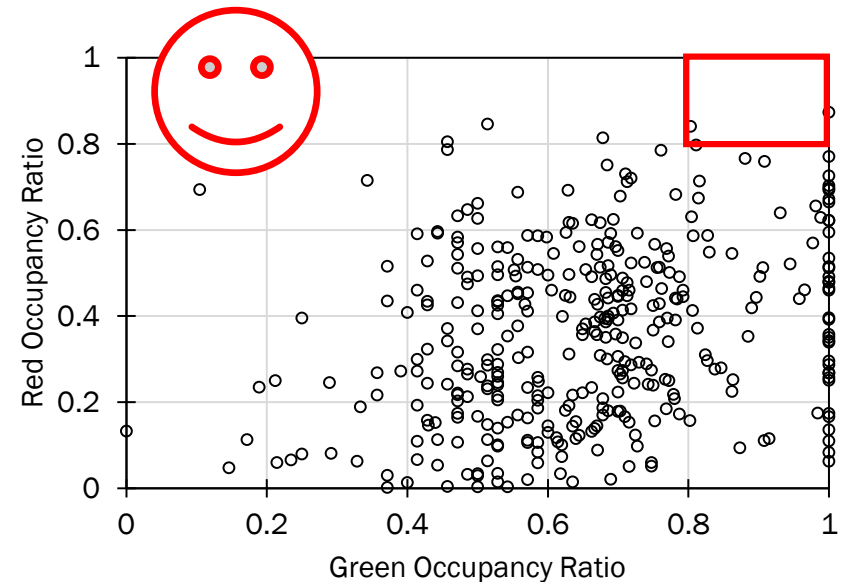Published December 23, 2013 10:04 pm

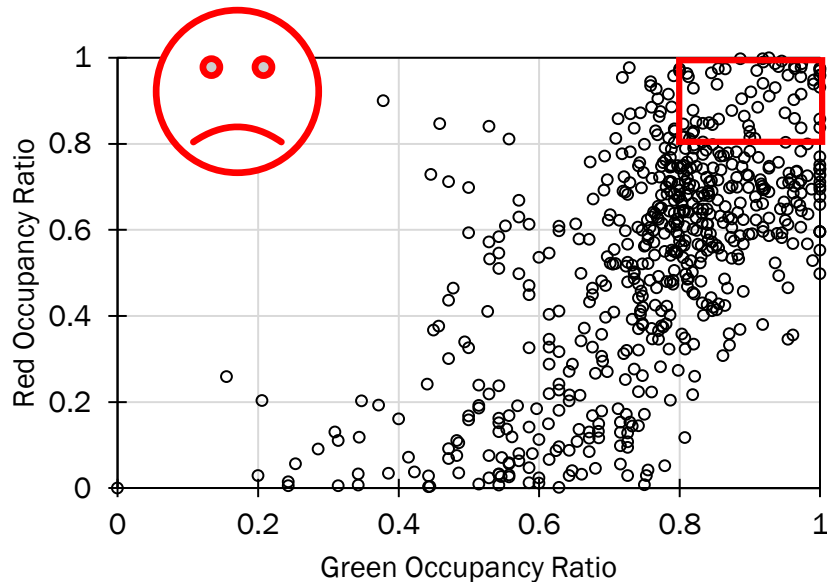# Adequate Intersection Capacity
Movement Capacity Analysis (ROR – GOR)

Purdue Univ.

Adequate Intersection Capacity
Movement Capacity Analysis (ROR – GOR)

Purdue Univ.

Adequate Intersection Capacity - 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)
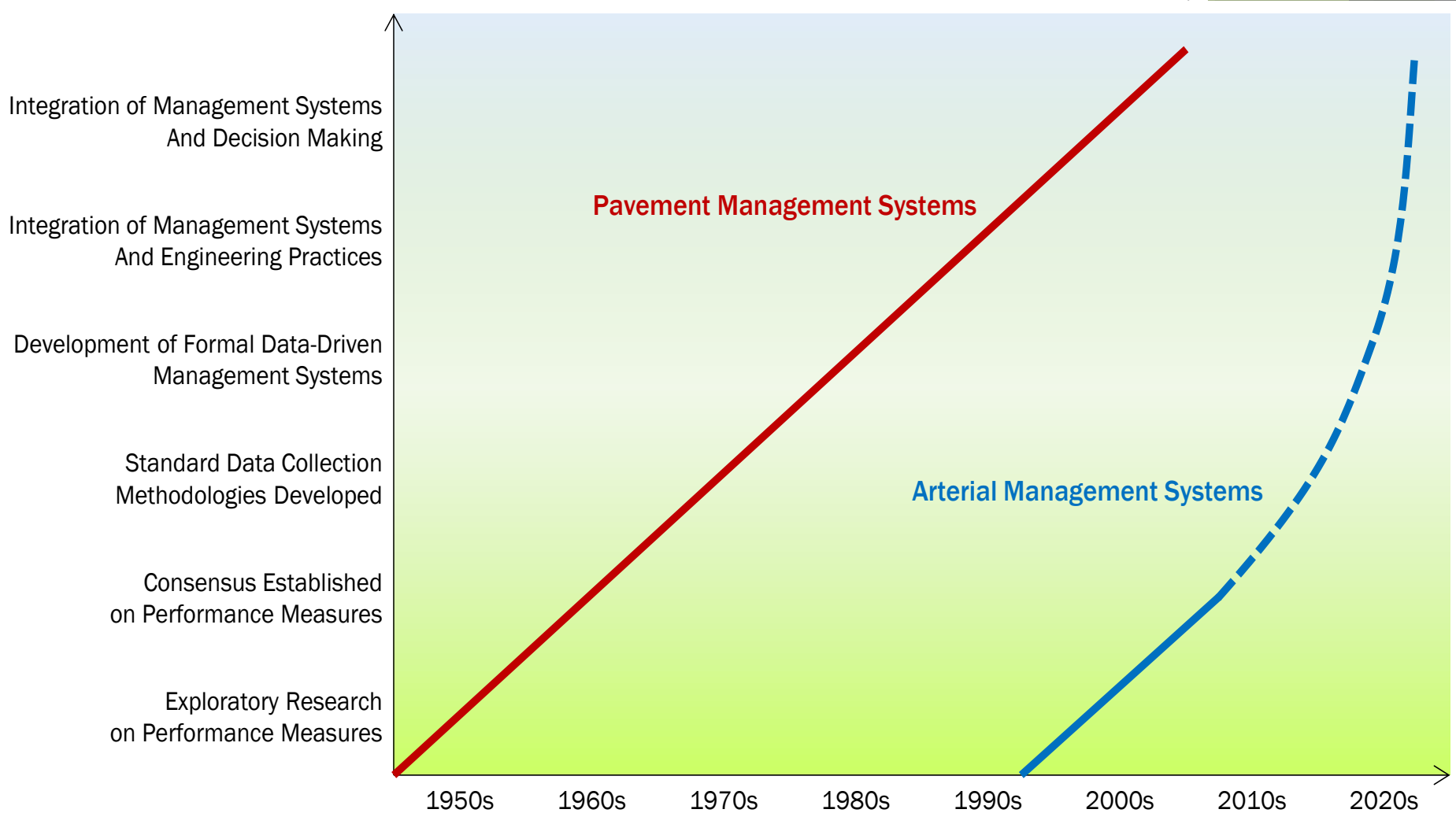
Challenges / Benefits to Arterial Performance Measures

- Created a common lexicon/language

- Standardize performance

  - **Performance Levels (Good, Mediocre, and Ugly)**

  - Communicate efficient with management and public

- Systematic approach

  - Link performance to budget/funding

  - Long term performance tracking

  - Predictable return on investment

- Extensions

  - **Include arterial operations in ITS**

  - **Extend to energy efficiency, GHG emissions**

Final Thoughts on Arterials

- Arterial Performance Measures
  - We can now measure – not model
  - Enable by Re-identification and Hi-Res Controller Data
- Key Measures
  - **Travel time** (Median of CFD)
  - **Travel-time reliability** (Slope of CFD)
  - **Percent Arrivals on Green**
  - **Adequate Intersection Capacity**
- Challenges include bridging culture and language barriers of traffic, ops, planning – and management.
- These Enable **Performance Management** of Arterials

And beyond … Volume Data Everywhere

- ▶ I95 Corridor Coalition to accelerate availability of real-time volume estimates from probe data
  - ▶ Volume estimates for all roadways, every 15 minutes
  - ▶ CONOPS - for accuracy and common data formats
- ▶ Testbed for Calibration and Validation
  - ▶ Pool of verified volume data contributed by states
  - ▶ Requirements for long-term viability
- ▶ Industry cooperative research project
- ▶ Contact Reuben Juster (rmjcar@umd.edu) or myself

Thank You!

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