Evaluating Multiple Data Sources for WisDOT Travel Times

T3E
TRAVEL TIME TECHNOLOGY EVALUATION

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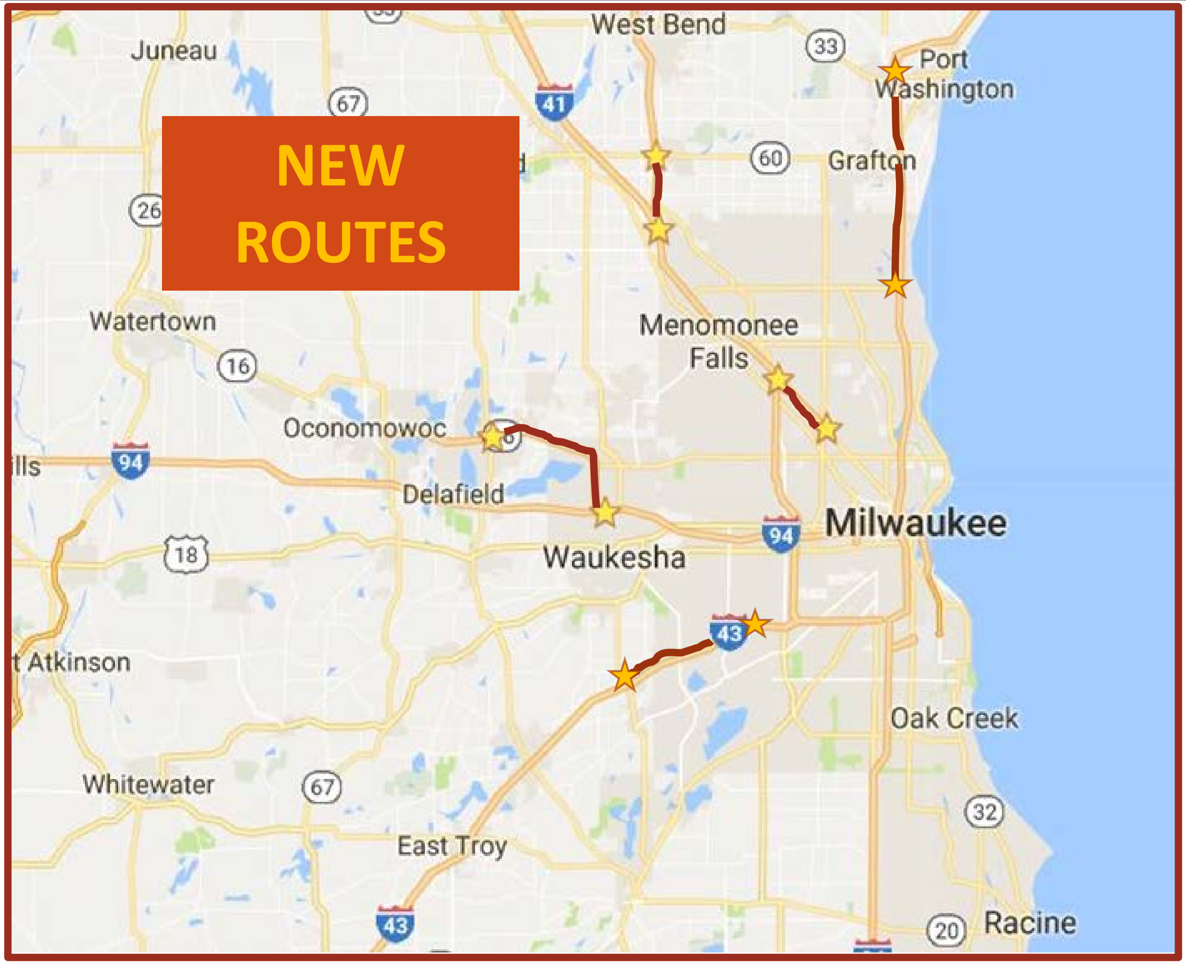
Outline

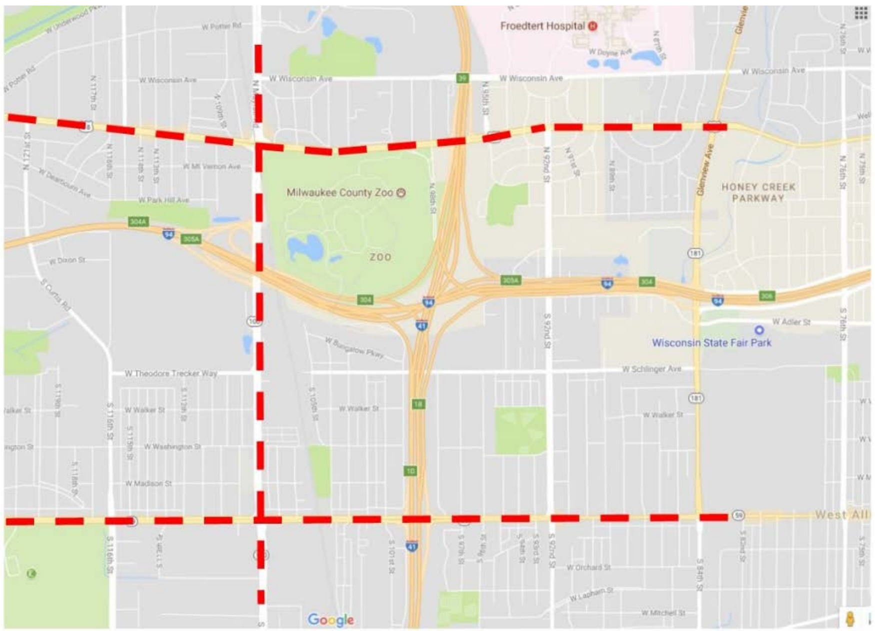
- T3E Project Background
  - WisDOT Travel Times
  - Why Analysis Needed
- Data Quality Comparison
  - Data Reliability
  - Travel Times and Analysis
  - Cost Effectiveness Assessment
- Conclusions and Recommendations

T3E Project Background

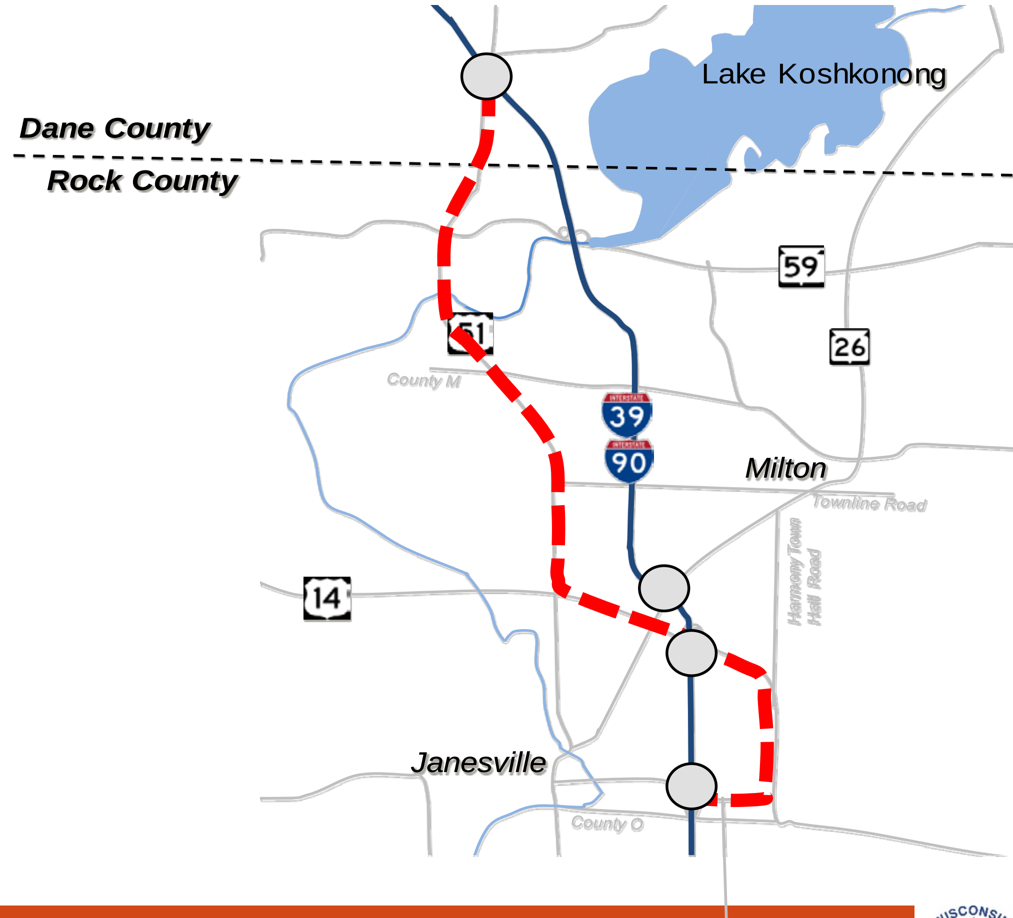
WISDOT TRAVEL TIMES



ARTERIAL TRAVEL TIMES



Milwaukee County



2015 Zoo I/C Reconstruction

COMPARABLE TIMES


TIME TO EDGERTON
VIA I-39/90 40 MIN
VIA ALT ROUTE 25 MIN


F
E


GAS - EXIT 183
bp
24 hrs-diesel

I-39/90 CONSTRUCTION

ALTERNATE ROUTE TRAVEL TIME – DATA SOURCES

- Probe Data
- License Plate
- Bluetooth
- Magnetometers
- Radar Detection

- **Data Type**
- **Familiarity**
- **Integration**
- **Reliability**
- **Cost**

Probe Data - $90k

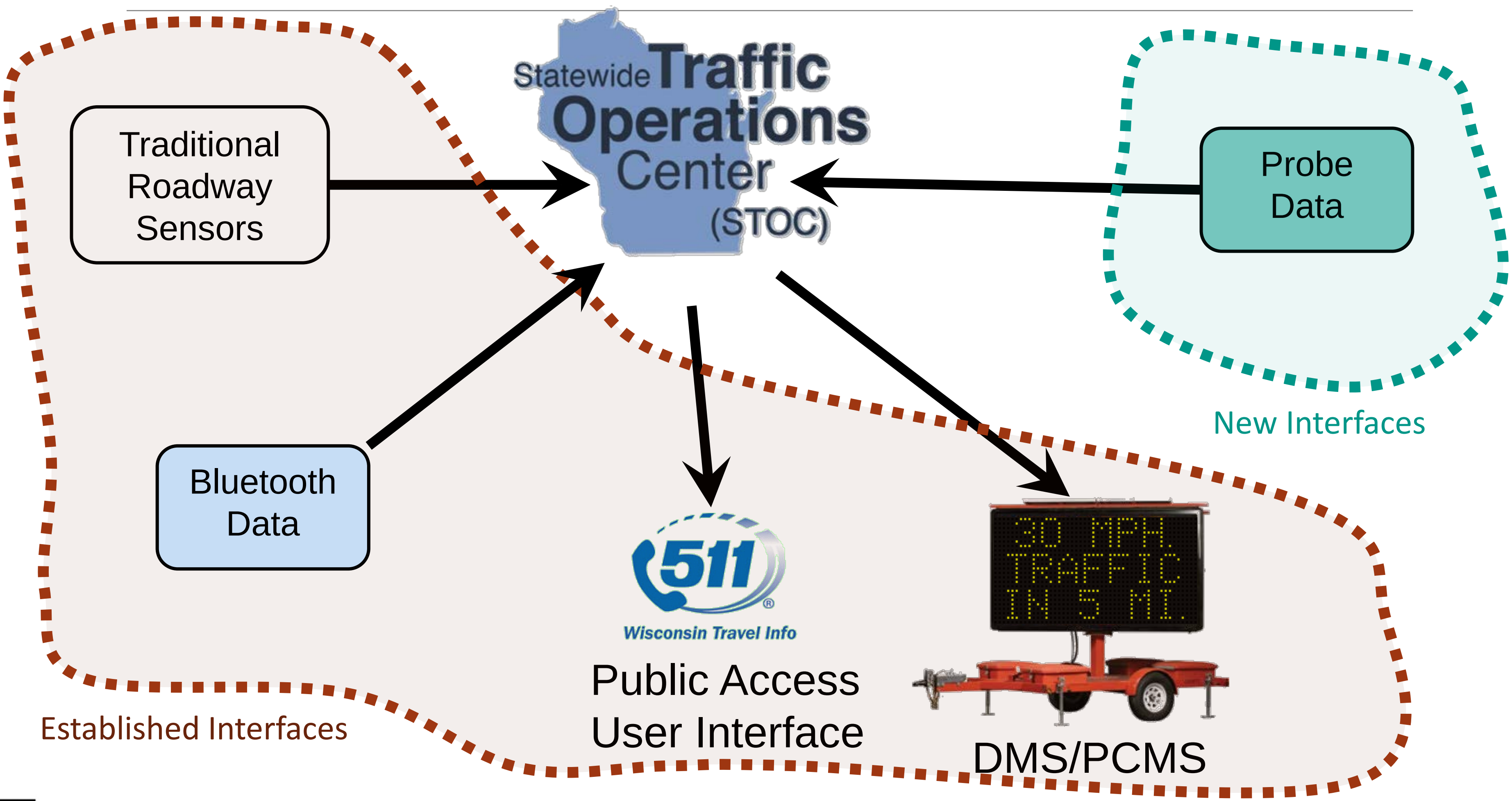
Microwave - $1.5M

Bluetooth - $1M

Magnetometers - $2M

License Plate Readers - $2.5M

STOC ATMS


Statewide Traffic Operations Center (STOC)
Traditional Roadway Sensors
Probe Data
Bluetooth Data
New Interfaces
511
Wisconsin Travel Info
Public Access User Interface
30 MPH TRAFFIC IN 5 MI.
DMS/PCMS
Established Interfaces

T3E Project Objectives

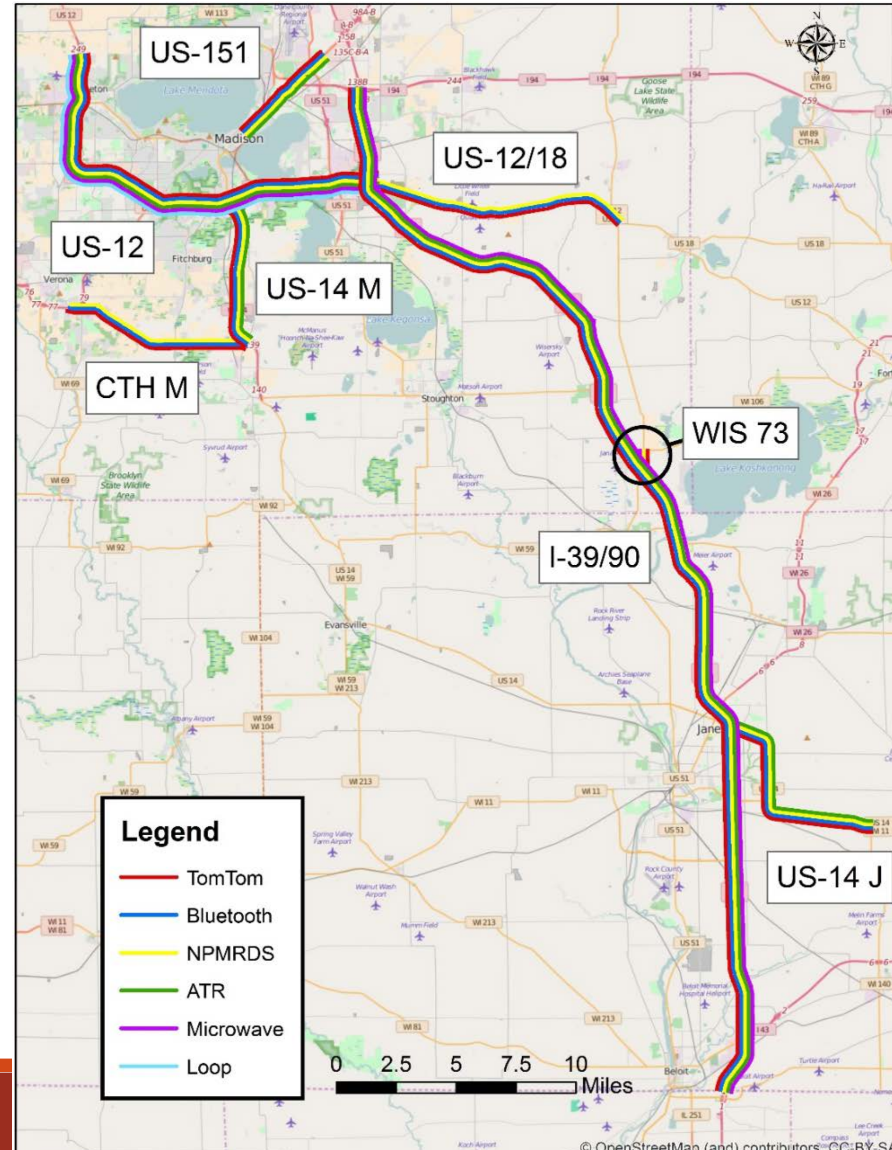
- Compare arterial versus freeway travel times
- Compare long term versus short term travel times (cases such as alternative routes for construction projects)
- Compare costs of acquiring and maintaining data among competing technologies
- Compare difficulty of accessing and processing data sources
- Determine other uses of travel time data
- Integrate technologies into the transportation systems management and operations (TSM&O) decision process for detection

Data Quality Comparison

T3E Study Overview – Study Area and Periods

Corridor	Corridor Start/End	Location	Route Type	Data Types
US 12/18	I-39/90 to WIS 73	East of Madison	Rural Arterial	TomTom, NPMRDS, Bluetooth
US 14 M (Madison)	US 12/18 to County MM	Fitchburg	Rural/ Urban Freeway	TomTom, NPMRDS, Bluetooth, ATR
County M	US 18/151 to County MM	Fitchburg/ Verona	Rural Minor Arterial	TomTom, NPMRDS
US 14 J (Janesville)	I-39/90 to WIS 140	East of Janesville	Rural/ Urban Arterial	TomTom, NPMRDS, Bluetooth, ATR
WIS 73	I-39/90 to WIS 106	Albion	Rural Arterial	TomTom, NPMRDS, Microwave
E Washington (US 151)	Blair St to Portage Rd	Madison	Urban Arterial	TomTom, NPMRDS, Bluetooth, ATR
I-39/90	IL Border to I-94	Dane/ Rock	Rural Freeway	TomTom, NPMRDS, Bluetooth, ATR, Microwave/Loop
US 12	I-39/90 to Parmenter St	South of Madison	Urban Freeway	TomTom, NPMRDS, Bluetooth, ATR, Microwave, Loop

Time Periods:
AM Rush, AM Peak, PM Rush, PM Peak, Weekday Daytime, Weekend Daytime, Nighttime



Data Quality

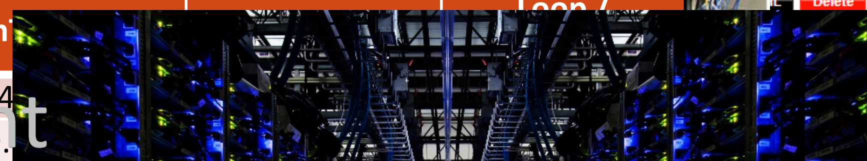
- Ease of Data Access
- Latency for Real-Time Application
- Reliability of Data Stream
- Ability to Archive Data
- Durability of Equipment
- Data Availability

TOMTOM

Welcome, Wisconsin_DOT_Madison (Log out)

T3E US-12 EB - VA

Bluetooth



Travel Time Outage (%)							
Percentage of Hours at Least 1% Outage	45.5	70.1	27.3	83.1	61.0	1.3	2.6

Data Availability Example – I-39/90

Total vehicle count – Number of vehicles counted/matched by detectors

Time Period	TT – CTT	BT	NPMRDS	µWave/Loop	ATR
AM Rush	82.2 | 61.4	163.7 | 138.5	Unknown	1813 | 1500	2233 | 1763
AM Peak	[illegible]	[illegible]	[illegible]	1936 | 1490	2353 | 1826
PM Rush	[illegible]	[illegible]	[illegible]	2066 | 2124	[illegible]489 | 2778
PM Peak	[illegible]	[illegible]	[illegible]	2121 | 2247	[illegible]551 | 2913
Weekday Daytime	[illegible]	[illegible]	[illegible]	1817 | 1714	2289 | 2232
Weekend Daytime	131.1 | 121.6	143.2 | 146.0	Unknown	1756 | 1682	2249 | 2305
Nighttime	33.3 | 29.9	71.5 | 67.5	Unknown	516 | 501	624 | 639

Units are in average number of vehicles per hour per segment or detector, NB | SB

Point detection can miss key incidents for travel times

Total vehicle percentage – Percentage of vehicles counted out of total on route

Time Period	TT – CTT	BT	NPMRDS
AM Rush	4.1 | 3.8	8.1 | 8.5	[illegible]
AM Peak	3.9 | 3.7	[illegible]	[illegible]
PM Rush	5.4 | 4.9	[illegible]	[illegible]
PM Peak	5.3 | 4.7	[illegible]	[illegible]
Weekday Daytime	12.8 | 11.9	[illegible]	[illegible]
Weekend Daytime	6.5 | 6.1	[illegible]	[illegible]
Nighttime	5.8 | 5.8	[illegible]	[illegible]

Units are in percent (num. of veh. per avg. ATR/µwave/loop count per seg. per detector), NB | SB

Probe data improving

Low total vehicle percentages do not equate to poor travel time estimates

Data Availability Example – I-39/90

Observation pct. – Pct. of segment-intervals that have at least one vehicle detected on route

Time Period	TT – CTT	BT	NPMRDS	µWave/Loop
AM Rush	Unknown	100.0 | 100.0	95 | 95.4	86.4 | 91.6
AM Peak	Unknown	100.0 | 100.0	95 | 95.3	86.5 | 91.7
PM Rush	Unknown	100.0 | 100.0	95.4 | 97.1	84.1 | 91.7
PM Peak	Unknown	100.0 | 100.0	95.2 | 96.9	84.2 | 92.0
Weekday Daytime	Unknown	99.8 | 100.0	95.6 | 96.8	84.3 | 91.6
Weekend Daytime	Unknown	99.9 | 100.0	94.9 | 95.7	86.2 | 90.5
Nighttime	Unknown	99.9 | 99.8	89.3 | 87.1	86.3 | 87.4

Units are in percentage of segment time periods with at least one observation, NB | SB

Useable travel time availability pct. – Pct. of time intervals that have calculable travel times

Time Period	TT – CTT	BT	NPMRDS	µWave/Loop
[illegible]	[illegible]	**100.0 | 100.0**	**100.0 | 99.8**	**100.0 | 100.0**
[illegible]	[illegible]	100.0 | 100.0	100.0 | 99.6	100.0 | 100.0
[illegible]	[illegible]	100.0 | 100.0	100.0 | 100.0	100.0 | 100.0
[illegible]	[illegible]	100.0 | 100.0	100.0 | 100.0	100.0 | 100.0
[illegible]	[illegible]	100.0 | 100.0	100.0 | 100.0	99.8 | 100.0
[illegible]	[illegible]	100.0 | 100.0	100.0 | 100.0	99.8 | 99.8
Nighttime	Unknown	100.0 | 100.0	97.2 | 92.5	100.0 | 100.0

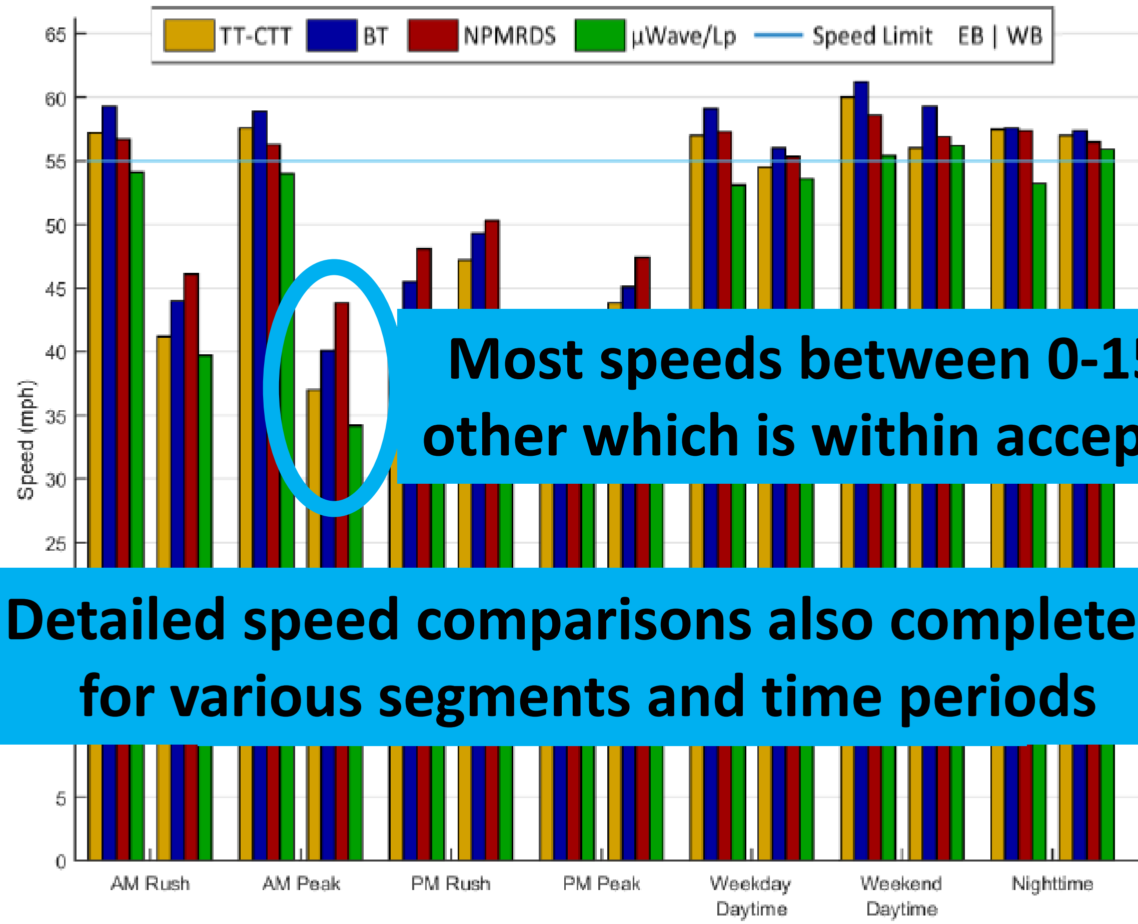
Bluetooth percentages include travel times that may not have been available in real time

Units are in percentage of travel times calculable for entire corridor for the entire month, NB | SB

Data Quality

- Ease of Data Access
- Latency for Real-Time Application
- Reliability of Data Stream
- Ability to Archive Data
- Durability of Equipment
- Data Availability
- Travel Time Accuracy

Average Travel Speeds for Urban Freeway (Beltline, Madison)



Most speeds between 0-15% of each other which is within acceptable limits

Detailed speed comparisons also completed for various segments and time periods

Ex reas; ns

Statistical Analysis – Basic

- Mean, standard deviation, and percentiles

I-39/90 Basic Travel Speed Statistics

Detection Type	Mean Speed	Standard Deviation	5th Percentile Speed	95th Percentile Speed	Minimum Speed	Maximum Speed
TomTo	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	N/A
Blueto	[illegible]	[illegible]	[illegible]	[illegible]	...6	98.39
NPMRI	[illegible]	[illegible]	[illegible]	[illegible]	...0	73.22
µWave	[illegible]	[illegible]	[illegible]	72.28	55.72	74.86

Units are in miles per hour

95th percentile
correspond well on
across detection

Bluetooth detectors have
the widest range of speeds,
even with outliers removed

Statistical Analysis – Detailed

- Mean absolute error (MAE) – Magnitude of Differences
- Root mean square error (RMSE) – Highlights Large Differences
- Correlation coefficient (Corr) – Linear Relationship
- Theil's inequality coefficient (U) – Alignment of time-series data
  - U^M – bias, U^S – variance, U^C – covariance --- 0=perfect match, 1=no pattern

I-39/90 Detailed Travel Speed Statistics

Detailed statistics show mixed results

Detection Type A	Detection Type B	Pairs	MAE	RSME	Corr	U	U^M	U^S	U^C
Bluetooth	NPMRDS	11,804	3.72	5.68	0.602	0.045	0.045	0.523	0.432
Bluetooth	µWave/Loop	11,670	5.83	8.21	0.288	0.063	0.270	0.104	0.626
NPMRDS	µWave/Loop	11,770	4.17	5.35	0.434	0.041	0.327	0.075	0.598

Units for MAE and RSME are in miles per hour while correlation and Thiel's coefficients are unitless

Cost Assessment Summary

	TomTom	NPMRDS*	Bluetooth	Microwave	Loop
10 mi.	9.2	15.1	17.3	20.9	25.2
100 mi.	1.5	1.5	9.6	13.2	17.5
1000 mi.	0.6	0.2	8.8	12.4	16.7

Net present cost estimates in thousands of dollars per mile, total for both directions
*NPMRDS cannot be used for real-time travel times

- Probe data are significantly less costly
- For short routes, costs similar
- All detection types gain from economies of scale
- Deployments at a small scale are very expensive

Conclusions and Recommendations

Cost-Benefit Comparison of Travel Time Technologies Used in this Study

	TomTom (CTT)	NPMRDS	Bluetooth	Microwave	Loop
Benefits					
Access					
Latency					
Reliability					
Archiving					
Durability					
Processing					
Available Observations					
Travel Time Availability					
Travel Time Accuracy					
Travel Time Consistency					
Costs					
Initial Cost					
Annual Cost					
Replacement Cost					
Averages					
Benefits	2.8	5.0	3.0	3.9	4.2
Costs	3.3	5.0	2.7	3.0	4.0
Overall	3.1	4.1	2.8	3.5	4.1

Conclusions

- **Which technology to use? It depends**
- **Temporary Deployment:**
  - **Bluetooth or microwave**
  - **unless you already have probe data**
- **Permanent Deployment:**
  - **Small scale – loops**
  - **Large scale – probe data**
- **If probe data contract in place, use that data exclusively and continue to verify with existing infrastructure**

Future Considerations

- Work with a variety of third-party probe data providers to secure the best price
- Study specific traffic events to get a better picture about latency
- Study TomTom data more precisely to determine true travel time availability percentages
- Study reported travel times as compared to travel times from the technologies in this study
- Be prepared to transition travel time messages to other technologies
- Integrate technologies into the TSM&O Traffic Infrastructure Process (TSMO-TIP)
- Continue to monitor connected vehicles (CVs) as an option for calculating Travel Times

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Thank You!

- Contacts

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