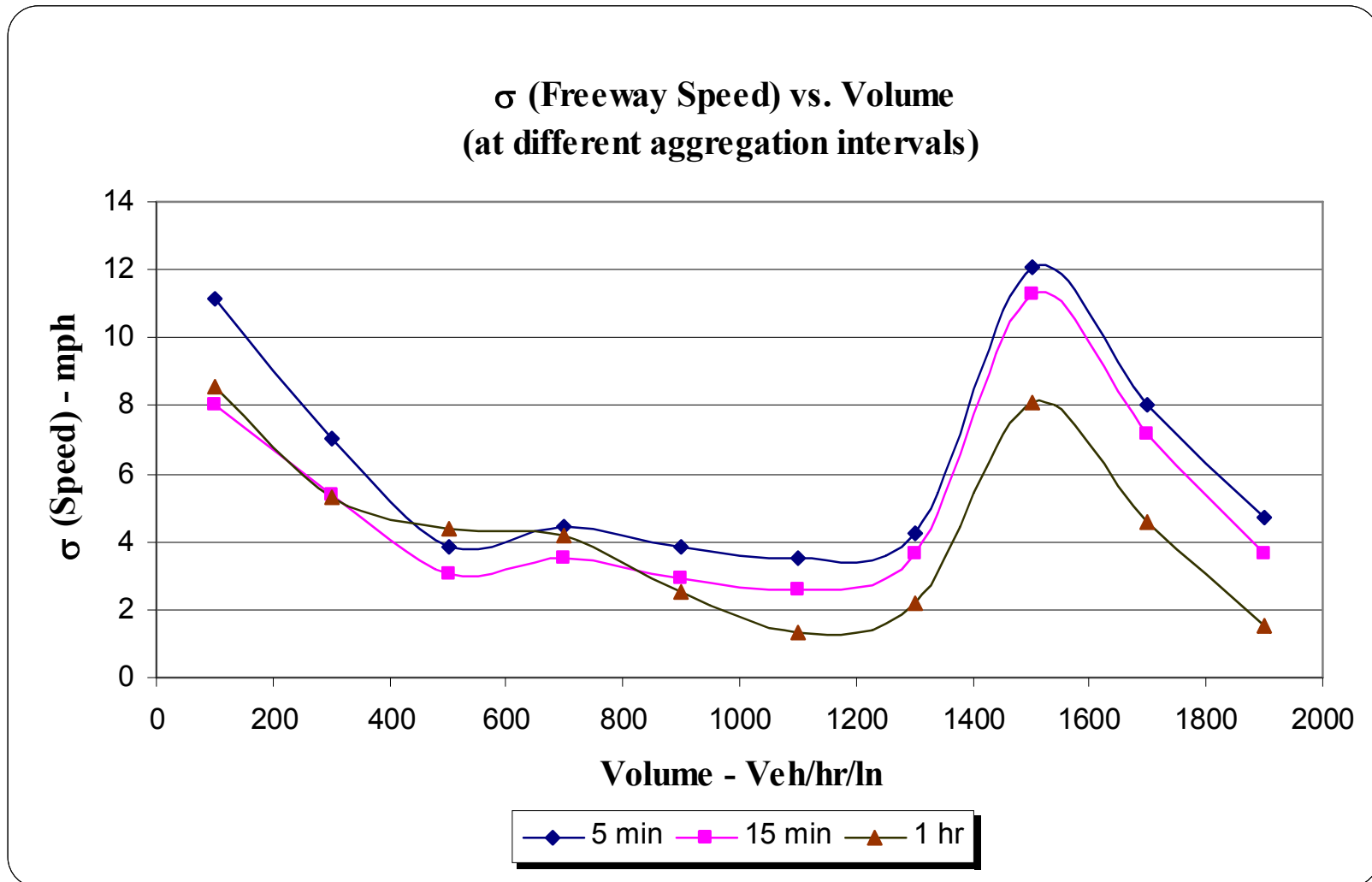


Dec 20, 2007
Operations Performance
Measures Conference Call

Required Accuracy of Measures

Performance Measure	Applications			
	Traffic Engineering	Transportation Planning	OPERATIONS	
			Traffic Management	Traveler Information
Customer Satisfaction	5% - 10%	5% - 20%		
Incident Duration			5% - 10%	
Throughput - Vehicle			5% - 10% [1]	
Throughput - Person			5% - 15%	
Speed	1% - 5%	2% - 10%	5% - 10% [1][2]	5% - 20% [1]
Travel Time - Facility				
Travel Time - Trip				
Travel Time - Reliability	5% - 10%	5% - 15%	5% - 10%	10% - 20%
Recurring Delay				
Non-Recurring Delay				
Extent of Congestion - Spatial				
Extent of Congestion - Temporal				

Fundamental Traffic Flow Variance



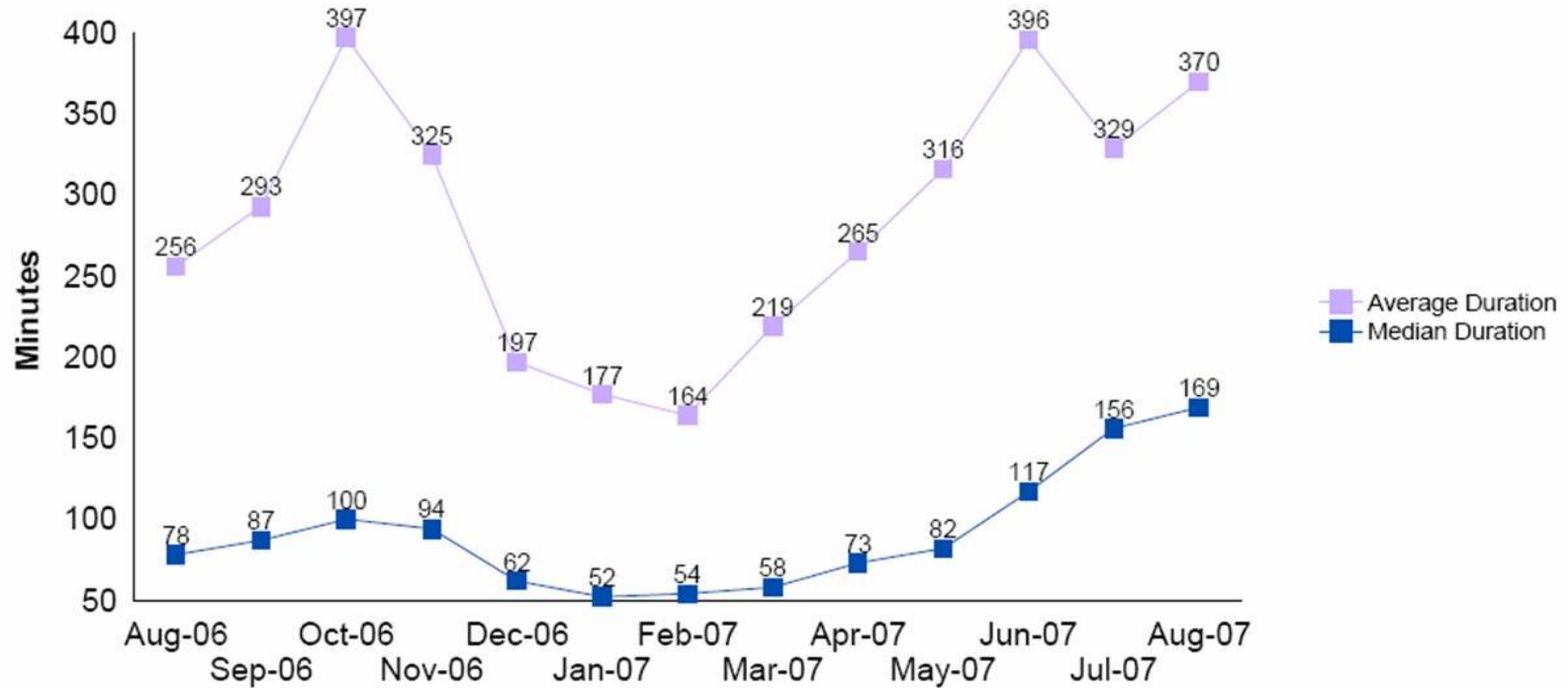
Pilot Testing Participants

		<div style="display: flex; justify-content: space-between;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Customer Satisfaction</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Travel Time - Facility</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Travel Time - Trip</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Travel Time - Reliability</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Delay - Recurring</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Delay - Nonrecurring</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Speed</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Extent of Congestion - Spatial</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Extent of Congestion - Temporal</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Throughput - Vehicle</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Throughput - Person</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Incident Duration</div> </div>											
Organization		1	2	3	4	5	6	7	8	9	10	11	12
1	Baltimore Metropolitan Council	X											
2	City of Overland Park, Kansas	X	X										X
3	Colorado DOT		X			X			X		X		
3	Florida DOT - District 4	X	X			X	X	X	X	X	X		X
4	Florida DOT - District 5		X		X				X	X			
5	Georgia Regional Transportation Authority (GRTA)		X		X								
6	Maricopa Association of Government (MAG)		X		X			X	X	X	X	X	
7	Maryland SHA												
8	MetroPlan Orlando	X											
9	Maryland SHA		X					X					X
10	Southern Nevada RTC		X		X	X			X	X	X		
11	Virginia DOT	X	X					X	X	X	X		X
12	Wasatch Front Regional Council		X			X		X			X		
13	Washington DOT		X		X			X	X	X	X	X	X

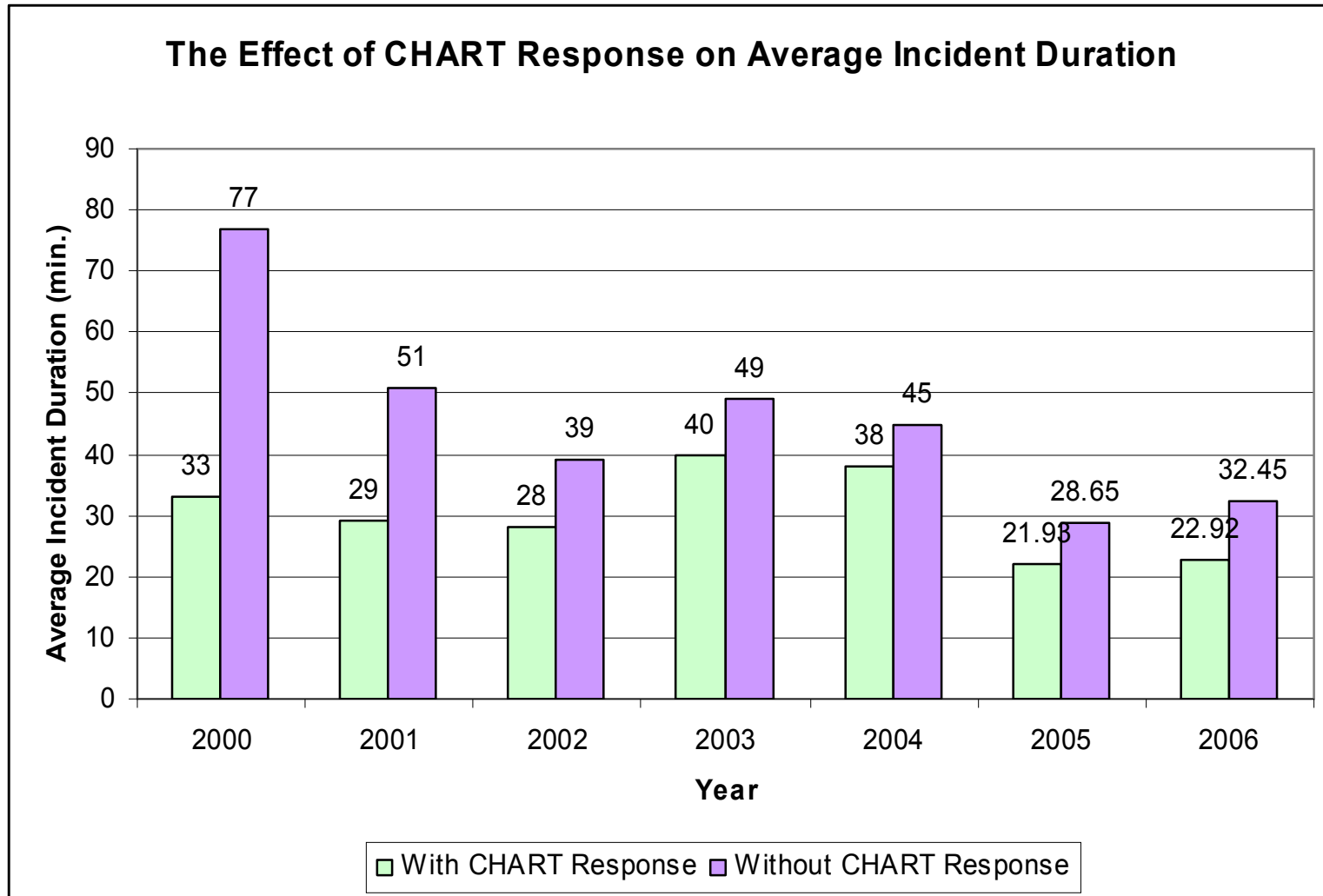
Mean vs Median

August 2007 Statewide Average Incident Duration = 370
August 2007 Statewide Median Incident Duration = 169

Statewide Average and Median Incident Duration



Effectiveness of Incident Management Systems



Traffic Flow Measures

Volume, Occupancy, Speed, and Travel Time Data Collection														
Agency	Type of Facilities	Data Collection Method or Technology	Extent of Data Collection / Study Area	History of Data Collection	Sampling Parameters	Performance Measures Assessed							Notes	
						Speed	Travel Time	TT - Reliability	Recurring Delay	Non-Recurring Delay	Extent of Congestion	Throughput		
Colorado DOT	Commuter & Recreational Corridors	Floating car	68 corridors (Length: 1 - 54 mi)	Since 2000 on some corridors	8 runs for each period		✓		✓		✓	✓	Data collection for 2007 estimated at \$318,000.	
Florida DOT District 4	Freeway	Fixed Sensors Side-fire Radar	Two interstate corridors ~40 miles in length, I95 & I595	Initiated 2007	Data is polled every 20 seconds	✓	✓					✓	Initial applications will be color coded maps and travel time on signs	
Florida DOT District 5	Arterial	Probe vehicle Toll Tag Transponders	135 mile arterial network, representing 74 corridors	Initiated 2007	Travel time from matched toll tags each minute		✓					✓	---	
Georgia Regional Transportation Authority (GRTA)	Freeway	Fixed Sensors: Video Based	16 bidirectional corridors (Length: 4 - 15 mi)	Reported since 2002	Aggregated to 15 minute intervals		✓	✓					Primary technical challenge was a calculation algorithm to account for high degree of sensor outages	
Maricopa Association of Government (MAG)	Freeway	Fixed Sensors: Passive Acoustic Detectors & Loops	6 corridors (Length: 8 - 10 mi)	Since 2000	Reported in 15 minute intervals	✓	✓	✓				✓	✓	AZ DOT provides data to MAG. Quality and maintenance concerns addressed in 2005 resulting in a higher quality data at the expense of a smaller network of
Maryland SHA	Freeway	Fixed Sensors: Side Fire Radar	70 Detectors throughout the Baltimore - DC area	Since 2002	5 minutes	✓	✓						Data quality control issues prevents use of sensor data for performance measures	
Overland Park, KS	Arterial	Floating car	25 corridors (Length: 0.25 - 3 mi)	1994 to 2007	10 runs per direction		✓						Data collection requires 150 hours of staff time yearly	
Southern Nevada Regional Transportation Commission	Freeway	Fixed Sensors: Side Fire Radar & Loop Detectors	8 centerline miles on I-15 in Las Vegas between I-215 at the south and US 95 at the north	Since Sept 2006	Aggregated to 15 minute intervals		✓	✓	✓			✓	✓	Data sets and procedures from the pilot test are intended to be used as a function sample for future production implementation.
Virginia DOT	Freeway	Fixed Sensors: Dual Loops	Statewide monitoring from 216 permanent count stations	Archive available since 2003	Polled every 15 minutes	✓						✓	Costs for permanent count stations are available	
		Fixed Sensors: Loop	6 corridors on I66 in Northern VA (Length: 7 - 11 miles each)				✓					✓	---	
Wasatch Regional Front Council (WFRC)	Freeway	Fixed Sensors	---	---	Continuous	✓	✓		✓			✓	Utah DOT is currently implementing new analysis software. WFRC provided sample calculations of recommended/intended measures	
Washington DOT	Freeway	Fixed Sensors: Loop Detectors 4000 Single Loop 100 Dual Loop	35 commuting corridors (Length: 7 - 25 mi)	At least since 2002	Polled every 20 seconds, aggregated to 5 minutes	✓	✓	✓				✓	✓	WSDOT uses an extensive quality control plan for maintenance, calibration, and error checking developed by University of Washington TRAC.

Contrast of Data Collection Methods

Contrast of Data Collection Methods														
Method	Sub-Method	Base Measurements	Typical Sampling Parameters	Freeway Use	Arterial Use	Performance Measures Supported							Costs	Primary Deployment Issues
						Speed	Travel Time	TT - Reliability	Recurring Delay	Non-Recurring Delay	Extent of Congestion	Throughput		
Fixed Sensor	Single Loops	Volume & Occupancy	5 Minute	✓		X	X	X	X	X	X	X	\$7500 to \$20000 per site depending on availability of existing structures	Costs, Sensor Density, Maintenance, Quality Control
	Dual Loops	Volume, Occupancy, & Speed	5 Minute	✓		X	X	X	X	X	X	X		
	Cross-Fire Radar	Volume, Occupancy, & possibly Speed	5 Minute	✓		X	X	X	X	X	X	X		
	Video Cameras	Volume, Occupancy & Possibly Speed	5 Minute	✓		X	X	X	X	X	X	X		
Floating Car	GPS Instrumented	Travel Time	8-10 Runs per year, per corridor	✓	✓	X	X		X		X		Budget \$300 to \$500 per mile	Minimum Sampling Parameters
Vehicle Probe	Toll-Tag Transponder	Travel Time	1-5 minute	✓	✓	X	X	X	X	X	X		\$15000 per site per direction (exclusive of structures)	Density of Toll-Tags and Cost of Equipment
	Fleet GPS Data		5 - 15 minutes	✓	?	X	X	X	X	X	X		\$500 - \$1000 / mile / year	Data Latency and Sampling Density
	Cell Phone Probes		1-10 minutes	✓	?	X	X	X	X	X	X		\$500 - \$1000 / mile / year	Accuracy, Privacy, and Business Model Sustainability

Fixed Sensor Issues

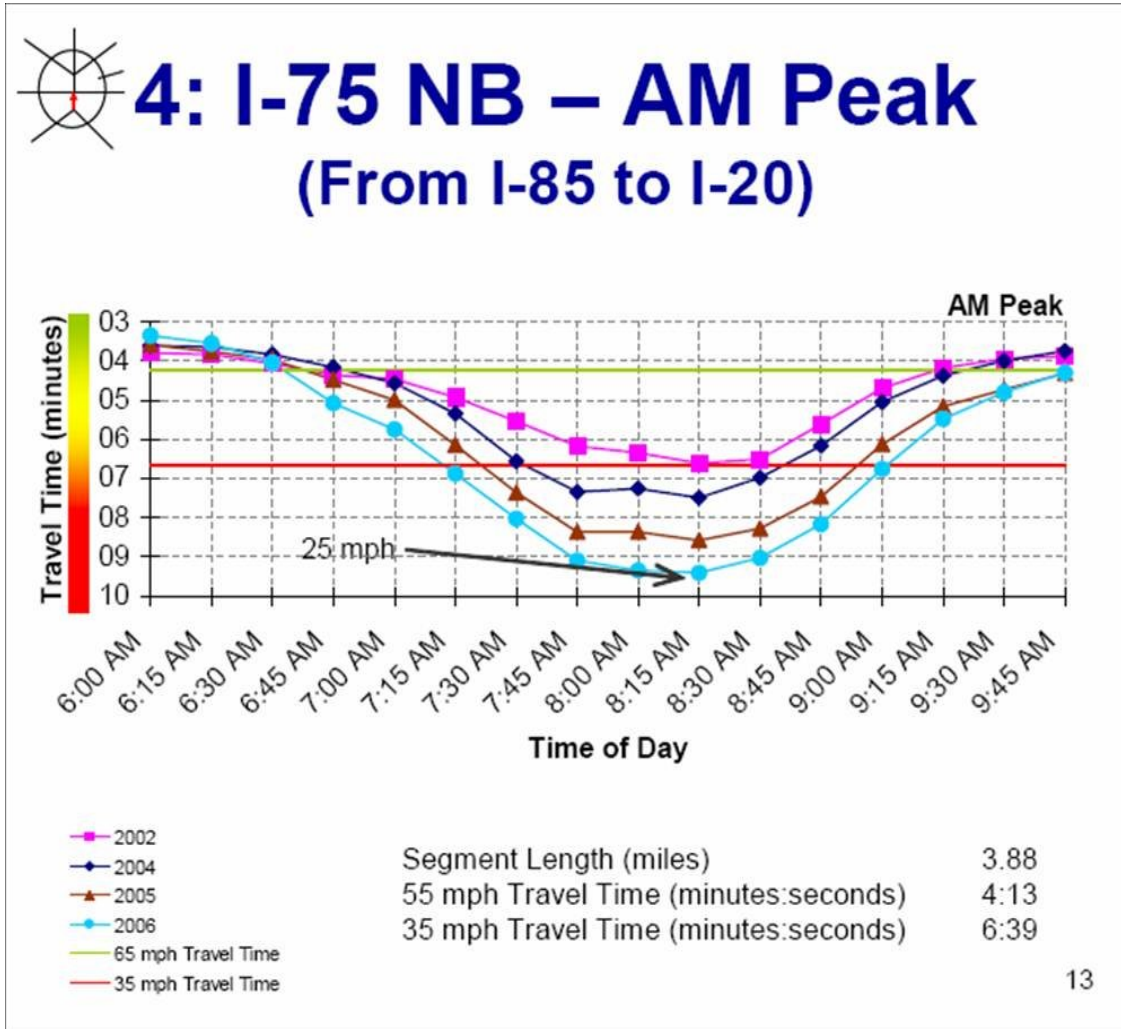
Fixed Sensor Spacing		
Agency	Sensor Spacing	Data Collection Method or Technology
Florida DOT District 4	1/2 mile	Side-fire Radar
Georgia Regional Transportatoin Authority (GRTA)	1/3 mile	Video Based
Maricopa Assocation of Government (MAG)	2-3 miles	Passive Accoustic Detectors & Loops
Maryland SHA	1.5 to 3 miles	Side Fire Radar
Southern Nevada RTC	1/3 mile	Side Fire Radar & Loop Detectors
Washington DOT	1/2 mile	Loop Detectors 4000 Single Loop 100 Dual Loop

- Effective for Freeways
- Not for Arterials
- Maintenance and Quality Control Issues
- Simple Conversion to Travel Time

Travel Time - Facility

Travel Time Performance Measure Summary						
Agency	Type of Facilities	Primary Application	Reporting Frequency & History	Periods of Reporting	Reporting Costs	Notes
Colorado DOT	Urban & commuter corridors	Congestion Tracking	Annually	Peak hours: 7 AM - 9 AM, 4 PM - 6 PM; Off-peak hours: 11 AM - 1 PM	Reporting costs included in data collection contract of \$318000	---
	Recreational corridors			Peak hours: 11:30 AM - 5:30 PM; Off-peak hours: 9:30 AM - 11:30 AM, 5:30 PM - 7:30 PM		---
Florida DOT District 4	~40 Miles from I-95 and I-595 near Miami	Traveler Information - travel time via SmartGuide website	In development	Continuous - Realtime	---	---
Florida DOT District 5	135 centralline miles of arterials in central Florida (Orlando area)	Traveler Information through the 511 System	Continuous through the 511 system	Continuous - Realtime	---	Extensive travel time reporting on a large arterial network
Georgia Regional Transportation Authority (GRTA)	16 major freeway commuting corridors in the Atlanta metropolitan area	Congestion Tracking	Annual Report since 2002, available on the internet	Travel time is reported every 15 minutes for the AM Peak: 6 AM - 10 AM and PM Peak: 3 PM - 7 PM	\$12,000 consulting fees plus an additional 80 staff hours annually	Exceptional clarity in use of graphics to display annual growth of travel time
Maricopa Association of Government (MAG)	6 heavy volume freeway commuter corridors in the Phoenix metro area	Congestion Tracking	Annual Congestion Report	Peak hours: 5 AM - 10 AM, 2 PM - 7 PM	62 staff hours annually	---
Maryland SHA	Freeway network in the Baltimore - DC metro area	Travel time on Changeable Message Signs	Under development	Continuous - Realtime	---	---
Overland Park, KS	Network of arterials in the city of Overland Park, KS	Assessment of Signal Coordination	Yearly Reporting since 1994	Travel Time is sampled yearly with floating cars, and reported for the AM Peak: 7 AM - 9 AM PM Peak: 4:30 PM - 6 PM	70 hours/year of staff time to compile annual report	Data also includes travel time without signal coordination
Southern Nevada RTC	Portion of freeway network in Las Vegas, NV	Congestion Tracking	The RTC is experimenting with various measures and reporting methods. Pilot results will serve as functional examples for production.			Data from the sensor network is currently reported as a distribution over speed and volume ranges.
Virginia DOT	I-66 in Northern Virginia	Traveler Information: Travel time on website	Under development	AM & PM Peak, and 24 hour	\$15,000 initial cost plus \$50,000/year in staff time	---
Washington DOT	Freeway commuting routes, 52 in the Puget Sound area, and two in Spokane	Congestion Performance Measures	Annually	Peak hours: 6 AM - 9 AM, 3 PM - 7 PM	---	Consistent, statewide monitoring and reporting methodology via the Grey Notebook
WFRC	Freeway network	Congestion Tracking	Utah DOT is currently implementing new analysis software. WFRC provided sample calculations of recommended/intended measures			---

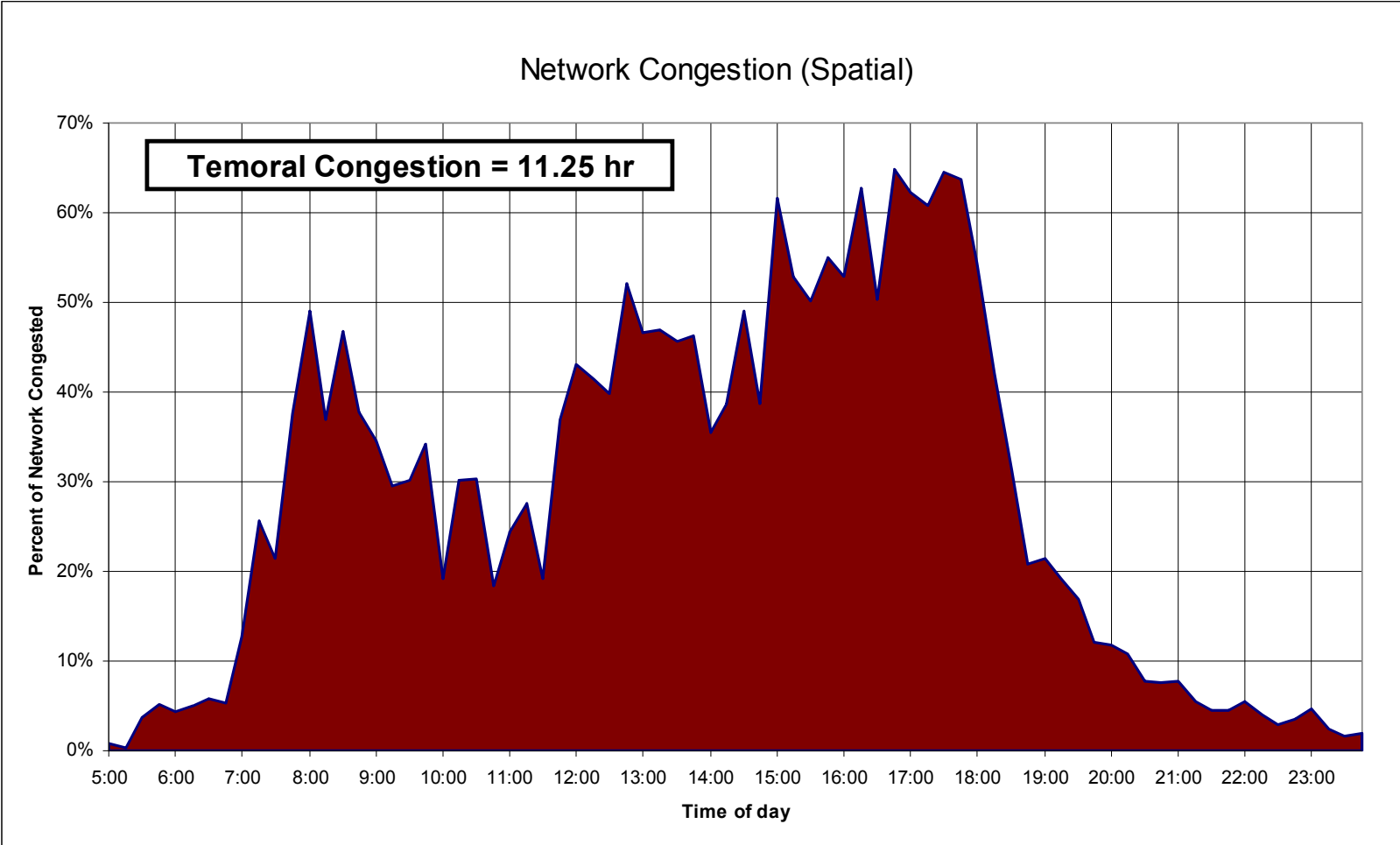
Effective Reporting - GRTA



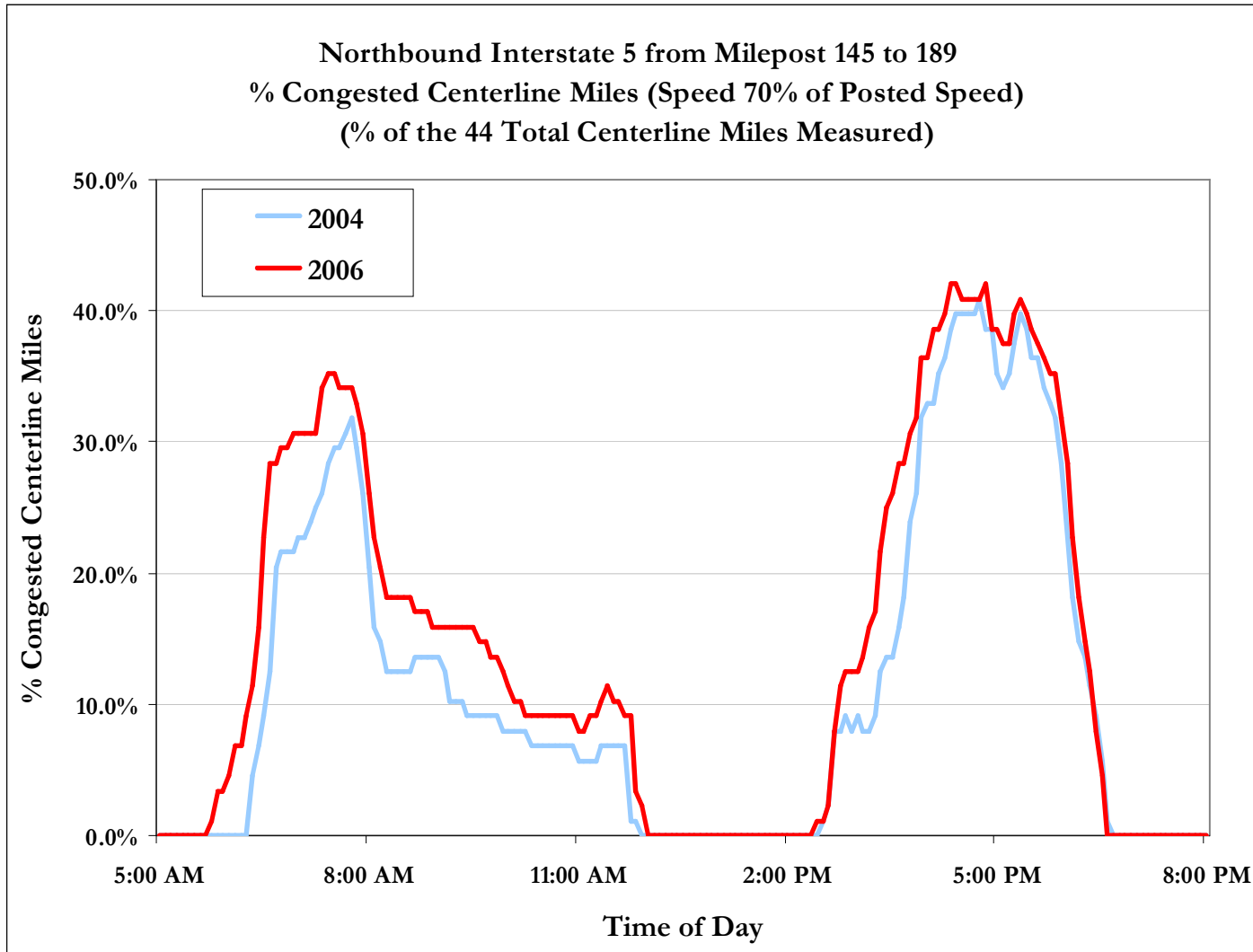
Extent of Congestion – Spatial & Temporal

Throughput - Vehicle & Person							
Agency	Vehicle Throughput			Person Throughput			
	Extent	Utility	Cost	Extent	Occupancy Factors	Utility	Cost
Colorado DOT	72 hour counts using tube/radar in conjunction with the floating car runs for 68 corridors (urban, commuter, & recreational)	Included in the corridor report and necessary for delay calculations	Included in the floating car data collectoin contract of ~\$318K				
Maricopa Association of Government (MAG)	Same network and extent as other measures, 26 locations on 6 selected corridors	Annual mobility report, calibrating/validating travel demand forecasting model	---	Same network and extent as other measures, 26 locations on 6 selected corridors	Manually collected vehicle occupancy data on each freeway detector location in 2006 - 2007.	Data has been reported on the MAG annual freeway mobility report, MAG regional traffic counts database and HPMS database.	---
Southern Nevada RTC	~ 8 mile portion of freeway network in LasVegas, NV	The RTC system is still in development. The system reports throughput as percentages in various volume ranges per section on a hourly basis to help identify congestion patterns.	---				
Virginia DOT	Statewide, 216 dual loop count stations	Used in conjunction with speed index to assess system's performance. Develop factors to create AADT and VMT estimates	---				
Washington DOT	Data is currently collected on most major freeways in the Puget Sound Region at approximately ½ mile intervals.	Volume measures are used to assess maximum throughput productivity, a primary congestion metric. Vehicle throughput is used in the Gray Notebook report distributed once/year.	Vehicle volume processing is a negligible percentage of the overall regional loop data collection system budget. This analysis is conducted annually as part of WSDOT's Performance Measurement work and consists of staff analysis time.	Selected locations are monitored each year throughout the Puget Sound region freeway network, on I-5, I-405, I-90, SR520, and SR167. Data are collected from both HOV and GP lanes	Based on up to thirty 30-minute peak period field counts per unique location/ travel direction /lane type during the Spring and Summer. Transit/vanpool ridership are based on all peak period ridership data from one transit service provider.	Three annual reporting mechanisms: (1) Gray Notebook external performance reporting document (2) a Seattle-area HOV lane system evaluation report (3) a Seattle-area freeway usage and performance monitoring report Person throughput estimates are also used by WSDOT to support a variety of HOV analyses, and as part of white papers and brochures.	\$176K/year for occupancy data \$6K/year for analysis and reporting

Extent of Congestion – applied to arterials, FDOT D5



Extent of Congestion – 30% Threshold



Travel Time Reliability

Travel Time Reliability								
Agency	Type of Facilities	Reporting Frequency & History	Periods of Reporting	Unit of Measure Reported			Reporting Costs	Notes
				95% Travel Time	Planning Time Index (PTI)	Buffer Time Index (BTI)		
Georgia Regional Transportation Authority (GRTA)	16 major freeway commuting corridors in the Atlanta metropolitan area	Annual Report since 2002, available on the internet	15 minute intervals during peak periods: 6 AM -10 AM and 3 PM - 7 PM			✓	\$12,000 consulting fees plus an additional 80 staff hours annually for all measures	
Maricopa Association of Government (MAG)	6 heavy volume freeway commuter corridors in the Phoenix metro area	Annual Congestion Report	15 minute intervals during peak periods: 5 AM - 10 AM and 2 PM - 7 PM	✓	✓		62 staff hours annually (all measures)	Included as a standard measure in travel time reporting
Southern Nevada RTC	Portion of freeway network in Las Vegas, NV	In Development, sample calculation from pilot study will serve a functional sample for later production.					---	
Washington DOT	Freeway commuting routes, 52 in the Puget Sound area, and two in Spokane	Annual report and also on its interactive "Calculate Your Commute" website.	5 minute intervals during peak periods: 6 AM - 9 AM and 3 PM - 7 PM The five-minute interval with the highest average travel time value is used for reporting of reliability measures.	✓			---	Reports reliability stats only on commutes experiencing congestion, 38 of the 52 routes in the 2007 report.

Recurring Delay

Recurring Delay				
Agency	Facility Type	Measures Reported	Definition of Unconstrained Travel Time	Reporting
Colorado DOT	Arterials & Freeways Commuter and recreation corridors	Annual vehicle hours per route Annual person hours per route Annual congestion cost per route	Travel time during off-peak period	Annual reports for each corridor
WFRC	Freeway system in and about Salt Lake City and Ogden Ares	Individual vehicle delay per mile (sec /mile) Total vehicle delay per lane-mile (veh-min/lane-mile or min/mile)	Based on posted speed or functional class or roadway	System currently in development
Southern Nevada RTC	Freeway Portion of LasVegas freeway system	In Development		
Washington DOT	Statewide monitoring of major commuter routes	Vehicle hours per day per mile Vehicle hours per day per metro area Statewide - daily and annual vehicle hours of delay Annual cost of delay on state highways	Optimal flow speed (~51 mph) Posted Speed	Annual reports as part of the Gray Notebook

- No submittals of Non-recurring Delay