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SENIOR MANAGEMENT PROGRAM

Module II
Measuring Mobility and Operations

Section 1
Considerations for Mobility Measures

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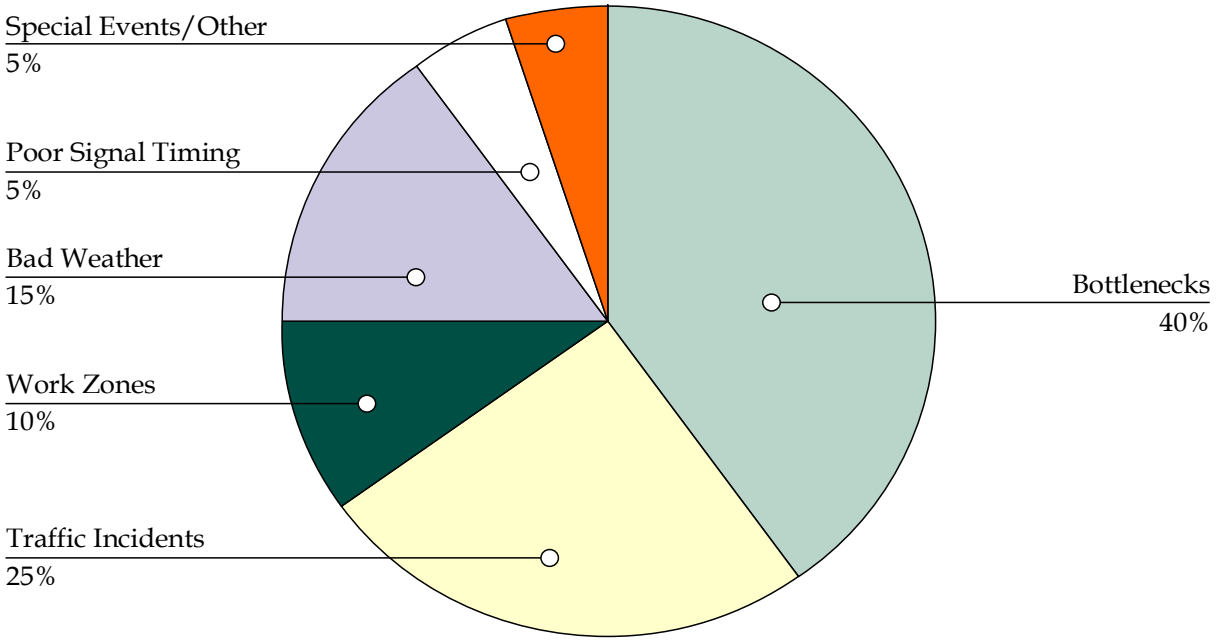
Potential Definitions of Congestion

Congestion *[kuh n-**jes**-chuh n]*

1. **Overcrowding; clogging**
2. **A giant headache.**
3. **It's relative. You know it when you see it.**
4. **Anything below the posted speed limit?**
5. **The inability of the highway to carry sufficient vehicles to meet demand, resulting in lower speeds and highways operating at below maximum efficiency**
6. **A good thing: a sign of economic success**
7. **Moving very slowly at less than 10 mph (17%). (U.K. Survey, 2001)**

Molecules Don't Think, but People Do: Sources of Congestion

Figure 5.10 The Sources of Congestion
National Summary



Source: NCHRP 3-68, Cambridge Systematics, et al. *Guide to Effective Freeway Performance Measurement. Preliminary Draft Final Report.*

Molecules Don't Think, but People Do: Sources of Congestion

	Cause of Delay	Large Urban Areas (>1 million)	Small Urban Areas (0.1-1.0 million)	Rural
Reporting Causes	Network Capacity Exceeds Demand	29-37%	20-26%	0
	Poor Signal Timing	4-5%	7-13%	2%
Total Recurring		33-42%	32-33%	2%
Non-Recurring Causes	Crashes	35-36%	19-26%	26%
	Breakdowns	6-7%	6-10%	25%
	Workzones	8-19%	26-27%	39%
	Weather	5-6%	7-10%	7%
	Special Events	1%		
Total Non-Recurring Causes		58-67%	67%	98%

Data Source: Lockwood, 21st Century DOT. Breakdown averaged from TTI and ORNL larger urban area figures as reported by FHWA

Source: TRB Project 20-24 The 21st Century Operations-Oriented State DOT. Breakdown averaged from TTI and ORNL larger urban area figures as reported by FHWA

Performance Tracking and Reporting: The Next Frontier

…The biggest challenge of performance measurement, especially when applied to the operations side of transportation, is that the field is behind the curve of both other professions and other areas of the transportation profession…some areas of transportation have embraced performance measurement for nearly two decades. Applying performance measurement to operations is much more of a recent focus…

(from Bertini, You are the Traffic Jam; 2006)

Performance Tracking and Reporting: The Next Frontier

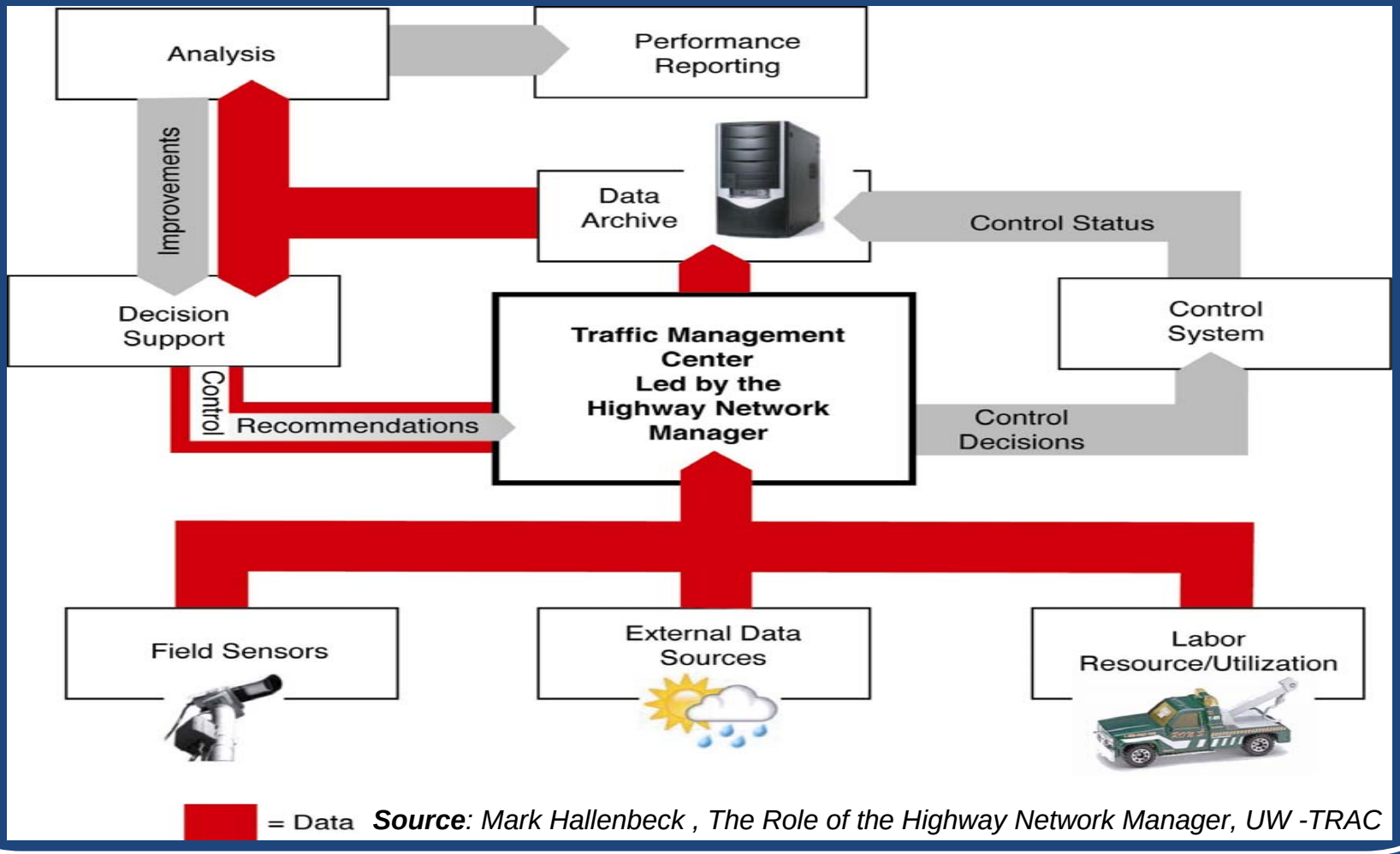
- Highway Systems (aka Mobility) performance measurement is a very complex, and often politically sensitive measurement area
- No “magic bullet” measurement system exists - One size does not fit all.
- Cultural shift to active, real time, customer focused system management continues to be difficult
- Real-time data needs pose significant challenges
- Mobility measures are constantly evolving - It’s an iterative process

Real-time Performance Information Needs To Feed Real-time Operational Decisions

- **Examples Include:**
  - **Ramp metering rates**
  - **Messages posted on dynamic message signs (DMS) or other information dissemination systems (e.g., the Internet)**
  - **Changes in lane control signs (LCS) and/or barriers**
  - **Toll rates (for High Occupancy Toll—HOT—lanes and other value priced, managed lanes)**
  - **Incident response actions**
  - **Requests for enforcement**

Source: Mark Hallenbeck , *The Role of the Highway Network Manager,* UW -TRAC

Real-Time Operational Data and Information Flow Within The Smart Highway



***Source**: Mark Hallenbeck , The Role of the Highway Network Manager, UW -TRAC*

What Should a Highway Agency Measure and Routinely Report On?

- The level of facility use and how is it changing
- How often the roadway is congested
- When and where that congestion takes place and how long it lasts
- How many incidents/accidents take place, where they are located, and their nature

It Should Also Routinely Examine the Effects of Management Actions

- **How does the congestion frequency/location/duration change as new traffic management actions are taken?**
- **How quickly are incidents cleared?**
- **Are specific staff more effective than others at clearing incidents?**
- **How do volumes and speeds change once specific message signs are placed?**
- **How large are queues at ramp meters?**
- **Are road maintenance contractors getting in and out of the right-of-way at the designated times, and are their traffic control strategies effectively mitigating congestion at the construction location?**

***Source**: Mark Hallenbeck , UW -TRAC*

...and How Do Customers React To Agency Policies and Strategies, i.e.:

- **How has demand changed when the pricing structure (for managed lanes) is changed (total demand, and patterns of use)?**
- **Does the new pricing structure result in an improvement in revenue/usage/congestion relief?**

National & International Efforts Related To Mobility Measurement and Reporting

- NTOC-Recommended Performance Measures: focused on quality of service (outcome).
- Texas Transportation Institute (TTI's) Urban Mobility Report (annual)
- American Society for Testing and Materials (ASTM) ITS data standards
- "National Strategy to Reduce Congestion on America's Transportation System and Urban Partnership Project (USDOT)
- National Traffic Incident Management Coalition: National Unified Goal for Traffic Incident Management
- International Efforts, UK, Japan, Victoria, Australia, etc.
- AASHTO: The 21st Century Operations-Oriented State DOT
- Strategic Highway Research Program (SHRP-2)'s Reliability Focus Area

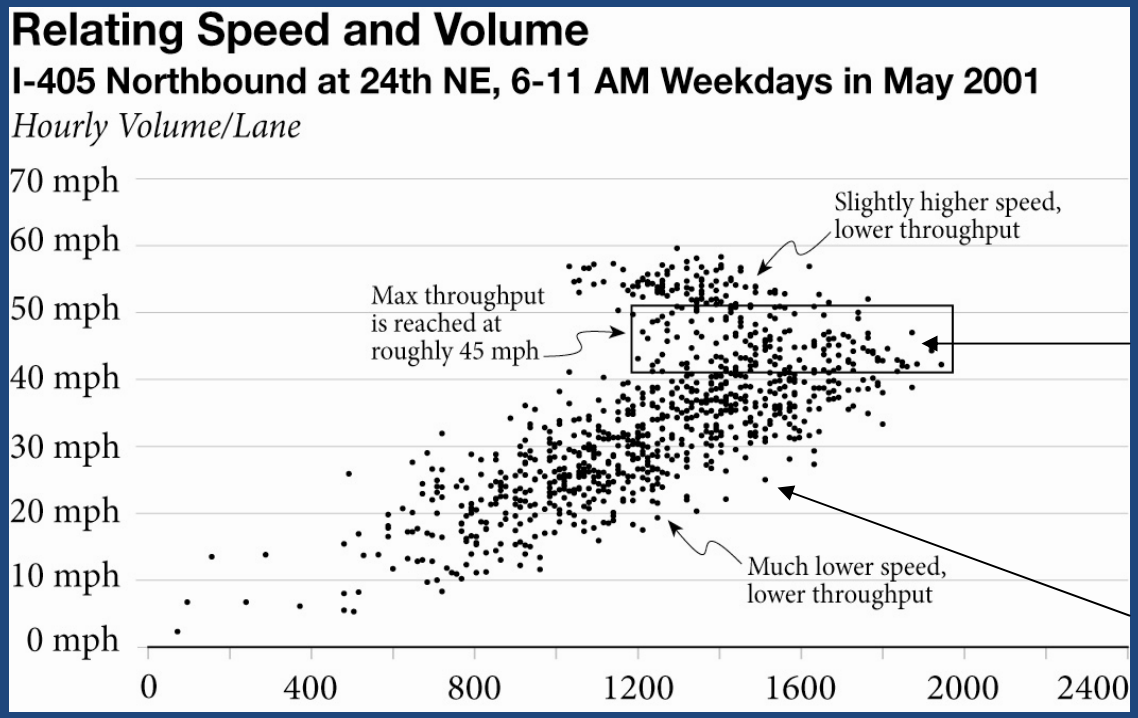
Defining System Management Goals and Targets

Optimization:

- Maximum number of vehicles/people?
- Maximizing revenue?
- Minimizing delays?
- Maximum benefit gained from dollars spent (cost/benefit)?

Maximizing System Throughput

The speed volume curve – What does it really mean?



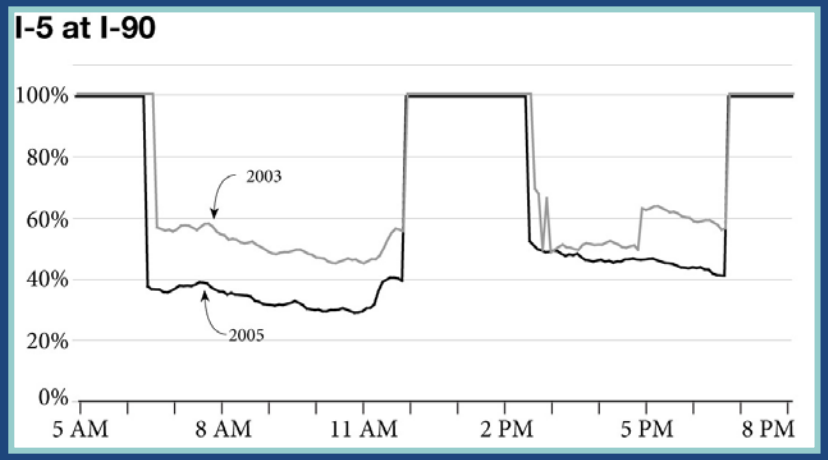
At speeds slightly below the speed limit, throughput is increased

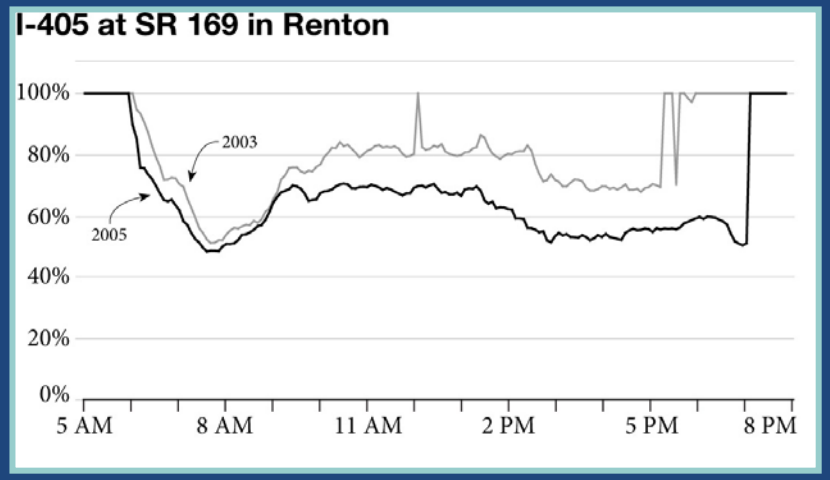
Max throughput is reached at roughly 42-50 mph

As congestion causes speed to drop, throughput declines dramatically

Maximizing System Throughput

...Showing the Data…





Measuring and Communicating the Productivity Gap

And Telling the Story:

…According to the real-time data recorded on some of the most congested freeways in the Central Puget Sound, less than half the existing capacity is effectively used at a time when it is needed the most. When cars are stuck in congestion, the difference between the potential capacity of the roadway and the actual number of cars that the road is serving is called "lost productivity," "lost throughput," or "lost capacity". Whatever the term, congested freeways deliver far fewer benefits to citizens than if the roads could be kept flowing smoothly…

Considerations for Mobility Measures: Related Resources

- Bertini, R. (2005) *You are the traffic jam: An examination of congestion measures.*
- Bremmer, D., Cotton, K., Coty, D., Prestrud, C., & Westby, G., *Measuring Congestion: Learning from Operational Data*; 2003, TRB
- Brydia, R. (2006) *Background development and concept of operations for a real-time performance measurement monitoring system*.
- *FHWA (2006) Travel Time Reliability: Making it There On Time, All the Time*
- Hallenbeck, M. UW-TRAC, unpublished White Paper, *The Role of the Highway Network Manager.* With permission.
- NCHRP 3-68, *Guide to Effective Freeway Performance Measurement* (2006)
- NCHRP 20-24 (21), *The 21st Century Operations-Oriented State DOT* (2005)
- NCHRP Synthesis 311; *Performance Measures of Operational Effectiveness for Highway Segments and Systems (2003)*
- Texas Transportation Institute. *Urban Mobility Report.* College Station, Texas: Texas A&M University, 2005
- WSDOT, *Gray Notebook*, September 2006, Annual Congestion Report
- WSDOT *Highway Congestion; What Is To Be Done* (Senate Presentation, January 16, 2006)
- Victorian Competition & Efficiency Commission. Making the right choices : Options for managing transport congestion. Melbourne, Victoria : Aus. Government Printing Office, (2006).
- U.S. Department of Transportation, *National Strategy to Reduce Congestion on America's Transportation Network* (May 2006).
- Japanese Ministry of Land, Infrastructure, and Transport, Road Bureau www.mlit.go.jp/road/road_e/index_e.html

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Module II
Measuring Mobility and Operations

Section 2
Principles of Mobility Measurement: Overview

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Mobility Performance Measures: Key Principles, Principle 1

Mobility performance measures must be based on the measurement or estimation of travel time.

Travel time: the average time consumed by vehicles traversing a fixed distance of freeway.

Handout: Key Principles of Mobility Performance Measurement, NCHRP 8-36: Guide to Effective Freeway Performance Measurement**.**

Mobility Performance Measures: Key Principles, Principle 2

2-a: Measure where you can – model everything else

2-b: Measure where you can –Develop Before and After Case Studies.

- **Lots of Data: Ongoing system monitoring and reporting**
- **Limited or Little Data: Before and After Project/Activity Analysis -show on a case-by-case basis the changes in system performance**

An Example of On-going, Real-time Data Reporting

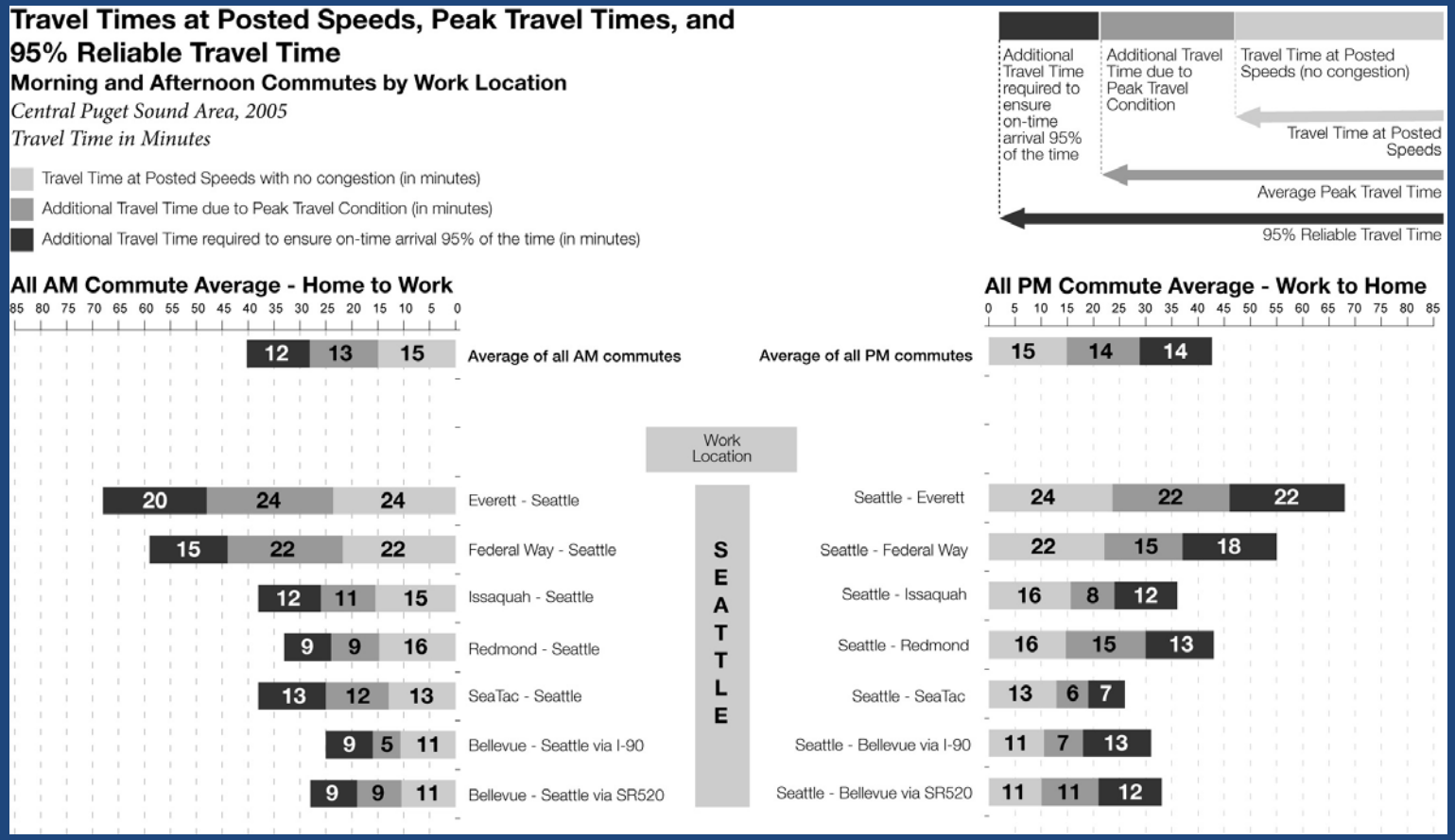


Figure Source: WSDOT 2006 Congestion Report

An Example of Before and After Analysis

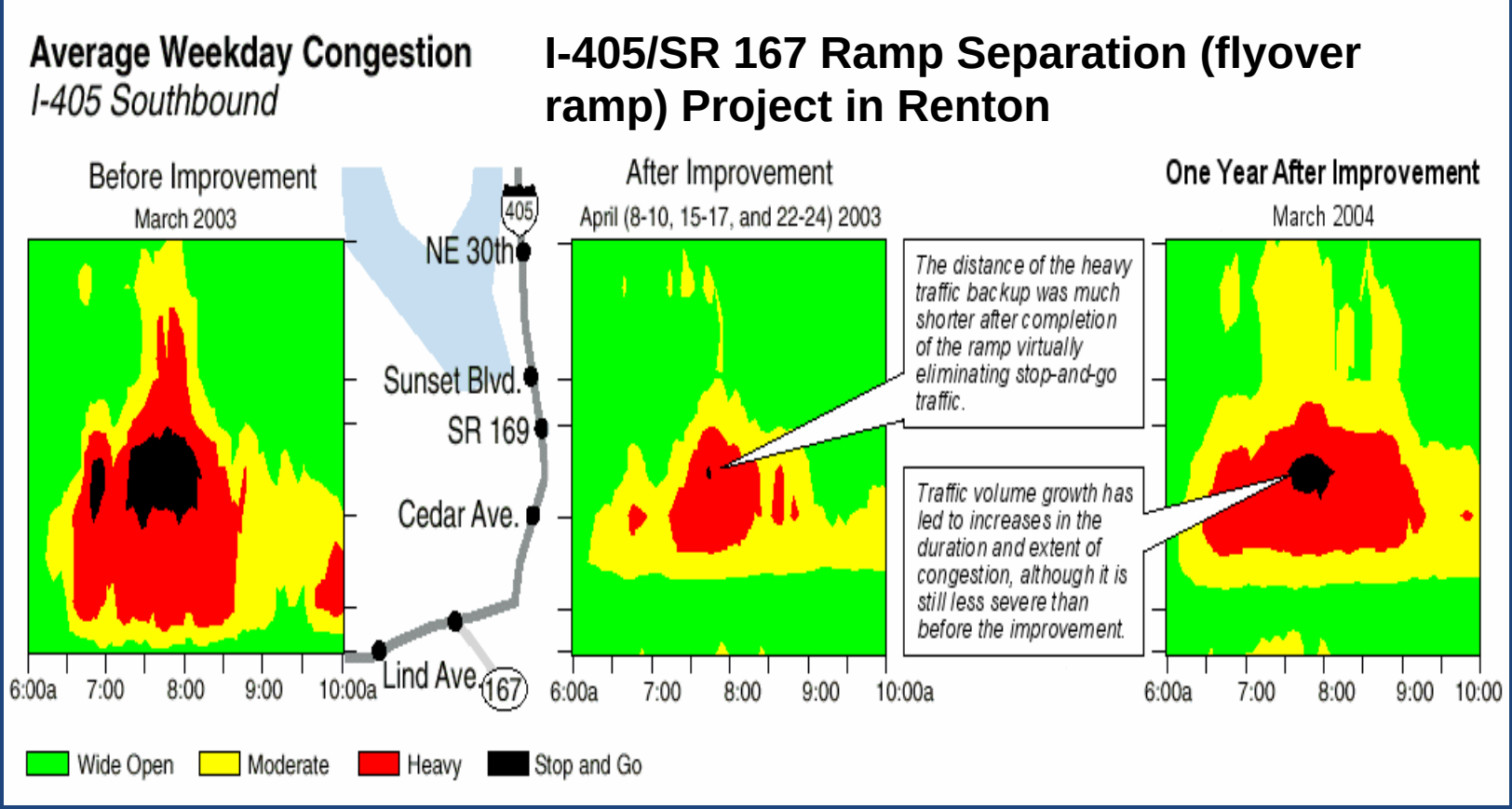


Figure Source: WSDOT 2006 Congestion Report

Mobility Performance Measures: Key Principles, Principle 3

Multiple metrics should be used to report freeway performance, especially for mobility:

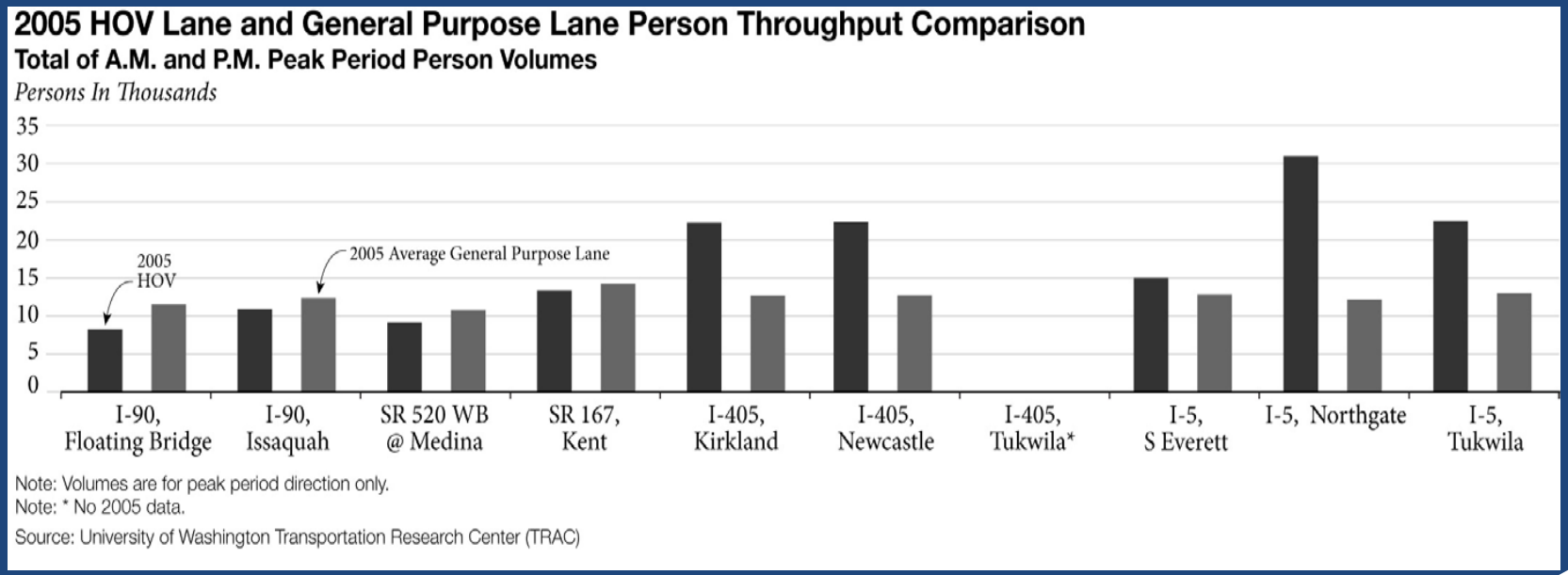
- **Average congestion conditions**
- **Capacity bottlenecks**
- **Throughput**
- **Customer satisfaction**
- **Safety**
- **Ride quality**
- **Environment**
- **Incident response**
- **Workzone**
- **Operational efficiency**

Mobility Performance Measures: Key Principles, Principle 4

Traditional Highway Capacity Manual-based performance measures for mobility (Volume to Capacity ratio and level of service) should serve as supplementary, not primary, measures of performance in most cases.

Mobility Performance Measures: Key Principles, Principle 5

Both vehicle- and person-based performance measures of throughput are useful and should be developed, depending on the application.



Mobility Performance Measures: Key Principles, Principle 6

Both quality of service (outcome) and activity-based (output) performance measures are required for freeway performance monitoring.

- **"Quality of service (outcome) measures are extremely important for agencies because they represent the "bottom-line for their customers (travelers)."**
- **Reporting trends in performance measures at one level of detail usually begs the question, "why did this happen?".**
- **Most incident response measures are output measures (how long it takes to clear)**
- **Cannot (yet) quantify what impact removing the obstruction has on traffic, which is the true outcome measure**

Mobility Performance Measures: Key Principles, Principle 7

Activity-based measures should be chosen to complement quality of service measures. Choose activity measures whose improvements can be linked to improvements in quality of service measures.

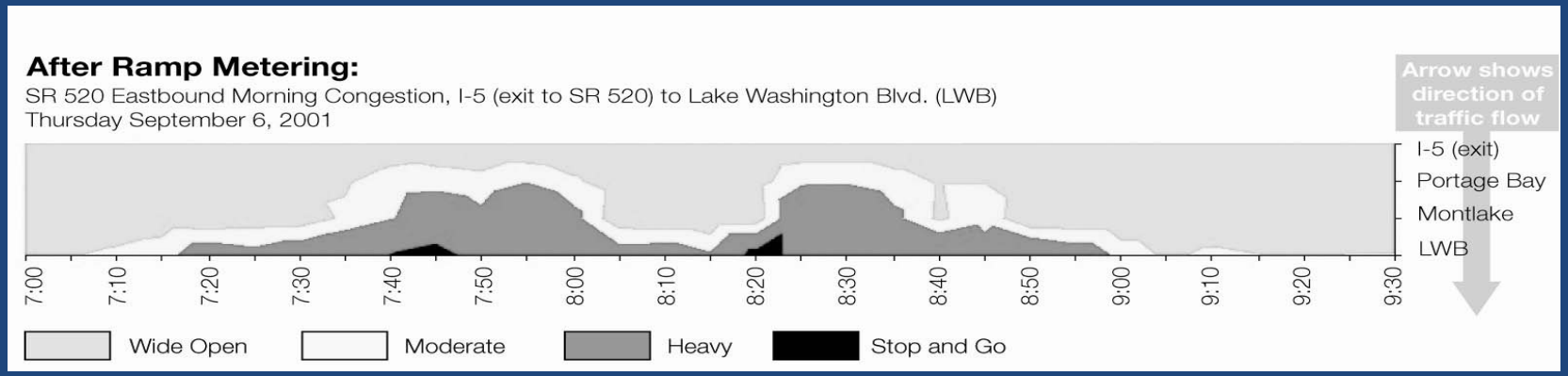
Mobility Performance Measures: Key Principles, Principles 8 & 9

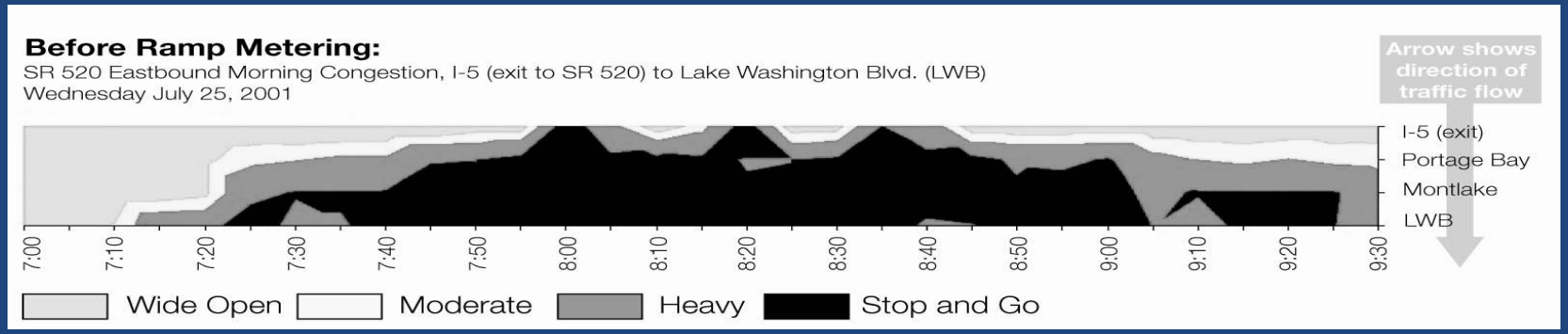
Principle 8: Customer satisfaction measures should be included with quality of service measures for monitoring freeway performance.

Principle 9: The measurement of travel time reliability is a key aspect of freeway performance measurement and reliability measures should be developed and applied.

Mobility Performance Measures: Key Principles, Principle 10

Three dimensions of freeway mobility: source of congestion, temporal aspects, and spatial detail.



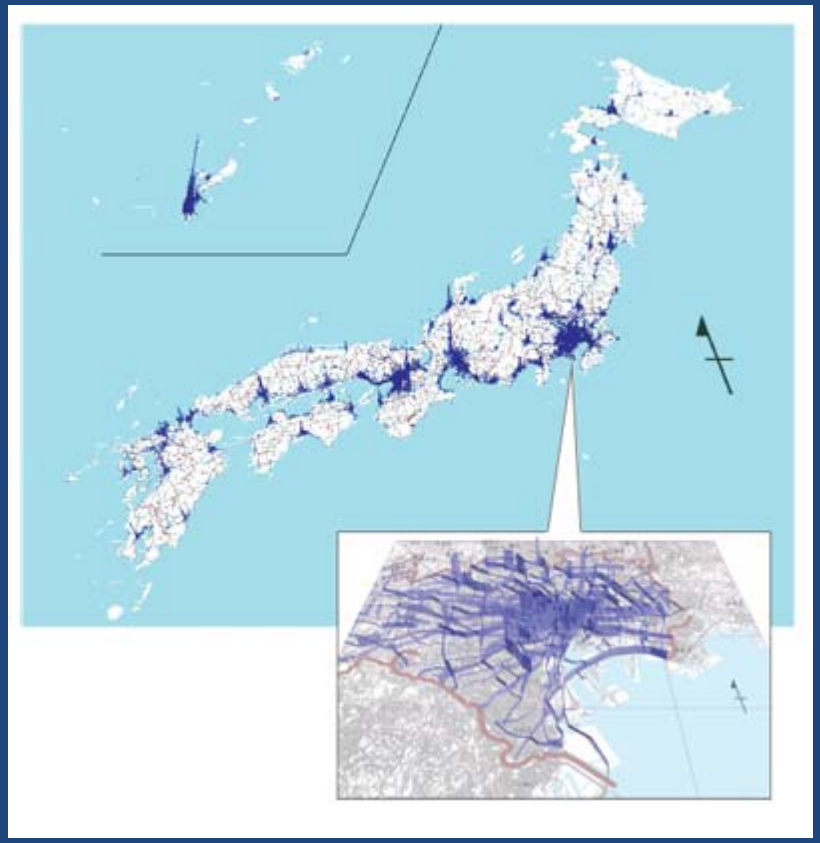


Figures Source: September 30, 2004 Gray Notebook, p. 51

Mobility Performance Measures: Key Principles, Principle 11

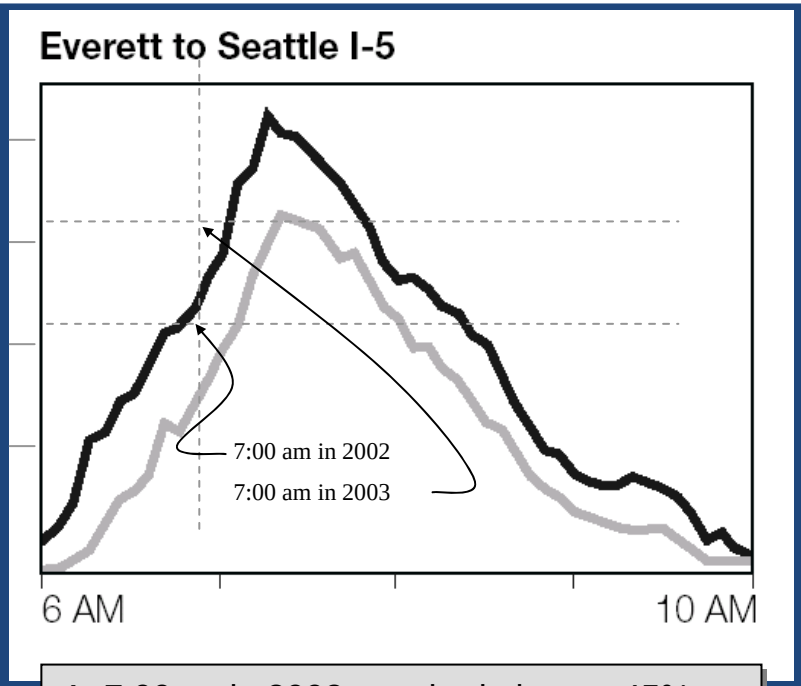
Communication of freeway performance measurement should be done with graphics that resonate with a variety of technical and non-technical audiences.

3D-Map of Congestion Loss Time

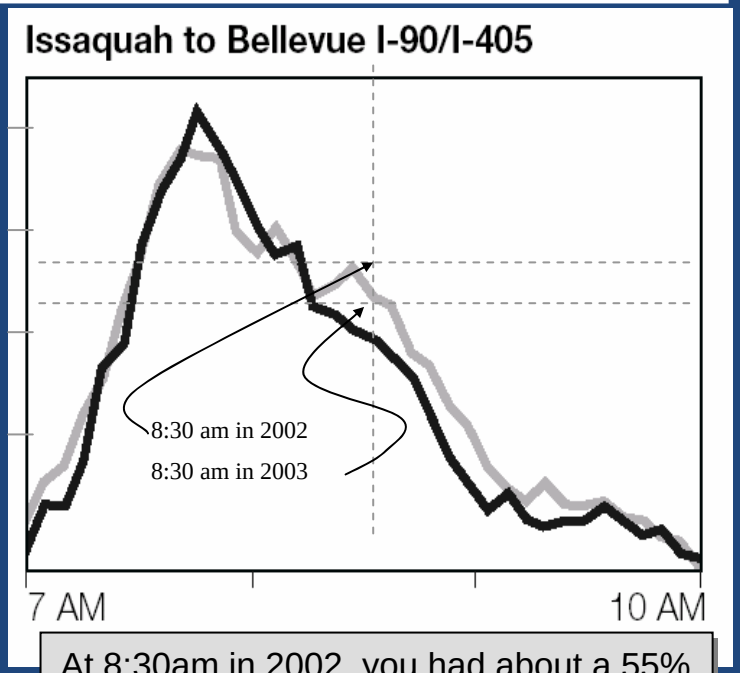


Source: Roads in Japan, Road Bureau, Ministry of Land, Infrastructure and Transport
www.mlit.go.jp/road/road_e/contents02/2-1-1.html

Finding Ways To Illustrate Changing System Conditions in Easy To Understand Terms: Measuring Speeds less than 35 mph on Key Commutes



At 7:00am in 2002, you had about a 45% chance that traffic would be moving at less than 35 mph. In 2003, the situation was a little worse (black line above the gray line); your chance that traffic would be moving slower than 35 mph was about 65%.



At 8:30am in 2002, you had about a 55% chance that traffic would be moving at less than 35 mph. In 2003, the situation was a little better (black line below the gray line); your chance that traffic would be moving slower than 35 mph was about 45%.

Mobility Performance Measures: Key Principles, Principle 12

Continuity should be maintained in performance measures across applications and time horizons; the same performance measures should be used for trend monitoring, project design, forecasting, and evaluations.

- **This is especially difficult, since often measures are evolving as well.**
- **Save your data sets so that when you pick a new measure, you have a chance to go back and recalculate past years using that data.**

Principles of Mobility Measurement: Related Resources

- Primary Source: NCHRP 3-68, *Guide to Effective Freeway Performance Measurement* (2006)
- Bertini, R. (2005) *You are the traffic jam: An examination of congestion measures.*
- Bremmer, D., Cotton, K., Coty, D., Prestrud, C., & Westby, G., *Measuring Congestion: Learning from Operational Data*; 2003, TRB
- Brydia, R. (2006) *Background development and concept of operations for a real-time performance measurement monitoring system*.
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- NCHRP Synthesis 311; *Performance Measures of Operational Effectiveness for Highway Segments and Systems (2003)*
- Texas Transportation Institute. *Urban Mobility Report.* College Station, Texas: Texas A&M University, 2005
- WSDOT, *Gray Notebook*, September 2006, Annual Congestion Report
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Module II
Measuring Mobility and Operations

Section 3
Congestion Mobility Measurements

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Mobility Performance Measurements for Congestion: Overview

Duration: Amount of time system is in congested conditions (how long)

Extent: Number of people or vehicles affected by congestion, and geographic distribution of congestion (how many)

Severity: Intensity of congestion (how bad)

Reliability: Trip predictability, impacted by first three elements

Mobility Performance Measurements for Congestion: Commonly Used Measures

1. Travel Time
2. Reliability
3. Indices
4. Delay
5. Throughput
6. Duration
7. Volume
8. Safety and Congestion
9. Other Measures

1. Speed/Travel-Time-Based Performance Measures

- *Average Peak Travel Time.* **The average travel time on a route during the peak travel period. (here worst five-minute peak)**
- *Average Travel Time*
- **Origin-destination travel times are well suited for real-time and corridor analyses**

***MORNING*: Key Commute Routes: Changes in Travel Time Performance, 2003 to 2005**

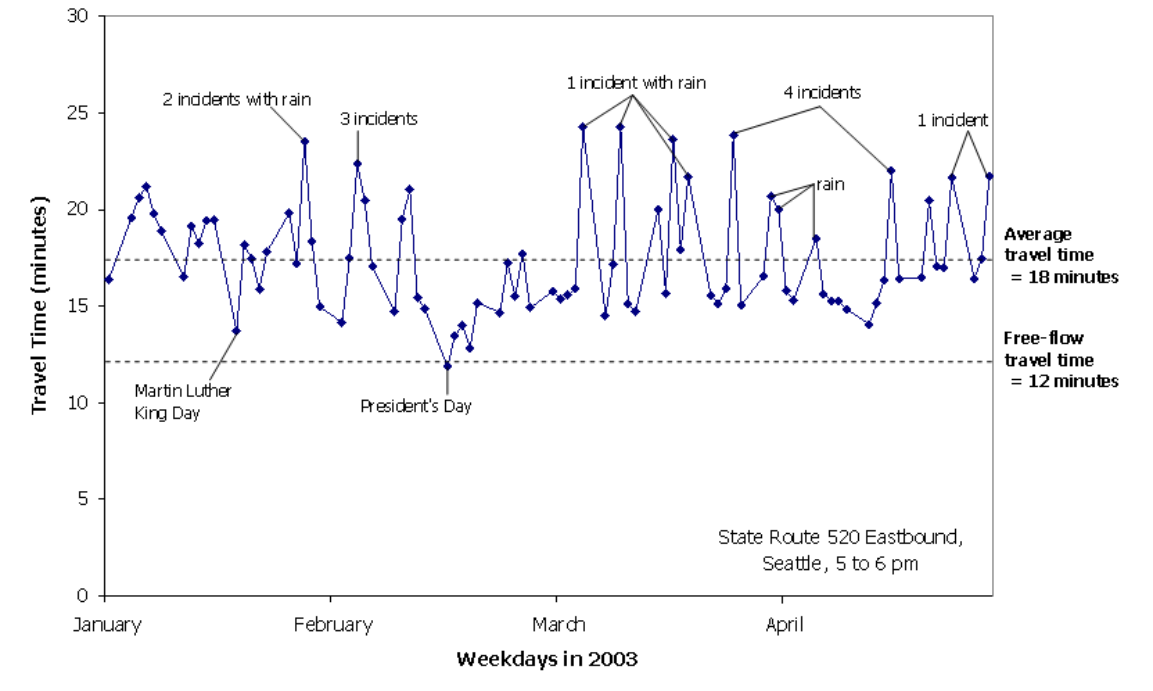
EXCERPT

				Travel Time (in min.)	Average Peak Travel Time, Based on Peak Time (in minutes)			95% Reliable Travel Time (in minutes)		
Route	Route Description	Peak time	Length (Miles)	At Posted Speeds	2003	2005	Change (%)	2003	2005	Change (%)
To Seattle										
I-5	Everett to Seattle	7:30 AM	23.7	24	47	48	2%	70	68	-3%
I-5	Federal Way to Seattle	7:40 AM	21.8	22	40	44	10%	54	59	9%
I-90/I-5	Issaquah to Seattle	8:10 AM	15.5	15	23	26	13%	32	38	19%
SR 520/I-5	Redmond to Seattle	8:40 AM	14.8	16	22	24	9%	29	33	14%
I-5	SeaTac to Seattle	7:40 AM	12.9	13	23	25	9%	29	38	31%

Source: WSDOT 2006 Congestion Report

2. Why Measure Reliability?

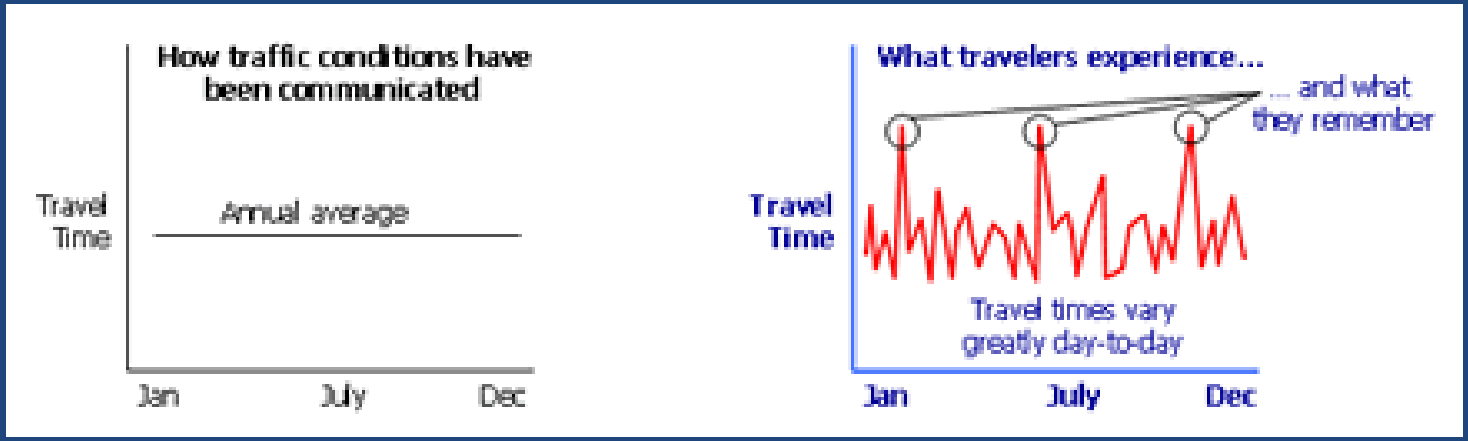
It matters to our customers. Commuters plan trips based on the worst days, not the average day.



2. Measuring Reliability: Buffer Index

Buffer Index: **The buffer index represents the extra buffer time (or time cushion) that most travelers add to their average travel time when planning trips to ensure on-time arrival. This extra time is added to account for any unexpected delay.**

For example, a buffer index of 40 percent means that, for a 20-minute average travel time, a traveler should budget an additional 8 minutes (20 minutes × 40 percent = 8 minutes) to ensure on-time arrival most of the time.



Graph source: FHWA,(2006) "Travel Time Reliability: Making it There ON Time, All the Time"

2. Reliability: 95% Reliable Travel Time

The 95% Reliable Travel Time. An estimated travel time with 95% certainty.

For example, if you travel during peak travel periods five days a week for a four-week period (20 weekdays), using the 95% reliable travel time, you will get to your destination on-time on 19 out of those 20 days.

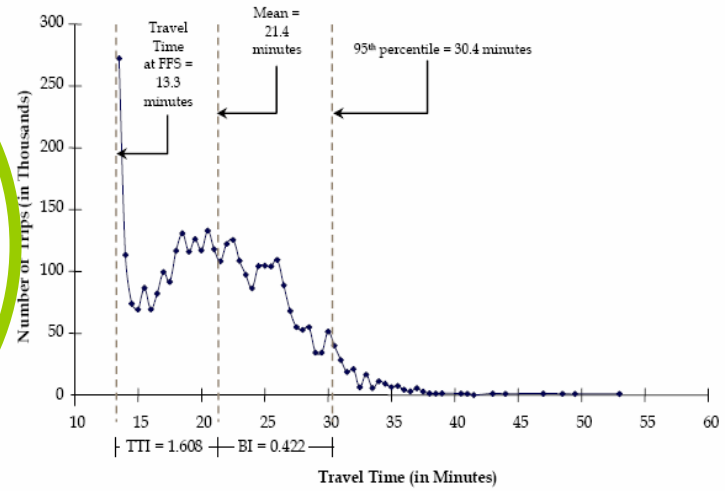
MORNING: Key Commute Routes: Changes in Travel Time Performance, 2003 to 2005

EXCERPT

Route	Route Description	Peak time	Length (Miles)	Travel Time (in min.) At Posted Speeds	95% Reliable Travel Time (in minutes) 2003	2005	Change (%)
To Seattle							
I-5	Everett to Seattle	7:30 AM	23.7	24	70	68	-3%
I-5	Federal Way to Seattle	7:40 AM	21.8	22	54	59	9%
I-90/I-5	Issaquah to Seattle	8:10 AM	15.5	15	32	38	19%
SR 520/I-5	Redmond to Seattle	8:40 AM	14.8	1[illegible]	29	33	14%
I-5	SeaTac to Seattle	7:40 AM	12.9	13	29	38	31[illegible]

Table Source: WSDOT 2006 Annual Congestion Report

Figure 9.28 Reliability Profile: I-75 Atlanta – I-285 to North Suburbs, NB
5-7 P.M. Weekdays, 2004



Graph source: NCHRP 3-68, Guide to Effective Freeway Performance Measurement (2006)

3. Index-Based Performance Measures

Travel Time Index: The ratio of travel time in the peak period to the travel time at free-flow conditions.

For example, a TTI of 1.5 means that a 20-minute free-flow trip takes 30 minutes in the peak period (Texas Transportation Institute – Mobility Report)

Index measures are well suited for larger geographies or combinations of system elements

EXCERPT: TTI's 2005 Urban Mobility Report

Table 1. Key Mobility Measures, 2003

Urban Area	Annual Delay per Traveler		Travel Time Index	
	2003 Hours	Rank	2003 Values	Rank
85 Area Average	47		1.37	
Very Large Average	61		1.48	
Very Large (13 areas)				
Los Angeles-Long Beach-Santa Ana, CA	93	1	1.75	1
San Francisco-Oakland, CA	72	2	1.54	3
Washington, DC-VA-MD	69	3	1.51	4
Atlanta, GA	67	4	1.46	5
Houston, TX	63	5	1.42	6
Dallas-Fort Worth-Arlington, TX	60	6	1.36	19
Chicago, IL-IN	58	7	1.57	2

3. A Maximum-Throughput-Based Index: The New Kid on the Block

Maximum Throughput Travel Time Index (MT^3I): Ratio of Peak Travel Time to Maximum Throughput Travel Time.

For example, an MT^3I of 1.5 means that a 20-minute maximum throughput trip speed takes 30 minutes in the peak period

EXCERPT

***MORNING*: Key Commute Routes: Changes in Travel Time Performance, 2003 to 2005**

Route	Route Description	Peak time	Length (Miles)	Travel Time (in min.) At Posted Speeds	Ratio of Peak Travel Time to Maximum Throughput Travel Time MT^3I 2003	2005
To Seattle						
I-5	Everett to Seattle	7:30 AM	23.7	2[illegible]	1.7	1.7
I-5	Federal Way to Seattle	7:40 AM	21.8	2[illegible]	1.6	1.7
I-90/I-5	Issaquah to Seattle	8:10 AM	15.5	1[illegible]	1.2	1.3
SR 520/I-5	Redmond to Seattle	8:40 AM	14.8	1[illegible]	1.3	1.4
I-5	SeaTac to Seattle	7:40 AM	12.9	13	1.5	1.6
I-405/I-90/I-5	Bellevue to Seattle	8:40 AM	10.7	11	1.2	1.3
I-405/SR 520/I-5	Bellevue to Seattle	8:40 AM	10.5	11	1.4	1.4

Figure Source: *WSDOT 2006 Congestion Report*

4. Delay-Based Performance Measures

Delay

- Vehicle-hours of delay
  - **Different Thresholds of Delay: free-flow and/or maximum throughput speeds**
  - **Could be measured separately, related to incidents, work zones, weather, or bottlenecks**
- Person-hours of delay
- Cost of delay
- Relative delay

4. Delay-Based Performance Measures: By Corridor and Statewide

Central Puget Sound Freeways: Average Weekday Delay Comparison 2003 and 2005

State Route	Center Lane Miles	Vehicle Hours of Delay per Day: Relative to 60 mph (posted speed limit)			Vehicle Hours of Delay per Day: Relative to approx. 50 mph (max throughput)			Vehicle Miles Traveled		
		2003	2005	Change	2003	2005	Change	2003	2005	Change
I-5	369	15,900	17,800	12%	6,800	9,000	32%	8,061,700	7,667,300	-5%
I-90	95	1,300	1,900	46%	250	700	180%	1,590,600	1,606,700	1%
SR 167	41	1,800	2,700	50%	400	1,000	150%	957,300	996,600	4%
I-405	152	9,400	13,200	40%	4,500	7,900	75%	3,660,300	3,647,200	0.4%
SR 520	52	2,500	2,500	0%	1,300	1,500	15%	987,150	982,500	-0.5%
Total	709	30,900	38,100	23%	13,250	20,100	52%	15,257,050	14,900,300	-2%

Source: WSDOT Urban Planning Office

Note: Because both the lengths and widths of these corridors are different, it is not possible to use the delay numbers to rank the corridors.

All State Highways: Average Weekday Delay Comparison (Daily and Annual) and Estimated Cost of Delay on State Highways (Annual), 2003 and 2005

Actual Travel Compared to	DAILY Average Vehicle Hours of Delay (Weekdays)			ANNUAL Average Weekday Hours of Vehicle Delay (in thousands)			ANNUAL Cost of Delay on State Highways (in Millions of 2005 dollars)		
	2003	2005	Change	2003	2005	Change	2003	2005	Change
Optimal Flow Speeds (Approx 51 mph)	82,200	99,400	21%	20,550	24,850	21%	$486	$598	23%
Posted Speeds	156,300	173,800	11%	39,075	43,450	11%	$920	$1,043	13%

Source: WSDOT Urban Planning Office

Source: WSDOT 2006 Annual Congestion Report

4. Delay-Based Performance Measures: Per Peak Traveler, and Cost of Delay

Measures of…	1982	1993	2002	2003
… Individual Traveler Congestion				
Annual delay per peak traveler (hours)	16	40	47	47
Travel Time Index	1.12	1.28	1.37	1.37
Number of urban areas with more than 20 hours of delay per peak traveler	5	37	50	51
The Nation's Congestion Problem				

***Source**: Texas Transportation Institute 2005 Urban Mobility Report*

All State Highways: Average Weekday Delay Comparison (Daily and Annual) and Estimated Cost of Delay on State Highways (Annual), 2003 and 2005

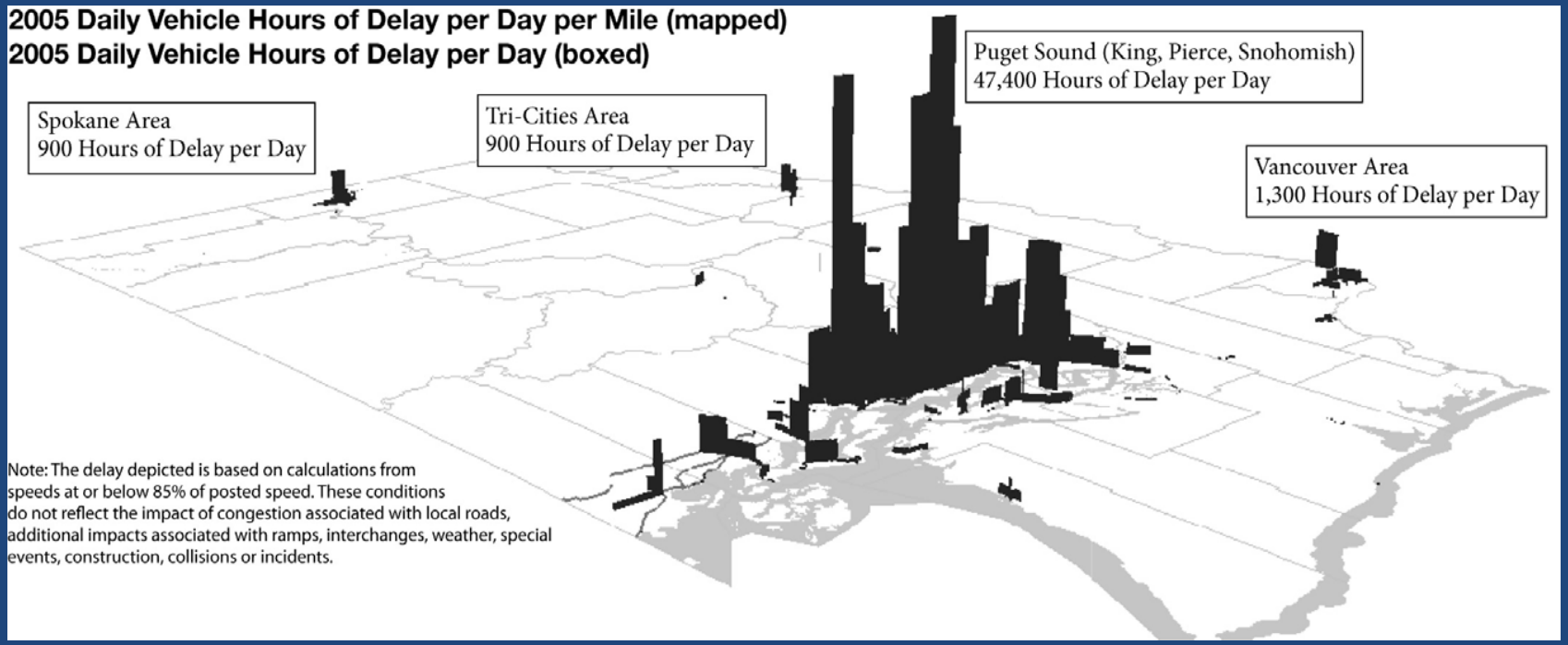
	DAILY Average Vehicle Hours of Delay (Weekdays)			ANNUAL Average Weekday Hours of Vehicle Delay (in thousands)			ANNUAL Cost of Delay on State Highways (in Millions of 2005 dollars)		
Actual Travel Compared to	**2003**	**2005**	**Change**	**2003**	**2005**	**Change**	**2003**	**2005**	**Change**
Optimal Flow Speeds (Approx 51 mph)	82,200	99,400	21%	20,550	24,850	21%	$486	$598	23%
Posted Speeds	156,300	173,800	11%	39,075	43,450	11%	$920	$1,043	13%

Source: WSDOT Urban Planning Office

***Source**: 2006 WSDOT Annual Congestion Report*

4. Delay-Based Performance Measures: Relative Delay

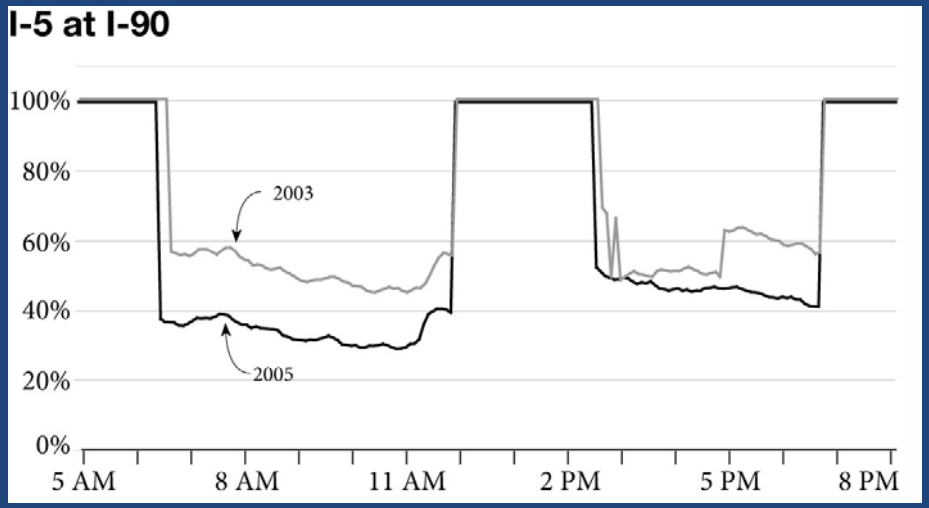
Relative Delay



***Source**: 2006 WSDOT Annual Congestion Report*

5. Efficiency-Based Performance Measures (Productivity/Throughput)

Percent of efficiency that your road is working at (as opposed to 100% efficiency based on the roadway's maximum throughput capacity)



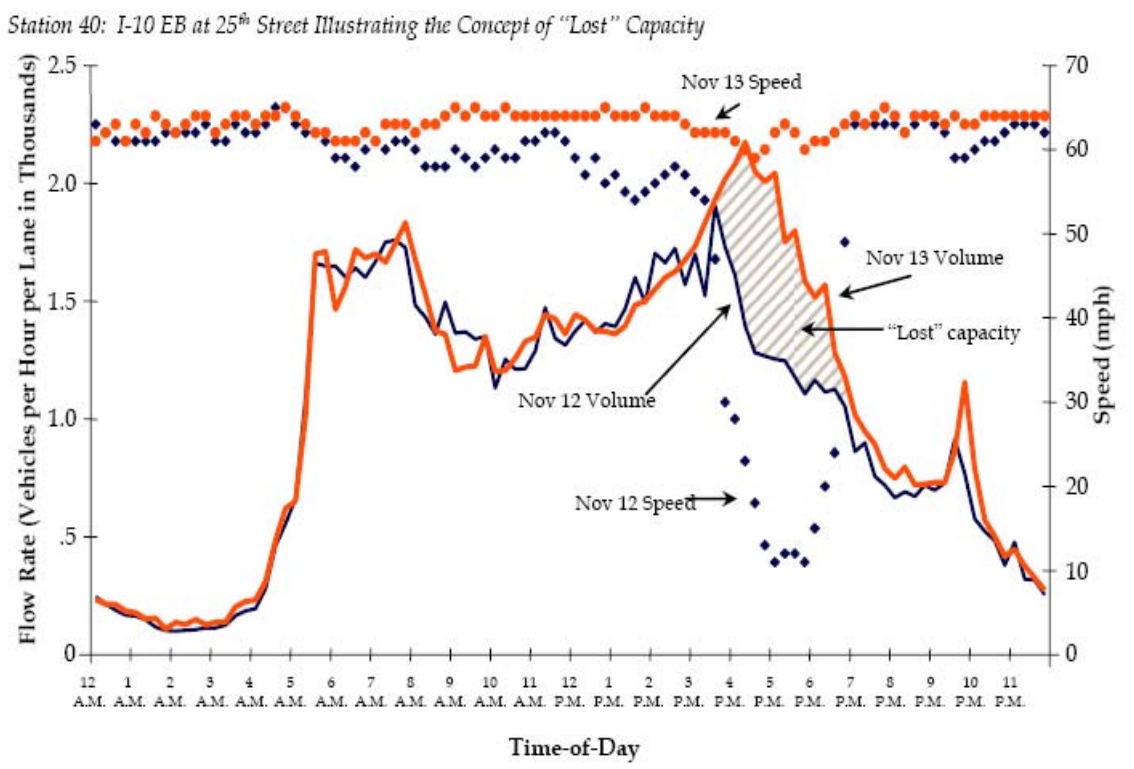
Percent of Lost Throughput Capacity Due to Lane or Shoulder Blocking Incidents

Based on 2000 vehicles per lane per hour highway capacity

# of lanes	Shoulder Blocked	Lanes Blocked		
		1	2	3
2	19%	65%	0%	n/a
3	17%	51%	83%	0%
4	15%	42%	74%	87%
5	13%	35%	60%	80%
6	11%	29%	50%	74%

Graph Source: 2006 WSDOT Annual Congestion Report
Table Source: Low Cost, High Benefit Congestion Relief from Better Highway Management, WSDOT, 2007

5. Efficiency-Based Performance Measures (Productivity/Throughput)



Source: *Freeway Traffic Conditions and Trends, 2004: Prototype Annual Report.* Prepared by Texas Transportation Institute for Maricopa Association of Governments, June 15, 2005.

6. Duration-Based Performance Measures

Changes in Duration of Peak Periods

For example: In WSDOT's measures, this period is defined as the period in which average weekday speed on a highway fell below 70% of posted speeds (about 51 mph, or optimum flow).

EXCERPT

***MORNING*: Key Commute Routes: Changes in Travel Time Performance, 2003 to 2005**

				Travel Time (in min.)	Duration of Peak Period (hours and minutes that average speed falls below 70% of posted speeds)[1]		
Route	Route Description	Peak time	Length (Miles)	At Posted Speeds	2003	2005	change (in minutes)
To Seattle							
I-5	Everett to Seattle	7:30 AM	23.7	24	2:30	2:35	5
I-5	Federal Way to Seattle	7:40 AM	21.8	22	2:30	2:45	15
I-90/I-5	Issaquah to Seattle	8:10 AM	15.5	15	0:10	1:10	60
SR 520/I-5	Redmond to Seattle	8:40 AM	14.8	16	0:20	1:00	40
I-5	SeaTac to Seattle	7:40 AM	12.9	13	2:25	3:15	50
I-405/I-90/I-5	Bellevue to Seattle	8:40 AM	10.7	11	*	0:20	*
I-405/SR 520/I-5	Bellevue to Seattle	8:40 AM	10.5	11	1:15	1:30	15

***Source**: 2006 WSDOT Annual Congestion Report*

7. Volume-Based Performance Measures

Vehicle Miles Traveled

Central Puget Sound Freeways: Average Weekday Delay Comparison 2003 and 2005

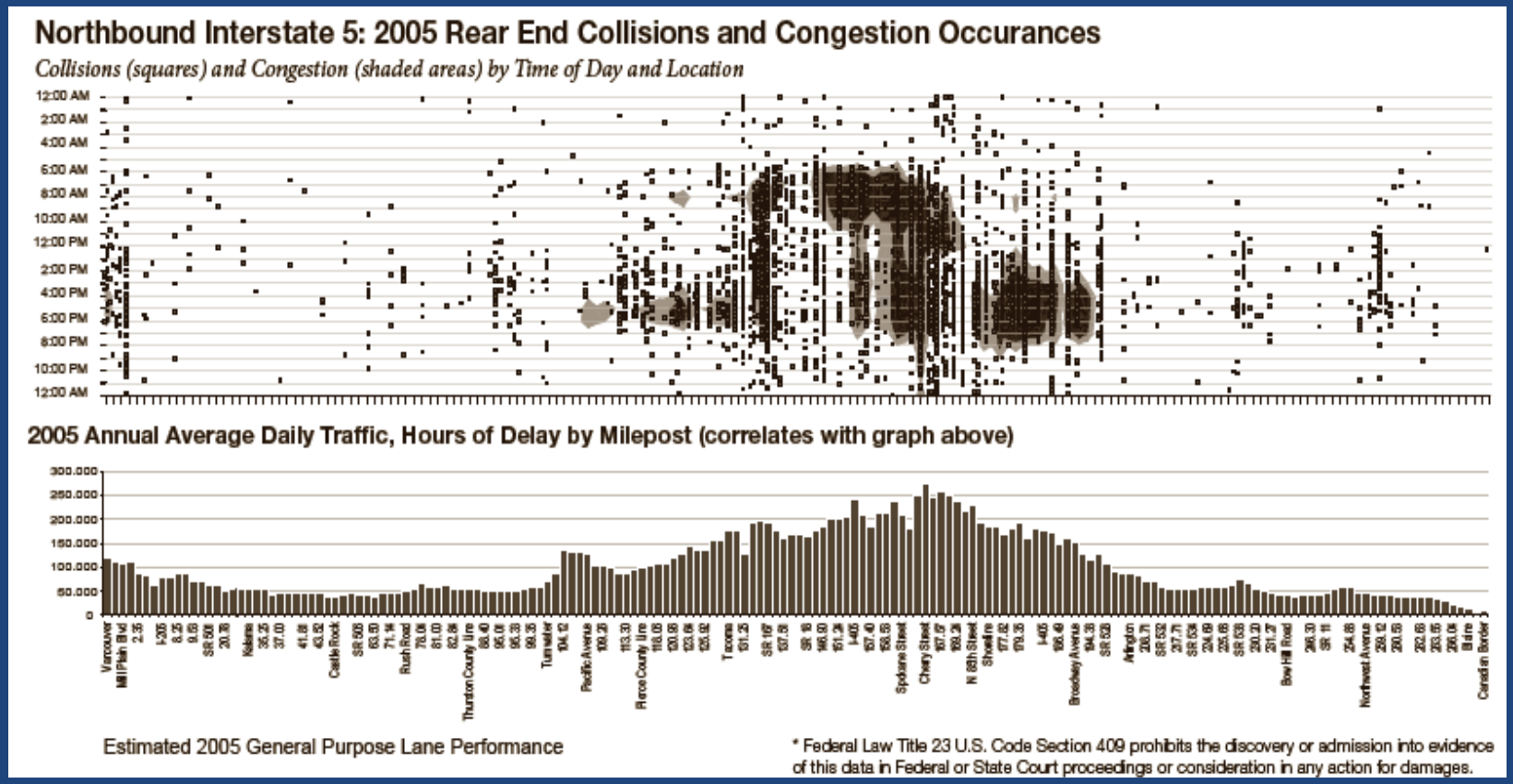
State Route	Center Lane Miles	Vehicle Hours of Delay per Day						Vehicle Miles Traveled		
		Relative to 60 mph (posted speed limit)			Relative to approx. 50 mph (max throughput)			2003	2005	Change
		2003	2005	Change	2003	2005	Change			
I-5	369	15,900	17,800	12%	6,800	9,000	32%	8,061,700	7,667,300	-5%
I-90	95	1,300	1,900	46%	250	700	180%	1,590,600	1,606,700	1%
SR 167	41	1,800	2,700	50%	400	1,000	150%	957,300	996,600	4%
I-405	152	9,400	13,200	40%	4,500	7,900	75%	3,660,300	3,647,200	0.4%
SR 520	52	2,500	2,500	0%	1,300	1,500	15%	987,150	982,500	-0.5%
Total	709	30,900	38,100	23%	13,250	20,100	52%	15,257,050	14,900,300	-2%

Source: WSDOT Urban Planning Office

Note: Because both the lengths and widths of these corridors are different, it is not possible to use the delay numbers to rank the corridors.

Source: *2006 WSDOT Annual Congestion Report*

8. Trying to Link Congestion and Safety



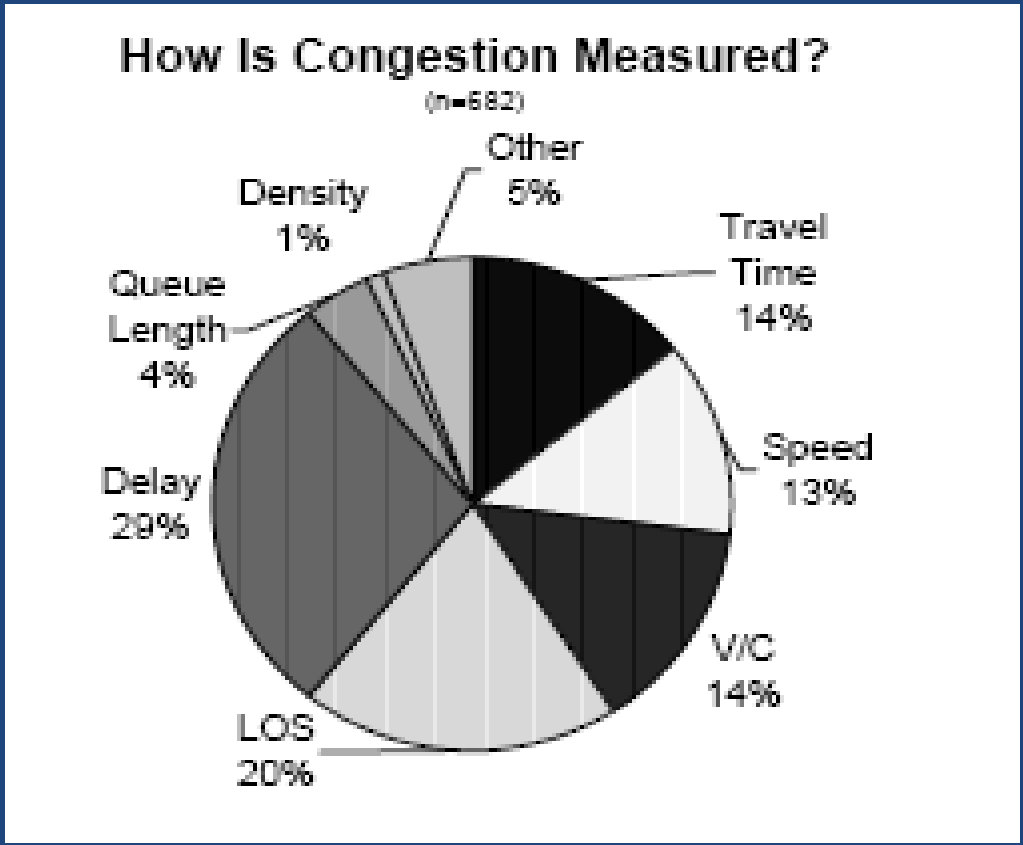
9. Other Measures

- Level of Service (LOS) and Volume/Capacity (V/C) based measures
- Multimodal measures to evaluate operations within the total system
- Queue length
- Customer satisfaction measures
- Ride quality measures
- Environment (i.e. air quality)

Mobility Performance Measurements for Congestion: Overview

Based on e-mail survey of 3,500 transportation professionals

From: Congestion and its Extent, R. Bertini, 2005,



Points to Consider

There is no right or wrong way, but some ways are better than others…

- Congestion is relative to the user; this leads to policy discussion on delay thresholds
- LOS or V/C limited value; does not account for duration
- Indices are difficult to communicate
- Travel Time/Speed resonates with the public but should not be the only consideration

Congestion Mobility Measures: Related Resources

- Bertini, R. (2005) *You are the traffic jam: An examination of congestion measures.*
- Bremmer, D., Cotton, K., Coty, D., Prestrud, C., & Westby, G., *Measuring Congestion: Learning from Operational Data*; 2003, TRB
- Brydia, R. (2006) *Background development and concept of operations for a real-time performance measurement monitoring system*.
- *FHWA (2006)* Travel Time Reliability: Making it There On Time, All the Time
- NCHRP 3-68, *Guide to Effective Freeway Performance Measurement* (2006)
- NCHRP 20-24 (21), *The 21st Century Operations-Oriented State DOT* (2005)
- NCHRP Synthesis 311; *Performance Measures of Operational Effectiveness for Highway Segments and Systems (2003)*
- Texas Transportation Institute. *Urban Mobility Report.* College Station, Texas: Texas A&M University, 2005
- WSDOT, *Gray Notebook*, September 2006, Annual Congestion Report
- WSDOT *Highway Congestion; What Is To Be Done* (Senate Presentation, January 16, 2006)

operationsacademy
SENIOR MANAGEMENT PROGRAM

Module II
Measuring Mobility and Operations

Section 4
Operational Measures for Mobility

CATT
CENTER FOR ADVANCED TRANSPORTATION TECHNOLOGY

Operational Measures for Mobility

1. Incident Response
2. Ramp Metering
3. Signal Coordination
4. Variable Message Signs and other Traveler Information
5. HOV Lanes
6. Work Zone
7. Operational Effectiveness
8. Maintenance –Example of a Measurement Program

1. Incident Response: The Importance of Collecting Good Data

- **Incidents are a significant cause of roadway delay**
- **High correlation between volume and delay: the greater the volume, the longer a delay an incident is likely to cause.**

TOTAL REDUCTION IN INCIDENT CONGESTION DELAY

The CHART incident management program continues to provide safety and economic benefits to motorists and commerce in Maryland. By June 2008, this program is anticipated to save motorists and commercial traffic approximately 30 million vehicle-hours annually, equivalent to $570 million a year in cost-savings.

Performance Measure	Calendar Year			
	2003	2004	2005	Target
Reduction in incident congestion delay	26.8 million vehicle hours saved	25.9 million vehicle hours saved	27.9 million vehicle hours saved	30.0 million vehicle hours saved

***From**: MDOT 2007 Attainment Report on Transportation Performance*

2 small collisions cause 1 big mess

I-90 BACKUP RUNS 11 TO 14 MILES

Fewer lanes, timing prove "catastrophic"

BY PEYTON WHITELY
AND CHRISTINE CLARRIDGE
Seattle Times staff reporters

Two small accidents, one big backup.

A couple of minor collisions Thursday morning on westbound Interstate 90 caused a "catastrophic" traffic backup that stretched an estimated 11 to 14 miles from Mercer Island to Issaquah, state traffic officials said.

So how do two small collisions cause a major backup?

Fewer lanes, timing and location added up to trouble, said Martin Dedinsky, state Department of Transportation traffic engineer.

"You've clamped off two-thirds of your capacity; there you go, you have a 10-mile bottleneck," he said.

The roots of the jams started with timing, he added, with the accidents taking place just after 7 a.m., at the peak of rush hour.

The collisions also took place on a part of I-90 that's already between two existing bottlenecks, one where traffic from I-405 flows into I-90, and another where traffic tends to slow because of tunnels on Mercer Island, with the tunnels themselves forming a visual distraction.

"You put an accident here, and you've connected two bottlenecks," he said.

State Patrol Trooper Jeff Merrill described the backup as "catastrophic" and "one of the worst backups during the morning rush that we've had in a long time."

The first accident occurred on I-90 in the Mercer Island tunnel and the second occurred in the aftermath of the first collision, Merrill said.

One accident involved a semi-truck and the other involved a box van, he said, adding that they likely were caused by drivers making careless lane changes.

There were no serious injuries, but one driver was taken to the hospital as a precaution, Merrill said.

Dedinsky said a little bit of arithmetic helps explain the extent of the traffic jam.

The three lanes of I-90 at that point normally carry about 5,500 vehicles an hour in free-flowing conditions, or approximately 1,800 to 2,000 in each lane in each hour, he explained.

With two lanes blocked, he said, that capacity was cut to a third of its normal volume.

"You're probably getting 1,500 an hour" through the remaining lane, he said.

The results aren't difficult to calculate.

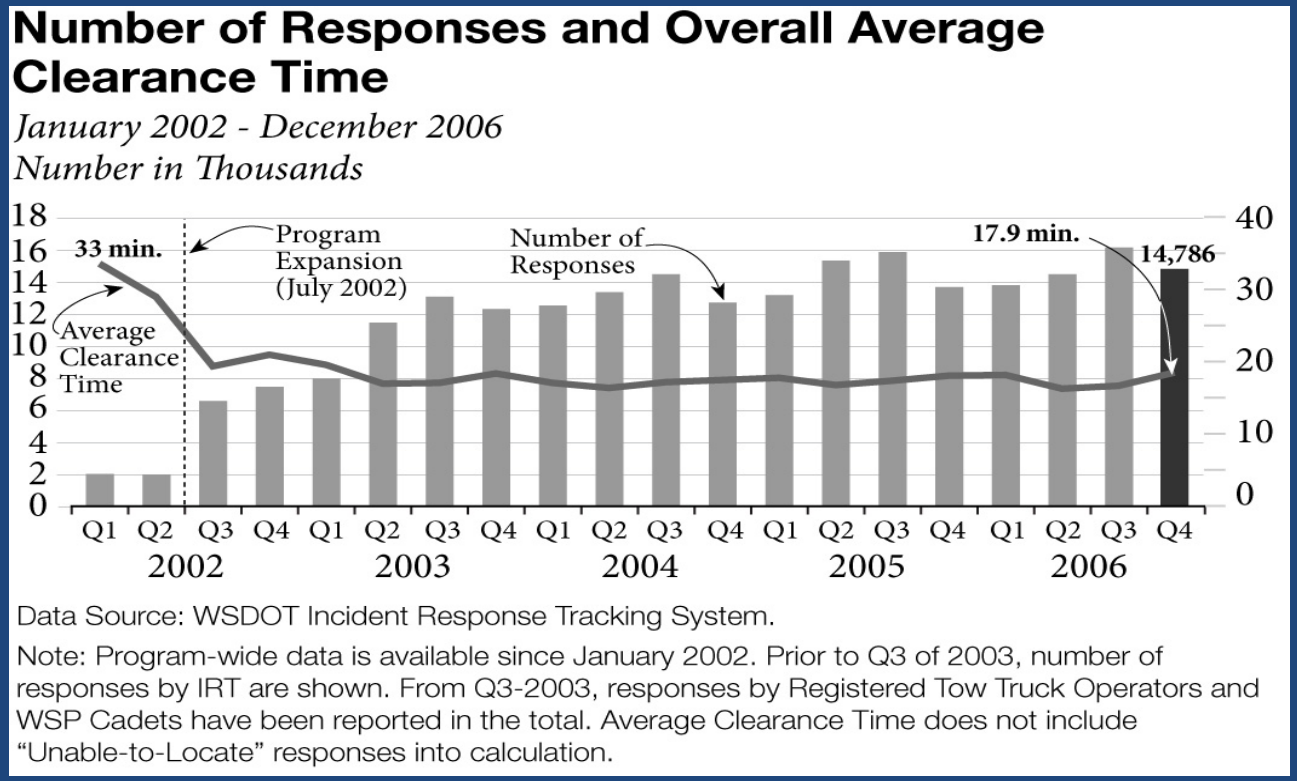
Assuming a car is about 20 feet long, and 4,000 of them are backed up in bumper-to-bumper traffic, that's 80,000 feet of cars. Divide that by 5,280 feet, the distance in one mile, and it comes to 15.15 miles — about what drivers faced on I-90 Thursday morning.

Peyton Whitely: 206-464-2259 or pwhitely@seattletimes.com

1. Incident Response: Data That Needs to Be Collected

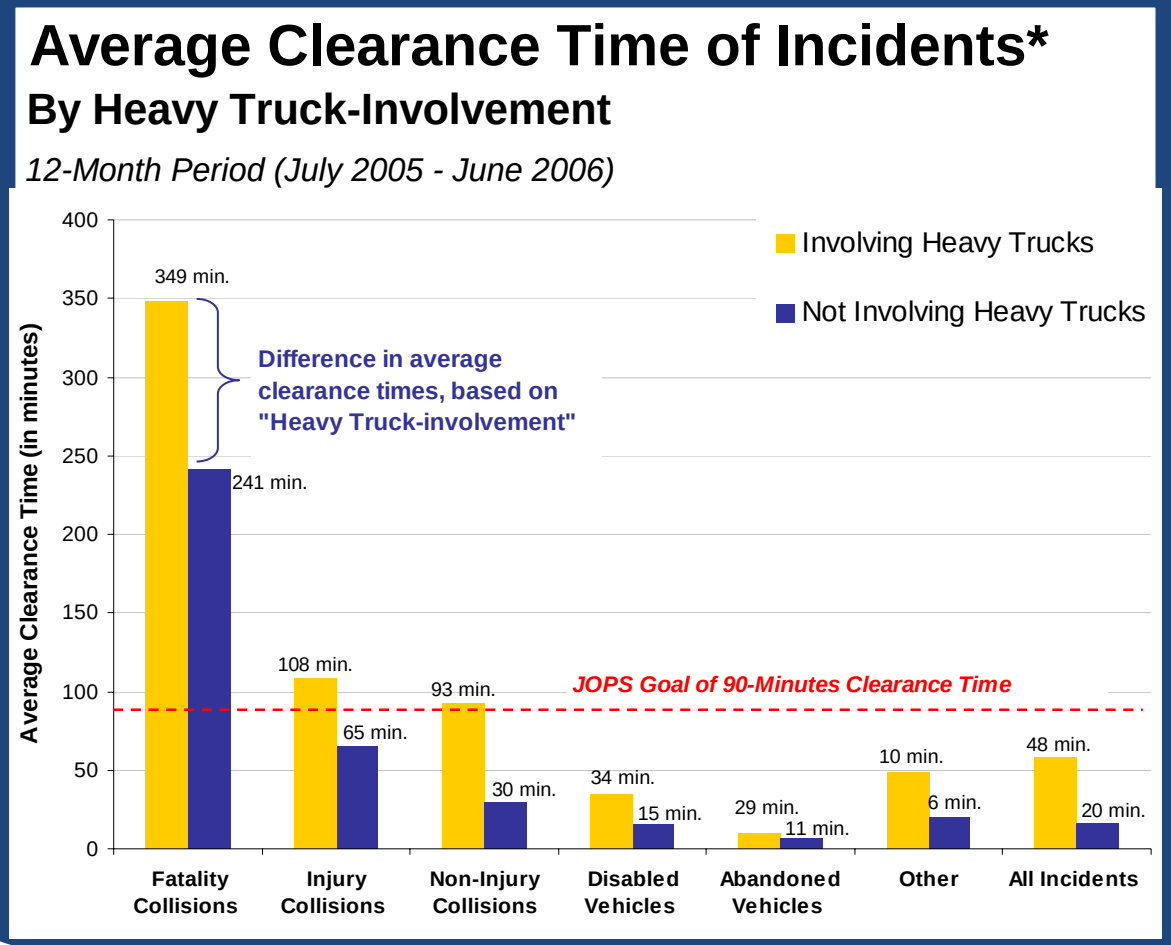
- **Characteristics of the Incident** – Location, type, severity
- **The Incident "Timeline"** – Key actions and milestones related to response actions
- **Details on the Blockage Characteristics** – Whenever lane or shoulder blocking changes, it is noted
- **Details of Incident Response** – What agencies responded, what equipment was used

1. Incident Response: Showing Trends



Overall Average Clearance Time to All Incidents had decreased significantly (34 minutes to 18 minutes) after program expansion

1. Incident Response Special Measures: Heavy Truck Involvement



WSDOT's *2007-09 Budget Request* includes funding for a tow performance program for heavy trucks, beginning July 2007.

- **Modeled after successful program in Florida that is responsible for clearing 94% of heavy truck collisions in under 90 minutes.**
- **Plan would provide incentives to the towing industry to improve equipment standards, improve training, and agree to a performance agreement.**

1. Incident Response: Showing Trends Leveraging Public Opinion

November 13, 2002

"This is a good use of my tax dollars. Car couldn't be fixed at the time but he really tried and he got me off the road safely. Very pleasant and helpful, keep him. He is very good!"

December 13, 2002

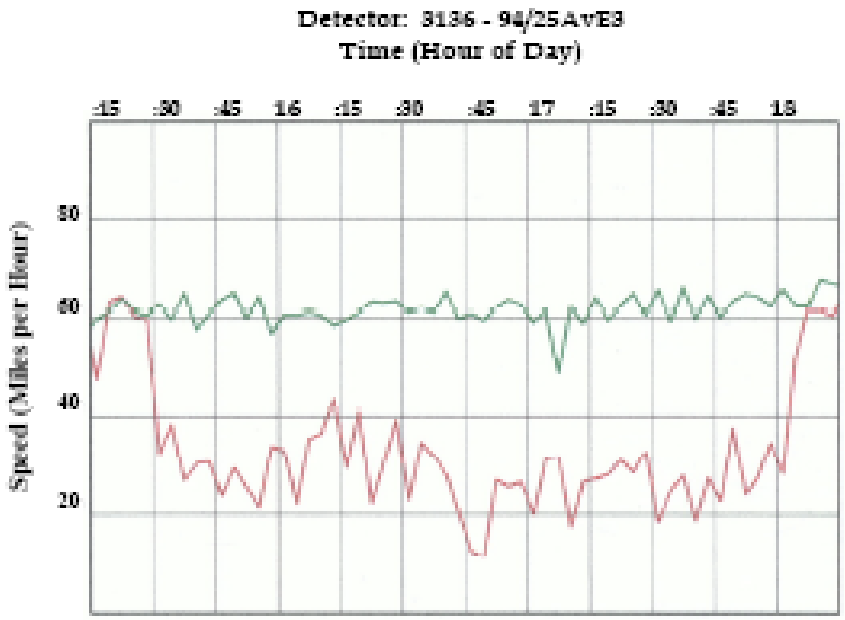
"The WSDOT person was outstanding and ensured my safety. Gladly pay taxes to ensure this service!"

December 26, 2002

"Please keep this service, we need it bad. Thank you so much!"

2. Ramp Metering: Before and After Approaches

Figure ES.5 Example of Increased Speed Variability (I-94 Corridor Location)



Condition	Date	Field	Sample	Volume
Meters off	Mon, Oct 16, 2000	25'	100%	25,181
Meters on	Mon, Oct 9, 2000	25'	100%	25,294

Twin Cities Ramp Meter Evaluation, Cambridge Systematics, 2001

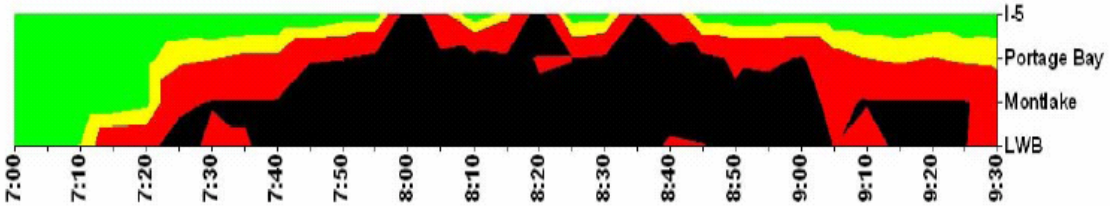
Twin Cities Ramp Metering Evaluation Project

2. Ramp Metering: Measuring Effectiveness

Ramp Metering

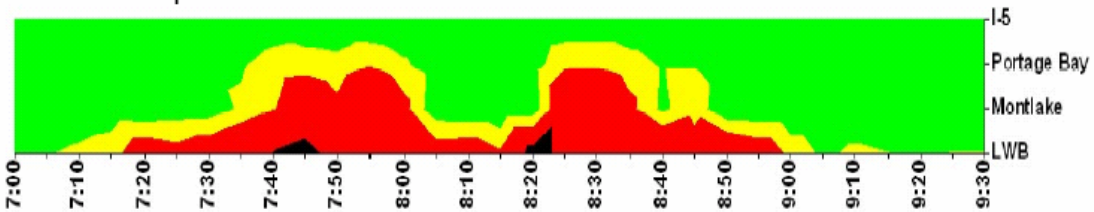
SR 520 Westbound Ramp Meter Effects

BEFORE a series of ramp meters were activated: EB morning congestion, I-5 to Lake Washington Blvd:



Wednesday July 25, 2001

AFTER ramp meter activation:



Thursday September 6, 2001

Wide Open ■ Moderate ■ Heavy ■ Stop and Go ■

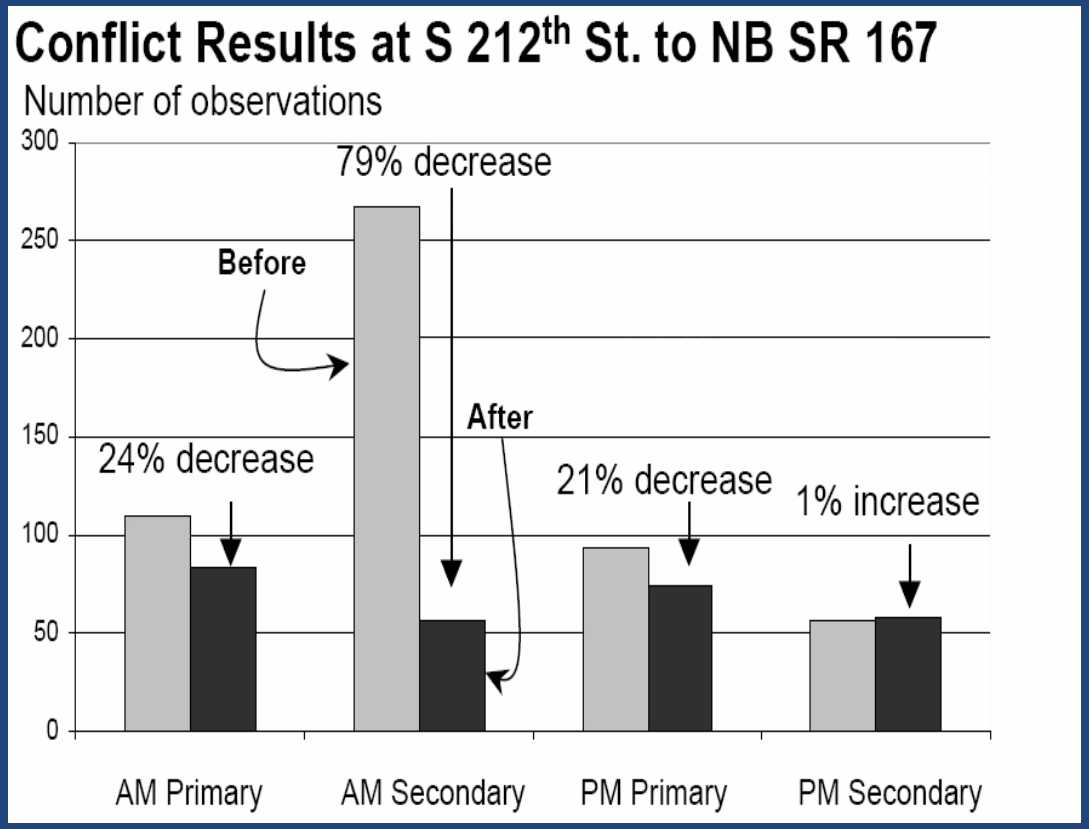
2. Ramp Metering: Measuring Conflicts Between Drivers

SR 167 at S. 212th St.

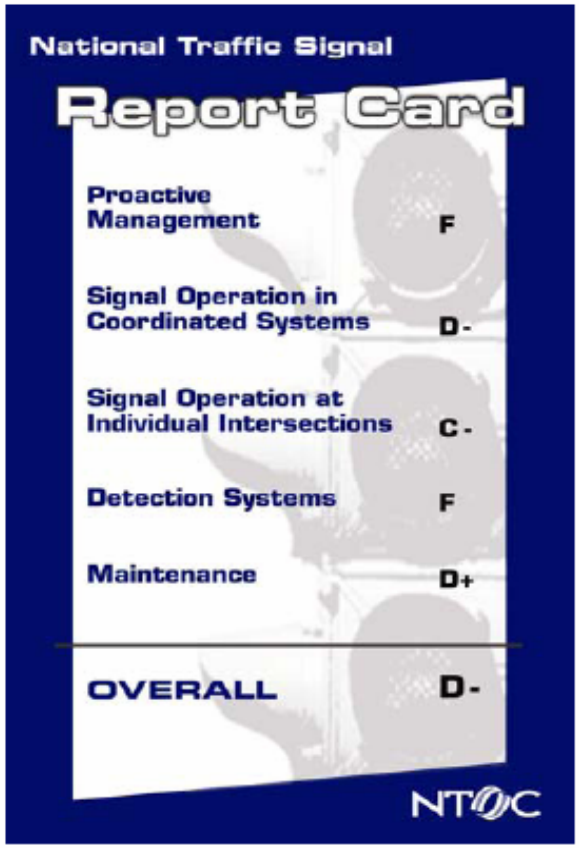
Before and After Ramp Meter Activation Analysis (2000)

Primary conflicts: when either the merging Behind or the adjacent mainline vehicle brake to avoid each other.

Secondary conflicts: mainline drivers behind a primary conflict that also must brake.



3. Signal Coordination



The National Traffic Operations Coalition published its first-ever traffic signal operation report card in 2005, and is preparing another report for 2007.

It is based on self-assessments

It is a grade-based system

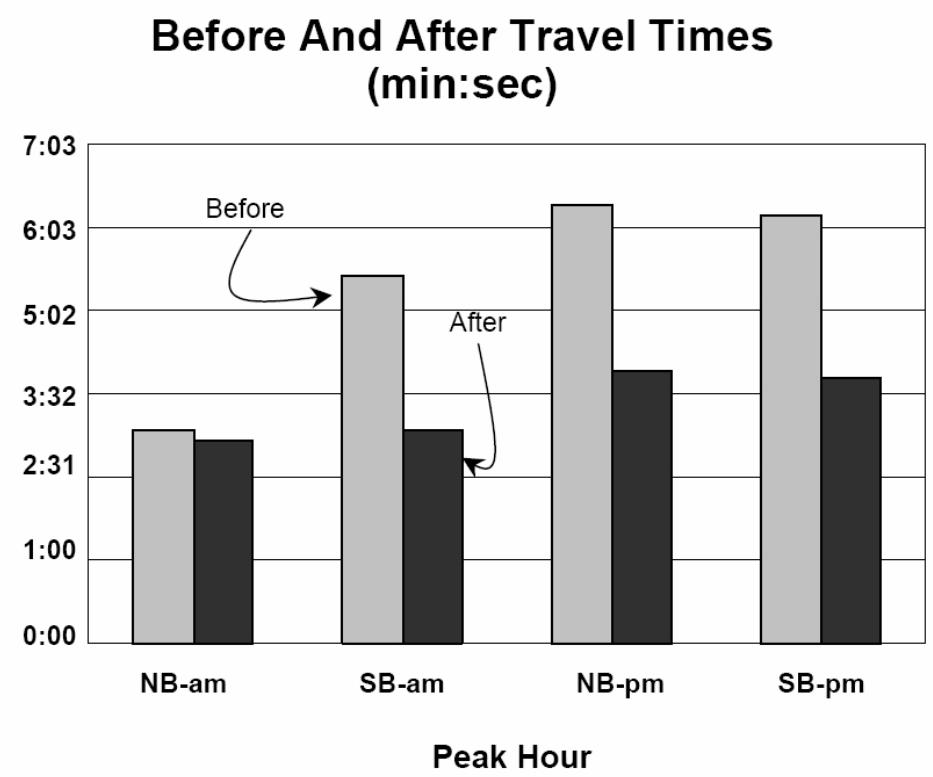
www.ite.org/selfassessment/default.asp

3. Signal Coordination: Before and After Study

Before and After Study

Average vehicle travel times were reduced ranging from 16 seconds (NB AM peak period) to 2 minutes and 27 seconds (NB PM peak period).

Stated otherwise, travel times improved 41% for the SB morning commute, and 38% for the NB evening commute.



Study conducted by the City of Bothell on retiming traffic signals on SR 527 between 228th Street SE and SR 524.

4. Variable Message Signs: Difficult to Measure Effectiveness

Pilot Project: *WSDOT activated four signs in the greater Seattle area and one sign at the U.S./Canada Peace Arch border crossing.)*

Qualitative Measure

"Compliment! …I also heard this morning on the news that it was a pilot program. Please keep it going!! It was great. I think it's a great use of the signs. And to however the time was estimated - it was right on. Thanks again." Citizen comment February 17, 2005

4. Other Traveler Information: Travel Times and Current Conditions

State Route/ Interstate	Route Description (for detailed locations click on links)	Distance (miles)	Average Travel Time (minutes)	Current Travel Time (minutes)
405 5	Bellevue to Everett	23.2	37	45
	Everett to Bellevue	23.5	28	26
5	Everett to Seattle	23.7	33	33
	Via Southbound Express Lanes	N/A	N/A	N/A
	Seattle to Everett	23.7	37	49
	Via Northbound Express Lanes	23.7	33	51
5	SeaTac to Seattle	13.0	18	29
	Seattle to SeaTac	13.0	20	15
405	Bothell to Bellevue	9.7	12	11
	Bellevue to Bothell	9.7	17	26
405	Tukwila to Bellevue	13.5	19	18
	Bellevue to Tukwila	13.5	24	29
167	Auburn to Renton	9.8	12	12
	Renton to Auburn	9.8	23	22
90 5	Issaquah to Seattle	15.5	24	34
	Seattle to Issaquah	15.7	21	29
520 5	Redmond to Seattle	14.8	28	41
	Seattle to Redmond	14.7	26	31
405 90	Bellevue to Seattle	10.7	23	32
	Via Westbound Express Lanes	N/A	N/A	N/A
	Seattle to Bellevue	10.6	17	22

Difficult to measure system impacts and benefits

5. HOV Lanes: Reliability

- **90% of the time, the HOV lane should be able to maintain an average speed of 45 mph or greater during the peak hour of the peak period.**
- **Other bases for reliability?**

Puget Sound Corridors Meeting HOV Lane Reliability Performance Goal *[Excerpt]*

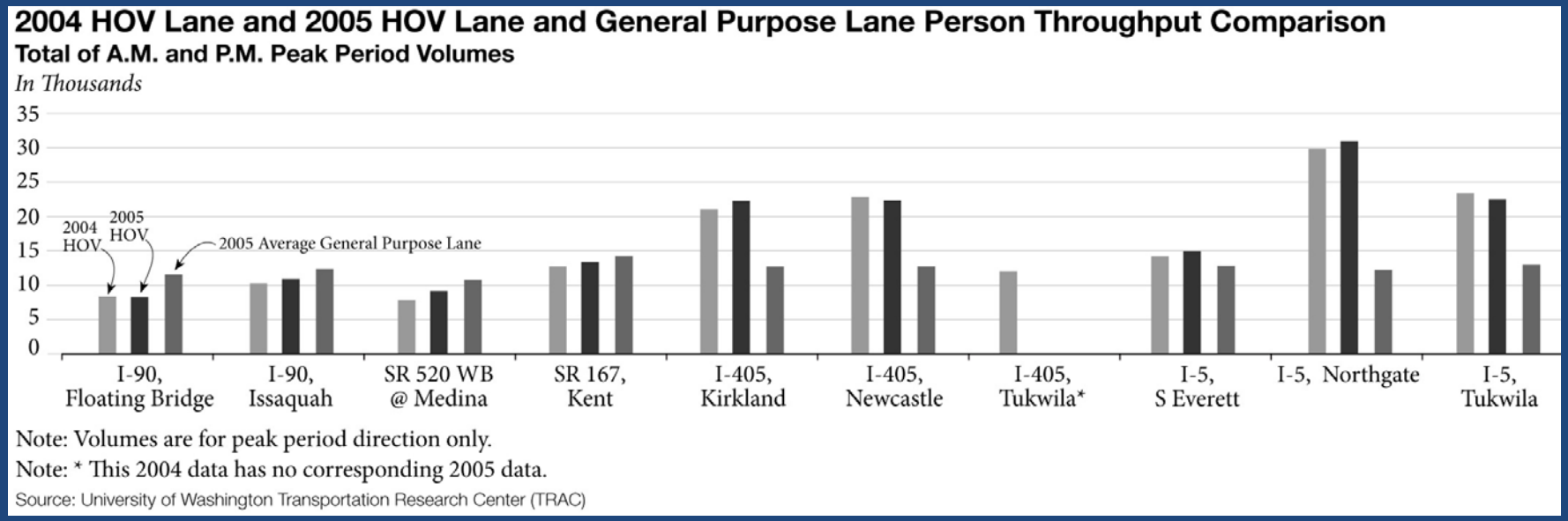
2004 and 2005, Based on Reliability Goal of the HOV Lane Maintaining a Speed of 45 mph for 90% of the Peak Hour[2]

Route	2004		2005	
	A.M.	P.M.	A.M.	P.M.
I-5, SR 522 to 112th St. (NB)	✓	Below	✓	Below
I-5, SR 526 to Northgate Way (SB)	Below	✓	Below	✓
I-405, I-5 Interchange (Tukwila) to NE 8th St. (NB)	Below[1]	✓	Below	✓
I-405, NE 8th St to I-5 Interchange (Tukwila) (SB)	✓	Below	✓	Below
I-90, S Rainier Ave to SR 900 (EB)	✓	✓	✓	✓

Source: University of Washington Transportation Research Center (TRAC)

Source: WSDOT 2006 Annual Congestion Report

5. HOV Lanes: Person and Vehicle Throughput



6. Suggested Measures for Work Zone Traffic Management

- Number of work zones by type of activity
- Number of miles lost
- Lane-mile-hours of work zones
- Average work zone duration by work zone type by lanes lost
- Average time between rehabilitation activities
- Average number of days projects completed late
- Ratio of inactive days to active days

***Source**: Brydia, Background development and concept of operations for a real-time performance measurement monitoring system.*

7. Suggested Measures for Operational Effectiveness

- Percent of freeway directional miles with traffic sensors, surveillance cameras, DMS, service patrol coverage
- Percent of equipment (DMS, surveillance cameras, traffic sensors, ramp meters, RWIS) in good or better condition
- Percent of total device days out-of-service (by type of device)

***Source**: NCHRP 3-68: Guide to Effective Freeway Performance Measurement*

8. Measuring Maintenance - Example of a Systematic Approach to Measurement

- **Maintenance is a broad field within operations- many DOT's have traditionally focused on individual maintenance activities.**
- **The new trend is to use a systematic approach to performance measurement in order to measure an entire program (instead of individual activities).**
- **This approach serves as an example of a best practice for a systematic approach to performance measurement for operations.**

8. Case Study: Maintenance Accountability Program (MAP)

- **WSDOT has measured maintenance program performance through the MAP since 1996**
- **MAP is a performance measurement and budgeting system that measures and communicates the performance outcomes of 33 highway maintenance activities**
- **Maintenance activities are prioritized by assessing their impact to meeting broad program objectives**
- **Each maintenance activity has a Level of Service (LOS) target with funding appropriated by the Legislature as primary driver for the target.**
- **Each maintenance activity also has a unique performance measure and is graded against the LOS target set by the Legislature.**

8. The 33 Maintenance Program Activities tracked in MAP

	Funded Service Target	Pass	Fail	% of Funding
Movable & Floating Bridge Operations	B+	✓		2.3
Traffic Signal System Operations	C	✓		3.5
Snow & Ice Control Operations	*C+*	✓		*21.0*
Keller Ferry Operations	B	✓		0.4
Urban Tunnel Systems Operations	B	✓		1.2
Structural Bridge Repair	C	✓		3.1
Regulatory/Warning Sign Maintenance	C+		✓	0.9
Slope Repairs	B	✓		1.6
Intelligent Traffic Systems	B-	✓		1.7
Maintain Catch Basins & Inlets	B	✓		1.4
Pavement Patching & Repair	*B+*	✓		*8.0*
Bridge Deck Repair	B-	✓		0.5
Guardrail Maintenance	A	✓		0.5
Pavement Striping Maintenance	A-	✓		3.2
Raised/Depressed Pavement Markers	B	✓		0.7
Control of Vegetation Obstructions	B-	✓		2.6

Funding choices by the Legislature determine "Funded Service Targets." Based on the funding provided to each activity, corresponding service targets are established by WSDOT. Any target that does not meet the legislatively-funded level of service is reported to have failed to meet expectations. WSDOT measures and assesses these 33 activities.

(Continued next slide)

8. The 33 Maintenance Program Activities Tracked in MAP (cont'd)

	Funded Service Target	Pass	Fail	% of Funding
Rest Area Operations	B	✓		3.6
Sweeping and Cleaning	B+	✓		2.5
Maintain Ditches	B	✓		3.6
Highway Lighting Systems	B+	✓		3.6
Guidepost Maintenance	C-	✓		0.9
Safety Patrol	C+	✓		2.2
Maintain Culverts	C	✓		1.9
Pavement Marking Maintenance	C-	✓		0.9
Noxious Weed Control	B	✓		1.8
Shoulder Maintenance	C+	✓		1.1
Guide Sign Maintenance	B-	✓		1.4
Maintain Detention/Retention Basin	C	✓		0.2
Bridge Cleaning & Painting	C	✓		0.7
Nuisance Vegetation Control	B-	✓		3.1
Landscape Maintenance	C-	✓		1.5
Crack Sealing	C-	✓		0.4
Litter Pickup	D	✓		2.3

8. Visual Representation of Level of Service Ratings

Service Level A

Service Level B

Service Level C

Service Level D

Service Level F

Operational Measures for Mobility: Related Resources

- Transportation Research Board. Maintenance Quality Assurance Program.(Publication No.: FHWA/IN/JTRP-2003/18, SP-2358) West LaFayette, IN: State of Indiana Printing Office, (2003)
- Replogle, M., & Funderburg, K. *No More Just Throwing Money Out the Window: Using Road Tolls to Cut Congestion, Protect the Environment, and Boost Access for all.* Washington, DC: Environmental Defense, 2006.
- Texas Transportation Institute. *Cell Phone Travel Time Data Collection White Papers.* DRAFT –not published - College Station, Texas: Texas A&M University, 2006. with permission
- NCHRP 3-68: Guide to Effective Freeway Performance Measurement
- Maryland State Department of Transportation. *2007 Attainment Report on Transportation System Performance.*
- Twin Cities Ramp Meter Evaluation. Cambridge Systematics, et al. February 2001.
- WSDOT 2006 Annual Congestion Report
- WSDOT Seattle Area Traffic. www.wsdot.wa.gov/traffic/seattle/
- WSDOT Seattle Area Travel Times. www.wsdot.wa.gov/traffic/seattle/traveltimes/

Measuring Maintenance: Related Resources

- NCHRP 14-12: Highway Maintenance Quality Assurance
- NCHRP 8-32(A): Multimodal Transportation - Development of a Performance-Based Planning Process
- NCHRP 14-13: Customer Driven Benchmarking for Highway Maintenance Activities
- Conferences/Surveys
  - National Workshop on Commonly Recognized Measures for Maintenance
  - AASHTO Survey on Performance Measures
  - National MQA Peer Exchange and Survey
- On-line MQA document library http://www.mrutc.org/outreach/MQA/library/