Research Report
KTC-05-32/SPR-303-05-1F

KENTUCKY TRANSPORTATION CENTER

College of Engineering

STATEWIDE PLANNING SCENARIO SYNTHESIS: TRANSPORTATION CONGESTION MEASUREMENT AND MANAGEMENT

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Research Report

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Statewide Planning Scenario Synthesis: Transportation Congestion Measurement and Management

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Statewide Planning Scenario Synthesis: Transportation Congestion Measurement and Management

Kentucky Transportation Center

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This study is a review of current practices in 13 states to: (1) measure traffic congestion and its costs; and (2) manage congestion with programs and techniques that do not involve the building of new highway capacity. In regard to the measures of congestion, the findings suggest two broad conclusions: (a) the most popular measures are not LOS or volume to capacity ratios; but rather the direct measures of either average time to traverse the distance between two points, or the average speed of vehicles. These are sometimes used to construct estimates of delay during peak traffic periods. (b) Five of the 13 states are either using or trying to devise more complex measures of congestion, measures that include estimates of the various costs associated with congestion. Regarding congestion management, most of the 13 states are implementing the 10 congestion management techniques identified by the study. When asked to rank the most effective techniques, the top four were incident management programs, signal coordination, traffic management centers, and access management.</td></tr>
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Executive Summary

Traffic congestion is a growing problem that plagues our nation’s transportation system, especially in urban and suburban areas. According to the Texas Transportation Institute, between 1982 and 2002, the annual hours of delay per peak hour traveler increased from 16 to 46 hours, the total hours of delay from .7 to 3.5 billion and the estimated cost of congestion in billions of 2002 dollars from 14.2 to 63.2 dollars. This is due to a surge in the number of vehicle miles traveled by Americans that is far greater than the rise in the number of lane miles available. The nation’s highway departments and agencies cannot keep pace with the rising number of drivers. To be sure, they have neither the available right-of-way nor the financial capacity to solve the congestion problem by building new lane miles of highways.

The congestion crisis must be met with a number of other techniques for improving traffic flow. But, before congestion can be solved, it must be measured so that resources can be directed to the places most in need of congestion relief.

The Kentucky Transportation Cabinet asked the Kentucky Transportation Center at the University of Kentucky to conduct a review of: (1) current practices to measure congestion and its costs; and (2) possible practices to reduce congestion that did not involve building new capacity. The transportation cabinet convened an advisory committee, which selected 13 states viewed as leaders in the field of congestion management. Senior transportation officials in the 13 states in table A were interviewed about their approaches to measuring and reducing congestion.

Table A: Focus States in the Study

Indiana	Washington	Ohio	Florida	Virginia
Michigan	Wisconsin	Texas	Oregon	Pennsylvania
New Mexico	Arizona	Colorado		

Each state was queried about its official and unofficial state “congestion performance measures.” Performance measures are quantitative indicators of the degree of congestion present on a roadway at a given time. In all our informants mentioned four types of indicators. Two are traditional measures: level of service and volume to capacity ratios. The other types fell into two other categories, which we labeled (see table B) time/speed measures and complex measures.

The time/speed measures were quantitative indicators of the time it took a driver to traverse a specific distance or the average commute speed from one point to another. These were measured at various times of day Sometimes this data was used to compute an estimate of delay by subtracting the free-flow time from the measured time during a peak hour. This type was most likely to be deemed a best measure, as nine states mentioned it as one of their top three.

The complex measures were not mentioned as often and each one was different. While incorporating measures of average speed or travel time, they include other factors as well. For example, Oregon is constructing a measure that includes an estimate of the cost associated with sprawling land use--in which a shorter but slower drive of 20 minutes would indicate less social cost than a longer drive in miles of 20 minutes. Many of the other complex measures involve estimates of time and/or financial cost associated with delay.

Table B: Respondent Indications of Best Congestion Performance Measures for Their States

Category of Measure	Specific Measures	Number of States Mentioning the Specific Measure as One of Top Three (1)
Level of Service	Level of Service	3
Volume/Capacity Ratio	Volume/Capacity Ratio	4
Time/Speed Measures of Corridors	1. Delay time 2. Average Travel/Com-mute time 3. Average Speed	2 6 1
Complex Measures	1. Benefit/Cost (HERS) 2. Virginia Vehicle Throughput Index 3. Texas Congestion Index 4. Lost Productivity Estimate 5. Oregon Travel Cost Index	1 1 1 1 1

1. Some states mentioned only one or two.

We also asked the respondents to identify and rank the most common congestion management solutions that do not involve adding capacity. The results are in table C. Incident management teams designed to quickly remove inoperable vehicles from the highway were mentioned most often (10 mentions); followed by signal coordination (5 mentions) traffic management centers (5 mentions); access management (4 mentions); and ramp meters (3 mentions). The others had only one mention each.

Table C: Respondent Indications of Best Congestion Management Solutions for Their States (the number of each ranked 1, 2, or 3)

Type of Solution	Number ranked first	Number Ranked Second	Number Ranked Third	Total Mentions
Ramp Meters	1	1	1	3
Incident Management	2	6	2	10
Signal Coordination	1	2	2	5
Access Management	3	0	1	4
Traffic Information on Web	0	1	0	1
Travel Times Information	1	0	0	1
Traffic Management Centers	2	3	0	5
HOV Lanes	1	0	0	1
511 Program	0	1	0	1

Each of the thirteen states in our study is grappling with the issue of rising congestion. They are measuring congestion with a wide variety of measures. However, when asked to mention the most useful or best measure, their responses suggest two broad conclusions. (1)The most popular measures are not LOS or volume capacity ratio. Rather, they are the relatively direct measures of either average time to traverse the distance between two points or, relatedly, the average speed of vehicles, or estimated delay. (2) Five of the 13 states are either using or trying to devise a more complex measure of congestion. These tend to build on measures of speed and time and then add additional factors to estimate the costs to the public of congestion.

All 13 states have implemented a majority of the congestion management solutions. When asked to identify the most effective or best, the top four were incident management programs, signal coordination, traffic management centers and access management. Traffic information on the web, HOV lanes, and travel times information were mentioned much less often as one of the three most effective.

Statewide Planning Scenario Synthesis: Transportation Congestion Measurement and Management

1.0 Research Issue and Strategy

1.1 Introduction

Traffic congestion is a growing problem that plagues our nation's transportation system, especially in urban and suburban areas. According to the Texas Transportation Institute, between 1982 and 2002, the annual hours of delay per peak hour traveler increased from 16 to 46 hours, the total hours of delay from .7 to 3.5 billion and the estimated cost of congestion in billions of 2002 dollars from 14.2 to 63.2 dollars. This is due to a surge in the number of vehicle miles traveled by Americans that is far greater than the rise in the number of lane miles available. The nation's highway departments and agencies cannot keep pace with the rising number of drivers. To be sure, they have neither the available right-of-way nor the financial capacity to solve the congestion problem by building new lane miles of highways.

Thus, the congestion crisis must be met with a number of other techniques for improving traffic flow. But, before congestion can be solved, it must be measured so that resources can be directed to the places most in need of congestion relief.

The Kentucky Transportation Cabinet asked the Kentucky Transportation Center at the University of Kentucky to conduct a review of: (1) current practices to measure congestion and its costs; and (2) possible practices to reduce congestion that did not involve building new capacity. The transportation cabinet convened an advisory committee, which selected 13 states viewed as leaders in the field of congestion management. Senior transportation officials in the 13 states in table 1 were interviewed about their approaches to measuring and reducing congestion.

Table 1: States in the Study

Indiana	Washington	Ohio	Florida	Virginia
Michigan	Wisconsin	Texas	Oregon	Pennsylvania
New Mexico	Arizona	Colorado		

1.2 Congestion Background

Traffic congestion continues to stretch the capacities of our nation's roadways. Once thought of as only a "Large-City" problem, it is now found throughout the country including small-market metropolitan areas. The Kentucky Transportation Cabinet has realized this and seeks to engage this issue in a pro-active manner instead of waiting for the problem to reach critical mass. With that goal in mind, a traffic congestion meeting was held on March 2, 2005 to determine the best approach to confront this issue. Experts in the field of transportation gathered together from several agencies as shown in Table 2 below.

Table 2: KTC Meeting Attendees

KTC Traffic Congestion Meeting: 3/02/2005		
	Name	***Agency/Institute***
1)	Nancy Miriuli	Kentucky Transportation Cabinet: Planning
2)	Len O'Connell	Kentucky Transportation Center
3)	Brian Howell	Kentucky Transportation Center
4)	Phil Flynn	Kentucky Cabinet for Economic Development
5)	Brandon Sanders	Kentucky Transportation Cabinet: Planning
6)	Rob Bostrom	Kentucky Transportation Cabinet: Multimodal
7)	Bruce Siria	Kentucky Transportation Cabinet: Planning
8)	Carl Dixon	Wilbur Smith Associates
9)	Doug Kreis	Kentucky Transportation Center
10)	Annette Coffey	Kentucky Transportation Cabinet
11)	Nancy Albright	Kentucky Transportation Cabinet: Division of Maintenance

The first and foremost issue of concern discussed at the meeting was the effectiveness of methods for quantifying congestion. When does a certain volume of traffic become unacceptable? Furthermore, how does one measure traffic congestion in a meaningful and thorough manner -- one that can be useful to both transportation planners and the public at large? These are complicated questions and the answers are not readily available. Currently, the US Department of Transportation has no binding requirements for states to follow concerning traffic congestion measures other than the standard Level of Service in reference to required traffic studies. However, many states are each independently seeking efficient and effective measures of traffic congestion. Such measures can be utilized to measure the 'performance' of a roadway system or capacity of the roadway to efficiently and effectively convey traffic flows.

The second issue of concern to the Kentucky Transportation Cabinet involves identifying innovative and economically feasible transportation solutions to reduce traffic congestion. Solutions, that is, that do not require constructing new lane miles of roadway. Continually adding roadway capacity to alleviate traffic congestion is no longer the automatic solution. Many factors render this option extremely expensive and often impractical: among the factors--the costs associated with: planning and design, right-of-way acquisition, relocation of residents, and the rising cost of construction to name a few. With large annual deficits facing the federal budget for the foreseeable future, states can no longer lean on the Federal Highway Administration to cover a large portion of their transportation spending. Therefore, it is critical that other methods for reducing traffic congestion be found, methods that effectively manage congestion without 'blowing-up' the state budget. The Kentucky Transportation Cabinet seeks alternative solutions for effectively dealing with traffic congestion, other than adding roadway capacity.

1.3 Research Strategy

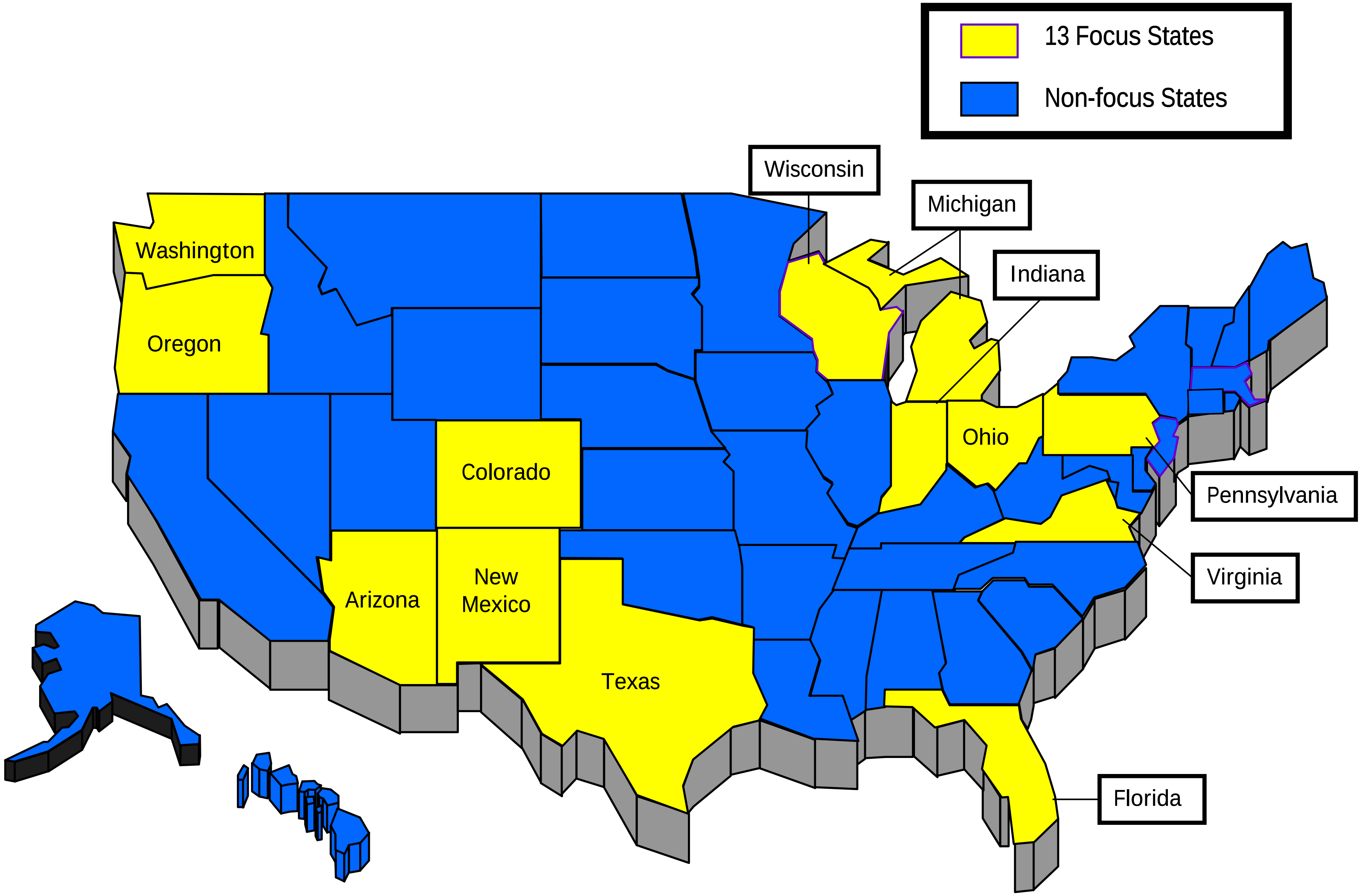
At the March meeting, it was determined that several states across the US appear to be leading the way in the field of congestion management. These 'focus' states have active traffic management programs. To acquire more information on their programs, it was decided that officials in traffic and planning in these states be interviewed about their techniques for measuring congestion and reducing its impact on their traffic systems. For a complete listing of these 'focus' states, please refer to Table 1. A US map of the focus states is shown in Figure 1.

A key list of popular, alternative transportation solutions for traffic congestion was identified by the Kentucky Transportation Center and incorporated into the analysis as shown in Table 3. Each of the focus states was asked which (if any) of these solutions were implemented in their state and they were asked to identify the solutions that were most effective in mitigating congestion

Table 3: Congestion Management Solutions

Traffic Management Centers	Travel times for Corridors	Webcams (Traffic-cams)
Traffic-Light Signalization	Ramp Metering	Incident Response Teams
511 (Traffic Information)	Access Management	HOV Lanes
Public Transit		

Figure 1: Focus States



2.0 Measures of Congestion

2.1 Introduction

In the today's economic environment of limited funding and budget constraints, states are always seeking ways to maximize the efficiency of their capital investments. Transportation infrastructure projects are often the most visible and highest form of discretionary spending dedicated to public facilities. Therefore, it is imperative that these projects maintain a maximum return on their investment. Increasingly, the way to do this for transportation projects is through the adoption of various performance measures.

Performance measures represent a means to measure traffic congestion. In order to find a meaningful way to determine trends in traffic, different performance measures are being adopted by state departments of transportation. As outlined in *NCHRP Synthesis 311: Performance Measures of Operational Effectiveness for Highway Segments and Systems*, performance measures should accomplish the following three goals: (1) determine efficient uses of resources and how well they are converted to outputs to reach organizational goals; (2) act as a grade to measure government performance; and (3) determine future financial priorities for transportation by giving policy analysts benchmarks for determining future allocations. [1]

Although they are increasingly vital, there has not yet been a consensus on the best ways to measure congestion at either the state or national level. So different states are each reaching their own conclusions on what constitutes the 'best' measure to estimate traffic congestion. Some common performance measures include: Level of Service (LOS), travel delay, travel times, and volume-to-capacity ratios (v/c), etc.

Leading the way in the promotion of performance measures is the Texas Transportation Institute (TTI), a recognized authority on transportation issues affecting the United States today. As shown in their 2004 Urban Mobility Report, there are many performance measures which can be utilized for these purposes.[2] Please refer to Table 4 below for a list of performance measures used in the 2004 Urban Mobility Report

Table 4: TTI Performance Measures: 2004 Urban Mobility Report	
1) Travel Delay	5) Wasted Fuel
2) Travel Rate Index	6) Congestion Costs
3) Travel Time Index	7) Percent of Congested Travel
4) Fuel Economy	8) Roadway Congestion Index

Using the questionnaire shown in Appendix A, DOT officials in the focus states were interviewed. A concerted effort was made to contact the official most knowledgeable about the states congestion measures and the methods used to reduce congestion. This often led to direct contact with supervisors, manager, engineers, and technical analysts working in Traffic Operations, Traffic Engineering, Congestion Management, and miscellaneous other departments in the different DOT's. Sometimes it was necessary to contact private-sectors transportation experts such as the case with Cambridge Systematics. For a complete list of all designated contact persons for the focus states, please refer to Appendix B.

In the questionnaire, the very first information to be ascertained was the adoption of performance measures by that particular state. The following questions were asked: "Are performance measures used in your state to quantify traffic congestion?"; "What are the 'official' performance measures and in addition, are there any 'unofficial' performance measures useful to transportation officials?” and "Which performance measure is most useful to your state in trying to reduce congestion (and second and third best)?". Please see Table 5 on the next page for a complete listing of the states and their responses.

Table 5: Focus States' Performance Measures						
	State	Agency	Representative	Official PM's	Unofficial PM's (if any)	"Best" Performance Measure/s
1.	AZ	AZDOT	Beverly Chenausky[iii]	1. LOS 2. Delay 3. % persons by alternative travel mode	1. HOV miles 2. Bike lane miles 3. Number of park-and-ride spaces	1. Avg. delay time (per trip) 2. % persons by alternative travel mode
2.	CO	CDOT	Tim Baker, Dave Busby[iv]	1. V/C ratios 2. New measures in development per Cambridge Institute)	1. Rate of change in vehicle-miles of travel 2. Customer ratings (surveys)	1. V/C ratio 2. Travel times to public
3.	FL	FDOT/ Cambridge Institute	Doug McLeod, [v] Anita Vandervalk - Ostrander[vi]	1. Person miles traveled 2. Truck miles traveled 3. Vehicle miles traveled 4. Average speed 5. Delay 6. % system heavily congested 7. % travel heavily congested 8. Vehicles per mile lane 9. Duration of congestion	None	1. Average Travel Times 2. Average Speed
4.	IN	INDOT	Frank Baukert[vii]	1. LOS 2. V/C ratio 3. Delay	1. Vehicle miles traveled, 2. Vehicle hours traveled 3. Total traffic volumes	1. LOS 2. Benefit/Cost ratio (per statewide travel demands model HERS)
5.	MI	MDOT	Brad Winkler[viii]	1. LOS 2. Duration	1. Delay 2. Density (future measures)	1. LOS 2. Duration/Speed
6.	NM	NMDOT	Ray Matthew[ix]	1. LOS	None [a]	None
7.	OH	ODOT	George Saylor, [x] Homer Suter, [xi] Leonard Evans[xii]	1. V/C ratio	1. TTI Congestion Index 2. Delay	1. V/C ratio [b]

8.	OR	ODOT	Brian J. Gregor, Richard D. Arnold	1. Travel Time Index 2. V/C Ratio 3. Average speed or travel time 4. Buffer time index		1. Travel Cost Index (in development) 2. travel time commute time 3. V/C ratio
9.	PA	PENNDOT	Bill Laubach	1. LOS 2. Travel Time Runs 3. V/C ratio		1. Travel time runs 2. V/C ratio
10.	TX	TXDOT	Al Kosik[xiii]	1. Annual Delay per person 2. Travel Rate Index	1. Texas Congestion Index (in development)	None [c]
11.	VA	VDOT	Lawrence Caldwell[xiv]	None [d]	1. Vehicle Throughput Index 2. Average Speed 3. Travel Times 4. LOS 5. V/C ratio 6. Density	1. Travel Times for Corridors 2. Vehicle Throughput Index [e]
12.	WA	WSDOT	Sandra Pedigo-Marshall, [xv] Shuming Yan[xvi]	1. Buffer Time Index 2. Two Times Free Flow 3. Delay	1. Congestion Index 2. Lost Productivity 3. LOS	1. Total Delay 2. Congestion Index 3. Lost Productivity *All coequal per Shuming Yan
13.	WI	WISDOT	Joseph Nestler[xvii]	1. LOS	1. Delay 2. Travel Time	1. LOS

[a] New Mexico is currently examining potential performance measures per Ray Matthew
[b] ODOT examined many performance measures in 2001 per "Congestion Management System Report" and only officially adopted V/C ratios as a performance measure
[c] Multiple congestion indices as outlined should be used in conjunction for overall performance per Al Kosik
[d] Unofficial performance measures are currently being examined for adoption by VDOT for "Official" status
[e] Vehicle Throughput Index is currently in development.

2.2 Best Congestion Performance Measures

In all our informants mentioned four types of “best” congestion measures. Two are traditional measures: level of service and volume to capacity ratios. The other types fell into two other categories, which we labeled (see Table 6) time/speed measures and complex measures. The time/speed measures were quantitative indicators of the time it took a driver to traverse a specific distance or the average commute time from one point to another. These were measured at various times of day. This type was most likely to be deemed a best measure, as nine states mentioned it as one of their top three.

The complex measures were not mentioned as often and each one was different. While incorporating measures of average travel time, delay, and speed, they contained other factors. For example, Oregon is constructing a measure that includes an estimate of the cost associated with sprawling land use--in which a shorter but slower drive of 20 minutes would indicate less social cost than a longer drive in miles of 20 minutes. The other complex measures involve estimates of various financial or monetized costs associated with delay. Brief descriptions of each are in Table 7

Table 6: Respondent Indications of Best Congestion Performance Measures for Their States

Category of Measure	Specific Measures	Number of States Mentioning the Specific Measure as One of Top Three
Level of Service	Level of Service	3
Volume/Capacity Ratio	Volume/Capacity Ratio	4
Time/Speed Measures of Corridors	1. Delay time 2. Average Travel/ Commute time 3. Average Speed	2 6 1
Complex Measures	1. Benefit/Cost (HERS) 2. Virginia Vehicle Throughput Index 3. Texas Congestion Index 4. Lost Productivity Estimate 5. Oregon Travel Cost Index	1 1 1 1 1

Table 7: Descriptions of Complex Congestion Performance Measures

1) Benefit/Cost (HERS) -- The Highway Economic Requirements System State Version is an engineering/economic forecasting software program that is utilized to identify perceived highway deficiencies and prioritize future projects accordingly. In this system, a set of engineering inputs are taken from across the focus state (speeds, road lengths, volumes, pavement conditions, etc.) to generate a set of predicted outputs. Outputs can include estimated costs associated with the project and predicted benefits generated from improvements such as reductions in travel delay

2) Buffer Time Index -- The additional time that must be added to a trip, to ensure that travelers making the trip will arrive at their destination at, or before, the intended time, 95% of the time. The equation is shown as follows:

$$\begin{array}{c}\text{Buffer}\\\text{Time Index}\end{array} = \begin{array}{c}\text{Weighted}\\\text{Average of}\\\text{All Sections}\\\text{(Using VMT)}\end{array}\left[\frac{\begin{array}{c}\text{95th Percentile Travel Rate}\\\text{(in minutes per mile)}\end{array} - \begin{array}{c}\text{Average Travel Rate}\\\text{(in minutes per mile)}\end{array}}{\begin{array}{c}\text{Average Travel Rate}\\\text{(in minutes per mile)}\end{array}} \times 100\%\right]$$

3) Lost Productivity Estimate or Lost Efficiency -- This measure is used by the Washington Department of Transportation and measures the 'efficiency' of the roadway. It is calculated by subtracting peak period volume from the roadway's official carrying capacity over a given time interval. Because of increased delays and subsequent drops in speed, the actual capacity can drop to as little as 50% of the theoretical capacity. This will result in productivity lost due to delay.

4) Oregon Travel Cost Index -- This index contains a trade-off between the “costs” of sprawling land use and the costs of delay. It is calibrated to favor compact land use. Thus, for example, a 20 minute ride on a 2 mile road is preferred to a 20 minute ride on a 10 mile road.

5) Texas (TTI) Congestion Index -- This multidimensional congestion index is under construction. Many variables are expected to go into this future index including such factors as: cars' recurring and non-recurring delays, bus delays, bicycle delays, rail delays, added capacity, increased system efficiency, freight delay, demand management, and potentially many more. This future index will initially be developed from the eight largest metropolitan areas' data with updates down the road.

6) Travel Rate Index -- This rate incorporates travel rates from both freeways and principal arterial streets to measure the overall rate of progression. It essentially shows the added time needed to make a trip under congested conditions across a network of roads.

7) Two Times Free Flow -- This measure seeks to examine the effects of extreme traffic congestion such as those usually associated with automobile accidents. It is measured by evaluating peak travel time which is two times free flow travel time.

8) Virginia Vehicle Throughput Index -- Although still in development (and not official), this index compares recent traffic volumes and travel speeds to a set baseline traffic volume at free-flow speeds. The plan is to be able to break down the Vehicle Throughput Index into smaller time components (quarters, weeks, days) as well as geographical areas (districts, road types).

3.0 Congestion Management Solutions

3.1 Introduction

Traffic congestion can be combated on three different fronts: demand management, operational improvements, and additional capacity. Demand management involves the use of incentives and disincentives to alter the number of vehicles on the road at a specific time of day. For example employers could institute a policy of flexible work hours to reduce the number of employees driving during the peak work hours. Imposing fees or tolls for driving during rush hour would be an example of a disincentive. This study did not research demand management policies.

Operational improvements utilize improvements in the efficiency of transportation infrastructure. This is often performed through the adoption of Intelligent Transportation Systems (ITS) techniques. Intelligent Transportation Systems improve network efficiency and traffic flow through several different mechanisms: for example, by providing the commuter with alternative routes when traveling; or by in effect maintaining 'eyes' and 'ears' with closed circuit cameras to observe accidents and other disruptions as they happen and then quickly clearing accidents in a timely manner with incident response management. Other ITS techniques improve traffic flow by fine-tuning traffic signals with more efficient cycling. In sum, ITS can include many different components but typically includes: traffic management centers, traffic light signal coordination, incident response teams, ramp metering, 511 travel information hotline, etc.

Finally, the familiar approach to alleviating traffic congestion (and by far the most expensive as well) involves adding capacity to the transportation network. For our project, we will not investigate the construction of new highways. Rather, public transit (buses, light-rail, etc.) and high-occupancy vehicle (HOV) lanes will be researched for their usefulness and popularity in the states involved in our study. For a complete list of our ten 'standardized' solutions to compare from state-to-state, please refer to Table 8 below. They are defined in Appendix C.

Table 8: Transportation Management Solutions	
1) Webcams	6) Access Management
2) Traffic Management Centers	7) 511 – Travel Information
3) Travel Times for Busy Corridors	8) Public Transit
4) Signal Coordination	9) High-Occupancy Vehicle Lanes
5) Ramp Metering	10) Incident Management

3.2 Prevalence of Adoption

The DOT professionals were asked to identify which of the ten congestion management techniques in table 8 were currently operating in their state. As shown in table 9, most states had instituted each of the ten. A Y (for yes) indicates that the state has the congestion solution; a N (for no) means it does not.

Table 9: Adoption of Ten Congestion Management Solutions in the Focus States

State	Ramp Meters	Incident Mgt.	Signal Coord.	Access Mgt.	Traffic Webcam	Travel Times for Public	TMC/s	HOV	511	Public Transit
AZ	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
CO	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
FL	*	Y	Y	Y	Y	N	Y	Y	Y	Y
IN	N	Y	Y	Y	Y	Y	Y	N	**	Y
MI	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
NM	N	Y	Y	Y	N	N	N	N	**	Y
OH	Y	Y	Y	Y	Y	N	Y	N	***	Y
OR	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
PA	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
TX	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
VA	Y	Y	Y	Y	Y	****	Y	Y	Y	Y
WA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
WI	Y	Y	Y	Y	Y	Y	Y	Y	N	Y

*Florida: to initiate ramp meters in year 2006
**Indiana & New Mexico: in development phase for implementation of 511
***Ohio: only Cincinnati area has 511

****Virginia: travel speeds for corridors instead of 'travel times'

We also asked the respondents to identify and rank the congestion management solutions that do not involve adding capacity. The results are in table 10. Incident management teams designed to quickly remove inoperable vehicles from the highway were mentioned most often (10 mentions); followed by signal coordination (5 mentions) traffic management centers (5 mentions); access management (4 mentions); and ramp meters (3 mentions). The others had only one mention each.

Table 10: Respondent Indications of Best Congestion Management Solutions for Their States (the number of each ranked 1, 2, or 3)

Type of Solution	Number ranked first	Number Ranked Second	Number Ranked Third	Total Mentions
Ramp Meters	1	1	1	3
Incident Management	2	6	2	10
Signal Coordination	1	2	2	5
Access Management	3	0	1	4
Traffic Information on Web	0	1	0	1
Travel Times Information	1	0	0	1
Traffic Management Centers	2	3	0	5
HOV Lanes	1	0	0	1
511 Program	0	1	0	1

4.0 Summary and Conclusion

Each of the thirteen states in our study is grappling with the issue of rising congestion. They are measuring congestion with a wide variety of measures. However, when asked to mention the most useful or best measure, their responses suggest two broad conclusions. First, the most popular measures are not LOS or the volume to capacity ratio. Rather, they are the relatively direct measures of either average time to traverse the distance between two points or, relatedly, the average speed of vehicles, or the estimated delay computed by subtracting the expected travel time at free flow from the measured time at peak hour.

Second, five of the 13 states are either using or trying to devise a more complex measure of congestion. These measures tend to build on measures of speed and time and then add additional factors to estimate the costs to the public of congestion.

All 13 states have implemented a majority of the congestion management solutions. When asked to identify the most effective or best, the top four were incident management programs, signal coordination, traffic management centers, and access management. Traffic information on the web, HOV lanes, and travel times information were mentioned much less often as one of the three most effective.

References

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Appendix A: Survey Instrument

Checklist

1) Confirmation: Go over "Congestion Performance Measures" currently utilized by study state

2) Recommendation: Which of these "Congestion Performance Measures" is most useful for planners trying to reduce congestion? (i.e. -- the "Best" PM in your opinion) Which is the second most effective?

3) Confirmation: Go over "Congestion Solutions" (other than adding roadway capacity) to alleviate congestion by study state

4) Congestion Solutions:

a) If have "Traffic Management Center", what other components of ITS go along with this (closed-circuit cameras, electronic signs, loop detectors, etc)?

b) Have you done anything to improve "Traffic-Light Signalization" in the last 5 years?

c) Which city do you think has the "Best" Signalization in your state?

5) Recommendation: Which of these "Congestion Solutions" is most effective at reducing congestion? ("Best")   Which is the second most effective?

6) Additional "Notes" or "References" questions?

7) Obtain all Point-of-Contact Information:

a) Name b) Agency c) Department d) Job Title e) E-mail

Appendix B: Focus States' Contact Persons

Focus State	Name	Agency/ Organization	Division or Department	Job Title	Business Phone	E-Mail
Arizona	Beverly Chenausky	AZDOT	Transportation Planning Div.	Supervisor	(602) 712-7487	bchenausky@azdot.gov
Colorado	Tim Baker	CDOT	Information Management Branch	Transportation Planner	(303) 757-9757	tim.baker@dot.state.co.us
Colorado	Dave Busby	CDOT	Planning Branch: Performance Measures Unit	Performance Measures Specialist	(303) 757-9700	dave.busby@dot.state.co.us
Florida	Doug McLeod	FDOT	Traffic Engineering Division	Congestion Mgt. Manager	(850) 414-4932	douglas.mcleod@dot.state.fl.us
Florida	Anita Vandervalk-Ostrander	Cambridge Systematics	NA	Director for Florida Operations	(850) 219-6388, ext. 204	avandervalk@camsys.com
Indiana	Frank Baukert	INDOT	Division of Env., Planning, and Engineering	Transportation Planner	(317) 232-1486	fbaukert@indot.state.in.us
Michigan	Brad Winkler	MDOT	Asset Management	Congestion Management Specialist	(517) 373-2240	winklerb@michigan.gov
New Mexico	Ray Matthew	NMDOT	Strategic Planning Bureau	Transportation Planner	(505) 827-5506	ray.matthew@nmshtd.state.nm.us

Ohio	George Saylor	ODOT	Office of Traffic Engineering	Senior ITS Engineer	(614) 752-8099	george.saylor@dot.state.oh.us
Ohio	Homer Suter	ODOT	Office of Traffic Engineering	Section Manager	(614) 752-9995	homer.suter@dot.state.oh.us
Ohio	Leonard Evans	ODOT	Office of Systems Analysis Planning	Office Administrator	(614) 466-8993	leonard.evans@dot.state.oh.us
Oregon	Brian J. Gregor	ODOT	Transportation Planning Analysis Unit	Senior Transportation Analyst	(503) 986-4120	Brian.J.Gregor@odot.state.or.us
Pennsyl.	Bill Laubach	PENNDOT	Bureau of Highway Safety and Traffic Eng.	Congestion Engineer	(717) 787-9787	wlaubach@state.pa.us
Texas	Al Kosik	TXDOT	Traffic Management	Director	(512) 506-5101	akosik@dot.state.tx.us
Virginia	Lawrence Caldwell	VDOT	Mobility Management Div.	Asst. State Mobility Mgt. Engineer	(804) 786-7779	lawrence.caldwell@vdot.virginia.gov
Wash. St.	Sandra Pedigo-Marshall	WSDOT	Traffic Operations Dept.	Manager	(360) 705-7283	pedigos@wsdot.wa.gov
Wash. St.	Shuming Yan	WSDOT	Traffic Operations Dept.	Congestion Engineer	(206) 464-1276	yans@wsdot.wa.gov
Wisconsin	Joe Nestler	WISDOT	Bureau of State Highway Programs	Chief	(608) 264-7263	joseph.nestler@dot.state.wi.us

Appendix C: Definitions of Congestion Management Solutions

Many of the solutions are associated with the emergence of Intelligent Transportation Systems – or ITS, as it is commonly referred to. ITS incorporates cutting-edge technology in modern transportation systems to seek technology-based solutions to transportation issues. Various components make up an ITS system. The components vary from city to city but can include: traffic management centers, closed-circuit cameras, induction loops, traffic signals (timing), dynamic messaging signs, and travel times (or speeds) posted on the internet. Along with these components, ITS is strategically tied to Incident Management Response (through activation of EMS) and the 511 traffic hotline system. Please refer to a), b), and c) below for a list of the primary components incorporated into this study.

1. Traffic Webcams: A system involving closed-circuit cameras located strategically across the traffic network of a city (usually high traffic corridors) connected electronically to a main traffic management center (TMC). These cameras are always utilized by transportation officials for traffic monitoring purposes but are increasingly being placed on that city/state agency's website for travel time information to the public. These travel times are incorporated as a measure of accountability to the public.

2. Traffic Management Center: This functions as the main base of operations for traffic monitoring and transportation management. The TMC will monitor traffic flows and measure volumes (through induction loops -- see Appendix B) as part of ongoing studies as well as detect traffic accidents. Non-recurrent congestion, normally associated with traffic accidents, is a huge contributor to overall delay and congestion. To counter this source of congestion, incident response teams are contacted and respond accordingly.

3. Travel Times: As the name implies, travel times are those total times associated with a certain travel commute (route or corridor). In today's multi-tasked world, people need to know how long commutes will take and plan accordingly. As such, travel times have become longer and increasingly burdensome to the general population for trip-planning purposes. Businesses need to know when their goods will be shipped and how long it will take to reach the market. Likewise, individual commuters need to know long it will take to get to work, pick-up their children from school, or plan a trip for recreational purposes. So city governments are increasingly taking the traffic information obtained from induction loops and electronic traffic management software to post associated travel times (or in certain cases travel speeds) on the internet.

4. Traffic Light Signalization -- timing traffic light signals so they will hit green right as major traffic flows approach them on the main arterial; also involves placing detector loops (located six inches below the pavement) that generate magnetic fields; these fields are disrupted by vehicles waiting over the top of them (side road traffic) and consequently the main traffic light will produce a side road green light at a proximal interval

5. Ramp Meters -- timing meters (red/green) placed at the entrance interchange to access a freeway; incoming freeway traffic are spaced out in pre-determined time intervals to smoothly

merge with freeway traffic; this reduces disruption to the volume of mainline traffic and produces a overall net benefit to travel times on the network

6. Access Management -- access to high volume roadways is managed through a limited number of intersections; collector roads are often placed parallel to mainline arterials to provide access to various businesses without disrupting the high volume of the main road; can also include providing turning lanes (left-and-right turns) to minimize throughway traffic

7. 511 -- a telephone call-in system relaying the most up-to-date traffic information regarding accidents, road closures, and weather information to the driver in the state; this information provides the traveler with important information to avoid potential pitfalls in his/her trip by taking an alternate route if available; this is a nationwide measure that has been implemented in some, but not all, states

7. Public Transit -- consists of any system of transportation that transports a maximum number of occupants in a high-density manner in an economically feasible manner; this system can include many different systems such as buses, light-rail, subways, etc.; this system is the most efficient form of transportation but also the most expensive and can suffer from low ridership incurring additional costs on the provider

8. High-Occupancy Vehicle (HOV) Lanes -- High-density lanes that stipulate only densely packed vehicular traffic can utilize such lanes. Typically, this says that only vehicles with two or more passengers can travel on an HOV lane. These can either be use during peak-hour traffic or 24-hrs / day at the discretion of the governing authority.

9. Incident Management Response -- This component seeks to minimize non-recurrent traffic congestion through rapidly and efficiently responding to traffic incidents. Although this is most often associated with EMT (police, ambulatory, city patrol teams, etc.) responding to traffic accidents, this can include a wide array of situations as in the event of a natural disaster or a terrorist act. It is estimated that the largest source of traffic congestion is through non-recurrent traffic congestion. Incident Management Response seeks to effectively mitigate this particular form of traffic congestion.

Endnotes

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[xiii] Kosik, Al. Personal phone interview. 27 April 2005 (TXDOT)

[xiv] Caldwell, Lawrence. Personal phone interview. 27 April 2005 (VDOT)

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