Government of the District of Columbia

Department of Transportation

d.

August 19, 2016

Gregory G. Nadeau
Administrator, Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Avenue SE
Washington, DC 20590

Re: Docket No. FHWA-2013-0054

Dear Administrator Nadeau:

The District of Columbia Department of Transportation (DDOT) is pleased to provide comments on the Federal Highway Administration (FHWA) "National Performance Management Measures to Assess Performance of the National Highway System, Freight Movement on the Interstate System, and Congestion Mitigation and Air Quality Improvement Program" proposed rule (Docket Number FHWA-2013-0054), published in the Federal Register on April 29, 2016. We appreciate the efforts of the FHWA staff to provide opportunities for commenting on this proposed rulemaking.

DDOT is a unique agency that is a simultaneously a state and local department of transportation (DOT) and serves an entirely urban jurisdiction. We particularly emphasize how the proposed rule should be changed so that urban areas with multimodal transportation systems will not be measured against inappropriate standards. In addition, the District of Columbia (the District) is at the center of a tri-state region and we wish to emphasize the importance of creating measures that can work across jurisdictions, so our Metropolitan Planning Organization (MPO) can effectively set targets and measure system performance for all member jurisdictions.

We are generally supportive of the comments submitted by the American Association of State Highway and Transportation Officials (AASHTO) and the National Capital Region Transportation Planning Board (TPB), our MPO. In particular, we wish to emphasize the following areas:

The speed thresholds proposed do not reflect urban conditions.
The threshold for uncongested freight movement (§490.613 (c)) is proposed to be 50 mph. This will not produce a useful performance measure for the District because we do not have any segments of the Interstate signed above 50 mph, and a significant share of them are signed below that speed.

Similarly, the thresholds to determine if excess delay occurs (§490.711 (c)) are proposed to be 35 mph for Interstates/expressways/freeways and 15 mph for all other NHS roads. These two thresholds do not reflect the operating characteristics of urban areas. Some portions of our Interstates are signed at 35 mph and nearly all of our non-Interstate NHS roads are signalized arterials. Due to this signalization, 15 mph can be the uncongested average speed over the length of these corridors, not a threshold for excess delay. Higher speeds on these NHS segments can actually run counter to safe operating conditions in our dense, complicated, urban environment

To measure our system against these thresholds would not provide useful data points to gauge performance. DDOT recommends that a percentage of posted speed limit be set as the threshold, in lieu of a fixed threshold speed, for both measures.

Flexibility is essential
We support the AASHTO comments that states should be provided with the flexibility to use measurement and target setting approaches that mitigate the effects of weather events and construction projects.

As noted in the AASHTO comments, applying congestion measures to uncongested rural areas is unduly burdensome. By the same token, we would suggest that non-Interstate NHS routes within the most urban areas should similarly be exempted from some or all of the measures. We recognize that congestion may be an issue on these segments, but the level of incremental improvement possible is difficult to capture in the measures as proposed. Also, failure to consider all modes using those roadways works counter to efforts to increase person throughput and encourage the use of non-automobile modes more generally.

Urban arterials often have bicycle, transit, and personal vehicles sharing the same limited roadway. Cities are choosing to improve system performance overall by prioritizing transit and improving bicycle and pedestrian safety, which increase the corridor throughput but could cause the vehicle-based measures of congestion to worsen. A person throughput measure would be more appropriate on these facilities.

Create measures that support the target setting approach in the final planning rule.
The final planning rule spelled out the coordination process between states and MPOs for target setting. The measures that are set in this rule need to allow for reasonable coordination in the target setting process. DDOT is the only state DOT that is entirely contained within a single MPO, and the TPB includes the District, Maryland, and Virginia. Performance measures need to be applicable across all parts of the MPO in order to set MPO-level targets. Focusing performance measurement on limited access or non-urban NHS segments would better allow collaborative target setting in a diverse urban region.

Per capita measures do not reflect the true population impacted.
The proposed hours of excessive delay per capita measure does not accurately reflect the true population impacted by the delay. The daytime population of the District doubles, with over half a million commuters and often over 100,000 visitors coming in on a daily basis. Measuring per capita delay based on residents would underestimate the actual population affected by these measures and therefore overestimate the delay each person experiences.

A preferable approach would use actual person counts, or vehicular volumes, on the measured corridors.

The freight travel time and overall vehicle travel time measures are redundant.
The proposed truck travel time reliability (TTTR) measure is nearly identical to the level of travel time reliability (LOTTR), but with different thresholds and is measured all day instead of during the peak hours. Truck travel during the peak will be affected by the same congestion as general vehicles. Targeting the measurement period to off-peak periods would isolate the impact on goods movement from general peak hour delays associated with commuting.

The measures do not reflect the multimodal nature of urban transportation.
We are committed to achieving the best possible transportation system performance within our available resources and have embarked on our own efforts to create a more holistic measure of system performance from a congestion and mobility perspective. In September, we will be launching DistrictMobility.org with measures of congestion, reliability, and accessibility for all surface modes – vehicular, transit, bicycle, and pedestrian.

The measures selected for this monitoring effort were particularly chosen to rely on available, repeatable, reliable data. Nonetheless, much effort was needed to make the datasets comparable across modes and to find measures that were meaningful for each mode. There remains more work, but we would hope that FHWA would consider our project's report and the lessons learned from that effort when exploring future multimodal measures for the transportation system. For reference, the measures we are employing are:

Category	Measure	Outputs	Temporal	Modes
Commuting	Commute Mode Split	• Percent of commuters using mode	Daily average	Pedestrian Bicycle Transit Auto
	Commute Time	• Average commute time • Commute time distribution	Daily average	Pedestrian Bicycle Transit Auto Overall

Category	Measure	Outputs	Temporal	Modes
Reliability	Auto Travel Time Reliability	• Top 10 most reliable/unreliable roads by planning time index, arterials and freeways separately • Planning time index for arterials	• AM & PM peak • Over the day and over the week	Auto
	Bus On-Time Performance	• On-time performance for all bus routes in the District	Over the day (can do up to 15 min increments)	Bus
Intensity of Use	Roadway Congestion	Auto travel time index	Over the day and over the week	Auto
	Bus Ridership	•Average bus stop level activity by time period • Route level ridership – citywide and top 10 routes	• Over the day (by time period) • Daily	Bus
	Bus Overcrowding	• Top 10 most crowded bus routes • Maximum load per route, by time period, on roadway links	Over the day (by time period)	Bus
	Bus Travel Speed (Time)	Average bus speeds per route	15-minute intervals	Bus
	Corridor Intensity (Persons)	Number of persons per corridor	Daily	Transit/ Auto
Accessibility/ Connectivity	Transit System Coverage	• Walksheds to all transit service (0.5 miles to Metrorail, 0.25 miles to bus) • Walksheds to high frequency transit service	Over the day and over the week	Transit
	Bikeshare System Coverage	Walksheds to bikeshare stations (0.25 miles)	N/A	Transit Bicycle
	Bike System Coverage	Walksheds to a bicycle facility, including low-stress streets and bikeshare stations (0.25 miles or 2 minute ride)	N/A	Bicycle
	Walkability Index	Scores based on walkability methodology	N/A	Pedestrian
	Accessibility to Jobs	Number of jobs accessible by mode	AM Peak	Pedestrian Transit Auto

In our next phase of this project we plan to develop a person throughput measure, which we have noted above is needed for understanding the affected population. We have also proposed to develop a measure of modal options available to individuals.

DDOT encourages consideration of specific non-auto metrics such as those above. It is essential that a holistic approach to performance measurement develop metrics associated with bicycling and walking.

For the accessibility to jobs measure in our study, we are relying on the work done by the University of Minnesota in their National Accessibility Evaluation Pooled Fund Study and would encourage FHWA to consider leveraging the work they have done in developing that dataset.

Thank you again for the opportunity to comment on this important proposed rulemaking. DDOT is committed to a performance-based approach to transportation, and we look forward to working closely with FHWA on this endeavor.

Sincerely,

Samuel Zimbabwe
Associate Director, Planning & Sustainability Administration
District Department of Transportation

Maryland Department of Transportation
The Secretary's Office

Larry Hogan
Governor

Boyd K. Rutherford
Lt. Governor

Pete K. Rahn
Secretary

August 19, 2016

Mr. Gregory G. Nadeau
Administrator
Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Avenue SE
Washington DC 20590

Re: Docket No. FHWA-2013-0054

Dear Administrator Nadeau:

The Maryland Department of Transportation (MDOT) is pleased to submit comments on the Federal Highway Administration's (FHWA) "National Performance Management Measures; Assessing Performance of the National Highway System, Freight Movement on the Interstate System, and Congestion Mitigation and Air Quality Improvement Program: Proposed Rule FHWA-2013-0054," published in the Federal Register on April 22, 2016.

MDOT looks forward to the finalization of this rule as part of a comprehensive set of measures required by the Moving Ahead for Progress in the 21st Century (MAP-21) law. MDOT is proud of its work in transportation performance management and believes that this national focus will encourage growth in the state of practice and the development of data and analytical approaches.

As a member of the American Association of State Highway and Transportation Officials (AASHTO), MDOT participated in the development of comments submitted by states through AASHTO. MDOT is supportive of AASHTO's comments related to improved data and enhanced guidance from FHWA on target setting and Metropolitan Planning Organization (MPO) coordination. MDOT also strongly agrees with AASHTO that the national measures should be limited to those required by statute.

However, MDOT also appreciates the challenges in developing national measures and in applying a data set that is nationally consistent for states and MPOs. MDOT believes that FHWA's intent in responding to the MAP-21 law requirements is to capture the most meaningful and applicable measures for federal reporting that states and MPOs can perform in alignment with a state or MPO's own performance programs. In this respect, MDOT looks forward to the finalization and implementation of the measures.

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MDOT offers the following principal comments on the NPRM:

MDOT is aware of several entities that are providing analytical and visualization tools related to the MAP-21 measures, and MDOT encourages FHWA to consider a national-level tool for consistent measurement and reporting. MDOT is experimenting with options and finds that using a pre-developed analytical tool could reduce the burden to states significantly. For example, MDOT has been experimenting with the University of Maryland's Regional Integrated Transportation Information System (RITIS) program, which has loaded the National Performance Management Research Data Set (NPMRDS) data and is developing the codes necessary to produce tabular and map results of the proposed performance measures. If MDOT had to calculate the measures individually, this effort would take a significant amount of staff time and results could differ between analysts depending on assumptions and methods used. MDOT understands that FHWA intends to provide training and guidance on calculating the measures exactly. However, MDOT encourages FHWA to consider providing analytical and visualization tools for measure calculation that could either transmit data to the Highway Performance Monitoring System (HPMS) or produce the resulting data in a way that easily translates to a state's HPMS for submittal as required.

MDOT believes that having an analytical and visual/geo-spatial platform for these measures would allow for better coordination and target setting due to the ability to visualize and display measure results for easy discussion on targets and areas for improvement. This information, in this format, also would serve states and MPOs well when developing and coordinating on the required reports, plans and programs.

MDOT encourages FHWA to consider recommendations offered in AASHTO's docket comments (**Appendix A**) for improvements to the NPMRDS. MDOT has spent considerable time analyzing the NPMRDS data and testing it internally. The Appendix A recommendations would strengthen the NPMRDS moving forward.

MDOT is especially concerned with the NPMRDS relationship to HPMS and encourages FHWA to provide the NPMRDS in a format that easily conflates to HPMS. MDOT understands that the next generation NPMRDS contract may require conflation to HPMS, which would make using the data for MAP-21 measures and beyond much easier for states.

MDOT encourages FHWA to clarify and provide guidance on MPO coordination for the peak hour and CMAQ measures. MDOT finds the proposed level of coordination rather nebulous as a majority of the MPOs in Maryland cross state lines and coordinating on setting one target for the urbanized area could be quite challenging. MDOT expects that FHWA's plans for training and guidance materials will specify best practices and clear steps for how these measures are implemented and how to negotiate targets.

With respect to consideration of a Greenhouse Gas (GHG) emissions measure, Maryland acknowledges that it is necessary to address GHG emissions and recommends that FHWA consider developing guidance, in lieu of regulations, at this time. We believe this is an important issue and offer highlights describing how Maryland is working collaboratively to track and reduce state-wide CO_2 emissions in the transportation sector.

Maryland has adopted the Greenhouse Gas Emission Reduction Acts of 2009 and 2016, which strives to understand the science behind climate change, addresses the associated impacts, and mitigates CO_2 and other greenhouse gas (GHG) emissions from all sectors. The 2016 reauthorization will drive an economy-wide reduction of GHG emissions of 40% by 2030 while supporting a strong economy and job creation in Maryland.

Emissions reductions from the transportation sector will be an integral part of the overall reductions required to meet Maryland's long-term GHG reduction goals. MDOT has been actively engaged in the Maryland Commission on Climate Change (MCCC), chaired by the Maryland Department of the Environment (MDE), and has been working with MDE since 2009 to develop transportation GHG inventories and forecasts, and to estimate the emissions reductions associated with current and proposed transportation policies and programs.

MDOT and MDE have worked together to draft a public report that communicates the progress Maryland has made toward meeting our emission reduction goals for GHGs and other air pollutants through vehicle and fuel efficiency standards. These emission redutctions are being accomplished with: diesel retrofits, electric vehicle incentives, MPO and Baltimore Port initiatives, transit-oriented development and other programs that would reduce mobile source emissions. This report would identify any additional work needed to achieve further reductions in the transportation sector while supporting a strong Maryland economy and job growth. You can access the report, entitled *"Charting the Path Forward: A Transportation Strategy for Meeting Long-term Air Quality and Greenhouse Gas Emissions Goals and Enhancing Maryland's Economy and Quality of Life"* at: http://www.mdot.maryland.gov/newMDOT/Environmental_Programs/Documents/MDOT_AQ_Final_07_28_2016.pdf.

MDOT respectfully offers the following responses to address several of the specific questions posed by FHWA.

1. ***Effective Dates***
   Question: FHWA seeks comment from the public on what an appropriate effective date(s) could be.

   Answer: Although MDOT is ready to implement the required measures, MDOT does support AASHTO's recommendation that FHWA consider a phased approach, which includes a two-year testing period following the effective date of the final rule to allow state DOTs and MPOs to develop non-binding targets in order to more fully understand the use of the data and the implications of those targets.

2. ***Maximize Opportunities for Successful Implementation***
   Question: FHWA encourages comments on how it can help maximize opportunities for successful implementation.

   Answer: MDOT believes that FHWA's provision or endorsement of an analytical tool would greatly help states and MPOs in calculating measures and setting targets. Analytical tools such as the RITIS program would help in the accurate calculation of the metrics and measures and aid in visualization of the measures for target setting. They also may assist in transmitting the data to HPMS or directly to FHWA. Additionally, these tools might encourage growth in performance measurement and management beyond MAP-21 as they would provide a consistent platform for states and MPOs when evaluating performance.

3. ***Use and Availability of Performance Throughput Data***

   Question: FHWA seeks comment on the use and availability of performance throughput data (e.g., Traffic Throughput Data).

   Answer: MDOT concurs with AASHTO's assessment that the data and methodologies to calculate a throughput measure do not currently exist. MDOT prefers that measures involving performance throughput data be used by state and local agencies for their purposes as they see fit.

4. ***Limitations in the Availability of Data and Potential Data Sources and Technologies Related to System Performance and Traffic Congestion Measures***

   Question: The FHWA is seeking comment on approaches for gathering throughput data for traffic congestion that would capture the total number of travelers passing through segments that make up a full system on a regular basis.

Answer: MDOT continues to work with federal and state partners, as well as the Transportation Research Board (TRB), private sector data providers and academics to improve data sources for transportation measurement. MDOT is not in a position to offer a specific recommendation at this time for these areas of data. Like AASHTO, MDOT supports an AASHTO, state and MPO discussion on data sources and improvement opportunities.

5. ***Improve Missing Data and Outlier Impacts***

Question: The FHWA is seeking comment on opportunities to improve missing data and outlier impacts.

Answer: MDOT understands the challenges presented to FHWA in having to establish metrics and measures that all states and MPOs must implement and the need to have a nationally consistent data source. While the currently proposed NPMRDS does have limitations, MDOT views the NPMRDS as a nationally consistent database that can be used for the proposed measures by all states and MPOs. MDOT encourages opportunities for FHWA to engage states and MPOs in data development discussions, especially for freight data. As an example, MDOT encourages FHWA to seek ways by which private data providers could improve on differentiating vehicle types in probe data to enhance the current truck probe data offered by the private sector.

6. ***Impact of Traffic Volumes on Travel Time Derived Measures***

Question: The FHWA is seeking comments on this approach and encourages comments suggesting alternative methods that may more effectively capture the impact of performance changes on differing levels of system use.

Answer: MDOT supports AASHTO's recommendation related to the instability in calculating the volume-based measure and the need for a volume-limiting function within the proposed performance measure as noted in AASHTO's Appendix B, "AASHTO Recommendations on Simplifying the Measures Used for Performance of the NHS, Freight Movement and Delay to the Extent they are Applicable."

7. ***Focus on Large Urbanized Areas for Assessing the Performance of the NHS and Traffic Congestion***

Question: The FHWA is requesting comments on whether a population threshold should be used for determining the measure applicability; and if so then whether 1 million is the appropriate threshold, or whether another threshold (e.g., population over 200,000) would be more appropriate.

Answer: MDOT strongly supports AASHTO's recommendation for the 1 million population threshold and encourages FHWA to adopt this threshold for the calculation of both CMAQ measures.

8. ***Starting with Highways and Expanding to other Surface Transportation Modes for Assessing Traffic Congestion***

Question: FHWA would like to move to a measure in the future that would consider the mobility of travelers using all surface modes of transportation and is seeking comment on feasible approaches that can be taken to move toward the development of such as measure.

Answer: MDOT supports a focus on measures that are currently required in statute. States and MPOs are currently engaged in the development of data and new forms of measurement. FHWA should focus limited resources on the statutory requirements while encouraging continued innovation in measurement practices that states and MPOs may use for comprehensive measurement programs in their jurisdictions.

9. ***Dealing with Missing Data when Assessing On-Road Mobile Source Emissions***

Question: State DOTs and/or MPOs would not be required to amend their project information, but we also are soliciting comments on other ways State DOTs and/or MPOs may update or amend their project information with quantitative emissions estimates for use in implementing this performance measure.

Answer: MDOT supports AASHTO's recommendations for improvements to the CMAQ Public Access System.

10. ***Optional Additional Targets for Urbanized Areas and the Non-Urbanized Area***

Question: The FHWA is seeking comments on this approach for establishing optional additional targets for urbanized areas and the non-urbanized area.

Answer: MDOT concurs with AASHTO's recommendation that "FHWA has asserted that if States engage in setting non-required targets, they must report to FHWA in FHWA approved formats. As a result of this approach, in order to avoid needless FHWA regulation, States that desire to undertake such additional planning are left with having to find a way to engage in the additional planning without using the word "target" (or perhaps even the words "measure" or "performance management") to describe the work in order to be able to take other steps that are relevant for its own needs without being subject to FHWA's recordkeeping and other regulatory requirements with respect to this self-initiated work. Thus, AASHTO recommends that FHWA strike (i), (ii), (iii), (iv), and (v) and make any other needed modifications so that the regulations do not discourage a

State DOT from establishing additional targets or undertaking additional performance management."

11. Voluntary Establishment of Additional Targets

Question: The FHWA also would like comments on any other flexibility it could provide to or identify for State DOTs related to the voluntary establishment of additional targets. Some examples include:

a. Providing options for establishing different additional targets throughout the State, particularly for the States' non-urbanized area; and
b. Expanding the boundaries that can be used in establishing additional targets (e.g., metropolitan planning area boundaries, city limit boundaries).

Answer: MDOT supports AASHTO's recommendation that FHWA strike (i), (ii), (iii), (iv), and (v) and make any other needed modifications so that the regulations do not discourage a State DOT from establishing additional targets or undertaking additional performance management.

12. Target Establishment Options and Coordination Methods

Question: The FHWA seeks comments on target establishment options and coordination methods that could be used by MPOs and State DOTs in areas where the MPO metropolitan planning area crosses multiple States.

Answer: MDOT believes that there are currently significant unknowns about the process MPOs and State DOTs will undertake to coordinate on target setting. Until that process actually occurs, it is difficult to suggest options that would be useful. An analytical tool with visualization capabilities would help States engage MPOs in discussions to see what performance looks like in MPO areas, especially those that cross state boundaries, to engage in meaningful target setting discussions.

13. State DOT and MPO Coordination

Question: FHWA is specifically requesting comment on the following questions related to State DOT and MPO coordination in light of the proposed performance management requirements in this rule:

a. What obstacles do states and MPOs foresee to joint coordination in order to comply with the proposed requirements?
b. What mechanisms currently exist or could be created to facilitate coordination?
c. What role should FHWA play in assisting States and MPOs in complying with these proposed new requirements?
d. What mechanisms exist or could be created to share data effectively between states and MPOs?

e. Are there opportunities for states and MPOs to share analytical tools and processes?
f. For those states and MPOs that already utilize some type of performance management framework, what are best practices that they can share?

Answer: MDOT generally supports AASHTO's recommendations made in the principal comments section of AASHTO's comments to the docket. MDOT strongly supports the provision of analytical tools and visualization systems so that states and MPOs can see the data in a consistent manner. One best practice that the I-95 Corridor Coalition states can offer is the use of the RITIS system developed by the University of Maryland. RITIS is capable of importing the NPMRDS data with geographic data to run the measures as required by the proposed rulemaking. In doing so, this system can generate both tabular data and maps that help to visualize which National Highway System (NHS) segments are not meeting the thresholds as proposed in this rule. This system is a very helpful tool that states and MPOs could use to support this work if provided nationally and consistently to all who are responsible for reporting. MDOT suggests that FHWA consider providing analytical and visualization tools for the required MAP-21 rules.

14. Alternative Approaches to Implementation

Question: The FHWA is seeking comment on alternative approaches that could be considered to effectively implement 23 U.S.C. 134(h)(2)(B)(i)(I) and 23 U.S.C. 150(d)(2) considering the need for coordination required under 23 U.S.C. 134(h)(2)(B)(i)(II) and 23 U.S.C. 135(d)(2)(B)(i)(II).

Answer: MDOT supports AAHSTO's recommendations for implementation made under their principal comments section.

15. Specificity for MPO and State Coordination

Question: The FHWA also is requesting comment on whether the regulations should include more information or specificity about how the MPOs and states should coordinate on target establishment. For some measures in this proposed rule, MPOs could establish targets up to 180 days after the state DOT establishes its targets.

Answer: AASHTO's comments on the rule focus on challenges with target setting between state DOTs and MPOs. MDOT looks for guidance and assistance from FHWA in setting targets and communicating with MPOs. As previously suggested, the use of visualization and analytical tools would facilitate the discussion and could be helpful to identify areas where performance challenges exist across borders so that states and MPOs can have a meaningful discussion on how to set targets.

16. MPA Description

Question: The FHWA seeks comment on whether the description of the MPA in place when establishing targets should be included in the system performance report and apply to the entire performance period.

Answer: MDOT strongly supports AASHTO's position that "the urbanized area geography is not well understood and the specific use of it in calculating the congestion metric involves a significant learning curve that will take time to better understand. Furthermore, FHWA has proposed significant changes to the definition of a Metropolitan Planning Area under the Metropolitan Planning Organization Coordination NPRM. At this time, it is difficult, if nearly impossible, to understand what the consequences of the urbanized areas and MPA definitions will have on target setting."

17. Future Measure of Congestion

Question: The FHWA encourages public comment on the following issues related to the measure approach and methods that can be used to realize a "future" measure of traffic congestion.

Answer: MDOT supports AASHTO's position that FHWA must focus on developing measures that are explicitly required in current statute. Thus, FHWA should not focus limited resources on the development of future national-level measures.

Question: Are there existing methods that can be used reliably to weigh the highway delay metric by "total vehicle occupants" rather than "total number of vehicles?" Are there technologies or methods that could be advanced in the next 3-5 years to capture vehicle occupancy data?

Answer: MDOT supports AASHTO's comments on existing methods and technologies or methods that could be advanced to capture vehicle occupancy data. "AASHTO proposes two different thoughts on this topic. First, average vehicle occupancy data has declined over the past 30 years. According to National Household Travel Survey (NHTS) data, work-trip vehicle occupancy (carpooling) is approximately 1.13, only 13 passengers ride with every 100 vehicle drivers. Approximately half of these 13 passengers are fellow commuters; the other half are persons sharing the ride for other trip purposes such as being dropped off at school. For all trips, vehicle occupancy rates range from 1.06 (New Hampshire) to 1.14 (Washington, DC). Thus, using these types of estimated and volume data will be a good representation of actual vehicle occupancy. Second, the state DOTs have funded the development of the Census Transportation Planning Products (CTPP) Program that develops robust work-based trip data. One important piece of data that is available from these calculations is total number of workers commuting by car (either alone or as part of a carpool). Thus, the highway delay metric could be easily normalized by the number of workers commuting by car."

Question: Which surface modes of transportation, other than highways, have readily available data that could be used to support a measure to assess traffic congestion? To what extent is this information available in the urbanized areas applicable to the measure proposed in this subpart?

Answer: MDOT continues to lead discussions with external entities about data and is testing multi-modal freight data through freight fluidity practices. Currently, MDOT does not have robust, reliable data for surface modes other than highways, transit, commuter and passenger rail, which is available in the urbanized area applicable to these measures. MDOT also is aware of aviation travel time data that can be processed, but this would show travel times and delay between cities.

Question: What would be the appropriate surface transportation network to use to measure traffic congestion in the future? Is data available off the NHS that can be used to assess traffic congestion that can be made available to all state DOTs and MPOs?

Answer: MDOT supports AASHTO's position on limiting the national-level measures to the NHS is good practice and that when measuring congestion, the national interest should be in congested areas and not uncongested rural areas.

MDOT appreciates the opportunity to provide these comments and looks forward to working with FHWA in the implementation of the final rule.

If you have any additional questions or concerns, please contact Ms. Nicole Katsikides, MDOT State Highway Administration Office of Planning and Capital Programming Deputy Director, at 410-545-5511 or via e-mail at nkatsikides@sha.state.md.us. Ms. Katsikides will be happy to assist you.

Sincerely,

Pete K. Rahn
Secretary

cc. Ms. Nicole Katsikides, Deputy Director, Office of Planning and Preliminary Engineering, State Highway Administration,

COMMONWEALTH *of* VIRGINIA

DEPARTMENT OF TRANSPORTATION
1401 EAST BROAD STREET
RICHMOND, VIRGINIA 23219 2000

Charles A. Kilpatrick, P.E.
Commissioner

August 19, 2016

U.S. Department of Transportation
Docket Operations, M–30
West Building Ground Floor
Room W12–140
1200 New Jersey Avenue SE.
Washington, DC 20590

RE: Notice of Proposed Rulemaking; National Performance Management Measures; Assessing Performance of the National Highway System, Freight Movement on the Interstate System, and Congestion Mitigation and Air Quality Improvement Program; Docket No. FHWA–2013–0054

To Whom It May Concern:

The Virginia Department of Transportation (VDOT) offers the following comments on the Federal Highway Administration's April 22, 2016 Federal Register Notice and Request for Comments: National Performance Management Measures Assessing Performance of the National Highway System, Freight Movement on the Interstate System, and Congestion Mitigation and Air Quality Improvement Program; Proposed Rule.

General Overview/Response

VDOT generally supports performance management, namely performance based planning and data-driven decision making relating to the nation's highways. Performance management should be meaningful, providing demonstrable benefits to the taxpaying public. If implemented appropriately, a performance management system helps to ensure that state Departments of Transportation are and remain responsible stewards of public funds.

The Commonwealth's support of system performance management is evidenced by various programs that utilize a performance-based management approach. For instance, VDOT currently has in place various operational transportation and highway related performance measures and targets in areas such as transportation safety, and pavement and bridge condition. In addition, the Commonwealth Transportation Board has recently adopted and VDOT has implemented a transportation project prioritization process (SMART SCALE) that bases project selection and funding on performance management principles. SMART SCALE utilizes 13 performance based measures/metrics in six categories (Safety, Congestion, Accessibility, Environmental Quality, Economic Development, and, in select urban areas, Land Use and Transportation Coordination) to rank projects for purposes of allocating funding and funding is allocated in a manner so that projects that are funded are fully funded. Under the first round of SMART SCALE, 321 project funding applications were received, 287 applications were scored and 163 projects were selected for funding and included in the Commonwealth Transportation Board's Six-Year Improvement Program for FY2017-2022.

The Commonwealth's statewide transportation plan, VTRANS 2040 utilizes a performance-based approach to transportation planning. In the VTRANS 2040 Vision, Goals & Objectives, and Guiding Principles[1], adopted by the Commonwealth Transportation Board in December 2015, each of the VTRANS five goals are supported by objectives which are similar in many respects to the performance measures proposed in this NPRM. For instance, the VTRANS Economic Competitiveness and Prosperity Goal is supported by objectives that would reduce the amount of travel that takes place in severe congestion, reduce the number and severity of freight bottlenecks, and improve reliability on key corridors for all modes. The VTRANS objectives serve as Virginia's system performance measures and the intent was to set targets for each of these.

VDOT's General Comments

- **The final rule should include performance measures that acknowledge and reflect the role that transportation plays in economic development and should not overemphasize congestion-related measures.** As noted by Virginia's Secretary of Transportation, Aubrey Layne, in a letter to Secretary Foxx, dated April 10, 2014: "The goal of the transportation system is to provide access to destinations, and a narrow focus on roadway delay could ignore the real benefits provided to the citizens of Virginia from efforts to improve access through multimodal improvements and reduced trip distances....Delay is not a valid measure of access - the goal of transportation investments. Further, the measures that will be developed will apply to a broad set of roadways - main streets, downtown streets, commercial corridors –where the goal may be lower travel speeds and slower traffic is a desirable side effect of successful community and economic development."

[1] http://www.ctb.virginia.gov/resources/2015/dec/reso/attach/Resolution15VTRANSAttachment.pdf

- Thus, VDOT would urge that USDOT/FHWA not create/mandate measures that imply that congestion can be eliminated in dense urban areas. VDOT would note, for instance, the interstates in northern Virginia that have essentially reached their ultimate profiles. Using congestion management/operational methodologies or strategies, such as managed lanes, is the most effective and realistic approach to addressing (managing) congestion on such roads and the more appropriate measure of performance in those cases would be one that measures how effectively congestion is being managed, as opposed to being eliminated.

- <u>**There are too many performance measures**</u>**:** The proposed rule would mandate implementation of 8 performance measures relating to systems travel time {4}, interstate freight movement {2}, and CMAQ {2}. While implementing the measures will impose a significant work burden in respect to planning, coordination, setting targets, evaluating performance, and reporting, there are more significant issues that warrant reconsideration or elimination of certain measures as proposed below:

    - As currently structured the proposed rule would require that congestion be measured three different ways on some urban interstates. Specifically, the proposed rule requires that congestion be measured on interstates in urbanized areas with a population over 1 million by (1) Annual hours of excessive delay per capita (AHED), (2) Average truck speed and (3) Peak hour travel time ratio (PHTTR). This would create redundancy and confusion for the public and other stakeholders who may not readily understand the nuances among the measures and how to reconcile disparate results such as improvements in one measure with degradation in another. As further explained below, VDOT is recommending that the Average Truck Speed and PHTTR measures be eliminated from the final rule.

    - VDOT recommends elimination of the Peak Hour Travel Time Ratio which is essentially a travel time index (TTI). As noted by FHWA in the NPRM documentation, stakeholders demonstrated little interest in travel speed indices like the travel time index and have expressed concerns that travel speed based measures alone may penalize densely developed communities that offer high levels of accessibility but not necessarily shorter travel times. Further, FHWA has acknowledged that TTIs do not capture system attributes in terms of shorter trips or better access to destinations and mode options, which may occur at the expense of greater delay, but nevertheless has included a form of TTI, the Peak Hour Travel Time Ratio. **For the reasons noted by stakeholders and acknowledged by FHWA, VDOT would recommend elimination of the PHTTR from the final rule.**

    - VDOT recommends eliminating the congestion-related performance measure/metric for freight, Average Truck Speed. As currently proposed, an interstate segment is deemed congested if average truck speed is under 50 mph. This is in conflict with another proposed congestion measure, the Annual Hours of Excessive Delay measure which uses a 35 mph speed as the threshold for congestion on interstates and with the PHTTR which provides the flexibility to agencies to select the desired peak hour speed. In addition, VDOT's analysis of the NPMRDS freight data set revealed a number of locations in mountainous areas that consistently failed to meet this threshold due to geometric constraints. Those locations had steep uphill grades, uncongested flow, and truck climbing lanes so there are no realistic solutions to bring the speeds above 50 mph. Further, the posted speed limits are around 55 mph on urban interstates for reasons other than congestion, in contrast to the 65 or 70 mph in rural areas. Using a uniform 50 mph threshold across all segments will show most urban segments as congested. This measure would create the inappropriate/unachievable expectation that congestion can be eliminated everywhere and if included in the final rule, would likely become the measure that governs all other measures.

- **Travel Time Reliability Measures:**

  - VDOT recommends that the final rule include consistent measures for travel time reliability relating to passenger vehicles and freight. Section 490.611(a)(1) specifies Truck Travel Time Reliability (TTTR) be calculated and section 490.611(b)(3) specifies that 95th percentile truck travel time be used. VDOT recommends that the calculation of freight reliability measures in proposed 23 CFR 490.611 be made consistent with the Level of Travel Time Reliability (LOTTR) measure in proposed 23 CFR 490.511. Specifically, it is recommended that 80th percentile travel time be used for both measures. VDOT believes that the 95th percentile travel time may be less affected by DOT actions than the 80th percentile travel time, so use of the 80th percentile travel time would be more meaningful for DOT performance measurement. The ability to effect change in the 80th percentile is noted by FHWA in the discussion of the measures where it is stated that the 80th percentile was chosen for LOTTR because it reflects the travel time where operational strategies can make the most impact on improving reliability. VDOT does not believe there is a valid basis for applying a different metric for purposes of measuring travel time reliability for freight vs passenger vehicles.

  - VDOT would also recommend that each of the travel time reliability measures be weighted for the applicable vehicle volumes, to give greater weight to high impact areas/segments that carry the most traffic.

- **Delay (Congestion Measure):**

  - The performance measure to assess traffic congestion for the purpose of carrying out the CMAQ program is Annual hours of Excessive Delay (AHED) Per

Capita. This measure falls short in consideration of alternate modes, such as buses, and travel demand management, as it does not give weight to vehicle occupancy. VDOT suggests instead that Person Hours of Excessive Delay be reported as this would provide an incentive to improve corridors that have higher vehicle occupancy rates. VDOT would note that the Federal Transit Administration's National Transit Database would serve as a source of data regarding transit vehicle/bus occupancy. Default values for vehicle occupancy could be used where more specific data was not available.

- AHED defines excessive delay as the extra amount of time spent in congested conditions when speeds fall below 35 mph on Interstates and other freeways and below 15 mph on all arterials. Since the function of arterials varies considerably it is not appropriate to measure all by the same threshold. Many arterials are not expected to operate over 15 mph; they provide access through dense commercial areas and a low operating speed is unavoidable. The lower operating speed is compatible with other users of the corridor such as pedestrians and cyclists and in providing access to key businesses. As such, VDOT recommends that this measure not be reported on arterials with speed limits below 45 mph within urbanized areas.

- **Air Quality (On-Road Mobile Source Emissions/Emissions Reduction Measure):**

  - Section 490.803 as proposed by the NPRM provides that the performance measure for assessing on-road mobile source emissions for the CMAQ Program does not apply to State DOTs and MPOs that do not contain any portions of nonattainment and maintenance areas. VDOT agrees with this provision, as no new burdens should be imposed on areas that are currently in attainment with all of the National Ambient Air Quality Standards (NAAQS). In addition, since CMAQ projects generally represent a small subset of transportation projects in nonattainment or maintenance areas and therefore have a limited impact on improving regional air quality, VDOT recommends that FHWA instead consider a region-wide air quality measure, such as compliance with EPA's transportation conformity regulations that already apply in nonattainment and maintenance areas. This would help to streamline compliance with the new performance measure requirements while helping to ensure that transportation planning remains consistent with region-wide air quality goals.

- **Data:** VDOT recommends greater flexibility in using data other than the NPMRDS, that improvements be made to future versions of the NPMRDS, and that clarifications be made as described below.

  - There currently may be other data sets that are of higher quality, more complete, and contain more consistent mapping information than the NPMRDS. Some examples of specific problems VDOT has noted when dealing with the NPMRDS over the last several years include the following:

- Inconsistencies in Route nomenclature. For example, a portion of I-64 is labeled US-60. This mistake leads to wrong functional classification.
- Reversible lanes on I-95 (Express Lanes) have NPMRDS data for all time periods and both directions. However, only one direction is valid for travel at specified intervals. Freight data is also available for some sections of the state network that restricts trucks.
- The network is not up to date; it does not currently include the extension of the I-95 express lanes which were completed and open to traffic in December 2014.
- Data availability is very low in NPMRDS in some situations:
  - Night time: The White Paper on NPMRDS Missing Data and Outlier Assignment[2] available on the FHWA docket and attached hereto confirms this; Figure one shows that data availability is much higher during the day and ranges from only 3 to 45% between the hours of 10 pm and 5 am when broken out by system and classification.
  - Non-Interstate NHS: Again, the white paper confirms this; Figure 1 shows a maximum average data availability on non-Interstate NHS during day times as less than 35% for all vehicles, for any given hour. These observations are in line with VDOT's detailed research findings on more than 300 select TMCs in Virginia.
  - Individual TMCs: NPMRDS data availability also spans the entire spectrum from some TMCs having near complete datasets for the year during daytime (6 am to 8 pm) to some TMCs having just one 5-minute data point for the entire year.

For these reasons, VDOT recommends more flexibility to use other data sets and that steps be taken and processes implemented to address data quality issues in NPMRDS. In addition, VDOT has the following comments and need for clarifications regarding the NPMRDS:

- NPMRDS (and all other probe data sets that we are familiar with) do not differentiate between hard shoulder and regular lanes, as well as turning movements on arterials. However, the NPRM/proposed rule would require that such facilities not be included in assessments of performance. Given the lack of differentiation between these facilities in the data, it is not clear how exclusion can be accomplished.

- NPMRDS shapefiles and data also contain many ramps, and the NPRM explicitly mentions that the performance measures pertain only to the mainline highways and do not include ramps. Further, ramps will inherently exhibit low traffic speeds. VDOT requests that (1) NPMRDS be cleaned of ramp data, (2) NPMRDS should contain data for only NHS, or include a field in the static file that designates a TMC as belonging to an NHS or not; and (3) the final rule not include measuring performance

[2] http://www.regulations.gov/contentStreamer?documentId=FHWA-2013-0054-0103&attachmentNumber=1&disposition=attachment&contentType=pdf

on ramps. This is particularly problematic for any performance measures that use a fixed speed threshold.

  - Data quality concerns are high with NPMRDS (both availability and variance across days). Quality screening is applied only for PHTTR measures but not for other measures. Based on our experience and examples of data being provided where it should not be, VDOT recommends more detailed screening tests be implemented. Specifically, VDOT recommends FHWA specify (1) detailed data quality screening tests, and (2) minimum data availability standards to monitor performance at a TMC.

  - With the lack of data availability relating to night time periods, VDOT recommends not calculating performance measures for night time periods using the NPMRDS.

  - VDOT believes that there are other sources/data bases containing more accurate data relating to non-Interstate NHS facilities than the NPMRDS and recommends that states be permitted to use those sources for calculating performance measures for the non-Interstate NHS facilities.

Finally, VDOT requests that FHWA specify the process for a state to obtain approval of an equivalent data set to include all information that would need to be submitted and the response time. For example, in 490.103(e)(5)(ii)(B), the proposed rule requires that the equivalent data set shall include "Average travel times for at least the same number of 5 minute intervals and the same locations that would be available in the NPMRDS". It is not clear how this determination will be made nor is it clear whose responsibility it will be to make this determination. VDOT recommends that FHWA provide an opportunity for data providers to have their products pre-approved for any states to use.

- **Resources:** VDOT strongly supports FHWA's proposal to "dedicate resources at the national level to provide on-site assistance, technical tools and guidance to State DOTs and MPOs ..." to help defray the significant cost and resources needed to implement these performance measures.

  - VDOT is very concerned about the additional costs that may be incurred in implementing these measures such as the costs associated with needed software and processing tools to deal with the extremely large data sets involved, hiring additional employees or contracting with consultants having appropriate skill sets, and the resources needed to conflate and keep conflation current as networks change. VDOT requests that FHWA identify and commit to providing technical and automated support systems and tools to help implement the measures.

In closing, VDOT appreciates the opportunity to provide comments on this proposed rule. If you have any questions, do not hesitate to contact Mena Lockwood, P.E., at (804) 786-7779, Ben Mannell, AICP, at (804) 786-2971, or for Air Quality matters, James Ponticello at (804) 371-6769.

Sincerely,

Charles A. Kilpatrick, P.E.
Commissioner of Highways
Virginia Department of Transportation

White Paper

NPMRDS Missing Data and Outlier Analysis

Prepared by:

Cambridge Systematics

Texas Transportation Institute

October 2015

1. INTRODUCTION

1.1 Data Used in the Analysis

To better understand the NPMRDS as a means to calculate reliability and freight performance measures some statistics and sample calculations were conducted for a few selected states and metropolitan areas. An analysis of the completeness of the NPMRDS data was conducted as well as the calculation and analysis of three measures when considering different levels of missing data and separately the effect of outliers on the measures. The three measures tested were Peak Hour Travel Time Ratio (PHTTR), Level of Travel Time Reliability (LOTTR) and the Congestion Mitigation / Air Quality (CMAQ) delay measure, which in part measures Annual Excessive Delay Per Capita.

The analyses were done using 10 months of NPMRDS data, 1 March 2014 to 31 December 2014.

For the LOTTR measure, 10 states were selected to represent a mix of urban and rural areas as well as different geographical regions:

1. Florida
2. Kentucky
3. Massachusetts
4. Mississippi
5. Nevada
6. New Mexico
7. South Dakota
8. Texas
9. Virginia
10. Washington

For the PHTTR measure, 11 urban areas were chosen:

1. Boston
2. Houston
3. Jacksonville
4. Las Vegas
5. Memphis
6. Miami
7. Minneapolis-St. Paul
8. Orlando
9. Providence
10. Seattle
11. Tampa

For the CMAQ analysis, NPMRDS travel time data and previously conflated volumes were used to calculate vehicle-hours of delay. Five urban areas were chosen:

1. Atlanta
2. Boston

3. Houston
4. Minneapolis-St. Paul
5. Seattle

Initial consideration was given to the completeness of the NPMRDS monthly data sets in the dimensions of state, area type, and roadway type across hour of the day (weekday and weekend/holiday) and day of the week. Once this was complete an analysis of the performance measures was conducted with consideration given to the level of missing or incomplete data and what effect replacing those values has on the measures.

1.2 Test Methods

Imputation of Missing Values

An analysis was conducted to determine what effect different methods for imputing data for missing values would have on measure calculation. The first step was to get an estimate of "ground truth" (e.g., a baseline for comparisons). An independent data source was not available, so the NPMRDS was used to establish the baseline by only considering TMCs in the analysis that were complete with travel time data, where "complete" is defined:

- at a level greater than 85% for LOTTR and PHTTR; and
- at a level greater than 85% during peak hours and greater than 50% for off peak hours for the CMAQ measure.

This approach assumes that the TMCs with 85% or 50% completeness rates are "ground truth", i.e., they represent a complete set of data for the 10-month time period. Setting the completeness thresholds higher would have resulted in too few TMCs to conduct reasonable analyses. Table 1 shows the number of TMCs that met the established thresholds for inclusion in the analyses. In some cases, the number of TMCs that met the criteria were too small; these conditions were excluded from further analysis.

The impact of missing data on the proposed measures was determined by removing random portions of the data from the baseline "pool" to the following levels: 70%, 50%, 30%, 20% and 10%, then calculating the measures. This was done on an hourly basis. For example, consider the 70% rate for LOTTR metric. For each hour from 6:00 AM to 8:00 PM for a TMC, a random sample of epochs is drawn that represents 70% of the total number of epochs in each hour.

Several types of imputation were studied:

- Do nothing, just treat the reduced datasets as samples.
- Fill in missing data with estimate of speed limit. Here, speed limit was assumed to be equal to the free flow speed, which was calculated as the 85^{th} percentile speed from weekend mornings from 6:00 – 10:00 am.
- Fill in missing data with historical speeds (CMAQ measure only). This procedure is described below.

For each of the tests, the "ground truth" based value of the metric was first computed. It was then recomputed using an imputation method listed above, and an error rate was calculated. The error rate shows the implication of using incomplete data for calculating the measures.

The method for handling missing data for the CMAQ delay assumes that the speed datasets are based on a "profile" setup for the average week of speeds by some time period (we have used 15-minute and hourly) for each TMC. This is done for 672 speed epochs (7 days in a week x 96 15-minute time periods each day). Each segment of road is classified based on two categories: functional class and traffic density. In this case functional class could be all Interstate Highways and other NHS highways. The traffic densities are split into the following categories:

Table 1. Number of TMCs Included in the Missing Data Analyses

Location	Interstate TMCs	Other NHS TMCs
LOTTR Analysis		
Florida	656	136
Kentucky	373	52
Massachusetts	314	43
Minnesota	232	N/A
Mississippi	254	89
Nevada	142	N/A
New Mexico	228	52
South Dakota	N/A	N/A
Texas	2,586	1,116
Virginia	625	106
Washington	403	64
PHTTR Analysis		
Boston	273	94
Houston	386	361
Jacksonville	106	28
Las Vegas	119	32
Miami	153	151
Minneapolis-St. Paul	143	N/A
Orlando	63	127
Providence	20	19
Seattle	181	53
Tampa	125	89
CMAQ/Delay Analysis (all NHS roadways)		
Atlanta	322	
Boston	127	
Houston	337	
Minneapolis-St. Paul	172	
Seattle	273	

Note: N/A indicates that 10 or less TMCs met the selection criteria. In these cases, analyses were not conducted (see Appendix B).

- Uncongested (less than 15,000 ADT/Lane)
- Moderate (15,000-17,500 ADT/Lane)
- Heavy (17,500-20,000 ADT/Lane
- Severe (20,000-25,000 ADT/Lane)
- Extreme (over 25,000 ADT/Lane)

For each combination of these categories (functional class x traffic density), the average speeds for the 672 epochs are calculated (the same can be done with percentiles etc.) for a given metro area. All of the speeds used to calculate the averages are weighted by VMT for each TMC that is included in each category combination. The same process is also done to calculate the average speeds for the 672 epochs for all of the category combinations at the statewide level.

The results of these calculations (metro area and statewide) are merged with the corresponding raw speed data, based on functional class and traffic density categories, and are used to fill in any missing average speeds in the raw 672 speed epochs.

The same process is repeated for the reference/free flow speeds although only one reference speed should be used for all 672 speed epochs for each category combination. Every time an average speed from the metro area or statewide category combination set is substituted into the raw data, the corresponding reference speed from the category combination should be substituted as well.

Methods for Removing Outliers

The entire 10 months of NPMRDS data were used, not just those TMCs that met the > 85% completeness criterion. The definition of what an outlier differed by performance measure. For the LOTTR and PHTTR measures, speed readings above 90 mph and 80 mph and below 5 mph, 2 mph, and 1 mph were used. For the CMAQ measure, only values on the low end of the speed distribution (5 mph, 2 mph and 1 mph) were use along with percentile "trimming" (smallest 1% and 0.5%); only the lower percentiles were considered since higher speed values do not contribute to the delay measure.

2. RESULTS

2.1 Completeness of the Data

The completeness of NPMRDS travel time data were analyzed from March to December of 2014 (i.e., 10 months). Completeness is defined as the ratio of 5-minute epochs with a travel time for all vehicles present to the total number of epochs during the 10-month analysis period. A variety of time periods and road types were considered.

The results show that data completeness was highest during weekday hours of peak travel on Interstate highways, as compared to other NHS highways in the 10 states (Figure 1). For all vehicles, the completeness rate is roughly 70 percent during daylight hours. Also, the completeness for "all vehicles" travel time data was always higher than "truck-only" travel time data (Figure 2). The state and area type (i.e., large urban, small urban and rural) had less impact on data completeness than road type and time of day (Figure 3). In most cases, however, the rural travel time data was more complete than large or small urban data.

The analysis also calculated data completeness for the road types and time periods that are including the in the performance measures definitions as of April 13, 2015 (Table 2). The data used in this analysis varied depending on the measure; see above for the states and urban areas used for calculating completeness for each measure. Table 2 shows Interstate highways separately from other NHS highways, even though the proposed FHWA measures did not make this distinction. Appendix A presents additional detail on the completeness calculations.

Figure 1

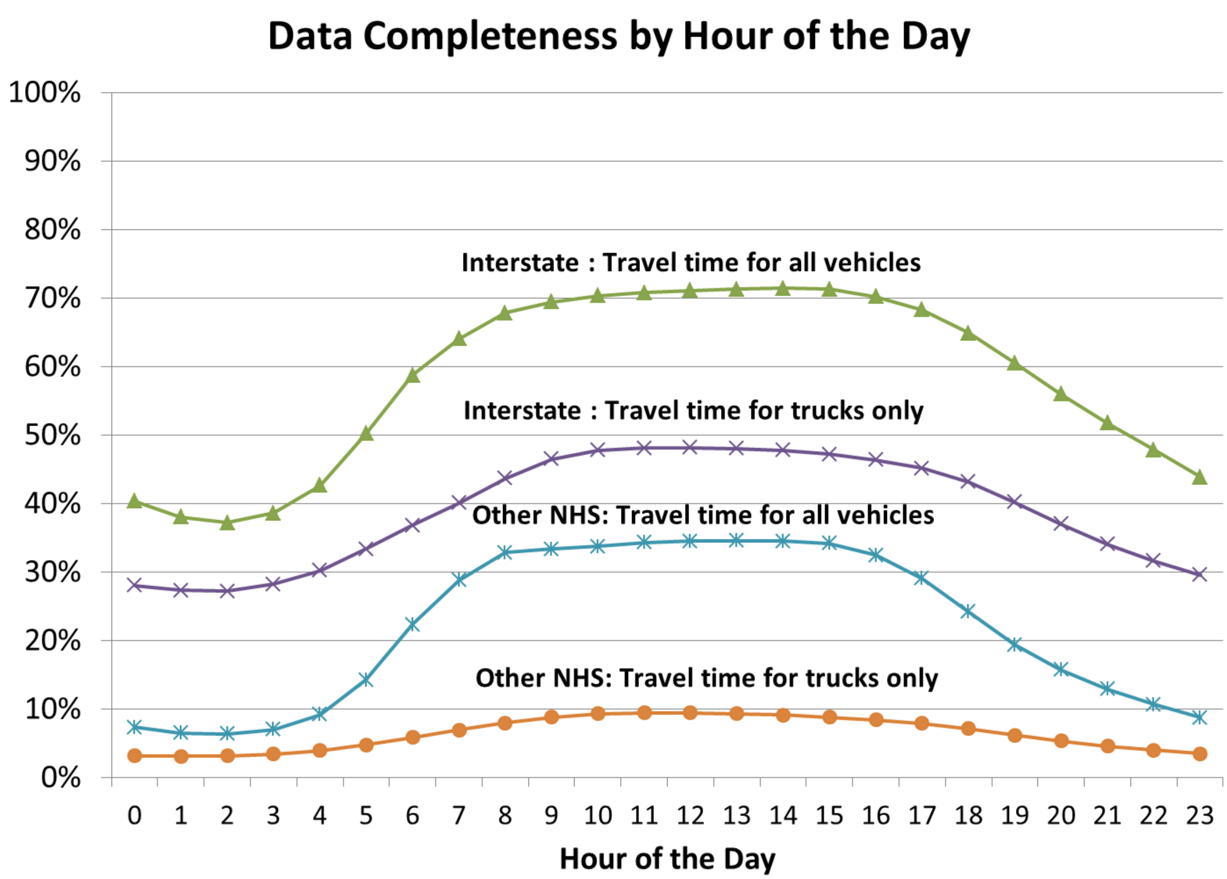


Figure 2

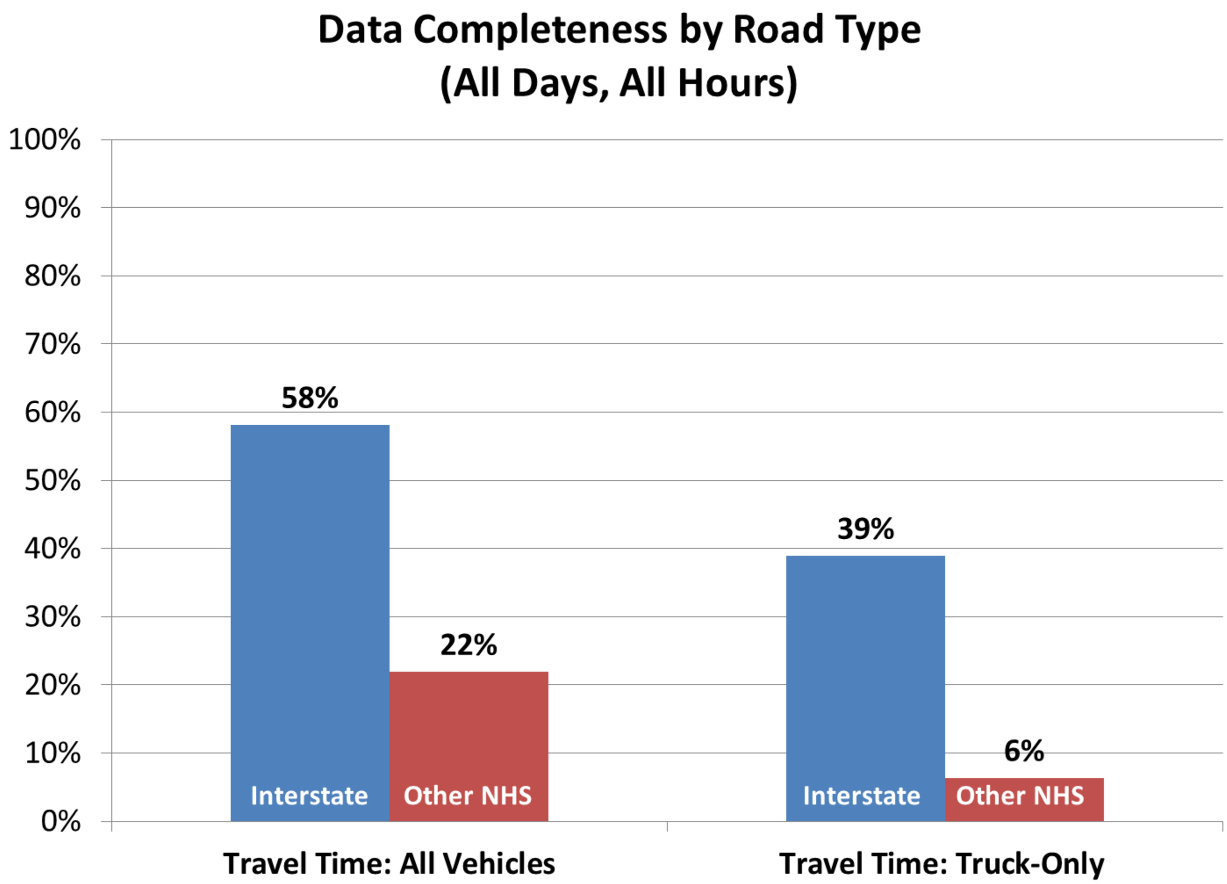

Data Completeness by Road Type
(All Days, All Hours)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
58%
22%
39%
6%
Interstate
Other NHS
Interstate
Other NHS
Travel Time: All Vehicles
Travel Time: Truck-Only

Figure 3

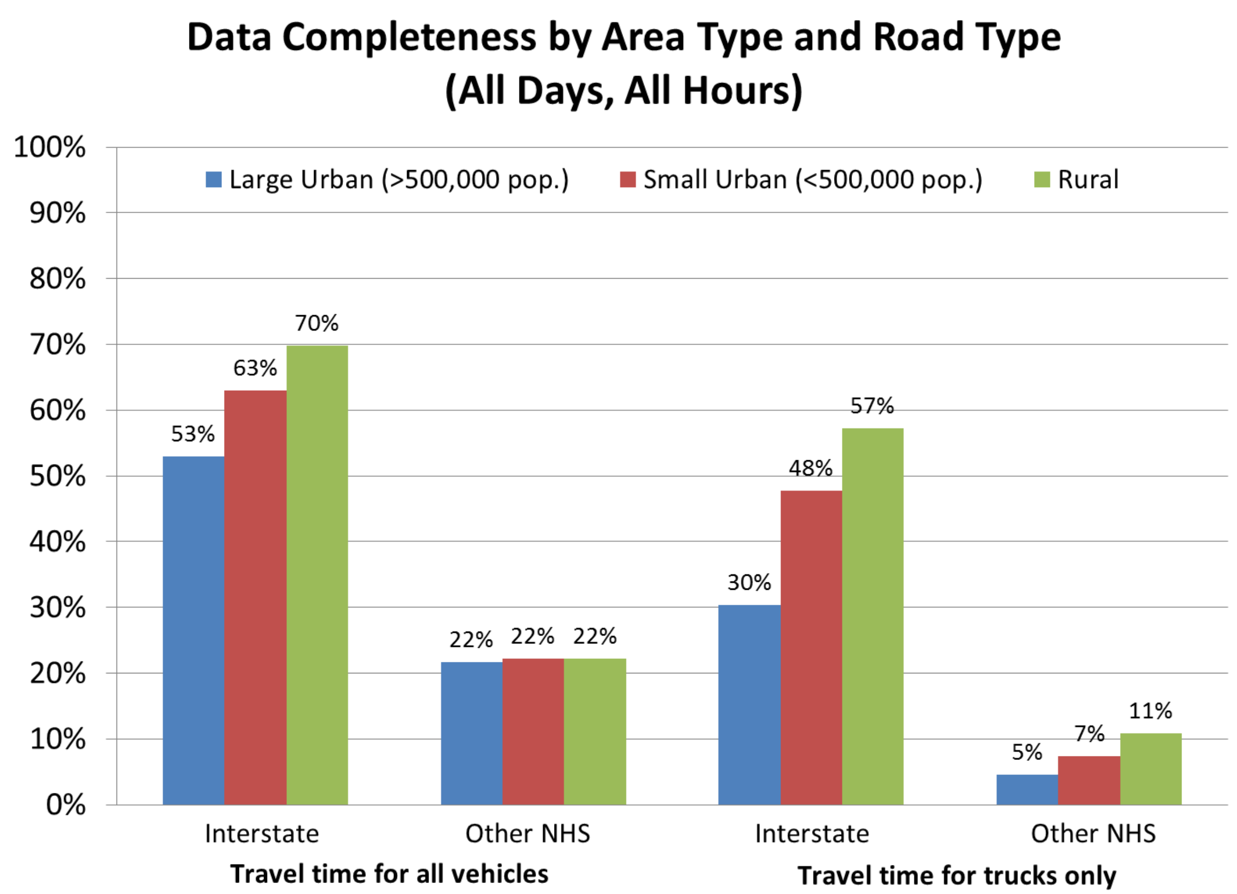


Table 2. Data Completeness for Proposed Performance Measures

Proposed Measure	Interstate	Other NHS
PHTTR (Urban 1M+, 6-9 am and 4-7 pm weekdays)	66%	34%
LOTTR (statewide NHS, 6 am to 8 pm every day)	68%	31%
CMAQ Excessive Delay (Urban 1M+, 24 hours every day)	53%	22%

2.2 Impact of Methods for Handling Missing Data

Table 3 presents a summary of the analyses. Appendix B provides detailed results for the imputation tests and Appendix C provides detailed results for the outlier tests.

Effect of Imputation

Level of Travel Time Reliability analysis showed that missing values that were not imputed did not have a large effect on the LOTTR measure. In fact, for all States and levels of completeness measured on the Interstate system the percent error was less typically than +/- 1%. The Non-Interstate roadways were slightly more variable with a couple of readings having -5% error. Using imputation based on free flow speed increased the percent error substantially across highway types, up to 50%.

The effect of missing values on the Peak Hour Travel Time Ratio was greater than for the LOTTR. Percent error ranged from 2% to -10% for Interstates while Non-Interstate roads again were more variable ranging from 37% to -40% error. The PHTTR also showed that imputation with free flow speed increased the percent error, but the effect was even more dramatic; absolute percent error was often well over 100%. The size of the error was inversely proportional to the percent complete in the baseline

The CMAQ delay measure is an aggregate measure and was reduced proportionately to the percent of data that was removed, typically error was within one half of a percent of the proportion removed. When missing data were imputed from free flow speeds, the measures didn't change, as expected, since there is no delay at the free flow speed by definition. When imputation was based on historical speeds, there was a slight decrease in the percent error. The reason for the slight decrease is that the historical speeds generally are above the threshold values for the CMAQ measure. This can be seen in the relatively stable delay numbers between no imputation and historical speed cases. Alternate imputation methods may produce different results.

Effect of Removing Outliers

The Level of Travel Time Reliability measure hardly changed for Interstates when outliers were removed; all errors were within 0.8%. Once again the variability of the Non-Interstate was much higher, one reading had a 27% error, but generally the errors were smaller and under 10%. This may be due to the higher number of very low speeds on signalized arterials in the data.

The Peak Hour Travel Time Ratio measure had almost no change when faster speeds were dropped. However when the slow speeds were removed the measure did change in the range of 1% to 13% for Interstates and quite a bit more for Non-Interstates, where the measure was roughly 2-3 times higher than the baseline measure.

The Congestion Mitigation / Air Quality measure is very dependent on the slower speeds. Removing the low speeds had a big effect on the CMAQ calculations, reducing the measure by 15% to 60% depending on the city and threshold level that was being evaluated.

Table 3: Summary of the Effects of Missing Values, Imputed Values, and Outliers on Performance Measure Values

	Level of Travel Time Reliability	**Peak Hour Travel Time Ratio**	**Congestion Mitigation / Air Quality**
Measure Definition	*The percentage of miles, as measured by TMCs, where the 80th percentile travel time is less than 1.5 times the mean or 50th percentile of travel time.*	*The percentage of miles, as measured by TMCs, where the longest annual travel time is less than 1.5 times the desired travel time.*	*The sum of the delay times the volume over all mileage in the TMCs for the entire year. This is then divided by the population to get a per capita statistic.*
Missing Values			
No Imputation	Very little effect. (Interstate <~1% error) (Non-Interstate <~5% error)	Significant effect. (Interstate 0 - 10% error) (Non-Interstate 0 - 40% error)	Very large effects that were proportional to the percent of missing data.
Replacements			
Using Free Flow Speed	Significant effect. Percent error varied widely (up to 27% for Interstates and 50% for other NHS).	Very large effect. Percent error larger when percent complete was small. Percent error varied widely (up to 265% for Interstates and 765% for other NHS).	No effect on measure.
Using Historical Average Speed	N/A1	N/A1	Slight effect but not close to approximating the desired baseline values.

Table 3 (Cont.)

	Level of Travel Time Reliability	**Peak Hour Travel Time Ratio**	**Congestion Mitigation / Air Quality**
Outliers			
Removing High Speeds	Nearly no effect. (Interstate and Non-Interstate within ~0.5% error)	Nearly no effect. (Interstate <~1% error) (Non-Interstate <~1% error)	N/A2
Removing Low Speeds	Generally small effects. (Interstate <~1% error) (Non-Interstate most <~10% error)	Significant effects. (Interstate 1 - 13% error) (Non-Interstate 25 -250% error)	Large effects that reduced the Measures by 15-60% depending upon the level of removal.

Note: Absolute errors are documented in this table.

N/A1: LOTTR & PHTTR Measures were not calculated with Historical Speed per scope of analysis.

N/A2: High speeds outliers were not removed since they are not used in calculating the measure.

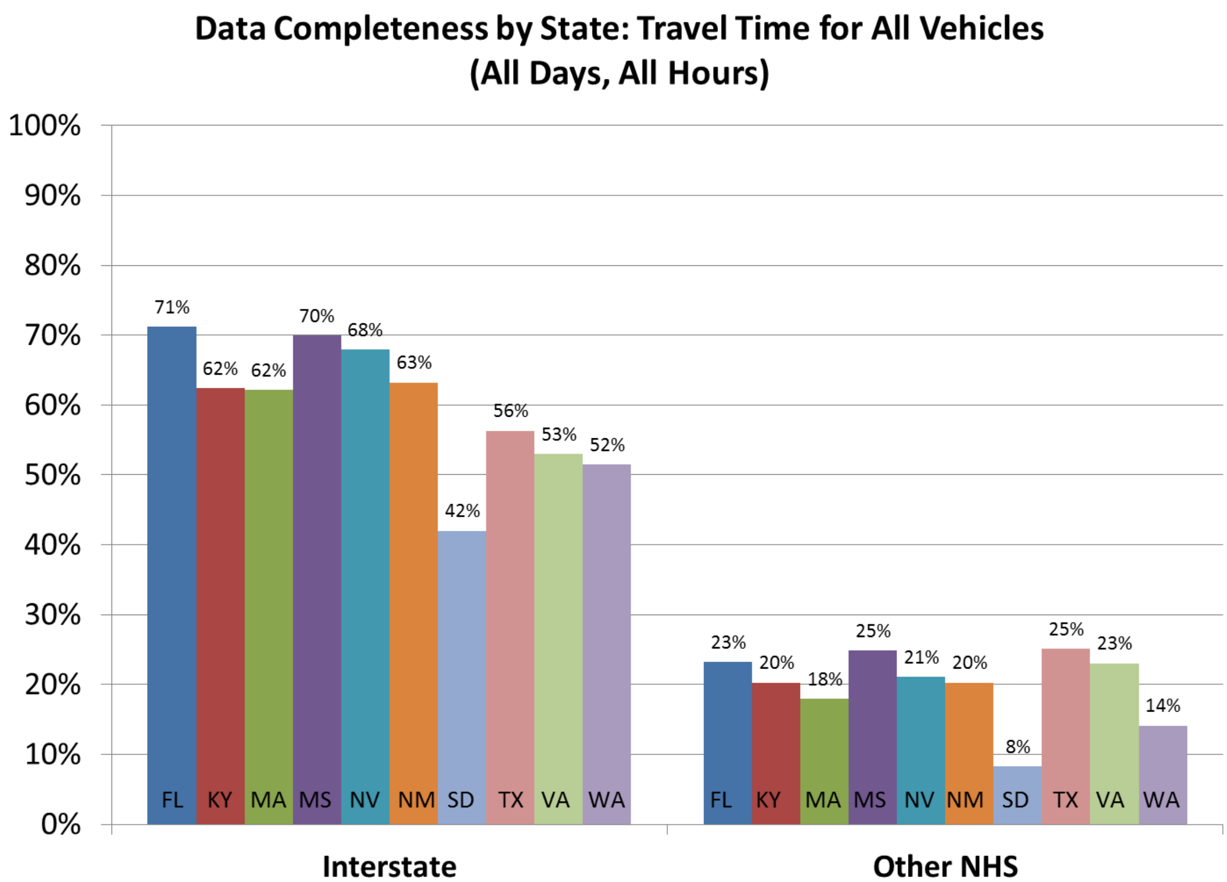
Color Code

Little Concern
Some Concern
Concerned

APPENDIX A

Completeness Results for 10 States[1]

[1] Florida, Kentucky, Massachusetts, Mississippi, Nevada, New Mexico, South Dakota, Texas, Virginia, Washington


Data Completeness by State: Travel Time for All Vehicles
(All Days, All Hours)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
71%
62%
62%
70%
68%
63%
42%
56%
53%
52%
23%
20%
18%
25%
21%
20%
8%
25%
23%
14%
FL
KY
MA
MS
NV
NM
SD
TX
VA
WA
Interstate
Other NHS

Area Type

	Interstate		Other NHS	
Area Type	**All**	**Truck**	**All**	**Truck**
Large Urban	53%	30%	22%	5%
Small Urban	63%	48%	22%	7%
Rural	70%	57%	22%	11%

Area Type by Time Period

Large Urban	**Interstate**		**Other NHS**	
	All	**Truck**	**All**	**Truck**
AM Peak (6AM-9AM)	65%	34%	35%	6%
Mid-Day (9AM-4PM)	70%	41%	40%	8%
PM Peak (4PM-7PM)	66%	38%	33%	6%
Overnight (7PM-6AM)	42%	26%	11%	3%
Weekend & Holiday	45%	24%	14%	3%

Small Urban	**Interstate**		**Other NHS**	
	All	**Truck**	**All**	**Truck**
AM Peak (6AM-9AM)	73%	53%	35%	9%
Mid-Day (9AM-4PM)	78%	60%	40%	12%
PM Peak (4PM-7PM)	75%	57%	33%	10%
Overnight (7PM-6AM)	54%	42%	12%	5%
Weekend & Holiday	56%	42%	14%	5%

Rural	Interstate		Other NHS	
	All	Truck	All	Truck
AM Peak (6AM-9AM)	75%	60%	31%	12%
Mid-Day (9AM-4PM)	82%	69%	37%	17%
PM Peak (4PM-7PM)	81%	68%	32%	15%
Overnight (7PM-6AM)	63%	50%	14%	8%
Weekend & Holiday	65%	53%	15%	8%

State

	Interstate		Other NHS	
State	**All**	**Truck**	**All**	**Truck**
Florida	71%	42%	23%	5%
Kentucky	62%	50%	20%	9%
Massachusetts	62%	26%	18%	2%
Mississippi	70%	57%	25%	13%
Nevada	68%	50%	21%	6%
New Mexico	63%	51%	20%	8%
South Dakota	42%	29%	8%	4%
Texas	56%	39%	25%	9%
Virginia	53%	33%	23%	6%
Washington	52%	31%	14%	4%

State by Time Period

Florida	Interstate		Other NHS	
	All	Truck	All	Truck
AM Peak (6AM-9AM)	86%	48%	37%	6%
Mid-Day (9AM-4PM)	89%	56%	44%	8%
PM Peak (4PM-7PM)	86%	52%	35%	6%
Overnight (7PM-6AM)	60%	37%	11%	3%
Weekend & Holiday	61%	31%	14%	2%

Kentucky	Interstate		Other NHS	
	All	Truck	All	Truck
AM Peak (6AM-9AM)	72%	55%	31%	11%
Mid-Day (9AM-4PM)	77%	63%	38%	16%
PM Peak (4PM-7PM)	76%	63%	31%	14%
Overnight (7PM-6AM)	55%	45%	11%	6%
Weekend & Holiday	54%	43%	12%	6%

Massachusetts	Interstate		Other NHS	
	All	Truck	All	Truck
AM Peak (6AM-9AM)	83%	33%	32%	2%
Mid-Day (9AM-4PM)	85%	40%	35%	3%

PM Peak (4PM-7PM)	78%	33%	25%	2%
Overnight (7PM-6AM)	47%	21%	7%	1%
Weekend & Holiday	51%	18%	10%	1%

Mississippi	**Interstate**		**Other NHS**	
	All	**Truck**	**All**	**Truck**
AM Peak (6AM-9AM)	82%	63%	37%	16%
Mid-Day (9AM-4PM)	86%	72%	43%	21%
PM Peak (4PM-7PM)	84%	71%	36%	18%
Overnight (7PM-6AM)	61%	49%	15%	9%
Weekend & Holiday	60%	48%	16%	9%

Nevada	**Interstate**		**Other NHS**	
	All	**Truck**	**All**	**Truck**
AM Peak (6AM-9AM)	79%	55%	31%	7%
Mid-Day (9AM-4PM)	85%	63%	37%	9%
PM Peak (4PM-7PM)	81%	60%	29%	8%
Overnight (7PM-6AM)	55%	40%	11%	4%
Weekend & Holiday	62%	47%	14%	4%

New Mexico	**Interstate**		**Other NHS**	
	All	**Truck**	**All**	**Truck**

AM Peak (6AM-9AM)	69%	51%	30%	9%
Mid-Day (9AM-4PM)	76%	59%	36%	12%
PM Peak (4PM-7PM)	73%	58%	27%	10%
Overnight (7PM-6AM)	54%	44%	11%	5%
Weekend & Holiday	60%	51%	15%	7%

South Dakota	**Interstate**		**Other NHS**	
	All	**Truck**	**All**	**Truck**
AM Peak (6AM-9AM)	52%	32%	12%	4%
Mid-Day (9AM-4PM)	60%	41%	16%	7%
PM Peak (4PM-7PM)	57%	39%	12%	5%
Overnight (7PM-6AM)	29%	20%	3%	1%
Weekend & Holiday	36%	26%	4%	2%

Texas	**Interstate**		**Other NHS**	
	All	**Truck**	**All**	**Truck**
AM Peak (6AM-9AM)	65%	42%	37%	10%
Mid-Day (9AM-4PM)	71%	49%	43%	14%
PM Peak (4PM-7PM)	68%	47%	38%	12%
Overnight (7PM-6AM)	48%	34%	15%	6%
Weekend & Holiday	50%	34%	17%	6%

Virginia	Interstate		Other NHS	
	All	Truck	All	Truck
AM Peak (6AM-9AM)	64%	36%	37%	7%
Mid-Day (9AM-4PM)	68%	42%	42%	10%
PM Peak (4PM-7PM)	65%	41%	35%	9%
Overnight (7PM-6AM)	43%	29%	12%	4%
Weekend & Holiday	47%	28%	15%	4%

Washington	Interstate		Other NHS	
	All	Truck	All	Truck
AM Peak (6AM-9AM)	64%	38%	22%	5%
Mid-Day (9AM-4PM)	70%	45%	27%	6%
PM Peak (4PM-7PM)	65%	39%	21%	5%
Overnight (7PM-6AM)	41%	26%	7%	2%
Weekend & Holiday	43%	23%	9%	2%

APPENDIX B

Impact of Missing Data and Imputation on the Measures

RESULTS FOR LEVEL OF TRAVEL TIME RELIABILITY, INTERSTATE SYSTEM

Group or Category	**Level of Travel Time Reliability** (measure values for different levels of NPMRDS data completeness)						**Percent Error** as Compared to Baseline (85+% complete) (for different levels of data completeness)				
	Baseline: 85%+	70%	50%	30%	20%	10%	70%	50%	30%	20%	10%
State (# TMCs in Baseline)		**IMPUTE OPTION 1: DO NOTHING TO FILL IN MISSING DATA, TREAT INCOMPLETE DATA AS A SAMPLE**									
Florida (656)	96.0%	95.9%	96.0%	96.0%	95.8%	95.9%	-0.1%	0.0%	0.0%	-0.2%	-0.1%
Kentucky (373)	96.1%	96.0%	96.1%	95.9%	96.0%	95.8%	-0.1%	-0.1%	-0.3%	-0.2%	-0.3%
Massachusetts (314)	79.0%	78.8%	79.2%	78.7%	79.1%	78.1%	-0.2%	0.3%	-0.4%	0.1%	-1.0%
Minnesota (232)	93.3%	93.3%	93.5%	92.3%	93.3%	93.5%	0.0%	0.2%	-1.1%	-0.1%	0.2%
Mississippi (254)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Nevada (142)	98.6%	98.6%	98.6%	98.7%	98.6%	98.7%	0.0%	0.0%	0.1%	0.0%	0.1%
New Mexico (228)	99.3%	99.3%	99.3%	99.3%	99.2%	99.2%	0.0%	0.0%	0.0%	-0.1%	-0.1%
South Dakota											
Texas (2,586)	93.5%	93.5%	93.5%	93.5%	93.6%	93.5%	0.0%	-0.1%	0.0%	0.1%	0.0%
Virginia (625)	92.2%	92.2%	92.1%	92.2%	92.2%	92.3%	0.0%	-0.1%	0.0%	0.0%	0.1%
Washington (403)	88.9%	88.9%	89.2%	89.1%	89.1%	89.1%	0.0%	0.4%	0.2%	0.2%	0.3%

Group or Category	**Level of Travel Time Reliability** (measure values for different levels of NPMRDS data completeness)						**Percent Error** as Compared to Baseline (85+% complete) (for different levels of data completeness)				
	Baseline: 85%+	70%	50%	30%	20%	10%	70%	50%	30%	20%	10%
State (# TMCs in Baseline)											
		IMPUTE OPTION 2: FILL IN MISSING DATA WITH ESTIMATE OF SPEED LIMIT (FROM ACTUAL FREE-FLOW SPEED)									
Florida (656)	96.0%	96.9%	97.8%	99.8%	100.0%	100.0%	0.9%	1.9%	4.0%	4.2%	4.2%
Kentucky (373)	96.1%	98.6%	98.8%	99.9%	100.0%	100.0%	2.6%	2.8%	3.9%	4.0%	4.0%
Massachusetts (314)	79.0%	79.6%	82.1%	96.6%	100.0%	100.0%	0.8%	4.0%	22.3%	26.6%	26.6%
Minnesota (232)	93.3%	94.6%	97.7%	100.0%	100.0%	100.0%	1.4%	4.7%	7.1%	7.1%	7.1%
Mississippi (254)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Nevada (142)	98.6%	98.9%	99.3%	100.0%	100.0%	100.0%	0.3%	0.7%	1.4%	1.4%	1.4%
New Mexico (228)	99.3%	100.0%	100.0%	100.0%	100.0%	100.0%	0.6%	0.7%	0.7%	0.7%	0.7%
South Dakota											
Texas (2,586)	93.5%	94.0%	94.7%	98.5%	100.0%	100.0%	0.5%	1.2%	5.3%	6.9%	6.9%
Virginia (625)	92.2%	93.5%	93.5%	98.4%	100.0%	100.0%	1.4%	1.4%	6.7%	8.5%	8.5%
Washington (403)	88.9%	89.2%	90.5%	97.0%	100.0%	100.0%	0.3%	1.7%	9.1%	12.5%	12.5%

RESULTS FOR LEVEL OF TRAVEL TIME RELIABILITY, NON-INTERSTATE NATIONAL HIGHWAY SYSTEM (NHS)

Group or Category	**Level of Travel Time Reliability** (measure values for different levels of NPMRDS data completeness)						**Percent Error** as Compared to Baseline (85+% complete) (for different levels of data completeness)				
	Baseline: 85%+	70%	50%	30%	20%	10%	70%	50%	30%	20%	10%
State (# TMCs in Baseline)		**IMPUTE OPTION 1: DO NOTHING TO FILL IN MISSING DATA, TREAT INCOMPLETE DATA AS A SAMPLE**									
Florida (136)	97.1%	97.1%	97.1%	97.1%	97.1%	97.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Kentucky (52)	99.7%	99.7%	99.7%	98.7%	99.3%	98.7%	0.0%	0.0%	-1.0%	-0.3%	-1.0%
Massachusetts (43)	66.4%	66.4%	63.0%	63.0%	66.4%	64.2%	0.0%	-5.1%	-5.1%	0.0%	-3.3%
Minnesota											
Mississippi (89)	99.5%	99.5%	99.5%	99.5%	99.5%	99.5%	0.0%	0.0%	0.0%	0.0%	0.0%
Nevada											
New Mexico (52)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
South Dakota											
Texas (1,116)	90.0%	90.4%	90.1%	90.7%	91.0%	90.5%	0.3%	0.1%	0.7%	1.0%	0.5%
Virginia (106)	93.3%	94.0%	94.0%	94.7%	93.4%	93.0%	0.7%	0.7%	1.4%	0.0%	-0.4%
Washington (64)	87.7%	87.7%	87.7%	87.7%	87.7%	88.2%	0.0%	0.0%	0.0%	0.0%	0.6%

Group or Category	Level of Travel Time Reliability (measure values for different levels of NPMRDS data completeness) Baseline: 85%+	70%	50%	30%	20%	10%	Percent Error as Compared to Baseline (85+% complete) (for different levels of data completeness) 70%	50%	30%	20%	10%
State (# TMCs in Baseline)		IMPUTE OPTION 2: FILL IN MISSING DATA WITH ESTIMATE OF SPEED LIMIT (FROM ACTUAL FREE-FLOW SPEED)									
Florida (136)	97.1%	96.6%	97.7%	99.4%	100.0%	100.0%	-0.5%	0.7%	2.4%	3.0%	3.0%
Kentucky (52)	99.7%	98.9%	99.3%	99.7%	100.0%	100.0%	-0.8%	-0.3%	0.0%	0.3%	0.3%
Massachusetts (43)	66.4%	61.1%	57.3%	97.2%	100.0%	100.0%	-8.0%	-13.7%	46.5%	50.6%	50.6%
Minnesota	86.8%										
Mississippi (89)	99.5%	99.5%	99.5%	100.0%	100.0%	100.0%	0.0%	0.0%	0.5%	0.5%	0.5%
Nevada	84.2%										
New Mexico (52)	100.0%	97.0%	92.5%	100.0%	100.0%	100.0%	-3.0%	-7.5%	0.0%	0.0%	0.0%
South Dakota	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Texas (1,116)	90.0%	90.5%	90.6%	98.6%	99.9%	99.9%	0.5%	0.6%	9.5%	11.0%	10.9%
Virginia (106)	93.3%	92.9%	88.2%	96.6%	100.0%	100.0%	-0.5%	-5.5%	3.6%	7.1%	7.1%
Washington (64)	87.7%	85.2%	90.8%	98.1%	100.0%	100.0%	-2.9%	3.6%	11.9%	14.0%	14.0%

RESULTS FOR PEAK HOUR TRAVEL TIME RATIO, INTERSTATE SYSTEM

Group or Category	Peak Hour Travel Time Ratio (measure values for different levels of NPMRDS data completeness)						Percent Error as Compared to Baseline (85+% complete) (for different levels of data completeness)				
	Baseline: 85%+	70%	50%	30%	20%	10%	70%	50%	30%	20%	10%
City (# TMCs in Baseline)		**IMPUTE OPTION 1: DO NOTHING TO FILL IN MISSING DATA, TREAT INCOMPLETE DATA AS A SAMPLE**									
Boston (273)	38.6%	38.6%	38.7%	38.5%	37.2%	35.1%	0.0%	0.4%	-0.1%	-3.7%	-9.1%
Houston (386)	54.3%	53.9%	53.9%	53.6%	53.3%	52.7%	-0.7%	-0.8%	-1.4%	-1.9%	-2.9%
Jacksonville (106)	84.8%	84.0%	82.9%	81.2%	82.9%	80.8%	-0.9%	-2.3%	-4.2%	-2.2%	-4.7%
Las Vegas (119)	92.0%	92.0%	92.0%	91.5%	89.6%	89.7%	0.0%	0.0%	-0.5%	-2.6%	-2.5%
Memphis											
Miami (153)	52.4%	52.4%	52.8%	51.9%	51.5%	51.9%	0.0%	0.8%	-1.0%	-1.8%	-0.8%
Minn-St. Paul (143)	60.9%	60.4%	60.5%	59.5%	59.9%	54.5%	-0.8%	-0.6%	-2.3%	-1.6%	-10.5%
Orlando (63)	27.4%	27.4%	29.1%	27.4%	27.4%	29.1%	0.0%	6.1%	0.0%	0.0%	6.1%
Providence (20)	76.1%	72.8%	76.1%	76.4%	76.9%	73.0%	-4.4%	0.0%	0.4%	1.0%	-4.1%
Seattle (181)	41.3%	42.3%	42.0%	39.9%	41.0%	40.7%	2.2%	1.6%	-3.5%	-0.7%	-1.6%
Tampa (125)	72.5%	72.5%	69.8%	69.2%	68.0%	64.8%	0.0%	-3.8%	-4.6%	-6.3%	-10.7%

Group or Category	Peak Hour Travel Time Ratio (measure values for different levels of NPMRDS data completeness)						Percent Error as Compared to Baseline (85+% complete) (for different levels of data completeness)				
	Baseline: 85%+	70%	50%	30%	20%	10%	70%	50%	30%	20%	10%
City (# TMCs in Baseline)		**IMPUTE OPTION 2: FILL IN MISSING DATA WITH ESTIMATE OF SPEED LIMIT (FROM ACTUAL FREE-FLOW SPEED)**									
Boston (273)	38.6%	47.3%	58.4%	75.8%	88.8%	99.2%	22.7%	51.5%	96.6%	130.1%	157.1%
Houston (386)	54.3%	60.6%	67.3%	79.1%	88.3%	98.5%	11.6%	23.9%	45.6%	62.5%	81.4%
Jacksonville (106)	84.8%	87.4%	89.5%	98.0%	99.8%	100.0%	3.1%	5.6%	15.6%	17.7%	17.9%
Las Vegas (119)	92.0%	93.9%	95.2%	98.9%	100.0%	100.0%	2.0%	3.5%	7.5%	8.7%	8.7%
Memphis											
Miami (153)	52.4%	70.3%	80.0%	95.2%	99.7%	100.0%	34.2%	52.7%	81.8%	90.3%	90.9%
Minn-St. Paul (143)	60.9%	75.9%	84.3%	92.8%	97.3%	99.3%	24.6%	38.4%	52.4%	59.8%	63.1%
Orlando (63)	27.4%	44.5%	65.9%	87.5%	94.4%	100.0%	62.6%	140.5%	219.3%	244.4%	265.0%
Providence (20)		96.6%	100.0%	100.0%	100.0%	100.0%	26.9%	31.4%	31.4%	31.4%	31.4%
Seattle (181)	41.3%	55.3%	61.4%	76.1%	89.2%	97.9%	33.8%	48.4%	84.2%	115.7%	136.7%
Tampa (125)	72.5%	78.8%	84.3%	91.5%	95.6%	99.8%	8.6%	16.2%	26.2%	31.8%	37.6%

RESULTS FOR PEAK HOUR TRAVEL TIME RATIO, NON-INTERSTATE NATIONAL HIGHWAY SYSTEM (NHS)

Group or Category	**Peak Hour Travel Time Ratio** (measure values for different levels of NPMRDS data completeness)						**Percent Error** as Compared to Baseline (85+% complete) (for different levels of data completeness)				
City (# TMCs in Baseline)	Baseline: 85%+	70%	50%	30%	20%	10%	70%	50%	30%	20%	10%
		IMPUTE OPTION 1: DO NOTHING TO FILL IN MISSING DATA, TREAT INCOMPLETE DATA AS A SAMPLE									
Boston (94)	45.4%	45.8%	45.8%	40.2%	45.4%	41.2%	0.8%	0.8%	-11.5%	-0.1%	-9.3%
Houston (361)	55.3%	55.1%	54.1%	54.4%	52.3%	49.2%	-0.3%	-2.1%	-1.5%	-5.3%	-10.9%
Jacksonville (28)	32.2%	44.4%	32.2%	26.0%	40.4%	26.0%	37.6%	0.0%	-19.3%	25.3%	-19.3%
Las Vegas (32)	11.6%	11.6%	11.6%	6.8%	6.8%	8.2%	0.0%	0.0%	-41.1%	-41.1%	-29.6%
Memphis											
Miami (151)	68.7%	68.7%	68.1%	65.0%	68.5%	61.5%	0.0%	-0.9%	-5.4%	-0.3%	-10.5%
Minn-St. Paul											
Orlando (127)	94.0%	94.0%	93.0%	94.0%	87.4%	73.0%	0.0%	-1.1%	0.0%	-7.0%	-22.3%
Providence (19)	50.8%	50.8%	50.8%	50.8%	50.8%	50.8%	0.0%	0.0%	0.0%	0.0%	0.0%
Seattle (53)	47.7%	45.3%	44.2%	42.8%	43.9%	39.3%	-4.9%	-7.2%	-10.2%	-7.9%	-17.6%
Tampa (89)	11.7%	11.7%	11.7%	11.7%	14.1%	11.6%	0.0%	0.0%	0.0%	20.6%	-0.6%

Group or Category	Peak Hour Travel Time Ratio (measure values for different levels of NPMRDS data completeness)						Percent Error as Compared to Baseline (85+% complete) (for different levels of data completeness)				
City (# TMCs in Baseline)	Baseline: 85%+	70%	50%	30%	20%	10%	70%	50%	30%	20%	10%
City (# TMCs in Baseline)		**IMPUTE OPTION 2: FILL IN MISSING DATA WITH ESTIMATE OF SPEED LIMIT (FROM ACTUAL FREE-FLOW SPEED)**									
Boston (94)	45.4%	51.4%	58.1%	77.6%	89.5%	100.0%	13.1%	27.8%	70.9%	97.0%	120.1%
Houston (361)	55.3%	63.5%	68.4%	82.5%	93.3%	99.0%	14.9%	23.8%	49.3%	68.9%	79.2%
Jacksonville (28)	32.2%	66.4%	77.3%	87.2%	87.2%	100.0%	106.0%	139.8%	170.5%	170.5%	210.2%
Las Vegas (32)	11.6%	91.7%	91.7%	96.8%	100.0%	100.0%	692.7%	692.7%	736.9%	764.2%	764.2%
Memphis											
Miami (151)	68.7%	74.9%	79.9%	89.4%	95.4%	99.2%	9.0%	16.2%	30.1%	38.9%	44.3%
Minn-St. Paul											
Orlando (127)	94.0%	95.5%	96.5%	98.4%	99.7%	100.0%	1.6%	2.7%	4.7%	6.1%	6.4%
Providence (19)		71.4%	71.4%	100.0%	100.0%	100.0%	40.4%	40.4%	96.7%	96.7%	96.7%
Seattle (53)	47.7%	58.5%	68.0%	85.7%	96.0%	100.0%	22.8%	42.7%	79.8%	101.5%	109.9%
Tampa (89)	11.7%	32.2%	64.4%	92.2%	97.8%	100.0%	175.6%	451.9%	690.0%	738.1%	756.9%

RESULTS FOR CMAQ EXCESSIVE DELAY, ALL NATIONAL HIGHWAY SYSTEM (NHS)

Group or Category	**CMAQ Excessive Delay (in Millions of Vehicle Hours)** (measure values for different levels of NPMRDS data completeness)						**Percent Error** as Compared to Baseline (85+% complete) (for different levels of data completeness)				
	Baseline: 85%+	70%	50%	30%	20%	10%	70%	50%	30%	20%	10%
		IMPUTE OPTION 1: DO NOTHING TO FILL IN MISSING DATA, TREAT INCOMPLETE DATA AS A SAMPLE									
City (# TMCs used)											
Atlanta (322)	11.3	7.9	5.6	3.4	2.3	1.1	-29.9%	-50.0%	-70.1%	-79.9%	-90.1%
Boston (127)	1.9	1.4	1.0	0.6	0.4	0.2	-30.2%	-49.8%	-70.0%	-79.9%	-89.8%
Houston (337)	47.5	33.3	23.7	14.2	9.4	4.6	-29.8%	-50.1%	-70.1%	-80.1%	-90.2%
Minn-St. Paul (172)	17.1	11.9	8.6	5.1	3.5	1.7	-30.1%	-49.6%	-70.4%	-79.5%	-90.0%
Seattle (273)	98.8	69.0	49.7	29.7	19.8	9.9	-30.1%	-49.7%	-70.0%	-80.0%	-89.9%
		IMPUTE OPTION 2: FILL IN MISSING DATA WITH ESTIMATE OF SPEED LIMIT (FROM ACTUAL FREE-FLOW SPEED)									
City (# TMCs used)											
Atlanta (322)	11.3	7.9	5.6	3.4	2.3	1.1	-29.9%	-50.0%	-70.1%	-79.9%	-90.1%
Boston (127)	1.9	1.4	1.0	0.6	0.4	0.2	-30.2%	-49.8%	-70.0%	-79.9%	-89.8%
Houston (337)	47.5	33.3	23.7	14.2	9.4	4.6	-29.8%	-50.1%	-70.1%	-80.1%	-90.2%
Minn-St. Paul (172)	17.1	11.9	8.6	5.1	3.5	1.7	-30.1%	-49.6%	-70.4%	-79.5%	-90.0%
Seattle (273)	98.8	69.0	49.7	29.7	19.8	9.9	-30.1%	-49.7%	-70.0%	-80.0%	-89.9%

Group or Category	CMAQ Excessive Delay (in Millions of Vehicle Hours) (measure values for different levels of NPMRDS data completeness)						**Percent Error** as Compared to Baseline (85+% complete) (for different levels of data completeness)				
	Baseline: 85%+	70%	50%	30%	20%	10%	70%	50%	30%	20%	10%
		IMPUTE OPTION 3: FILL IN MISSING DATA WITH HISTORICAL SPEED									
City (# TMCs used)											
Atlanta (322)	11.3	7.9	5.6	3.4	2.3	1.1	-29.8%	-49.9%	-70.0%	-79.8%	-90.0%
Boston (127)	1.9	1.4	1.0	0.6	0.4	0.2	-30.2%	-49.8%	-70.0%	-79.9%	-89.8%
Houston (337)	47.5	35.8	27.8	19.9	16.0	12.0	-24.6%	-41.5%	-58.0%	-66.4%	-74.7%
Minn-St. Paul (172)	17.1	12.4	9.4	6.2	4.7	3.1	-27.4%	-45.1%	-63.9%	-72.2%	-81.8%
Seattle (273)	98.8	77.8	64.3	50.1	43.1	36.2	-21.2%	-34.9%	-49.2%	-56.3%	-63.3%

RESULTS FOR CMAQ EXCESSIVE DELAY, ALL NATIONAL HIGHWAY SYSTEM (NHS)

Group or Category	CMAQ Excessive Delay (Vehicle Hours per Capita) (measure values for different levels of NPMRDS data completeness)						Percent Error as Compared to Baseline (85+% complete) (for different levels of data completeness)				
	Baseline: 85%+	70%	50%	30%	20%	10%	70%	50%	30%	20%	10%
		IMPUTE OPTION 1: DO NOTHING TO FILL IN MISSING DATA, TREAT INCOMPLETE DATA AS A SAMPLE									
City (# TMCs used)											
Atlanta (322)	2.14	1.49	1.06	0.64	0.44	0.21	-29.9%	-50.0%	-70.1%	-79.9%	-90.1%
Boston (127)	0.42	0.31	0.22	0.13	0.09	0.04	-30.2%	-49.8%	-70.0%	-79.9%	-89.8%
Houston (337)	8.02	5.62	4.00	2.40	1.59	0.78	-29.8%	-50.1%	-70.1%	-80.1%	-90.2%
Minn-St. Paul (172)	5.11	3.55	2.57	1.52	1.05	0.51	-30.1%	-49.6%	-70.4%	-79.5%	-90.0%
Seattle (273)	28.72	20.06	14.45	8.63	5.76	2.88	-30.1%	-49.7%	-70.0%	-80.0%	-89.9%
		IMPUTE OPTION 2: FILL IN MISSING DATA WITH ESTIMATE OF SPEED LIMIT (FROM ACTUAL FREE-FLOW SPEED)									
City (# TMCs used)											
Atlanta (322)	2.14	1.49	1.06	0.64	0.44	0.21	-29.9%	-50.0%	-70.1%	-79.9%	-90.1%
Boston (127)	0.42	0.31	0.22	0.13	0.09	0.04	-30.2%	-49.8%	-70.0%	-79.9%	-89.8%
Houston (337)	8.02	5.62	4.00	2.40	1.59	0.78	-29.8%	-50.1%	-70.1%	-80.1%	-90.2%
Minn-St. Paul (172)	5.11	3.55	2.57	1.52	1.05	0.51	-30.1%	-49.6%	-70.4%	-79.5%	-90.0%
Seattle (273)	28.72	20.06	14.45	8.63	5.76	2.88	-30.1%	-49.7%	-70.0%	-80.0%	-89.9%

Group or Category	CMAQ Excessive Delay (Vehicle Hours per Capita) (measure values for different levels of NPMRDS data completeness)						**Percent Error** as Compared to Baseline (85+% complete) (for different levels of data completeness)				
	Baseline: 85%+	70%	50%	30%	20%	10%	70%	50%	30%	20%	10%
		IMPUTE OPTION 3: FILL IN MISSING DATA WITH HISTORICAL SPEED									
City (# TMCs used)											
Atlanta (322)	2.14	1.49	1.06	0.64	0.44	0.21	-29.8%	-49.9%	-70.0%	-79.8%	-90.0%
Boston (127)	0.42	0.31	0.22	0.13	0.09	0.04	-30.2%	-49.8%	-70.0%	-79.9%	-89.8%
Houston (337)	8.02	6.05	4.70	3.36	2.70	2.03	-24.6%	-41.5%	-58.0%	-66.4%	-74.7%
Minn-St. Paul (172)	5.11	3.70	2.81	1.85	1.40	0.93	-27.4%	-45.1%	-63.9%	-72.2%	-81.8%
Seattle (273)	28.72	22.62	18.69	14.56	12.53	10.52	-21.2%	-34.9%	-49.2%	-56.3%	-63.3%

APPENDIX C

Results for LOTTR, PHTTR, and Excessive Delay When Removing Outliers

RESULTS FOR LEVEL OF TRAVEL TIME RELIABILITY WHEN REMOVING OUTLIERS, INTERSTATE SYSTEM

Group or Category	Level of Travel Time Reliability when Removing Outliers (measure values for different levels of outlier removal)						Percent Error as Compared to Baseline (for different levels of outlier removal)				
	Baseline:	>90mph	>80mph	<5mph	<2mph	<1mph	>90mph	>80mph	<5mph	<2mph	<1mph
		REMOVE OUTLIERS AND CALCULATE MEASURE									
Florida	94.9%	94.9%	94.9%	95.0%	95.0%	95.0%	0.0%	0.0%	0.1%	0.1%	0.1%
Kentucky	95.4%	95.4%	95.4%	95.7%	95.4%	95.4%	0.0%	0.0%	0.3%	0.0%	0.0%
Massachusetts	83.7%	83.7%	83.6%	83.9%	83.7%	83.7%	0.0%	-0.1%	0.2%	0.0%	0.0%
Minnesota	92.1%	92.1%	92.0%	92.4%	92.2%	92.2%	0.0%	-0.1%	0.3%	0.1%	0.0%
Mississippi	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Nevada	98.8%	98.8%	98.8%	98.8%	98.8%	98.8%	0.0%	0.0%	0.0%	0.0%	0.0%
New Mexico	99.1%	99.1%	99.1%	99.2%	99.1%	99.1%	0.0%	0.0%	0.1%	0.0%	0.0%
South Dakota	99.6%	99.6%	99.6%	99.6%	99.6%	99.6%	0.0%	0.0%	0.0%	0.0%	0.0%
Texas	86.0%	86.0%	86.0%	86.7%	86.2%	86.1%	0.0%	0.0%	0.8%	0.2%	0.1%
Virginia	90.1%	90.1%	90.1%	90.8%	90.3%	90.3%	0.0%	0.0%	0.7%	0.2%	0.2%
Washington	88.6%	88.6%	88.6%	89.1%	88.8%	88.6%	0.0%	0.0%	0.6%	0.2%	0.1%

RESULTS FOR LEVEL OF TRAVEL TIME RELIABILITY WHEN REMOVING OUTLIERS, NON-INTERSTATE NATIONAL HIGHWAY SYSTEM (NHS)

Group or Category	**Level of Travel Time Reliability when Removing Outliers** (measure values for different levels of outlier removal)						**Percent Error** as Compared to Baseline (for different levels of outlier removal)				
	Baseline:	>90mph	>80mph	<5mph	<2mph	<1mph	>90mph	>80mph	<5mph	<2mph	<1mph
		REMOVE OUTLIERS AND CALCULATE MEASURE									
Florida	68.1%	68.1%	68.2%	77.6%	72.4%	70.7%	0.0%	0.1%	14.0%	6.3%	3.8%
Kentucky	76.6%	76.6%	76.6%	82.0%	78.9%	77.9%	0.0%	0.0%	7.1%	3.0%	1.7%
Massachusetts	49.5%	49.5%	49.5%	63.1%	55.3%	52.9%	0.0%	0.0%	27.5%	11.7%	6.9%
Minnesota	79.2%	79.2%	79.2%	83.0%	80.7%	80.2%	0.0%	0.0%	4.7%	1.9%	1.3%
Mississippi	84.2%	84.2%	84.2%	87.6%	85.8%	85.1%	0.0%	0.0%	4.0%	1.9%	1.1%
Nevada	79.5%	79.6%	79.9%	84.1%	82.3%	81.4%	0.1%	0.5%	5.8%	3.5%	2.4%
New Mexico	87.1%	87.1%	87.1%	90.8%	89.0%	88.0%	0.0%	0.0%	4.2%	2.2%	1.0%
South Dakota	80.9%	80.9%	80.9%	84.1%	82.3%	81.6%	0.0%	0.0%	4.0%	1.7%	0.9%
Texas	70.4%	70.4%	70.4%	76.0%	72.5%	71.6%	0.0%	-0.1%	8.0%	3.0%	1.7%
Virginia	73.7%	73.7%	73.7%	81.1%	77.1%	75.7%	0.0%	0.0%	9.9%	4.5%	2.7%
Washington	64.2%	64.2%	64.2%	73.3%	67.6%	66.2%	0.0%	0.0%	14.3%	5.5%	3.2%

RESULTS FOR PEAK HOUR TRAVEL TIME RATIO WHEN REMOVING OUTLIERS, INTERSTATE SYSTEM

Group or Category	**Peak Hour Travel Time Ratio when Removing Outliers** (measure values for different levels of outlier removal)						**Percent Error** as Compared to Baseline (measure values for different levels of outlier removal)				
	Baseline:	>90mph	>80mph	<5mph	<2mph	<1mph	>90mph	>80mph	<5mph	<2mph	<1mph
		REMOVE OUTLIERS AND CALCULATE MEASURE									
Atlanta	49.1%	49.1%	49.1%	51.8%	51.3%	50.1%	0.0%	0.0%	5.5%	4.5%	2.0%
Boston	49.7%	49.7%	48.9%	52.1%	50.9%	50.2%	0.0%	-1.6%	4.8%	2.4%	1.0%
Houston	44.6%	44.6%	44.6%	48.0%	46.1%	45.8%	0.0%	0.0%	7.4%	3.2%	2.6%
Jacksonville	81.3%	81.3%	81.2%	81.7%	81.7%	81.6%	0.0%	-0.12%	0.49%	0.49%	0.37%
Las Vegas	86.9%	86.9%	86.9%	89.1%	88.9%	88.9%	0.0%	0.0%	2.5%	2.3%	2.3%
Miami	54.1%	54.1%	54.1%	65.1%	59.6%	58.2%	0.0%	0.0%	20.3%	10.2%	7.6%
Minn-St. Paul	50.0%	50.0%	50.0%	56.5%	53.3%	52.4%	0.0%	0.0%	12.9%	6.5%	4.8%
Orlando	32.3%	32.3%	32.3%	35.5%	33.4%	33.4%	0.0%	0.0%	9.9%	3.4%	3.4%
Seattle	35.1%	35.1%	35.1%	37.2%	36.2%	35.7%	0.0%	0.0%	6.2%	3.1%	1.8%
Tampa	72.5%	72.5%	70.4%	76.3%	75.4%	74.6%	0.0%	2.9%	5.2%	4.0%	2.9%

RESULTS FOR PEAK HOUR TRAVEL TIME RATIO WHEN REMOVING OUTLIERS, NON-INTERSTATE NATIONAL HIGHWAY SYSTEM (NHS)

Group or Category	**Peak Hour Travel Time Ratio when Removing Outliers** (measure values for different levels of outlier removal)						**Percent Error** as Compared to Baseline (measure values for different levels of outlier removal)				
	Baseline:	>90mph	>80mph	<5mph	<2mph	<1mph	>90mph	>80mph	<5mph	<2mph	<1mph
		REMOVE OUTLIERS AND CALCULATE MEASURE									
Atlanta	6.9%	6.9%	6.9%	17.2%	12.3%	10.8%	0.0%	0.0%	149.3%	78.3%	56.5%
Boston	5.6%	5.6%	5.6%	18.0%	11.1%	8.3%	0.0%	0.0%	221.4%	98.2%	48.2%
Houston	15.9%	15.9%	15.9%	31.1%	23.4%	19.8%	0.0%	0.0%	95.9%	47.7%	24.6%
Jacksonville	11.4%	11.4%	11.4%	40.4%	30.3%	23.5%	0.0%	0.0%	254.4%	165.8%	6.1%
Las Vegas	34.4%	34.4%	34.4%	45.3%	43.4%	40.2%	0.0%	0.0%	31.7%	26.2%	16.9%
Miami	15.6%	15.5%	15.5%	26.1%	20.7%	19.0%	0.0%	0.0%	67.3%	32.7%	21.8%
Minn-St. Paul	26.0%	26.0%	26.0%	46.5%	38.5%	35.0%	0.0%	0.0%	79.3%	48.2%	35.0%
Orlando	36.9%	36.9%	36.9%	55.8%	48.0%	44.4%	0.0%	0.0%	51.2%	30.1%	20.3%
Seattle	5.0%	5.0%	5.0%	17.7%	10.2%	8.4%	0.0%	0.0%	251.3%	101.5%	65.8%
Tampa	9.8%	9.8%	9.8%	37.8%	27.9%	21.1%	0.0%	0.0%	285.7%	184.7%	115.3%

RESULTS FOR EXCESSIVE DELAY WHEN REMOVING OUTLIERS, ALL NATIONAL HIGHWAY SYSTEM (NHS)

Group or Category	**Congestion Mitigation / Air Quality (in Millions of Vehicle Hours)** (measure values for different levels of outlier removal)						**Percent Error** as Compared to Baseline (measure values for different levels of outlier removal)				
	Baseline:	Lowest 0.5%	Lowest 1.0%	<5mph	<2mph	<1mph	Lowest 0.5%	Lowest 1.0%	<5mph	<2mph	<1mph
		REMOVE OUTLIERS AND CALCULATE MEASURE									
Atlanta	64.2	36.1	30.6	29.8	38.9	45.0	-43.8%	-52.3%	-53.6%	-39.4%	-29.9%
Boston	103.1	61.1	55.3	38.1	53.8	64.1	-40.7%	-46.4%	-63.0%	-47.8%	-37.8%
Houston	53.3	34.1	28.1	38.0	44.2	46.3	-36.0%	-47.3%	-28.7%	-17.1%	-13.1%
Minn-St. Paul	49.2	29.1	23.3	31.4	37.1	39.8	-40.9%	-52.6%	-36.2%	-24.6%	-19.1%
Seattle	140.1	106.0	91.3	100.7	113.8	120.2	-24.3%	-34.8%	-28.1%	-18.8%	-14.2%

RESULTS FOR EXCESSIVE DELAY WHEN REMOVING OUTLIERS, ALL NATIONAL HIGHWAY SYSTEM (NHS)

Group or Category	Congestion Mitigation / Air Quality (Vehicle Hours per capita) (measure values for different levels of outlier removal)						Percent Error as Compared to Baseline (measure values for different levels of outlier removal)				
	Baseline:	Lowest 0.5%	Lowest 1.0%	<5mph	<2mph	<1mph	Lowest 0.5%	Lowest 1.0%	<5mph	<2mph	<1mph
		REMOVE OUTLIERS AND CALCULATE MEASURE									
Atlanta	12.14	6.83	5.79	5.64	7.36	8.51	-43.8%	-52.3%	-53.6%	-39.4%	-29.9%
Boston	22.65	13.42	12.15	8.37	11.82	14.08	-40.7%	-46.4%	-63.0%	-47.8%	-37.8%
Houston	9.00	5.76	4.75	6.42	7.47	7.82	-36.0%	-47.3%	-28.7%	-17.1%	-13.1%
Minn-St. Paul	14.69	8.69	6.96	9.38	11.08	11.88	-40.9%	-52.6%	-36.2%	-24.6%	-19.1%
Seattle	40.73	30.82	26.54	29.27	33.08	34.94	-24.3%	-34.8%	-28.1%	-18.8%	-14.2%