



## **I-95 Corridor Coalition**

# **Vehicle Probe Project Guide for Posting Travel Times on Changeable Message Signs**

Draft Report



**I-95 CORRIDOR  
COALITION**

*October 2011*

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# **Vehicle Probe Project Guide for Posting Travel Times on Changeable Message Signs**

## *Draft Report*

*Sponsored by:*

I-95 Corridor Coalition

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Center for Advanced Transportation Technology

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## ***Abstract***

Posting travel times on changeable message signs (CMS) is a traveler information service of growing interest throughout the I-95 Corridor. With the success of the I-95 Vehicle Probe Project (I-95VPP) many states now have an affordable and accurate data source to drive this application. As a result, several inquiries for guidance on the use of I-95VPP data for this purpose have been made to the Coalition. Travel time on changeable message signs (TTCMS) requires higher quality and more immediate real-time data than many other traveler information services, due to its high visibility and direct impact on driver behavior. In addition to data quality concerns, consistent and effective program and message display policies have proven critical for successful deployments.

This guide was assembled to provide recommendations for the appropriate use of the I-95VPP data as the source of posting travel times on signs and to provide recommendations for program policies related to the display of travel time messages. This guide reviews existing practice within the I-95 Corridor, explores technical best practices for aggregating, smoothing, and filtering sensor data, and overviews policy considerations for items such as segment length, message priority and content, and frequency of update. Case studies and lessons learned are drawn from states with existing TTCMS programs.

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## Introduction

Posting travel time on changeable message signs (CMS) arguably has greater potential to influence driver behavior than other conduits of traveler information. Radio traffic updates, given at most once every ten minutes, provide drivers a geographically broad view of congestion. Telephone-based 511 systems provide audio updates of specific routes, but are designed to be accessed prior to departure, and may cause a driver distraction if accessed while in route. Internet-based 511 systems and other electronic maps typically display congestion in three to five color-coded regimes rather than provide link specific travel times. Similar to telephone counterparts, these Internet-based systems are designed to be accessed prior to departure. Travel time on CMS provides the most current, detailed, and route specific reporting of traffic conditions directly applicable to drivers, in the safest, most easily accessible form. For these reasons, travel time on CMS is arguably the most effective method to inform and impact driver behavior.

The technology to support posting travel time on signs has been evolving for two decades. Hardware and communications for modern CMS matured during the 1990s when central operations software, communications, and flexible LED based CMS began proliferating. Much of the initial content for CMS was event-based, such as notifications of incidents, road closures, or major construction. Research during 1990s indicated that clear, objective flow measures such as speed and travel time were preferred by motorists over general information such as ‘congestion ahead’, or ‘expect slowdowns.’ Technical advances in sensing and increased demand for traffic flow data led to the investments in sensor networks. Though costly to install and maintain, several metro areas estimate and post travel time based on an extensive network of point sensors. The cost of point-sensor networks limited deployment to high impact areas. The process of turning point-sensor data into travel time information further increased complexity of systems.

Between 2000 and 2010 travel time emerged as the preferred metric to report traffic flow both for traveler information and traffic performance measures. With CMS infrastructure in place and expanding, the demand for travel time on changeable signs (TTCMS) continued to grow. The emergence of outsourced data, exemplified by the I-95 Vehicle Probe Project (I-95VPP), provided a ubiquitous, cost-effective data source to enable TTCMS. The cost to implement travel time on CMS was subsequently reduced by eliminating the need for a dedicated sensor network, thus allowing state departments of transportation (DOTs) to adopt and/or accelerate TTCMS programs. Some states within the I-95 Corridor Coalition have already initiated TTCMS based on I-95VPP data, while others are considering similar programs, or considering expanding legacy systems to include the use of this new data source. The need for sharing best practices, both technically and programmatically, led to the development of this guide.

This guide is organized into three sections. The first is a review of the status of TTCMS systems within the Coalition. The information is intended to give Coalition members knowledge of adjoining states systems, data sources, and critical design and operations considerations, as well as contact information for additional questions. The second part of the guide is dedicated to technical processing of the base-level data from the Vehicle Probe Project into meaningful travel time information for posting to signs. It encompasses such topics as methods for aggregating data from individual segments into longer routes, filtering and smoothing of data, and placing limits on travel time. These processing guidelines are tailored to the I-95VPP, although concepts are applicable to a number of data sources. The third section deals with the programmatic policy of TTCMS that impact the effectiveness of systems. It includes discussions on such topics as selection of routes and end destinations, times of day to display travel time messages and their relative priority to other types of messages, proper formatting to maximize readability and utility, guidelines for phasing and updating messages, use of travel time ranges, and display of distance to the destination.

Technical and policy guidelines are based on literature review, analysis of I-95VPP data sponsored by the Coalition, survey of Coalition members, and interviews with national experts in the field. This guide is intended for I-95 Corridor Coalition members planning to implement or expand programs for posting travel time on CMS based on VPP data.

## Section 1: Existing and Planned Travel Time Systems in the I-95 Corridor

Systems for the display of travel time on changeable message signs (TTCMS) are in various stages of implementation throughout the I-95 Corridor. In 2011, Coalition members were surveyed to ascertain the following:

- the status of any existing or planned TTCMS systems,
- the data sources used in the system, and
- any operating policies and procedure in active use.

This section summarizes the status of TTCMS systems based on the survey, and provides a synopsis for each state. The map at the right, in Figure 1, charts the status of TTCMS systems as provided by the survey. Eight states currently have active TTCMS systems. Of those, five are based on point sensor data, and three use the VPP data. Four states are in various stages of developing travel time systems for use on changeable message signs (CMS), two states responded indicating no TTCMS systems are currently planned, and two states did not respond to the survey.

Figure 1 Status of Travel Time on Signs within the Coalition

When reviewing the survey data, the reader should keep in mind that the administration of travel time programs varies from state to state. Some states have centrally managed TTCMS system such as Maryland and New Jersey in which central data systems facilitate statewide implementation, and thus induce uniformity. Other states are decentralized such as Florida and Pennsylvania in which independent TTCMS systems exist in different districts and/or metropolitan areas.

## **1.2 Existing TTCMS Systems in the Coalition**

A summary of the status of TTCMS system are provided for the states in the Coalition in geographical order from north to south. The primary goal of the survey was to determine the status, critical issues and/or decision points for each member. For members with existing systems, additional detail is provided related to the technical data processing and program policies. A summary is provided only for those states who responded to the survey.

**New Hampshire**- *New Hampshire (NH) began building its intelligent transportation system (ITS) infrastructure in 2007. Since then infrastructure investments have yielded 20 portable CMS permanently mounted along major highways, 15 cantilever or bridge mounted CMS boards, and another 30 portable CMS for use in construction zones, in addition to a central TMC and a network of closed circuit television (CCTV) cameras.*

*NH is developing software integration efforts so travel time on CMS can be posted, and anticipates that an outsourced data feed such as the VPP can provide quality travel time data for portions of the freeway system starting at Concord and going south where 90 percent of the state's population resides. Acquiring accurate travel time information north of Concord is a concern due to the rural nature where freeway annual average daily traffic (AADT) can be 6000 or less. Policy development for TTCMS will be addressed as well.*

*NH has active smart work zone systems utilizing 30 portable DMS that are linked with construction projects and controlled via the state TMC. These CMS post travel time based on temporarily deployed point speed sensors within the work zone.*

**Vermont** - *Vermont has not implemented, nor has any immediate plans to implement travel times on CMS. Due to the rural nature of the state, traveler information systems are more focused on weather events rather than congestion.*

**Massachusetts** - *MassDOT is prepared to implement travel time information on their system of permanent CMS. Their current vision is to implement based on a network of point sensors. However, significant issues with maintaining traffic monitoring equipment and overall data quality have prevented full implementation. Written guidelines have not been developed for posting travel times, and they are awaiting resolution of data issues.*

*MassDOT currently outsources the state 511 traveler information system. INRIX is a subcontractor to the 511 service provider, and INRIX data is the basis for travel time estimates to the public. In the future MassDOT is evaluating the development of a "minimum" sensor-based traffic monitoring program for speed (to serve ITS) and volume/vehicle class (for Federal Highway Administration (FHWA) Highway Performance Monitoring System (HPMS)) requirements and supplementing this data with private global positioning system (GPS)/cellular-*

based data. This system of sensors is planned to serve as statistical control points in the event that private data is purchased.

**Rhode Island** - The initial travel time pilot program in Rhode Island was rolled out in early August 2011 consisting of two overhead signs in the Metro Providence area, both displaying the travel time to TF Green Airport (PVD). The remaining signs were turned on in September 2011. The travel time program currently utilizes seven overhead DMS and three portable VMS, providing coverage for all of I-95 in Rhode Island. The major destinations include Downtown Providence, PVD, major interchanges (I-195 and Rt. 4) and the CT and MA state lines. All signs are multi-purpose signs, so at any time the travel time may be overwritten to display accident information or detour instructions. There are three additional overhead DMS on I-95 that are currently displaying detour messages 24/7 due to a bridge replacement. After bridge work is completed, these signs will be switched over to travel times service as well. A technical memorandum issued by the Rhode Island DOT in July of 2010 provides programmatic guidance, see bibliographic reference 3.

In the Rhode Island, system data is collected from approximately 30 radar detectors (Wavetronix brand) previously deployed by the state. In order to post travel times on additional corridors it will require deploying new detectors, integrating partner's sensor data (such as Navteq/Traffic.com), integrating vehicle probe data, or a combination of two or more of these options. Rhode Island is currently evaluating the best way to move forward.

In the initial phase emphasis was placed on lowering cost by utilizing equipment originally purchased and deployed for other reasons. The sensors were originally installed primarily for data collection under several different contracts including the Iway (I-195 realignment). DMS have been deployed in the state for years to disseminate travel information to the public. The communication infrastructure (mostly T1 connections) were already installed and used to transmit camera images from the same locations as the sensors and signs. The bandwidth required for the travel time system is extremely low compared to a camera, so no additional communication investment was needed. The travel time system was therefore a relatively low investment to tie together these existing systems.

Rhode Island would like to extend the coverage to I-295, which is the beltway around the city. This would allow travelers to make an informed choice to take I-295 as an alternative to I-95 based on current conditions. Plans are currently being drawn up to extend the sensor and DMS network onto I-295, but these are subject to availability of funding. Other corridors under consideration for deployment include I-195, Rt. 6 / Rt. 10, Rt. 146, and Rt. 4 / Rt. 138 (especially for summer beach traffic).

**Connecticut** - Connecticut Department of Transportation (ConnDOT) has yet to begin posting travel times on CMS due to lack of travel time information for input into the central

management software. Their central management software is capable of delivering travel time messages on the state's CMS infrastructure, though integration would be needed for the specific travel time data feed and protocol. ConnDOT was prevented from participating in the VPP project due to issues with executing the data use agreement, but continues to search for a means to obtain appropriate travel timed data for display on CMS.

**New Jersey** - Currently the New Jersey Department of Transportation (NJDOT) posts travel time along a couple of corridors where data is available from toll-tag information. The data is made available to NJ through participation in TRANSMIT, a regional traffic monitoring consortium supported by New York, New Jersey and Connecticut. All current posting of travel time in NJ is hardware and sensor specific. NJDOT is upgrading software that will provide the capability to post travel times from the newly developed data fusion engine. The data fusion engine is a processing engine that combines data from multiple sources (such as the VPP, point sensors, toll-tag data from TRANSMIT, and Bluetooth) into a single comprehensive traffic monitoring system. The new software will allow for more robust, expandable command and control within their transportation management centers allowing NJDOT to take advantage of the best data available to post travel time. Expected to be available by the end of 2011, the system will provide and post travel times to CMS statewide.

One key technical hurdle to enable statewide coverage was increasing the granularity of the Traffic Message Channel (TMC) codes used in the VPP. TMCs as used in the VPP encompass about 8800 base level segments for the entire freeway system in New Jersey. To enable the data fusion engine to utilize the VPP data, NJDOT converted to a system with higher granularity, using approximately 88,000 base level segments for New Jersey. This allowed more thorough travel time calculations and placement of DMS locations. NJDOT also anticipates providing cross-border travel times, such as Newark to Yankee Stadium. NJDOT also posts travel time in some work zones. They are experimenting with VPP data for such applications, and finding it more stable than point sensors in some areas.

**Pennsylvania** -Travel times are posted by the Pennsylvania Department of Transportation (PennDOT) in Pittsburgh and Philadelphia metro areas. These efforts are initiated by PennDOT engineering districts 6 & 11 respectively. Currently PA does not have an existing statewide policy that addresses TTCMS.

#### *Philadelphia Metropolitan Area (District 6)*

The effort was initiated in November 2009 with a system of nine signs on US 202, US 30 and PA 100. In September 2010, 13 more signs were added on I-76 and I-476. Travel time data are calculated through a system of EZ Pass tag readers and RTMS detectors. Presently, the system has grown to 53 total DMS that display travel time throughout the region.

*District personnel noted increased costs for DMS when used for posting travel time. This included both monthly power consumption and increased routine and preventative maintenance. A one-time response to a DMS taking into account manpower, equipment, parts, and materials could run in excess of \$3000. The cost of preventative and response maintenance of devices (sensors) is also notable, as well as routine maintenance of servers and software. Some of this can only be performed by experienced engineers familiar with the operation of the system and placement of devices.*

*District 6 advises other agencies to be prepared for a significant increase in operating and maintenance costs, to anticipate more sign failures from using the sign more intensively than before posting travel times. Regular routine maintenance of signs and devices is necessary to ensure dependable system operation.*

*Pittsburgh Metropolitan Area (District 11)*

*Travel times are posted on two DMS along I-376 WB between the PA Turnpike and downtown Pittsburgh. Point speed detection is currently used to determine travel time. Bluetooth™ traffic monitoring technology is also being tested.*

*Initial deployment was based on legacy RTMS devices. The required refurbishment and reconfiguration prior to implementing travel times was a substantial cost. The software system was designed so that travel times in other areas could be configured by the transportation management center (TMC) Manager or Information Technology (IT) department, without relying on the developers to add routes as the system grows.*

*Travel time data is validated by comparison with data from Traffic.com who also provides travel time in the area, as well as the INRIX probe data used by PA's 511 vendor. The system was tested for several months prior to implementation. TMC Operators perform accuracy checks at least once a day since deployment commenced.*

**Delaware** - *Delaware is currently developing centralized travel time software based on a network of point sensors recently deployed throughout the major highways within the state. After testing, Delaware plans to provide travel times via the web and radio, with smartphone apps following hopefully in 2012. Plans to post to CMS are still under review.*

**Maryland** - *The Maryland State Highway Administration's (MdSHA) Coordinated Highways Action Response Team (CHART) program gained access to real-time travel-time information via the VPP in 2008, enabling them to accelerate plans to disseminate travel time information to traveling motorists through its dynamic message sign (DMS) infrastructure. The ability to post travel time on DMS required upgrades in the CHART system software. These upgrades were originally planned for future releases of CHART software, coinciding with the deployment of a point sensor network budgeted to begin in 2012. MdSHA's sister organization, the Maryland*

*Transportation Authority (MdTA) also owns DMS infrastructure that would display travel time information using the CHART system.*

*Software upgrades were initiated in 2009 ahead of the original schedule so that if the VPP data was of sufficient quality for posting travel times, then the CHART system would be poised to deploy TTCMS based on VPP. With the software upgrade completed in 2009 and the positive results of the Coalition's validation program, CHART posted the first travel time to a DMS in January of 2010. Since then the program has grown steadily. VPP coverage was expanded to the entire state and now supports statewide TTCMS.*

*In 2009, CHART initiated a study to develop a set of procedural guidelines for the travel time implementation. The guidelines provided procedural recommendations for launching the DMS travel time capability using the CHART software, and were developed specifically targeting VPP as the base data for travel time. (See bibliographic reference 6)*

*In short, Maryland was able to leverage the Vehicle Probe Data to deliver statewide TTCMS two years ahead of schedule, while avoiding a large capital investment in upgrading their sensor infrastructure. Much of the technical and policy work is fully documented. See bibliographic references 5 and 6.*

**Virginia-** *Virginia Department of Transportation (VDOT) has no active TTCMS systems, but plans are in place to initiate systems in the Northern Virginia and Hampton Roads area within twelve months. Beginning in August 2011, four signs in Northern Virginia will display travel time based on the I-95 VPP data. Further deployment is planned after initial system is verified using Bluetooth™ traffic monitoring technology. In October 2011 a TTCMS system in Hampton Roads will become operational based on point sensor data. Though these two systems are independently operated by the respective districts, each will follow statewide policies currently being developed.*

**North Carolina –** *North Carolina Department of Transportation (NCDOT) has two TTCMS systems in operation, one automated and one manual. NCDOT developed Standard Operating Procedures (SOPs) to insure consistent practice between the two programs. (North Carolina SOPs for TTCMS are included in Appendix A). The automated system in Raleigh is based on point sensors. It was implemented as part of a capital improvement anticipated to increase traffic volume, and thus induce congestion on older sections of the network. The TTCMS is intended to inform drivers of anticipated travel times, and encourage alternate routes when appropriate. The system in Raleigh is fully automated, using point sensors as the basis to calculate travel times. Sensor reliability has been an issue, particularly during rain. NCDOT is considering the use of VPP going forward.*

*The other TTCMS system provides travel time based on VPP data for defined routes through a central server accessed via the internet. The calculation of travel time is automated, however operators must manually post travel time information to the state's CMS, requiring nine additional operator positions. Development efforts are currently underway to automate this process. The new process will create a single system that combines data from multiple sources to maximize travel time accuracy. The current system based on VPP data includes defined routes through the mountains. The accuracy of travel time on mountainous routes has been problematic, related to the differing speeds between private automobiles commercial trucking in such areas. NCDOT has also had challenges obtaining VPP data on new roadways. For example, a new section of freeway completed in 2008 currently does not have coverage through the VPP due to issues related to the unavailability of Traffic Message Codes (TMCs). TeleAtlas has not created TMC codes for this section, so even through INRIX collects data on the freeway, no traffic data appears in the VPP due to the lack of TMC codes. NCDOT is currently working with INRIX on a way to report non-TMC coded areas.*

**South Carolina** – *Within South Carolina, the program to display travel on signs program began in 2008 and currently incorporates 33 signs statewide. Data to estimate travel times is obtained from the I-95 Vehicle Probe Project. Travel times are displayed whenever travel time is greater than normal, and updated once per minute. Travel times are validated periodically by staff through ride checks.*

*South Carolina noted increased power costs should be considered. It is estimated that it costs \$13.00 per day per sign to run 24/7.*

**Georgia** – *Only metropolitan Atlanta has travel time posted on signs. The system consists of about 100 CMS, the earliest of which dates to the Olympic Games (1996). The original system was primarily internal to the Atlanta beltway and constitutes about 25 percent of the current system, but has since grown to cover a large portion of the Atlanta metro, both inside and outside the beltway. Destinations are typically chosen 5-12 miles downstream, and travel times are displayed from 5AM to 10PM every day.*

*Owned and maintained by the GeorgiaDOT, the system is based exclusively on approximately 2800 point sensors, of which 80 percent are video-based, and the remaining 20 percent are radar (RTMS). Sensors are typically on 1/3 mile spacing. Filtering of data is based on point sensor data availability. If 50 percent or more of the sensors report, the system post travel times, otherwise the system reverts to the next lowest message in the CMS message queue.*

*Validation of travel time is performed whenever a new sign or route is activated or in response to a user complaints. Validation is performed using video and a stop watch. A unique vehicle is identified at the upstream camera, and then timed until it arrives at the downstream camera.*

**Florida** – Florida Department of Transportation (FDOT) ITS Operations are decentralized, with each major metropolitan area hosting its own system. Florida as a whole has invested heavily in ITS infrastructure, and over the last ten years has deployed DMS and active TTCMS systems in the state’s metropolitan areas. Practices and procedures for each district differ slightly. Florida is currently establishing central policy and practices for TTCMS. A statewide policy for the display of messages on dynamic messages signs is included in Appendix B. Most metro areas use a network of point sensors to estimate travel time with some exceptions. Orlando has invested heavily in toll tag sensors, and the toll tag data is a major contributor to their travel time system. Others areas are considering the use of probe data such as the VPP for use/integration in existing TTCMS systems.

Table 1.1 summarizes the status of each state in the Coalition.

	Active TTCMS System/s	Utilizes VPP Data	Utilizes Point Sensor Data	Plans for implementation/upgrade	Published policies and procedures	Validation program	Notes
Maine							-- No survey data --
New Hampshire			✓				
Vermont							No Plans due to rural nature of state
Massachusetts			✓				Data Quality issues of point sensor has inhibited progress
Rhode Island	✓	✓		✓	✓		Rolled out initial phase on I95 in through Providence in 2011
Connecticut							Lack of data has inhibited progress
New York							-- No survey data --
New Jersey	✓	✓	✓		?		Moving toward centralized system with data fusion engine
Pennsylvania	✓	✓				✓	Pittsburgh and Philadelphia hosts separate systems
Delaware							Currently completing sensor infrastructure
Maryland	✓	✓			✓	✓	Statewide implementation based on VPP data
Virginia			✓				Planned systems in NOVA and Hampton Roads
North Carolina	✓	✓	✓	✓	✓		Moving toward centralized, VPP-driven system
South Carolina	✓	✓				✓	Statewide implementation based on VPP data
Georgia	✓		✓			✓	System is in Atlanta metro area
Florida	✓		✓			?	Multiple systems in metro areas

Table 1.2 State Contacts for Additional Information

	Name	Phone	Email
Maine			
New Hampshire	Denise Markow	603-271-6862	dmarkow@dot.state.nh.us
Vermont	Robert White	802-828-2781	robertt.white@state.vt.us

Massachusetts	Russ Bond	617-973-7358	russ.bond@state.ma.us
Rhode Island	Michael Wreh	401-222-5826 ext. 4200	mwreh@dot.ri.gov
Connecticut	Harold Decker	860-594-2636	harold.decker@ct.gov
New York			
New Jersey	Dennis Motiani	856-486-6610	Dhanesh.Motiani@dot.state.nj.us
Pennsylvania	Jay Sengoz	717-265-7557	csengoz@state.pa.us
Delaware	Gene Donaldson	302-659-4601	gene.donaldson@state.de.us
Maryland	Richard Dye	410-582-5619	rdye@sha.state.md.us
Virginia	Scott Silva	804-786-0186	Scott.Silva@VDOT.Virginia.gov
North Carolina	Jennifer Portanova	919-696-8857	jportanova@ncdot.gov
South Carolina	Dan Campbell	803-737-1459	jportanova@ncdot.gov
Georgia	Mark Demidovich	404-635-8014	mark.demidovich@dot.state.ga.us
Florida	Gene Glotzbach	850-410-5616	gene.glotzbach@dot.state.fl.us

## Section 2: Data Processing

In this section, the steps and processes of transforming the I-95 Vehicle Probe Data (VPP) into meaningful travel time information for selected routes and destinations are explained. These steps include processes that aggregate, filter, smooth, and place limits on travel time information with the end result of travel time information, as illustrated in the block diagram of Figure 2.0.1.

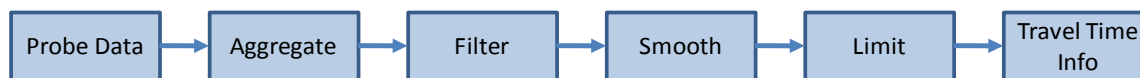


Figure 2.0.1 Block diagram of travel time processing

Data from the Vehicle Probe Project comes primarily from the vehicles operating as anonymous probes. INRIX Inc. provides the VPP data feed to the Coalition by combining instantaneous speed and trajectory information from various sources to estimate traffic conditions. The primary source of data comes from fleet vehicles equipped with Global Positioning System (GPS) equipment that periodically report location, speed and direction. Although other sources of data are used in the process, the majority of base data comes from these GPS equipped fleets. The fidelity of the resulting traffic data is largely dependent on the number and frequency of reporting vehicles. As volume of traffic increases and as the percentage of commercial fleets increase, the density of probe data increases, improving the accuracy of the resulting traffic data.

Traffic data is at the heart of the VPP system. Some data items in the VPP were explicitly specified in the contract, while INRIX provides other items as value added, and others have been added in collaboration with INRIX in order to improve the usability of the VPP data. All

data items can be viewed from the project monitoring website at [www.i95.inrix.com](http://www.i95.inrix.com), and are also available in the XML data feed used to support real-time travel time calculations for specified routes and destinations. The VPP data items include:

- *Speed* - the current space mean speed for the roadway segment in miles per hour.
- *Travel Time* - the current travel time it takes to traverse the roadway segment in minutes.
- *Reference Speed* –the calculated “free flow” mean speed for the roadway segment in miles per hour (capped at 65 miles per hour). This attribute is calculated based upon the 85th-percentile of the observed speeds on that segment for all time periods, which establishes a reliable proxy for the speed of traffic at free-flow for that segment.
- *Average Speed* - the historical average mean speed for the roadway segment for that hour of the day and day of the week in miles per hour.
- *Score*- three discrete values are defined:
  - “30” – Real-time time data for that specific segment
  - “20” – Estimate of speed relies heavily on historical data, specifically the average speed. May have some real-time data.
  - “10” – Estimate of speed is based on historical data, specifically the reference speed.
- *Confidence Value (C-Value)* - in December 2009, INRIX began publishing a confidence value separate from the score attribute to provide supplemental information on the fidelity of real-time data. C-Value ranges from 0 to 100 and is provided only when the Score = “30”. A C-Value equal to 100 represents the combination of (1) high data density, (2) the current data is very consistent with the data over the past 45 minutes, and the (3) current data is very consistent with the historical data. As each of the three criteria degrade, the C-Value will decrease until it reaches a minimum value of 0, corresponding to the lowest possible confidence in the estimate of traffic conditions. See the project interface guide for additional details.
- *Date and Time* - the UTC timestamp at which the response was generated.
- *TMC Segment* - the Traffic Message Channel (TMC) code that defines the beginning and ending point of the roadway segment being reported. TMC codes are maintained by an industry consortium of electronic map providers. Generally TMC segments begin and end at breaks in access, typically ramps for freeways and major intersections for arterial roadways.

Data from the XML feed is updated every minute, but the data may be requested at less frequent intervals.

For purpose of illustrating the various processing steps in this section, a sample route is defined on the outer-loop of the Washington DC I-495 beltway (counter-clockwise travel direction) of roughly 6.1 miles in length as shown in Figure 2.0.2. At point A is an overhead changeable message sign (CMS). At point B is a major interchange between the Beltway and I-95 heading north to Baltimore. The route from A to B represents a typical route of interest to post on the CMS at point A, and which requires the calculation of travel time based on the data provided by the VPP.

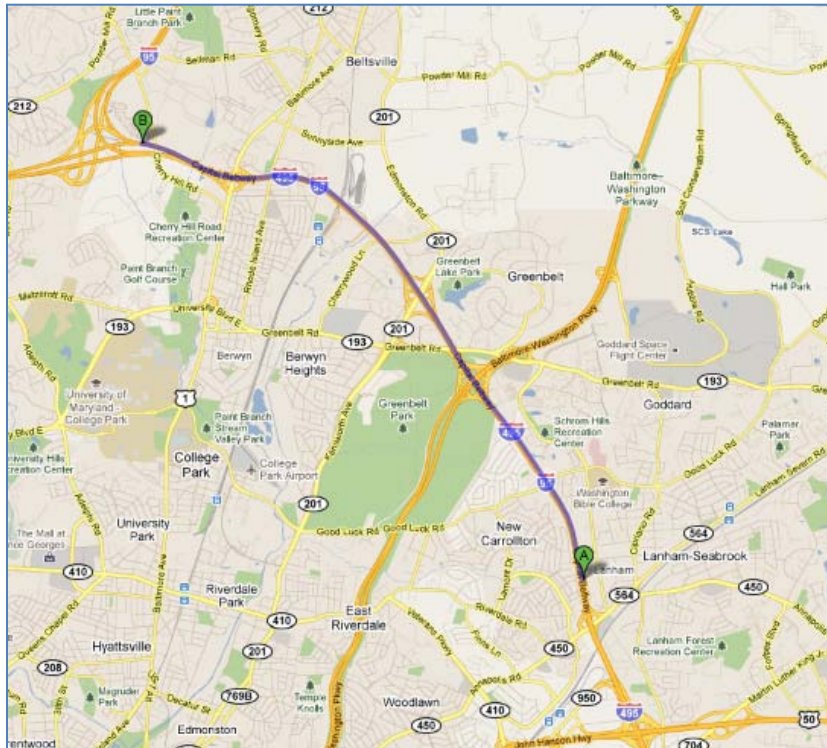


Figure 2.0.2 Sample route for illustrating processing steps

## 2.1 Aggregating Segments into Routes

Routes of interest are typically a combination of several base level segments. Within the VPP, the base level segments are reported using a convention from the electronic mapping industry called Traffic Message Channel (TMC) codes. The code scheme is explained in detail in the Project Interface Guide available from the project web site at <http://www.i95coalition.org/i95/Projects/ProjectDatabase/tabid/120/agentType/View/PropertyID/107/Default.aspx>. In most cases traffic information from several TMC segments must be aggregated to form travel time information for a route of interest.

Table 2.1.1 provides a precise naming convention for data items used in the processing of VPP data. A *route* refers to a roadway path for which travel time is needed. It is typically several miles in length, possibly spanning multiple interchanges as in our example. A *segment* refers specifically to TMC segments which are short sections of roadway between highway entrances/exits. Multiple *segments* are typically combined to form a *route* of interest for travel time calculation.

**Table 2.1.1 Naming Conventions**

$TT_{route_i}$	Travel time in minutes for the route of interest at time period $i$
$TT_{segment^n}_i$	Travel time in minutes for TMC segment $n$ at time period $i$
$S_{route_i}$	Speed in mph for the route of interest at time period $i$
$S_{segment^n}_i$	Speed in mph for TMC segment $n$ at time period $i$
$D_{route}$	Distance in miles for the route of interest
$D_{segment^n}$	Distance in miles for TMC segment $n$
$SCORE_{route_i}$	Score for the route of interest at time period $i$
$SCORE_{segment^n}_i$	Score for TMC segment $n$ at time period $i$
$CV_{route_i}$	C-Value for the route of interest at time period $i$
$CV_{segment^n}_i$	C-Value for TMC segment $n$ at time period $i$
$N$	Number of TMC segments comprising the route

Note that the time period,  $i$ , represents the current time period of interest. This time period may be as short as 1 minute, reflecting the maximum update frequency supported by the VPP. The maximum recommended time period is 5 minutes.

The relationship between segment and route data items are defined mathematically in Equations 2.1.1 through 2.1.6. Travel time ( $TT_{segment^n}_i$ ) and speed data ( $S_{segment^n}_i$ ) for TMC segments are available directly from the VPP data feed. Segment travel time can also be calculated from segment speed divided by segment length as shown in EQ 2.1.2.

$$TT_{segment^n}_i = [D_{segment^n} / S_{segment^n}_i] * 60 \quad \text{EQ 2.1.1}$$

Route distance and travel time are obtained by accumulation of distance and travel time of the individual TMC segments comprising the route. These equations are given in EQ 2.1.2 and EQ 2.1.3 respectively.

$$D_{route} = \sum_{n=1}^N D_{segment}^n \quad \text{EQ 2.1.2}$$

$$TT_{route_i} = \sum_{n=1}^N TT_{segment_i}^n \quad \text{EQ 2.1.3}$$

Route speed is obtained from the route distance divided by the route travel time as given in EQ 2.1.4.

$$S_{route_i} = 60 * D_{route} / TT_{route_i} \quad \text{EQ 2.1.4}$$

Score and C-Value for routes are produced using a weighting scheme based on the distance of the individual segments. The Score for each segment in the route is multiplied by its distance. The sum of these values is then divided by the total distance of the route to obtain a Score value for the route. The same process is used to obtain C-Value for a route. See EQ 2.1.5 and 2.1.6 respectively for corresponding mathematical equations. Note that C-Value is only reported if Score = 30. If C-Value is not reported for a specific segment because the corresponding Score is less than 30, set C-Value equal 0 in equation 2.1.6.

$$SCORE_{route_i} = \frac{\sum_{n=1}^N (SCORE_{segment_i}^n \cdot D_{segment}^n)}{D_{route}} \quad \text{EQ 2.1.5}$$

$$CV_{route_i} = \frac{\sum_{n=1}^N (CV_{segment_i}^n \cdot D_{segment}^n)}{D_{route}} \quad \text{EQ 2.1.6}$$

Note: C-Value is reported only if Score = 30. If C-Value is not reported for segment  $n$  for time period  $i$  in EQ 2.1.6, set it equal to 0.

The sample route on the DC Beltway as shown in Figure 2.0.2 is used to illustrate the processing. The sample route is comprised of nine TMC segments. The 6.1 mile route traverses three full interchanges including the Baltimore-Washington Parkway (Route 295), Kenilworth Avenue (Route 201), and US Route 1. The route also includes an entrance ramp from a DC metro station between Kenilworth Avenue and US Route 1. The listing of the individual TMC segments beginning at the changeable message sign (location A on the map) is given in Table 2.1.2

Table 2.1.2 TMC segments comprising the sample travel-time route

	TMC Code	Route	Associated Interchange	State	Length	Diagram
					Miles	Label
CMS location →	110-04631	I-495	MD-295/MD-193/Exit 22	MD	2.00	-31
	110N04631	I-495	MD-295/MD-193/Exit 22	MD	0.61	N31
	110-04630	I-495	MD-201/Kenilworth Ave/Exit 23	MD	0.26	-30
	110N04630	I-495	MD-201/Kenilworth Ave/Exit 23	MD	0.60	N30
	110-04629	I-495	Greenbelt Metro Dr/Exit 24	MD	0.47	-29
	110N04629	I-495	Greenbelt Metro Dr/Exit 24	MD	0.34	N29
	110-04628	I-495	US-1/Baltimore Ave/Exit 25	MD	1.04	-28
	110N04628	I-495	US-1/Baltimore Ave/Exit 25	MD	0.22	N28
End of route →	110-04627	I-495	I-95/Exit 27	MD	0.63	-27
					6.18	

A strip-map diagram of the sample route is shown in Figure 2.1.1. The strip map reads from left to right beginning at the CMS location and ending at the exit to I95 NB. The major interchange ramps mark the beginning/ending of each TMC segment as shown above in Table 2.12.

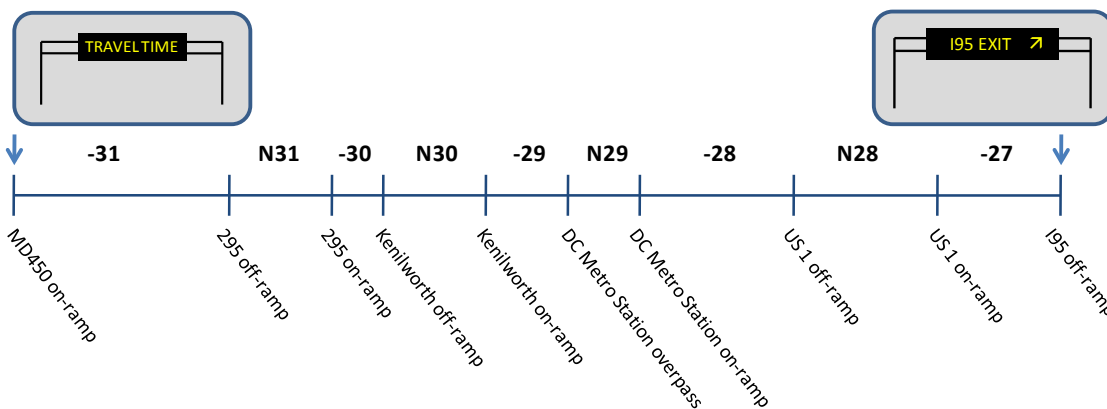


Figure 2.1.1 Logical diagram of sample route showing corresponding segments

Table 2.1.2 provides sample minute-by-minute VPP data for the nine TMC segments for a 15 minute period beginning May 3, 2011 at 3:30 PM. The calculation of route travel time is illustrated based on individual segment travel times, and then converted to its equivalent speed based on equations 2.1.2 through 2.1.4. The first matrix provides speeds for each segment as reported by the VPP. The speed data is color coded to highlight congested flow. The second matrix shows the corresponding travel times for each segment. The last row of the second matrix, labeled 'route', is the sum of the segment travel times. The route speed data shown in the third matrix (containing only a single row) is calculated by the route travel times divided by the route distance. It is color coded to highlight congested flow similar to the first matrix.

**Table 2.1.2 Calculation of travel time and speed for sample route**

5/3/2011 - 3:30 PM to 3:45 PM																Length Miles	
Minutes Past the Hour																	
TMC Segment	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	
SPEED - MPH																	
110-04631	68	68	68	67	67	67	67	65	64	62	62	62	61	62	62	2.00	
110N04631	61	61	61	61	61	60	62	62	59	59	59	59	57	56	56	0.61	
110-04630	65	63	63	61	61	61	62	62	60	60	59	59	53	53	52	0.26	
110N04630	63	64	64	62	62	61	62	61	49	46	44	43	43	43	31	0.60	
110-04629	63	63	63	40	40	39	39	33	28	27	29	27	27	27	26	0.47	
110N04629	61	61	61	45	45	36	36	31	29	31	31	31	31	31	31	0.34	
110-04628	45	45	45	29	29	25	32	32	32	36	43	49	49	49	50	1.04	
110N04628	32	23	23	24	24	24	31	31	30	35	38	55	55	55	55	0.22	
110-04627	34	32	32	32	32	32	34	34	37	42	44	56	56	56	51	0.63	
TRAVEL TIME - MINUTES																	
110-04631	1.76	1.76	1.76	1.79	1.79	1.79	1.79	1.79	1.85	1.87	1.94	1.94	1.94	1.97	1.94		
110N04631	0.60	0.60	0.60	0.60	0.60	0.61	0.59	0.59	0.62	0.62	0.62	0.62	0.64	0.65	0.65		
110-04630	0.24	0.24	0.24	0.25	0.25	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.29	0.29	0.30		
110N04630	0.58	0.57	0.57	0.59	0.59	0.59	0.59	0.59	0.74	0.79	0.82	0.84	0.84	0.84	1.17		
110-04629	0.45	0.45	0.45	0.71	0.71	0.73	0.73	0.86	1.02	1.05	0.98	1.05	1.05	1.05	1.09		
110N04629	0.33	0.33	0.33	0.45	0.45	0.56	0.56	0.65	0.70	0.65	0.65	0.65	0.65	0.65	0.51		
110-04628	1.39	1.39	1.39	2.16	2.16	2.51	1.96	1.96	1.96	1.74	1.46	1.28	1.28	1.28	1.25		
110N04628	0.42	0.59	0.59	0.56	0.56	0.56	0.44	0.44	0.45	0.39	0.36	0.25	0.25	0.25	0.25		
110-04627	1.11	1.18	1.18	1.18	1.18	1.18	1.11	1.11	1.02	0.90	0.86	0.67	0.67	0.67	0.74		
<b>Route</b>	6.88	7.12	7.12	8.29	8.29	8.79	8.01	8.24	8.61	8.27	7.95	7.57	7.62	7.66	8.04		
SPEED - MPH																	
<b>Route</b>	53.86	52.1	52.1	44.72	44.72	42.19	46.29	44.99	43.09	44.83	46.67	49.02	48.68	48.41	46.11	6.18	

The Score and C-Value are useful for filtering as discussed in the next section. The distance weighted calculation of the Score and C-value are illustrated for the sample route based on EQ 2.1.5 and EQ 2.1.6 in Table 2.1.3. The last row in each matrix provides the distance weighted Score and C-Value for the sample route, respectively. In each table simple color highlights are used to identify below optimal Scores and C-Value (Recall optimum Score is 30 and optimum C-Value is 100.) The use of Score and C-Value for filtering poor quality data are addressed in the next section.

**Table 2.1.3 Calculation of Score and C-Value for the sample route**

5/3/2011 - 3:30 PM to 3:45 PM

Minutes Past the Hour

	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
<b>SCORE</b>																
110-04631	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
110N04631	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
110-04630	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
110N04630	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
110-04629	30	30	30	30	30	30	30	30	30	30	20	30	30	30	20	30
110N04629	30	30	30	30	30	30	30	30	30	30	20	20	30	20	20	30
110-04628	30	30	30	30	30	30	30	30	30	30	30	20	30	20	30	30
110N04628	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
110-04627	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
<b>Route</b>	30	30	30	30	30	30	30	30	30	30	28.69	27.76	30	27.76	28.69	30
<b>CONFIDENCE VALUE</b>																
110-04631	100	100	100	100	100	100	100	100	100	100	100	100	90	70	40	40
110N04631	100	100	100	100	100	100	100	100	100	80	70	60	50	40	40	80
110-04630	100	100	100	100	100	100	100	100	100	100	50	40	30	20	0	20
110N04630	100	100	100	100	100	100	100	100	100	100	90	50	70	20	20	80
110-04629	100	100	100	100	100	100	100	100	100	70	80	0	50	30	60	0
110N04629	100	100	100	100	100	100	100	100	100	70	90	0	0	10	0	0
110-04628	100	100	100	100	100	100	100	100	100	50	70	20	0	20	0	60
110N04628	100	100	100	100	100	100	100	100	100	70	60	40	30	30	30	40
110-04627	100	100	100	100	100	100	100	100	100	100	90	80	70	50	30	30
<b>Route</b>	100	100	100	100	100	100	100	100	100	84.54	84.36	57.8	54.19	41.79	27.6	44.15

## 2.2 Filtering

Filtering and smoothing are tools to identify and minimize the impact of random errors that can occur in the VPP data. These techniques can be applied by agencies to the VPP data, and they are recommended for agencies that use the data for real-time applications. To be clear, these techniques are NOT completed before agencies receive the data, but are applied by agencies to the data prior to use in applications.

The VPP data acquired by the I-95 Corridor Coalition from INRIX is intended to provide samples of travel time and speeds as frequently as every minute along selected roadways within the I-95 corridor. The accuracy of this data is continuously validated by the University of Maryland (UMD) to verify that it correctly reflects travel conditions along these roadways. The UMD validation is conducted to verify that the INRIX data satisfies the following contractual requirements:

- 1) Average Absolute Speed Error (AASE): Speed data shall have a maximum average absolute error of 10 mph in each of the following speed ranges: 0-30 mph, 30-45 mph, 45-60 mph and >60 mph. This is the primary accuracy metric, measuring the average deviation from ground truth.

- 2) Speed Error Bias (SEB): Speed data shall have a maximum error of +/- 5 mph in each of the same speed ranges as those that are specified for the average absolute speed error. The SEB indicates whether the speed data provided from the project is consistently higher or lower than ground truth.

These specifications have served the Coalition well, providing its members with confidence that the VPP data is of adequate accuracy for use in a variety of applications. It is important to recognize however, that both the AASE and the SEB are long term averages of the data that is collected during the evaluation period. As such, they do not capture significant short term deviations that might be present in the VPP data. These types of errors could be the result of anomalies such as data captured from a vehicle whose speed is not representative of the overall traffic stream. It is these short-term deviations that filtering and smoothing tools address.

Filtering relies on two data quality measures that are reported with each record within the VPP data feed. These are the Score and the Confidence Value (or C-Value).

From the onset, the VPP has provided (and continues to provide) a data parameter known as the "Score" along with the speed and travel time information on every segment and for every time period. Score reflects the level of base data available from which traffic conditions are estimated. Three discrete Score values are defined. Additional details on the three discrete levels are discussed below:

- "30" – Real-time base data is sufficient to estimate travel time and speed for the segment at the specific time period. Estimate of speed and travel time does not rely on historical data.
- "20" – Real-time data is insufficient to estimate traffic conditions. The method used to estimate travel time and speed data relies heavily on historical data by time of day and day of week. This method is typically used during daytime hours from 5AM to 10PM when real-time base data is insufficient.
- "10" – Real-time data is insufficient to estimate traffic conditions. Estimates of speed are based on historical data, specifically the reference speed. This method for estimating speed and travel time is typically used during overnight hours from 10PM to 5AM when real-time base data is insufficient.

The Confidence Value (C-Value) was initiated in December 2009 in order to supplement the Score, providing additional data on the fidelity of real-time data. The C-Value provides an added degree of detail to the real-time data and is only available to speed and travel time estimates that have a score of 30. The C-Value is based on a number of additional factors including the

degree to which the current traffic matches historic conditions, the rate of change of the speed data, and the length of time that the same speeds are being reported. A detailed discussion of the C-Value is presented in the Project Interface Guide. C-Value ranges from 0 to 100 and is provided only when the Score = "30". When Score < "30", the C-Value is assumed equal to 0 for mathematical processes.

Figure 2.2.1 is a conceptual flow diagram of the filtering process that should be considered as a guide for agencies as they utilize the VPP data. The input to the filtering process is route data that has been aggregated from segments as described in Section 2.1. Filter criteria includes thresholds placed on Score and/or C-Value.

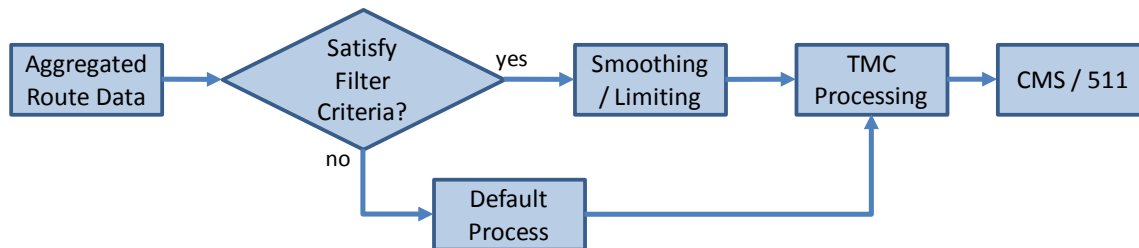


Figure 2.2.1 Conceptual Flow Diagram of the Filtering Process

Aggregated Score and/or C-Value route data should be continuously monitored as speed data is received from the VPP. If the aggregated Score and/or C-Value passes the filter criteria, route speed and travel time data are processed without interruption, proceeding onto the smoothing and limiting functions. If the Score and/or C-Value fail the filter criteria, a default mode of operation should be activated within the Traffic Management Center (TMC). This default process should be defined by the user, and may include actions such as:

- Blanking travel time displays on CMS and Websites
- Inserting default travel times on these displays
- Requiring manual operator intervention

The challenge faced by the user is to select an appropriate threshold for Score and C-Value to use in their applications. Proposed threshold filter criteria are outlined below. The Coalition recommends at a minimum, criteria one should be applied. The effect of using C-Value at various thresholds is still under study.

Filtering Criteria:

- 1) Score of the aggregated route data should equal or exceed 27.0 for use in posting travel time to CMS. A Score of 27.0 or more indicates that real-time data is sufficient to report

travel time and speed on at least 70 percent of the route.

- 2) C-Value of the aggregated route data should exceed 30.0 for use in posting travel time to CMS.

A paper titled *Analysis of Quality Metrics in VPP*<sup>1</sup> characterizing the effectiveness of filtering by Score and C-Value was presented at ITSWC in 2011 and is available in the VPP literature archive on the project web site (<http://www.i95coalition.org/>). Supporting analysis for the above criteria is beyond the scope of this guide.

In summary, the implementation of the filtering requires users to (1) select the aggregated Score and Confidence Value thresholds to be used, and (2) determine a default operation to be activated in the event that the aggregated Score or Confidence Value falls below the selected threshold.

Using the sample data from Table 2.1.2, all aggregated route Score data pass Criteria #1. Although Scores of “20” are reported for a few of the segments, the aggregate Score for the route remains greater than or equal to 27.0. If Criteria #2 is applied, the aggregate data from minute 44 would not pass, requiring a default action to be taken.

## 2.3 Smoothing

Smoothing can be used in conjunction with filtering, and is intended to prevent sudden deviations in the data from a sudden jump in speed. As with filtering, smoothing is NOT completed before agencies receive the data, but is applied by agencies to the data prior to use in applications. Smoothing transforms sudden changes to a more gradual transition. The theory of the smoothing is based on the fact that sudden deviations between two distinctly different speeds for the overall traffic stream rarely occur in practice.

The input into the smoothing algorithm is the aggregated route speed ( $S_{route_i}$  as given in Eq. 2.1.4), and the previous output of the smoothing algorithm, designated as  $SV_{i-1}$ . The output of the algorithm is the smoothed speed route data ( $SV_i$ ) to be used as the basis for posting travel time on signs. (Note, if smoothing is not implemented, then  $S_{route}$  serves as the basis to post travel time on signs.) The smoothing process is given by the following equation:

$$SV_i = SV_{i-1} + K * (S_{route_i} - SV_{i-1})$$

---

<sup>1</sup> Analysis of Quality Metrics in the I-95 Vehicle Probe Project, University of Maryland

Where:

- $SV_i$  = Smoothed Value of route speed calculated for the current time period,  $i$ .
- $SV_{i-1}$  = Smoothed value of speed calculated for the previous time period,  $i-1$ . (this could be two minutes ago for example)
- $Sroute_i$  = The value of speed that has just been received from VPP (aggregated route speed data for current time period  $i$ .)
- $K$  = Smoothing constant (a value of 0.5 is recommended)

This is a very simple equation. Its function is to update the value of the smoothed speed that was previously calculated with the difference between that value and the current unsmoothed speed measurement (received from the VPP) multiplied by the factor “K.” If the recommended value of 0.5 is used for K, the updated value of smoothed speed will then be influenced by ½ the difference between the current INRIX speed measurement and the previous value of smoothed speed.

Table 2.3.1 and Figure 2.3.1 illustrates the impact of applying the smoothing algorithm on the sample data set.

**Table 2.3.1** Smoothed speed data from sample route.

Route Speed	Minutes Past the Hour															
	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Unsmoothed	53.86	52.1	52.1	44.72	44.72	42.19	46.29	44.99	43.09	44.83	46.67	49.02	48.68	48.41	46.11	48.47
Smoothed	53.86	52.98	52.54	48.63	46.67	44.43	45.36	45.17	44.13	44.48	45.57	47.3	47.99	48.2	47.16	47.81

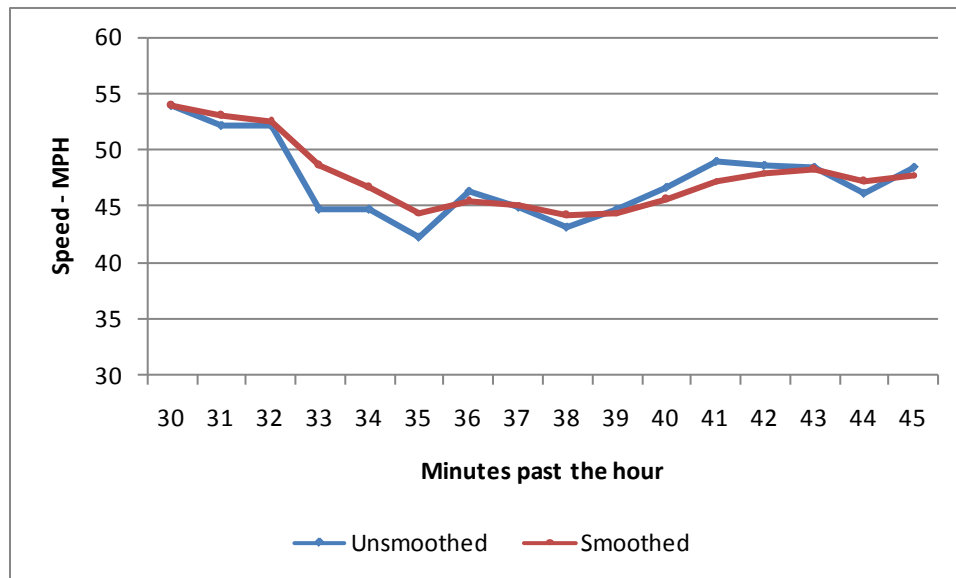


Figure 2.3.1 Graph of smoothed versus unsmoothed data from sample route.

#### Implementation Notes:

On startup, or immediately after a void caused by the filter mechanism, the previous smoothed values ( $SV_{i-1}$ ) will not be available. In these instances, ( $SV_{i-1}$ ) can be assumed equal to  $Sroute_i$ .

The equation and the recommended K value of 0.5 are based on an evaluation of the relative effectiveness of a number of alternative smoothing techniques and K values, which concluded that they produced the most effective techniques. Details of these analyses are available from the literature archive on the project page of the Coalition web site.

The smoothing function is inserted in the processing stream after filtering, and prior to the applications of travel-time or speed limitations.

## 2.4 Limiting

In order to avoid posting travel times that may appear to violate speed limits, speed is typically limited to posted speed along the route. Even though traffic may be flowing at 70 to 75 mph, the output of the smoothing function may be capped at prevailing speed limits, typically 60 to 65 mph in much of the I-95 Corridor. If the speed is capped, the corresponding travel time for

use on CMS signs reflects the minimum travel time if obeying speed limits. All active systems surveyed place limits on the posted travel time based either on posted speed limit, or a maximum speed of 55, 60, or 65 mph.

## **Section 3: Policy and Display Issues**

Program policy encompasses selection of routes and end destinations, times of day to display travel time messages, the priority of travel time messages relative to other types of messages, and policies for media and public interaction to promote its use and educate drivers. Display issues include the proper organization of message content to maximize utility and minimize driver confusion. These guidelines encompass such items as formatting of the message, phasing and updating guidelines, use of travel time ranges, and display of distance to the destination.

The discussion in this section is a synthesis of practice based on standards (such as the Manual on Uniform Traffic Control Devices (MUTCD), national guidance, prevailing practice as reported by Coalition states, and input from national experts. Terms ‘shall’, ‘should’, and ‘may’ reflect the relative level of guidance provided in decreasing order from mandatory to suggested practice.

### ***3.1 Location of Changeable Message Signs***

TTCMS systems typically take advantage of existing CMS erected for other traveler information services. As the TTCMS system grows and expands, the locations of new CMS’s will increasingly be influenced by travel time concerns. The effectiveness of travel time information is maximized if signs are placed in areas with significant destinations, on sections of roadway within minimal visual activity (that is existence of other messages critical to the driver), and in advance of major decision points that give the driver alternative routes. Guidelines for placement prior to diversion opportunities are generally 0.5 to 2.0 miles in advance of major interchanges, providing the driver the opportunity to change lanes appropriate to the diversion maneuver.

### ***3.2 Selection of Routes and End Destinations***

Significant destinations include intersecting freeways, major state routes, major landmarks such as bridges and tunnels and venues for special events such as sports stadiums and civic centers. Destinations typically remain constant, but may be changed based on the time of day to accommodate destinations whose demand is time sensitive such as sports stadiums and special event venues.

Survey results indicate that travel times are typically reported for destinations between 5 to 20 miles upstream. Destinations less than five miles ahead may be reported but diversion opportunities and lack of granularity in reporting travel time (if reporting to the nearest minute) impacts effectiveness. Reporting travel time for routes greater than 20 miles upstream are less common, but provides even greater opportunities for diversion to avoid congestion. Prevailing practice uses the current travel time as an estimate of future travel time. At distances greater than 20 miles, more sophisticated prediction algorithms may be warranted.

Routes less than 20 miles typically identify a precise roadway or landmark, such as a major interchange. As route distance increases, the landmarks may be to a region, city or area. Travel time to a city or region 30 miles ahead may need to only identify the area by name. For example, “Travel Time to Newark, DE 45-55 minutes”, is sufficient. Exact exits or crossroads are not required in these cases.

### ***3.3 Priority of Travel Time Messages***

The hierarchy of travel time among all CMS messages is typically medium to low relative to other types of messages. It is difficult to classify priority in a format that is common to all systems, because each Traffic Management Center uses varying nomenclature for various message types. Examples from several of the states that responded to the survey are given below.

Maryland message priority is as follows:

1. Urgent Messages – any message given top priority
2. Incident Messages
3. Planned Roadway Closure Messages
4. Toll Rate Messages
5. Travel Time Messages
6. Congestion Messages
7. Shazam Messages – type of message with simulated flashing lights
8. Weather Messages
9. Special Messages – such as sporting or special events
10. Action Messages – such as “Debris in Roadway”
11. Safety Messages – such as “Ozone Alert”

Within PA District 6, all travel time messages are replaced by messages for incidents/roadwork/lane restrictions and delays. Those messages take priority over anything.

In Florida, travel time messages are pre-empted by other messages as needed in the following order: (1) Conditions that require motorists to take action or alter their driving, such as emergency events including evacuations or road closures, (2) Traffic incidents, hazardous

and/or uncommon road conditions, work zone activities, and severe weather conditions, (3) Law enforcement alerts (such as Amber alerts), and (4) Traveler information related to special events, emergencies, and incidents impacting mobility and safety.

In South Carolina travel time messages are second to lowest priority. Ozone alerts is the only message lower in priority.

In Rhode Island, travel times messages are configured as the lowest priority. If they are preempted by another traffic message, the travel time returns automatically after the priority message is blanked.

### ***3.4 When to Display Travel Time Messages***

The prevailing practice indicated by majority of Coalition member's survey is to display travel time messages throughout the day, as indicated below.

- Rhode Island – 6AM to 7PM
- PA District 6 – 6AM to 10PM
- PA District 11 – All Day
- Maryland – 5AM to 9PM
- North Carolina – 6AM to 9AM, and 4PM to 7PM
- South Carolina – throughout the day whenever travel time is longer than normal
- Georgia, Atlanta – 5AM to 10PM (previously 6AM to 9PM)

At a minimum, travel time messages should be displayed during times of expected congestion such as the morning and evening commuter peak hours. Once implemented, customer expectations (and positive customer response) tend to expand the service from early morning until nighttime hours.

### ***3.5 Publicity and Driver Education***

Responses to the Coalition member survey indicated that at most, standard press releases were issued when the system was first implemented, and after expansions to include additional highways and/or signs. No ongoing advertisements or driver education was indicated.

The Maryland implementation that began in 2010 followed a similar path. Media attention was drawn to the system shortly after implementation due to observed slowdowns at the CMS's. Commentary attributed the slowdowns to the display of travel time, though no objective measurements were able to confirm the phenomenon in terms of extent or duration of slowdown. The Maryland travel time program was the first in its region, so driver education may have been an issue. In response, Maryland CHART deactivated travel time on a couple of

signs in the region that appeared to exhibit (or was reported to exhibit) this phenomenon to a greater degree. The slowdown effect was transitory and is no longer an issue. Driver education through repeated exposure and use of the system appears to have eliminated any such concerns.

### ***3.6 Travel Time Display Format***

The predominant display format is the direct posting of the travel time in minutes. FHWA has no specific policy for the posting of travel time on CMS [6], but encourages following any pertinent guidance in the MUTCD. The MUTCD provides the following guidance:

- Shall's
  - Messages shall be centered within each line either as
    - Text fully centered
    - Left element - left justified and right element - right justified (within a line)
  - No more than two messages shall be displayed on a 3-line sign
  - Display techniques such as fading text, exploding graphics, animation, or other dynamic elements shall not be used.
- Should's
  - No more than two phases in one message cycle
  - One thought per display
  - Avoid simple, vague messages such as 'CONGESTION AHEAD'
  - Limit to 3 lines, 20 characters per line
  - Letter size 18" (desired), 10.6" minimum
  - Readable at least twice by motorist on approach

A pooled fund study dating to 2007 indicates FHWA encourages each state to develop their own standards. Results from the survey of Coalition members reinforces that any standards set are maintained either at the state or district level. Although no national standards are in effect, the states or districts attempt to remain consistent with neighboring jurisdictions, for the most part, and attempt to implement best practices at the time the system was developed.

Suggested message format for a single destination based on a 3 line and 21 character per line sign includes:

- First line - Message heading (i.e., TRAVEL TIME TO)
- Second line - Destination, distance (if there is space for it, see section 3.10)
- Third line - Travel time.

Suggested message format for a multiple destination based on a 3 line and 21 character per line sign includes:

- First line - Message heading (i.e., TRAVEL TIME TO)
- Second line - Destination 1 and corresponding travel time
- Second line - Destination 2 and corresponding travel time

Figure 3.6.1 illustrates a multi-destination sign using left element left justified and right element right justified (meeting MUTCD guidelines). Note in this example a range of travel times is displayed, as discussed in 3.9.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
			T	R	A	V	E	L		T	I	M	E		T	O				
I	-	8	9	5								1	0	-	1	5		M	I	N
I	-	3	9	5								2	0	-	2	5		M	I	N

Figure 3.6.1 Left Element - Left Justified and Right Element - Right Justified Travel Time Display [5]

### 3.7 Phasing and Updating Messages

Although MUTCD allows for multiple phasing of messages, it is recommended that two phase travel time messages be avoided if possible. While being displayed, the travel time message should remain up on a continuous basis. For a single-phase message, the text should be continuously displayed. If a two-phase message is used (though discouraged), the full cycle should be displayed continuously, with each phase displayed long enough for motorists to read the text twice, while traveling at the posted speed limit.

The frequency for travel time updates on CMS depends on the frequency of the travel time data update in the system. Nominally, a five-minute minimum update cycle should be provided to keep travel times accurate. Travel time display should be fully automated and must be dynamic.

### 3.8 Maximum and Minimum Travel Times

All Coalition members surveyed post a minimum travel time consistent with either the posted speed limit, or a constant maximum speed of 55, 60, or 65 mph.

Policies for maximum or excessive travel time vary for Coalition members. For example in Maryland, at a travel time 4x (where x is the travel time corresponding to the posted speed limit), the TMC software alerts the operator, but continues to display travel time. At a travel time 10x, the display automated switches to "Blank" or other appropriate messages, such as "Stop and Go" or "Congestion Ahead". South Carolina does not display any travel time over 40 minutes or less than 5 minutes.

### 3.9 Travel Time Ranges

A range may be used for travel time display instead of a single number. The range may vary on a graduated scale, i.e., narrower range at a lower value and wider range at a higher value. The range maybe capped at a higher value (30 minutes and above). Table 3.9.1 presents suggested travel time ranges based on distance as used in the Maryland implementation.

Table 3.9.1 Suggested Travel Time Ranges from Maryland Implementation

Travel Time Display Range Reported Travel Time, Min	Suggested Range	Example
0-10	+/- 1	5 will be shown as 4-6
11-20	+/- 2	15 will be shown as 13-17
>20	+/- 3	25 will be shown as 22-28

### 3.10 Displaying Distance to Destination

If space is available on the sign, distance may be displayed along with location and travel time. Distance, in association with travel time, offers a sense of level of congestion to the motorists. [5]



Figure 3.10.1 Example of displaying distance to destination, Georgia DOT

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- (3) “Posting of Travel Times on RIDOT Dynamic Message Signs, Technical Memorandum”, Rhode Island Department of Transportation, Transportation Management Center, July 14, 2010
- (4) “Travel Time Research Project, Deliverable #1 – Travel Time Best Practices Manual, Final report”, The ENTERPRISE Pooled Fund Program, April 3, 2007.  
<http://ops.fhwa.dot.gov/travelinfo/practices/bestpractices.pdf>
- (5) Manzur Elahi, G. McLaughlin, B. Grasso, S. Daniel, “Implementing Travel Time on DMS for Maryland’s CHART Program”, Maryland State Highway Administration
- (6) “Procedural Guidelines for Implementing Travel Time on DMS in CHART”, Maryland State Highway Administration, Office of CHART and ITSD, 2008

## APPENDIX A - North Carolina SOP's for Posting Travel Time on Changeable Message Signs

### Travel Time Guidelines

1. WHEN:
  - a. Travel times shall be posted on weekdays (Monday through Friday) between morning rush (6am – 9am) and evening rush (4pm – 7pm) on pre-determined DMS'.
  - b. Travel Time messages shall not take precedent over “real” incident messages notifying of roadway conditions, incident locations, AMBER or SILVER Alert messages, or any other messages related to situational awareness of the motorists.
  - c. Travel times shall be updated on each of the specified signs during peak times every 10 minutes.
  
2. WHERE:
  - a. On the DMS corresponding to the predetermined segments as outlined in the Link View website (<http://64.79.136.88/linkviewBeta/linkview.aspx>).
  - b. Identify which DMS will be associated with each segment and what link is associated with that travel time (examples below);
    - i. Evening Rush Hour: DMS Locations as follows
      1. CMS0-0I0077SB0011.97
        - a. Link 14  
Segment: I-77 SB, mm 12 to mm 0  
Travel Time shall not be less than the **MINIMUM TRAVEL TIME** is 12 minutes  
(Speed Limit TT value is 11.06 min, so round up to nearest whole number - 12 min)
      2. CMS0-0I0077NB0016.87
        - a. Link 15  
Segment: I-77 NB, mm 17 to mm 30  
Travel Time shall not be less than the **MINIMUM TRAVEL TIME** is 13 minutes  
(Speed Limit TT value is 12.01 min, so round up to nearest whole number - 13 min)
      3. CMS0-0I0085SB0033.64
        - a. Link 16  
Segment: I-85 SB, mm 33 to mm 17  
Travel Time shall not be less than the **MINIMUM TRAVEL TIME** is 14 minutes  
(Speed Limit TT value is 13.63 min, so round up to nearest whole number - 14 min)

3. INFORMATION PROVIDED:

- a. Travel Time speeds are provided at <http://64.79.136.88/linkviewBeta/linkview.aspx> (shown below);
  - i. Users should navigate to the area for which they will be providing travel times by selecting their area from one of the drop down menus located in the upper left-hand corner of the page.
- b. Discrepancies should be accounted for and, if present, augmented appropriately by the trained Operator.

Link	Link Description	Travel Time	Speed Limit TT	Update Time
<b>10</b>	I-77 SB from mm 22 to mm 14 MM22 <-> MM14	<b>5.31</b>	<b>7.36</b>	03/29 13:35:02
<b>11</b>	I-77 NB, mm 0 to mm 14 MM0 <-> MM14	<b>14.99</b>	<b>12.92</b>	03/29 13:35:02
<b>12</b>	I-85 SB, mm 52 to mm 39 MM52 <-> MM39	<b>12.83</b>	<b>12.92</b>	03/29 13:36:32
<b>13</b>	I-85 NB, mm 28 to mm 39 MM28 <-> MM39	<b>9.30</b>	<b>8.86</b>	03/29 13:36:32
<b>14</b>	I-77 SB, mm 12 to mm 0 MM12 <-> MM0	<b>17.26</b>	<b>11.06</b>	03/29 13:35:02
<b>15</b>	I-77 NB, mm 17 to mm 30 MM17 <-> MM30	<b>10.89</b>	<b>12.01</b>	03/29 13:35:02
<b>16</b>	I-85 SB, mm 33 to mm 17 MM33 <-> MM17	<b>14.73</b>	<b>13.63</b>	03/29 13:36:32
<b>17</b>	I-85 NB, mm 40 to mm 54 MM40 <-> MM54	<b>12.30</b>	<b>12.92</b>	03/29 13:36:32

4. WHO:

- a. A designated Operator shall be the responsible party for displaying travel times on DMS' and for accurately recording Travel Time activity within the appropriate day's Travel Time Log.
- b. All Operators are responsible for assisting with the workload during peak hours – no breaks are to be taken during Peak Travel Times.

5. FORMAT:

- a. The following format shall be used on all signs to display Travel Times  
**TRAVEL TIME MESSAGE FOR TRAVELING ALONG A ROUTE:**

<p><b>EST TIME TO</b></p> <p><b>“ROUTE NAME”</b></p> <p><b>## MINUTES</b></p>
---

<p><b>EST TIME TO</b></p> <p><b>“ROUTE NAME”    ## MIN</b></p> <p><b>“ROUTE NAME”    ## MIN</b></p>
---

<p><b>EST TIME TO</b></p> <p><b>AVIATION PKWY</b></p> <p><b>16 MINUTES</b></p>
--

<p><b>EST TIME TO</b></p> <p><b>CITY BLVD            10 MIN</b></p> <p><b>BRUTON SMITH    26 MIN</b></p>
--

**TRAVEL TIME MESSAGE FOR TRAVELING TO A ROUTE:**

<p><b>TIME TO XXXX VIA</b></p> <p><b>“ROUTE NAME”    ## MIN</b></p> <p><b>“ROUTE NAME”    ## MIN</b></p>
--

<p><b>TIME TO 85 VIA</b></p> <p><b>485 EAST            24 MIN</b></p> <p><b>485 WEST            28 MIN</b></p>
--

- b. Travel Times shall **ALWAYS** be rounded “up” to the next whole minute (i.e. – A travel time of 9.30 minutes will be given as 10 minutes).
- c. Travel Time posted shall not be below the Speed Limit Travel Time (i.e. – If the value listed within the “Travel Time” column is less than the value provided in the “Speed Limit TT” column, then the Operator will display the “Speed Limit TT” value on the DMS).

6. DOCUMENTATION:

- a. A Travel Time Log shall be filled out daily and turned in to the Supervisor at the end of each shift.

7. TRAINING

- a. Training will be provided upon request.

**APPENDIX B** - Florida Policy for Displaying Messages on Dynamic Message Signs



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### POLICY

Effective: September 17, 2009  
Office: Traffic Engineering & Operations  
Topic No.: 000-750-015-c

## DISPLAYING MESSAGES ON DYNAMIC MESSAGE SIGNS PERMANENTLY MOUNTED ON THE STATE HIGHWAY SYSTEM

### PURPOSE:

The main purpose of dynamic message signs (DMS) is to convey timely and important en-route and roadside information to motorists and travelers. The Florida Department of Transportation's guiding principles on posting DMS messages shall conform to the Federal Highway Administration's *Manual on Uniform Traffic Control Devices (MUTCD)*.

### DEFINITION:

Dynamic Message Sign — Refers to dynamic, changeable or variable message signs, defined as programmable traffic control devices that display messages composed of letters, symbols/graphics or both. They are used to provide information about changing highway conditions in order to improve operations, reduce accidents, and inform travelers. These signs may inform drivers to change travel speed, change lanes, divert to a different route, or simply to be aware of a change in current or future traffic conditions.

### POLICY STATEMENT

It is the policy of the Florida Department of Transportation (FDOT) to designate the use of DMS on the State Highway System for managing travel, controlling and diverting traffic, identifying current and anticipated roadway and environmental conditions, or regulating access to specific lanes or the entire roadway.

**The default display on dynamic message signs shall be travel time display.**

[www.dot.state.fl.us](http://www.dot.state.fl.us)

Travel time messages can be preempted with other messages as needed in the following order:

- 1) Conditions which require motorists to take action or alter their driving, such as emergency events including evacuations or closures required by FDOT, the State Emergency Operations Center, state and local law enforcement, the military, or the Department of Homeland Security.
- 2) Traffic incidents, hazardous and/or uncommon road conditions, work zone activities, and severe weather conditions.
- 3) Florida Department of Law Enforcement Alerts such as America's Missing: Broadcast Emergency Response (AMBER) Alerts, Law Enforcement Officer (LEO) Alerts and Silver Alerts.
- 4) Traveler information related to special events, emergencies, and incidents impacting mobility and safety.


**In the absence of accurate travel time information, at locations where travel time information would not be useful, or when not being preempted with other messages listed above, the default display shall be a blank sign.**

The use of DMS for the display of general public information, advertisements, and non-essential messages is prohibited. However, public information messages that assist the Department in improving highway safety and reducing congestion may be used. These messages shall only be displayed when any of the following conditions are met:

- a. Display of the message will have a positive effect on highway safety and congestion in the area.
- b. The message is a supplement to a specific national or statewide highway safety media campaign on the same topic.

The total duration of any such highway safety campaign message shall not exceed two hours per day, shall not be displayed during peak hour travel periods, shall not last more than two weeks in duration, and shall not exceed six events per year.

The message display must be approved by the State Traffic Engineer prior to displaying the message. A library of acceptable standard messages is included in the *Traffic Engineering Manual (TEM)*, Topic No. 750-000-005.

  
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