Survey of Best Practices in Real Time Travel Time Estimation and Prediction

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ABSTRACT

Over the last decade, there has been a push towards the development and deployment of Intelligent Transportation Systems (ITS) because of the many benefits that these systems can provide. One of the important components of ITS is Advanced Traveler Information Systems (ATIS). These systems aim to provide the users with pre-trip or en route travel information so that users can choose their transportation options in order to maximize their travel efficiency. As part of ATIS, many states provide the travelers with information of current roadway conditions such as speeds, travel times, occurrence of incidents, lane closures and such. The Oregon Department of Transportation (ODOT) currently provides real time travel time estimates on three dynamic message signs. In the future, ODOT wants to expand this feature by providing travel times on other DMS, online through the web (www.tripcheck.com) and via phone (511). Currently, approximately twenty five metropolitan areas around the country provide travel times whereas seventeen other areas have plans to provide travel times. This paper seeks to examine and evaluate the methodology followed by different metropolitan areas in generating real time travel time estimates. The data will be gathered by conducting a survey of different state department of transportation's (DOT's) in order to identify and learn the best practices for travel time estimation. In addition, ODOT's travel time estimation will be compared with the methods adopted by other state DOT's. Finally, the lessons learned from this study will benefit metropolitan areas around the country that are seeking to provide accurate travel time estimates.

INTRODUCTION

Most metropolitan areas in the United States and around the world are facing high levels of congestion. Since the addition of capacity in most urban areas is not a viable option, in order to manage the growing levels of congestion, many state departments of transportation have invested heavily in ITS infrastructure to efficiently operate the transportation network. As part of the ATIS, many agencies are providing travelers with travel times, speeds, road closures and other information that can aid in improving their travel experience. Travel information is disseminated to the public in a wide variety of ways – websites, DMS, cellular phones, PDA's, in-vehicle navigation, radio broadcasts and other emerging technologies (1). The Federal Highway Administration (FHWA) issued a memorandum in 2004, encouraging states to use existing DMS to post travel times (2).

The accurate provision of travel times is challenging, as traffic conditions are highly dynamic. Previous research has demonstrated that error rates up to 20% are acceptable and can still provide useful information to the public. Various states have taken different approaches to generating and displaying travel times. The complexity of approach depends on the type of infrastructure that generates data as well as whether calculation of travel times takes place in-house or is outsourced to a vendor.

The rest of this paper is organized into the following sections. The following section deals with different data collection approaches. A review of the methodology followed by different jurisdictions is outlined next, followed by conclusions and some recommendations.

DATA COLLECTION APPROACHES

One of the important decision facing states before they start providing travel times is the approach to data collection. A review of the data collection approaches reveals four main options. These include fixed detection of volume and occupancy, fixed detection of speed, direct travel times and other proprietary approaches (3). The fixed detection of volume and occupancy requires a vast network of sensors, which in turn require a lot of capital investment as well as regular maintenance. The volume and occupancy measurements are generally provided by loop detectors or radar sensors. The fixed detection of speed allows for gathering of speed data, which can be used for travel time calculations. This data is also often collected through loop detectors or radar sensors. A third approach to collecting travel times directly includes automatic toll tag readers, which have the ability to record the time of the passage of a vehicle carrying a toll tag. This method is employed in states that have toll facilities and an automatic toll collection program. The main feature in this approach is the need for toll readers, which are generally placed on the side of the highway. This approach enables the direct collection of travel times; with the accuracy increasing with increased density of the toll readers. Finally another approach is to fuse the data derived from different sources such as fixed sensors, probe vehicles, cellular phones etc. to derive travel times. This approach is generally followed by private vendors who often use proprietary algorithms and data fusion techniques to derive travel times. Some states have outsourced the generation of travel times to these private vendors (Inrix, Traffic.com).

PROVISION OF TRAVEL TIMES – METHODOLOGIES

A number of states have been providing travel time information or have plans to provide such information in the near future. For states that are seeking to provide such information, a review of practices followed by other states will be beneficial when they deploy their systems.

Portland, Oregon

The Oregon Department of Transportation (ODOT) currently provides travel times on three DMS along the I-5 corridor as shown in Figure 1. Travel times are provided in a 2-3 minute range. These times are estimated from speeds reported by dual loop detectors embedded in the pavement. Currently there are approximately 500 loop detectors that report count, speed and occupancy every 20 seconds to the Traffic Management Operations Center (4). The midpoint algorithm, which uses a ratio of distance to speed, is used to generate travel times.

Figure 1: Travel Times on DMS in Portland, Oregon

A research study undertaken by Portland State University is currently underway to assess the accuracy of the estimates and propose refinements and other recommendations to increase the accuracy of these estimates.

Seattle, Washington

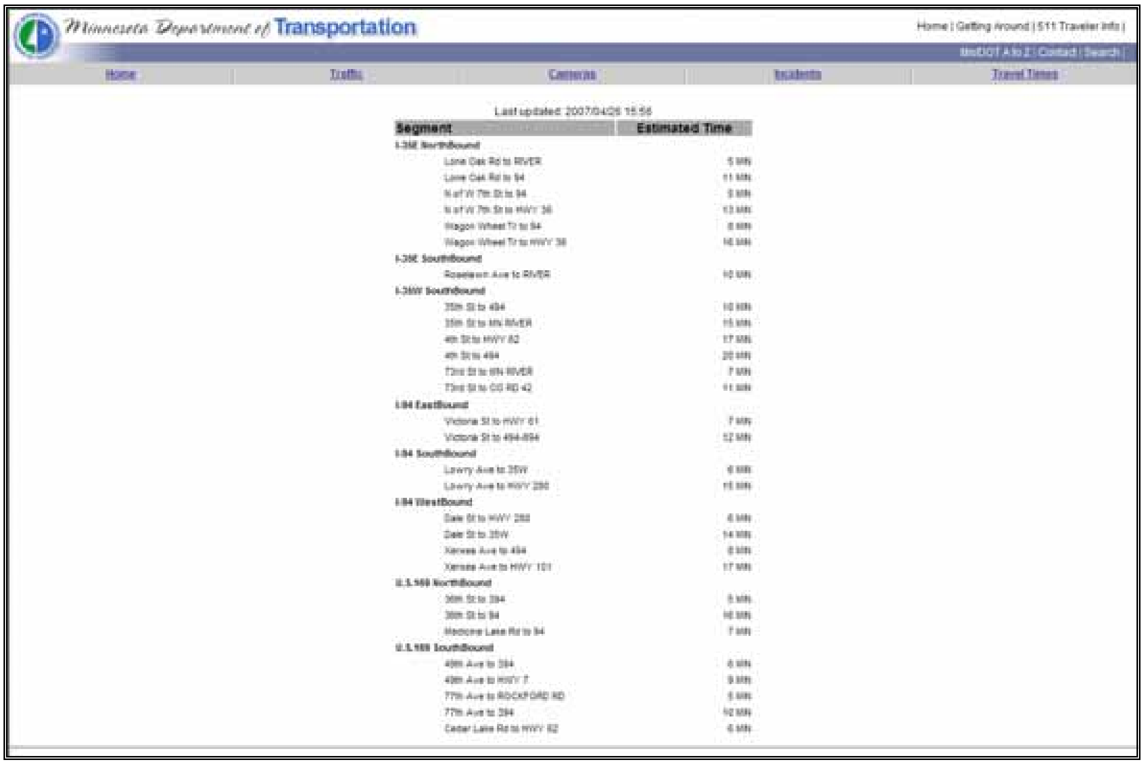
Travel times in Seattle, Washington are estimated by using occupancy measurements from single loop detectors which are spaced 0.25 – 0.5 miles apart. The speeds and segment lengths are used to estimate travel times for different links. These current status travel times are compared to the historical travel times and are adjusted if the historical travel times report a higher value.

Figure 2: Seattle Travel Times on the Web
(Source: http://www.wsdot.wa.gov/traffic/seattle/traveltimes)

These travel times are disseminated through DMS as well as web and are updated approximately every two minutes. The performance of the algorithm is checked through cameras as well as customer feedback. Tests show accuracy greater than 90%.

Minneapolis – St. Paul, Minnesota

Travel times in the twin cities are estimated based on speeds, which are calculated from volume and occupancy measurements from single loop detectors spaced approximately 0.5 miles apart. A modified midpoint algorithm is used to estimate travel times based on calculated speeds. These travel times are reported on DMS and software developed by the Minnesota DOT's Traffic Management Center (TMC) is used to control the signs and post messages. Figure 3 shows the sample travel times for twin cities.


Minnesota Department of Transportation

Home | Getting Around | 511 Traveler Info |

MnDOT A to Z | Contact | Search |

Home Traffic Cameras Incidents Travel Times

Last updated: 2007/04/26 15:56

Segment	Estimated Time
I-35E NorthBound	
Lone Oak Rd to RIVER	5 MIN
Lone Oak Rd to 94	11 MIN
N of W 7th St to 94	5 MIN
N of W 7th St to HWY 36	13 MIN
Wagon Wheel Tr to 94	8 MIN
Wagon Wheel Tr to HWY 36	16 MIN
I-35E SouthBound	
Roselawn Ave to RIVER	10 MIN
I-35W SouthBound	
35th St to 494	10 MIN
35th St to MN RIVER	15 MIN
4th St to HWY 62	17 MIN
4th St to 494	20 MIN
73rd St to MN RIVER	7 MIN
73rd St to CO RD 42	11 MIN
I-94 EastBound	
Victoria St to HWY 61	7 MIN
Victoria St to 494-694	12 MIN
I-94 SouthBound	
Lowry Ave to 35W	6 MIN
Lowry Ave to HWY 280	15 MIN
I-94 WestBound	
Dale St to HWY 280	6 MIN
Dale St to 35W	14 MIN
Xerxes Ave to 494	8 MIN
Xerxes Ave to HWY 101	17 MIN
U.S.169 NorthBound	
36th St to 394	5 MIN
36th St to 94	16 MIN
Medicine Lake Rd to 94	7 MIN
U.S.169 SouthBound	
49th Ave to 394	6 MIN
49th Ave to HWY 7	9 MIN
77th Ave to ROCKFORD RD	5 MIN
77th Ave to 394	10 MIN
Cedar Lake Rd to HWY 62	6 MIN

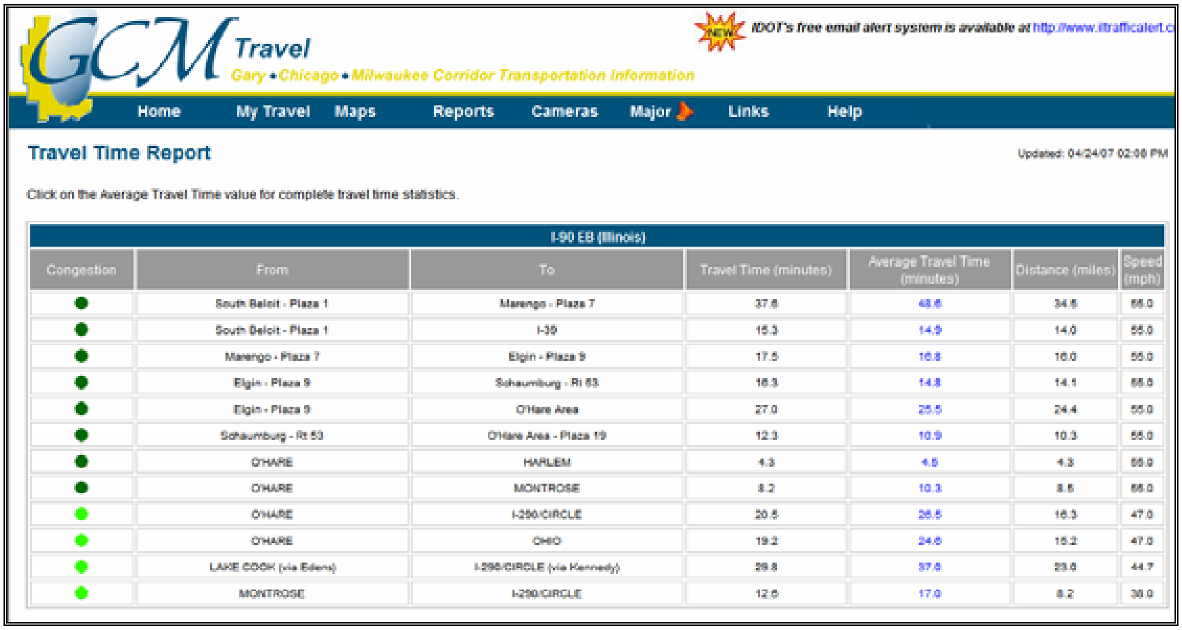
Figure 3: Travel Times for Twin Cities

(Source: http://www.dot.state.mn.us/tmc/trafficinfo/traveltime.html)

Estimated travel times have been found accurate most of the time except when conditions are changing. The DOT has encountered favorable public and media response to the posting of travel times.

Chicago, IL

The highway network in Chicago consists of both tolled and untolled facilities. Illinois DOT operates the untolled highway network, where loop detectors are present every 0.5 miles. These detectors record volume and occupancy and speeds are calculated from these observations. Travel times are calculated as a simple ratio of distance to speed, with the algorithm also including a fudge factor to account for extremely congested conditions where occupancy is greater than 95%. Figure 4 displays some travel times on the web.


GCM Travel
Gary • Chicago • Milwaukee Corridor Transportation Information
IDOT's free email alert system is available at http://www.iltrafficalert.c
Home | My Travel | Maps | Reports | Cameras | Major | Links | Help

Travel Time Report

Updated: 04/24/07 02:08 PM

Click on the Average Travel Time value for complete travel time statistics.

I-90 EB (Illinois)						
Congestion	From	To	Travel Time (minutes)	Average Travel Time (minutes)	Distance (miles)	Speed (mph)
	South Beloit - Plaza 1	Marengo - Plaza 7	37.6	48.6	34.6	66.0
	South Beloit - Plaza 1	I-39	15.3	14.9	14.0	55.0
	Marengo - Plaza 7	Elgin - Plaza 9	17.5	16.8	16.0	55.0
	Elgin - Plaza 9	Schaumburg - Rt 53	16.3	14.8	14.1	66.8
	Elgin - Plaza 9	O'Hare Area	27.0	25.5	24.4	55.0
	Schaumburg - Rt 53	O'Hare Area - Plaza 19	12.3	10.9	10.3	55.0
	O'HARE	HARLEM	4.3	4.5	4.3	66.9
	O'HARE	MONTROSE	8.2	10.3	8.6	66.0
	O'HARE	I-290/CIRCLE	20.5	26.5	16.3	47.0
	O'HARE	OHIO	19.2	24.6	15.2	47.0
	LAKE COOK (via Edens)	I-290/CIRCLE (via Kennedy)	29.8	37.6	23.6	44.7
	MONTROSE	I-290/CIRCLE	12.6	17.0	8.2	38.0

Figure 4: Chicago Travel Times on Web
(Source: www.gcmtravel.com)

Travel times are posted on DMS signs as well as on the web as seen in Figure 4. The accuracy of travel times has been found to be within +/- 2 minutes of actual travel times.

The tolled facilities are managed by Illinois State Highway Toll Authority (ISHTA). Initial calculations of travel times used data from electronic toll plazas (ETC) and automatic vehicle identification (AVI) tags. Since large gaps existed between toll plazas, Radar Traffic Management Sensors (RTMS) were installed to fill in the gaps. These RTMS sensors were installed and are maintained by a private vendor (traffic.com). The travel time algorithm fuses the ETC and the RTMS data to generate travel times. These estimates are posted both on the DMS as well as the web. However only travel times calculated from ETC data are posted on the web due to contract restrictions, whereas travel times derived from both sources (ETC and RTMS) are posted on the DMS. Tests are conducted routinely to assess the accuracy of the estimates. It has been observed that the accuracy had improved with the deployment of the RTMS sensors.

San Francisco – Bay Area, CA

Travel times in the San Francisco – Bay Area are estimated from data obtained from a variety of sources – loop detectors, AVI toll tag readers and spot speed loop sensors. The travel time algorithm employed for calculation of estimates fuses data from all three sources to predict travel times. A private vendor provides the travel times and maintains the algorithm. These travel times are available through DMS, web as shown in Figure 5, as well as the 511 system.

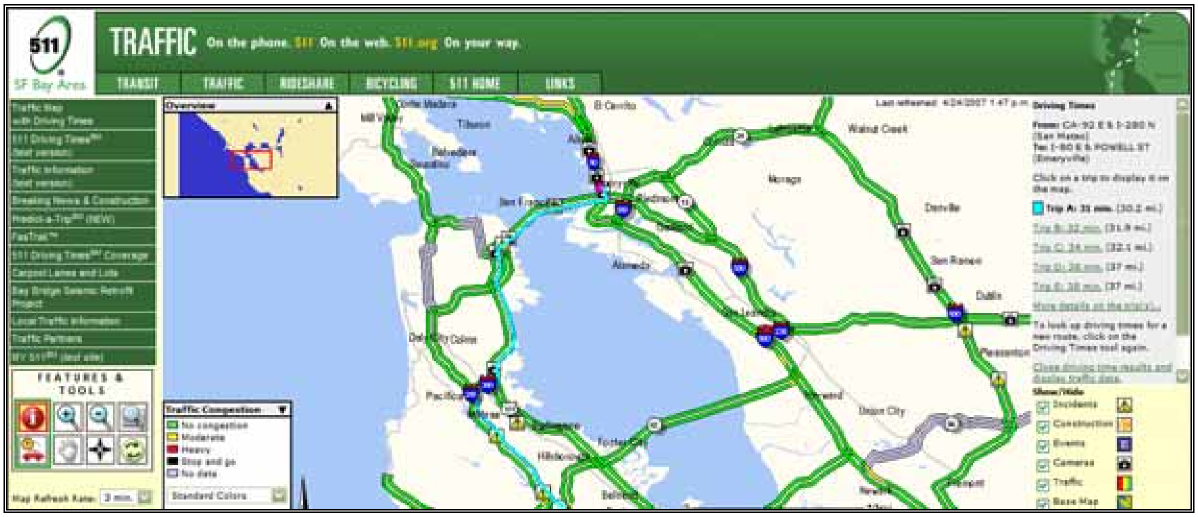
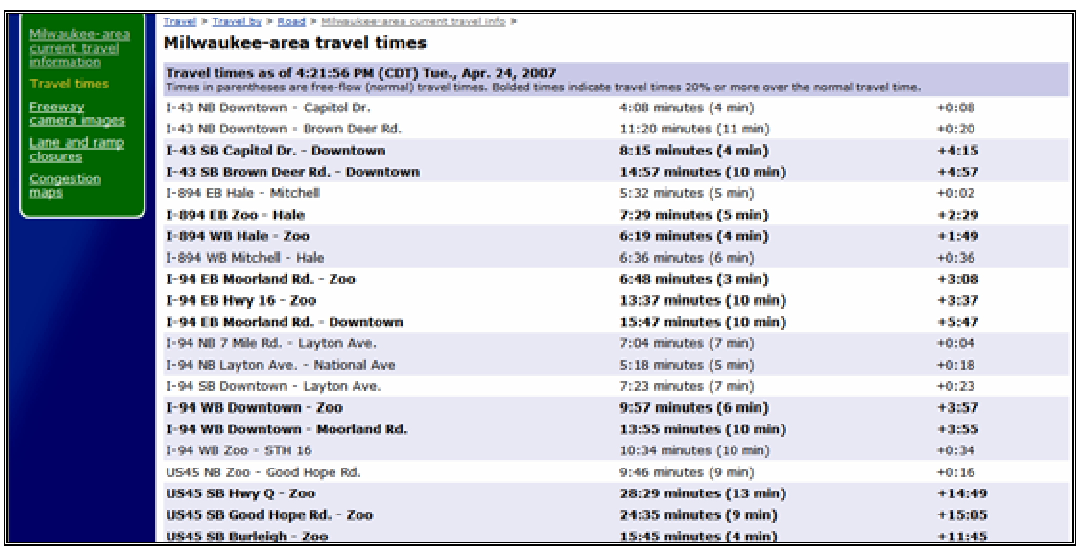


Figure 5: San Francisco Bay Area Travel Times
(Source: www.511.org)

Routine checks on accuracy are performed by third party vendors. Feedback from the public indicates that the travel times are accurate even during periods of high congestion. It is estimated that 90% of the time, the travel time estimation errors are less than 20%.

Milwaukee, WI

Loop detectors form the primary source of data collection in Milwaukee. These detectors are spaced every 0.25 mile in the urban area, with the average spacing between detectors higher in the suburban areas. In some cases, microwave detectors are also present to supplement the data collection. Travel time is calculated as the ratio of distance to speed, with speed being averaged across lanes for a fixed location. Travel times are not reported if 33% or more of the detectors are not functioning. Software at the TMC computes the travel times which are updated on the website every three minutes and the DMS is updated every minute. Figure 6 displays the Milwaukee travel times on the web.


Milwaukee-area current travel information
Travel times
Freeway camera images
Lane and ramp closures
Congestion maps

Travel > Travel by > Road > Milwaukee-area current travel info >

Milwaukee-area travel times

Travel times as of 4:21:56 PM (CDT) Tue., Apr. 24, 2007
Times in parentheses are free-flow (normal) travel times. Bolded times indicate travel times 20% or more over the normal travel time.

I-43 NB Downtown - Capitol Dr.	4:08 minutes (4 min)	+0:08
I-43 NB Downtown - Brown Deer Rd.	11:20 minutes (11 min)	+0:20
I-43 SB Capitol Dr. - Downtown	**8:15 minutes (4 min)**	**+4:15**
I-43 SB Brown Deer Rd. - Downtown	**14:57 minutes (10 min)**	**+4:57**
I-894 EB Hale - Mitchell	5:32 minutes (5 min)	+0:02
I-894 EB Zoo - Hale	**7:29 minutes (5 min)**	**+2:29**
I-894 WB Hale - Zoo	**6:19 minutes (4 min)**	**+1:49**
I-894 WB Mitchell - Hale	6:36 minutes (6 min)	+0:36
I-94 EB Moorland Rd. - Zoo	**6:48 minutes (3 min)**	**+3:08**
I-94 EB Hwy 16 - Zoo	**13:37 minutes (10 min)**	**+3:37**
I-94 EB Moorland Rd. - Downtown	**15:47 minutes (10 min)**	**+5:47**
I-94 NB 7 Mile Rd. - Layton Ave.	7:04 minutes (7 min)	+0:04
I-94 NB Layton Ave. - National Ave	5:18 minutes (5 min)	+0:18
I-94 SB Downtown - Layton Ave.	7:23 minutes (7 min)	+0:23
I-94 WB Downtown - Zoo	**9:57 minutes (6 min)**	**+3:57**
I-94 WB Downtown - Moorland Rd.	**13:55 minutes (10 min)**	**+3:55**
I-94 WB Zoo - STH 16	10:34 minutes (10 min)	+0:34
US45 NB Zoo - Good Hope Rd.	9:46 minutes (9 min)	+0:16
US45 SB Hwy Q - Zoo	**28:29 minutes (13 min)**	**+14:49**
US45 SB Good Hope Rd. - Zoo	**24:35 minutes (9 min)**	**+15:05**
US45 SB Burleigh - Zoo	**15:45 minutes (4 min)**	**+11:45**

Figure 6: Milwaukee Travel Times
(Source: http://www.dot.wisconsin.gov/travel/milwaukee/times.htm)

The accuracy of the travel times is periodically checked and generally a favorable response has been found to the posting of travel times. Often times, errors are reported by the public and these are often the result of bad or missing data.

Houston, TX

Travel times in Houston, TX are primarily derived from AVI toll tag transponders. Over 200 toll tag readers are present in addition to the toll plazas. Another advantage is the is vast number of customers (2 million) with toll tags. Travel times are posted automatically onto the DMS every ten minutes by software developed by Texas Transportation Institute (TTI) and Southwest Research Institute (SWRI). A sample travel time message on the DMS is shown in Figure 7.

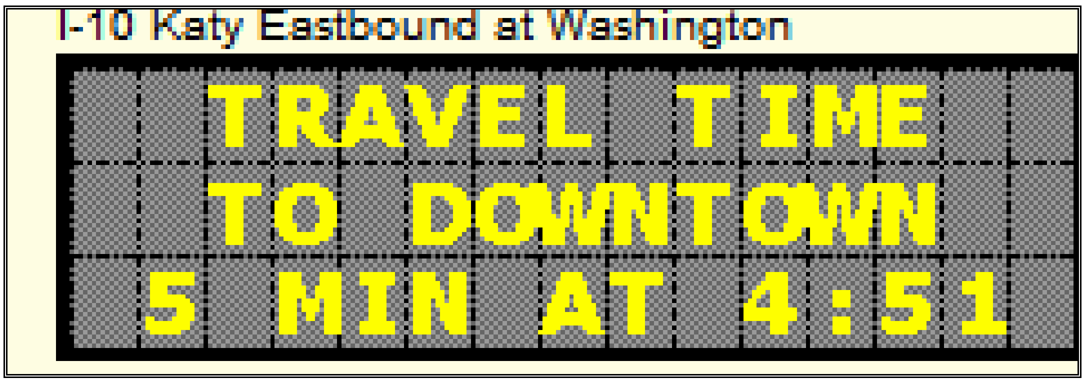


Figure 7: DMS Travel Time Message in Houston, TX
(Source: traffic.houstontranstar.org)

As shown in Figure 7, the DMS messages also include the time at which the estimate was made. Public response to the posting of travel times has been highly favorable and the travel times are generally considered accurate. Based on the information provided, users were observed to change routes.

Nashville, TN

RTMS sensors form the primary source of data collection in Nashville, TN. These are spaced 0.25 miles apart, and are subjected to periodic maintenance to ensure optimal performance. Travel times are calculated knowing the distance and average speed that is obtained from the RTMS sensors. Travel times are posted to destinations that are not more than 5 miles away from the DMS. The travel times are posted in 2-3 minute ranges and also contain the distance to the destination. As in other cities, the public has responded positively to the posting of travel times on DMS. TDOT ensures accuracy by verification with CCTV cameras as well as regular calibration of the RTMS sensors.

Atlanta, GA

A number of Video Detection System (VDS) cameras are present on the highways in Atlanta, GA and continuously record speed and volume and transmit this data to the TMC, where travel times are generated and posted onto the DMS. A picture of the VDS camera is shown in Figure 8.

Figure 8: Video Detection System Cameras in Atlanta, GA
(Source: http://www.georgia-navigator.com/about)

Figure 9: DMS Travel Time Message in Atlanta, GA
(Source: http://www.georgia-navigator.com/about)

Travel times are calculated from average speeds obtained from the VDS cameras. The travel time information is provided between 6 am and 9 pm. In addition to the main lane DMS, high occupancy vehicle (HOV) DMS are also present and provide information specifically to HOV commuters. Figure 9 shows a sample DMS message in Atlanta, GA.

San Antonio, TX

Travel times in San Antonio, TX are obtained from speeds from loop detectors and video detection systems. These sensors are placed 0.5 miles apart. The travel time algorithm assumes that a segment is bounded by detector stations on either end, and the speed for the segment is chosen as the lower of the speed displayed by the upstream or downstream station. The ratio of the distance covered by each method of detection to the speed generates the travel times. These times are displayed on the DMS as well as on the web. The destinations for which travel times are displayed on the DMS are 5-10 miles away and travel times are always displayed in a range of values. Figure 10 shows sample travel times in San Antonio as found on the web.

Highway	Starting Point	Ending Point	Distance	Segment Travel Time	Average Speed (MPH)
IH 10 Eastbound	Loop 1604	Loop 410	7.0 mi.	7 min	>60
	Loop 1604	I 35 Interchange North of Downtown	13.2 mi.	11 min	>60
	Loop 410	I 35 Interchange North of Downtown	6.2 mi.	No data	No data
	Huebner	Hildebrand	6.7 mi.	[illegible]	>60
IH 10 Westbound	IH 35 Interchange North of Downtown	Loop 410	6.2 mi.	[illegible]	>60
	Loop 410	Wurzbach	2.5 mi.	2 min	>60
	Loop 410	Loop 1604	7.0 mi.	[illegible]	>60
	Hildebrand	Huebner	6.9 mi.	[illegible]	>60
	IH 35 Interchange North of Downtown	Loop 1604	13.2 mi.	11 min	>60
LP 410 Westbound	Perrin Beitel	US 281	4.5 mi.	No data	No data
	US 281	IH 10	4.5 mi.	Construction	No data
	IH 10	Bandera	3.6 mi.	[illegible]	>60
	Perrin Beitel	Bandera	8.1 mi.	Construction	No data
LP 410 Eastbound	Bandera	IH 10	3.6 mi.	4 min	>60
	IH 10	US 281	4.5 mi.	Construction	No data
	US 281	Perrin Beitel	4.5 mi.	No data	No data
	Bandera	Perrin Beitel	9.0 mi.	Construction	No data

Figure 10: San Antonio Travel Times
(Source: http://www.transguide.dot.state.tx.us/TravelTimes/commontimes.php)

The posting of travel times onto the DMS is automated. The posting of travel times on the web as well as on DMS has been well received by the public.

Toronto, CA

Loop detectors placed every 1/3 rd mile in Toronto provide speeds that are used to calculate travel times. The initial travel time algorithm used to generate times used distance over speed to compute time. Due to large errors in estimation, a more complex algorithm was developed which incorporated queue formation and dissipation, time of day etc. Travel times are displayed on the DMS in ranges of times. When travel times exceed 40 minutes, the DMS does not display travel times; instead a message "stop and go conditions" is displayed. Public reaction has been positive to the display of travel times, which have been accurate. More research is being conducted to display travel times on arterials.

CONCLUSIONS

The increase in congestion has made the provision of traveler information and in particular travel times essential. A review of the methodologies followed by different jurisdictions around the country indicates that there are two main approaches that states follow in order to generate travel times. The travel times are either generated in-house or outsourced to a private vendor. Different data collection approaches are followed by different states – loop detectors, RTMS and AVI toll tag transponders/readers. Most states that calculate travel time in-house use the midpoint algorithm to generate travel times. The states that outsource the generation of travel times to private contractors use proprietary algorithms developed by the contractors.

In general, the provision of travel times has evoked a positive response from the public in almost all places, where they have been provided. Most states that are providing travel times maintain high standards of data quality by periodic checks on accuracy. Therefore, states that have not yet provided travel times to the public should be encouraged to provide travel times, while placing special emphasis on accuracy.

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