

Extending the Use of Archived ITS Data As a Potential Management Tool to Evaluate Traveler Information on Dynamic Message Signs

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July 30, 2007

Submitted for presentation and publication to the
87th Annual Meeting of the Transportation Research Board
January 13–17, 2008

Word Count = **6,067** words [3,317 words + 5 tables and 6 figures]

ABSTRACT

Dynamic Message Signs (DMS) on freeways are often used to provide a variety of information to motorists including incident and construction information, travel time estimates and public service announcements such as Amber Alerts. The display of accurate travel time messages is currently of high importance to the Federal Highway Administration (FHWA) and state departments of transportation. The objective of this paper is to describe the development of an automated system for superimposing DMS messages on top of contour speed plots within an ITS data archive system. In order to aid operations personnel in the assessment of travel time message accuracy, the DMS messages are displayed as boxes that graphically represent the time, location and content of the message. Such a display can be used by traffic managers to visually assess the accuracy of DMS travel time messages. The new plotting system has been developed as an addition to the Portland Oregon Regional Transportation Archive Listing (PORTAL). PORTAL is the transportation data archive for the Portland metropolitan region and consists of a database of transportation data and a web-based interface providing graphical tools and data access for transportation managers, engineers and researchers. This paper describes how the DMS messages are processed, analyzed and interpreted. The addition of the DMS display to PORTAL will allow traffic engineers to quickly verify the validity of DMS travel time messages in near real-time.

INTRODUCTION

The Oregon Department of Transportation (ODOT) monitors traffic across the state of Oregon through the use of an ATMS system. In the Portland metropolitan area, the ATMS system includes 671 detectors (including sensors from Vancouver, Washington across the Columbia River), 98 closed-circuit television (CCTV) cameras and 34 dynamic message signs (DMS). ODOT provides traveler information to the public using a variety of methods. The primary dissemination from the ATMS is via the TripCheck website (www.tripcheck.com). Among many features, TripCheck provides a real-time speed condition map for Portland-area freeways based on measurements from the freeway sensor network as well as access to regularly-updated images from the CCTV cameras.

In addition, travel information messages are relayed to the public via the 34 DMS on freeways throughout the state. These messages include information about construction, incident location and severity and public service announcements such as Amber Alert messages. A typical display message includes an incident statement, an approximate incident location, and a suggested course of action (1). In addition, three DMS on I-5 in the Portland area are used to display travel time estimates, indicating the current estimated travel time from the particular DMS to a given location, typically a highway interchange or other significant destination. Figure 1 shows the locations of DMS in the Portland area; DMS currently used for travel time display are distinguished with separate symbols.

The FHWA is strongly encouraging the use of the existing signs to provide travel time estimates (2). DMS are valuable tools for communicating with the general public to provide them with information about freeway conditions and potential courses of action. DMS messages help improve the traveling experience and may reduce congestion by allowing travelers to make informed decisions. Appropriate use of DMS messages can also ultimately provide network benefits, as shown in (3).

The Portland Oregon Regional Transportation Archive Listing (PORTAL) is the official archived data user service (ADUS) for the Portland region. PORTAL has been archiving 20-second speed, volume and occupancy data from the approximately 671 inductive loop detectors on Portland-area freeways since July 2004 (4). This data is received by Portland State University (PSU) as a live data stream from the ODOT Advanced Traffic Management System (ATMS). In addition to loop detector data, the PORTAL archive includes weather, incident and traffic count data, and the DMS messages. In this paper, we describe the integration of these messages both into the PORTAL data archive and into PORTAL's web-based front end. For all messages, the location and time are graphically displayed in the time-space plane of a speed contour plot. For travel time messages, color-coded boxes are used to convey the time, location, duration and content of the messages. The importance of providing accurate travel time estimates is well known and the accuracy of these messages has usually been validated by comparing probe vehicle data and estimates as part of systematic evaluation projects (5,6) during particular experiments. However, for day-to-day assessment this level of rigor is generally not possible.

This paper presents the development of an on-line tool that incorporates a visual, automated method for assessing the appropriateness and general accuracy of messages using archived ITS data. The paper describes how the data from the ATMS system have been parsed, cleaned, and archived in an automated manner. The paper then presents methods for graphically displaying these messages combined with other archived data to allow assessment. The paper highlights the graphical overlay of travel time messages on speed contour plots. This should allow traffic managers to visually verify the accuracy of travel time messages as part of ongoing operations improvements.



FIGURE 1 Map of DMS Locations in Portland

MOTIVATION

The addition of DMS data to the PORTAL transportation archive will help PORTAL users better understand traffic patterns and more effectively utilize the archived data. Table 1 shows a representation of the type of information that is available in the raw DMS data. It is apparent that this information is of high value for an archived data system. Since the location, time and content of the message is known a user of the archived data would be able to associate an unusual traffic pattern with an event if the event information was displayed on a DMS. Clearly, the availability of DMS messages may help researchers filter data; researchers may check DMS messages to ensure that special event-related traffic is included or excluded from research as appropriate. A primary focus of PORTAL is visualization of data in a way that is intuitive and usable by researchers, practitioners and planners. The PORTAL interface can be used to plot speed over the length of a freeway for a specified period of time. Incident data and weather data is

already associated with those plots so that a user observing an unusual traffic pattern in a speed plot, may be able to correlate that pattern with an incident or adverse weather. The visualization of DMS messages described herein will allow users to relate traffic patterns to DMS messages. Having DMS messages archived within the PORTAL database increases PORTAL users' ability to understand and interpret the large amount of freeway traffic data already stored in the database.

TABLE 1 Sample of DMS Messages

Message Time Stamp	Sign ID	DMS message
2006-09-21 05:59:20	3	Accident I-5 NB 3 Min of I-84 Left Lane Closed
2006-09-21 10:43:54	2	Stall On I-5 NB 3 Miles Ahead Expect Delays
2006-09-21 16:51:42	4	Bridge Work Ahead Expect Loud Noises
2006-09-21 19:29:27	2	Road Work Right Lane Closed 5 Miles Ahead
2006-09-29 16:41:43	8	Travel Time To I-205 10-12 Min.

ARCHIVING THE DMS DATA

To begin this study, ODOT provided Portland State University with a listing of all messages displayed on their DMS from February 4, 2004 through December 31, 2006. The raw data from ODOT was not immediately suitable for incorporation into PORTAL. In the time period February 4, 2004 through December 31, 2006, ODOT displayed 46,020 messages on their DMS signs. Table 2 shows a breakdown of some common types of message by message type.

TABLE 2 Summary of DMS Messages by Message Type, February 4, 2006 to December 31, 2006

Type of Message	Number of Messages
Travel Time Estimate	13,507
Accident	9,303
Blank	6,479
Stall	4,523
Route Closure	3,900
Road Work	3,372
Bridge Lift	1,134
Special Event	1,045
Road Conditions	1,039
Public Safety	589
Test	589
Amber Alert	327
Other	213
Total	46,020

This section describes how the raw DMS message data was processed and restructured so it was suitable for upload in to the PORTAL database and for use in DMS message visualization. Figure 2 contains a sample of the raw DMS message data received from ODOT. In this data, each (Timestamp, MessageText) pair represents a message display event. The Timestamp field represents the time of the display event. The MessageText field includes several distinct pieces of information: the operator id, the sign id and the text of the message itself. The message text is divided into three lines separated by the text strings (Line 1), (Line 2) and (Line 3). The operator id is a unique identifier for the operator who posted the message and the sign id identifies the sign on which the message was displayed. Ideally, each column in a database table contains one piece of information; therefore, the MessageText field was broken up into five columns for database storage. The translation of the ODOT raw data to database data is as follows: the Timestamp in the raw data is represented by Message Timestamp column of type timestamp in the database. The MessageText field is broken into the fields: OperatorId, SignId, MessageLine1, MessageLine2 and MessageLine3. Table 3 shows the database entries corresponding to the raw data in Figure 2.

```
"TIMESTAMP", "MESSAGETEXT"
2/24/2004 7:50:00, "Operator atmssvr displayed message on sign 2: (Line 1)
Travel Time To (Line 2) I-405 (Line 3) 10-12 Min"

2/24/2004 7:50:04, "Operator atmssvr displayed message on sign 1: (Line 1)
Travel Time To (Line 2) Hwy 217 (Line 3) 8-10 Min."

2/24/2004 7:50:57, "Operator atmssvr displayed message on sign 2: (Line 1)
Travel Time To (Line 2) I-405 (Line 3) 10-12 Min"
```

FIGURE 2 Raw DMS message data received from ODOT.

TABLE 3 Database Representation of DMS Data

Message Timestamp	Sign Id	Operator Id	Message Line1	Message Line 2	Message Line3
2004-02-24 07:50:00	2	atmssvr	Travel Time To	I-405	10-12 Min
2004-02-24 07:50:04	1	atmssvr	Travel Time To	Hwy 217	8-10 Min.
2004-02-24 07:50:57	2	atmssvr	Travel Time To	I-405	10-12 Min

Note that future ATMS software implementations could make exporting these messages easier, but archiving and automating the interpretation of these messages was not a consideration when the ATMS was initially implemented.

ADDING FUNCTIONALITY TO THE DMS DATA

This section describes development of the tool for displaying the DMS messages graphically within the PORTAL system. For the purpose of this work, the DMS messages have been divided into two types: travel time messages and informational messages. The following sections describe the processing and display of the travel time and information messages.

Travel Time Messages

ODOT's ATMS system is currently configured to generate estimated travel times to key points along I-5 using readings from the freeway sensor network. Point speed estimates from individual sensors are assigned to a particular segment of highway which are then combined to predict travel time along that route. Experiments have been conducted to validate these messages (6) but traffic managers may be interested in a more ad-hoc evaluation of the messages. The visualization of DMS messages in PORTAL graphically displays the content, time and location of the message. Each message is displayed as a color-coded box; the vertical position of the box indicates the location (milepost) of the DMS on which the message was displayed along the vertical (distance) axis. The horizontal position and horizontal extent of the box indicate the start time and duration of the message, respectively, along the horizontal (time) axis. The color of the box is correlated with the speed associated with the estimated travel time displayed. Long travel times (slow speeds) are represented by red boxes, mid-range travel times (medium speeds) are shown with yellow boxes, and short travel times (fast speeds) with green boxes. In this way, it was hoped that the color of the box could be associated with the colors in the speed plot so that a quick visual diagnosis could be made. Matching colors would indicate reasonably good travel time estimation accuracy, while a red box on a green background would indicate that the travel time message was inaccurate. Displaying travel time messages on the speed plots required three types of data processing: finding the duration of a message, color-coding the content of the message, and plotting on speed contour plot. This processing is described in the following sections.

Color Coding the DMS Travel Time Message

As discussed above, messages are displayed as color-coded boxes; the colors in those boxes should correlate with the colors in the speed plots. For every travel time estimate, one can calculate a corresponding average speed that a driver viewing the DMS should experience. ODOT displays the travel time messages in ranges. For this tool, the two estimated speeds for each message were averaged. Corresponding speeds less than 25 mph are coded red, between 25 and 50 mph yellow and greater than 50 mph are coded green. The travel time estimation messages were then color coded as described above. In Table 4, '-' indicates the absence of a travel time message; the PORTAL message color is green during those periods. The calculations are shown in Table 4.

TABLE 4 Speed Calculations Based on DMS Predicted Travel Times

DMS	DMS Milepost	Destination	Destination Milepost	Distance (miles)	Estimated Travel Time	Corresponding Average Speed (mph)	PORTAL DMS Message Color
Wilsonville	285.26	Hwy 217	292.12	6.8	8-10 min	40.3	Yellow
	285.26	Hwy 217	292.12	6.8	10-13 min	36.4	Yellow
	285.26	Hwy 217	292.12	6.8	13+ min	< 31.4	Red
	285.26	Hwy 217	292.12	6.8	-	>50	Green
Terwilliger	298.38	I-205	289.27	9.1	10-12 min	50.1	Green
	298.38	I-205	289.27	9.1	12-15 min	41.0	Yellow
	298.38	I-205	289.27	9.1	15+ min	<36.4	Red
	298.38	I-205	289.27	9.1	-	>50	Green
Carman	291	I-405	300.00	9.0	10-12 min	49.5	Green
	291	I-405	300.00	9.0	12-15 min	40.5	Yellow
	291	I-405	300.00	9.0	15+	<36	Red
	291	I-405	300.00	9.0	-	>50	Green

Message Display

Figure 3 shows a sample display of travel time messages for October 17, 2006 at the Terwilliger Blvd DMS near milepost 298 on I-5 southbound. The background speed contour plot shows measured average speed (across all lanes) for the entire section of southbound I-5 (y-axis) for the entire day (x-axis). Speeds between 0 and 70 mph are displayed by color as shown by the associated color bar and, as indicated, the direction of travel is downwards to the right. On this day, the message “Travel Time to I-205 10-12 Mins” was displayed from 15:32 until 17:36. This message is associated with an estimated speed of more than 50 mph; as shown in Table 4, therefore, a green horizontal bar is used to represent the travel time message. The speed contour plot in Figure 3 is mostly green for travel downstream of the DMS to the I-205 during the 15:30 to 17:30 time period indicating that measured speeds were around 50 mph or greater for this time period on this segment. The correlation between the green travel time bar and green on the speed contour plot indicates that travel time estimates agree with measured speeds. In (6) most of the uncongested travel time estimates were generally accurate.

To demonstrate the usefulness of the plotting technique consider the speed map and travel time estimates from November 8, 2006 for the same Terwilliger Blvd DMS on southbound I-5 as shown in Figure 4. On this day, the message “Travel Time to I-205 10-12 Mins” was displayed from 15:30 to 17:41, which translates to a speed greater than 50 mph, therefore a green bar is drawn for the specified time duration at milepost 298. Between 17:41 and 17:46, the message “Travel Time To I-205 12-15 Min” was displayed on the DMS. According to the translation in Table 4, a yellow bar is displayed for this time period. Since the duration of the message was very short, the yellow bar is not visible at the scale presented in Figure 4. From 17:46 to 18:34 the message “Travel Time to I-205 10-12 Mins” was displayed as indicated by the green bar. “Travel Time To I-205 12-15 Min” was displayed from 18:34 to 18:42 as is indicated by the small yellow bar. Finally “Travel Time To I-205 10-12 Mins” was displayed from 18:42 to 19:00. This is indicated by the green bar at the end.

To view this particular message series in more detail, Figure 5 provides an improved scale.

In Figure 5, hypothetical vehicle trajectories have been annotated on the figure. A solid line style is used to show the trajectory for a vehicle expecting to experience “green” conditions and a dashed line for “yellow” conditions. The ODOT travel time estimates are instantaneous; that is the estimates are made based on the speeds available at the time the message is displayed (speed measurements in a vertical line for a particular time period). However, conditions on the freeway may vary after a vehicle has passed the DMS. The hypothetical trajectories show the speed conditions vehicles encountering DMS would experience, and thus it is possible to compare the message displayed to the traffic conditions experienced by drivers who viewed that message. This proves crucial, as it has been found while DMS are effective in travel time estimation during periods of free flow, the margin of error greatly increases with periods of congestion and large surges in traffic (6). Based on these extensions, it is clear that drivers experienced congestion after viewing the travel time messages on the Terwilliger VMS to I-205, with speeds slowing as low as 20 mph. As shown in Figure 5, the predicted travel time and the actual travel time experienced by the traveler do not match. The actual speeds experienced by the traveler can be seen in the region between the green bar and the arrows. The end point of the arrows indicates the end of the segment for which travel time was predicted.

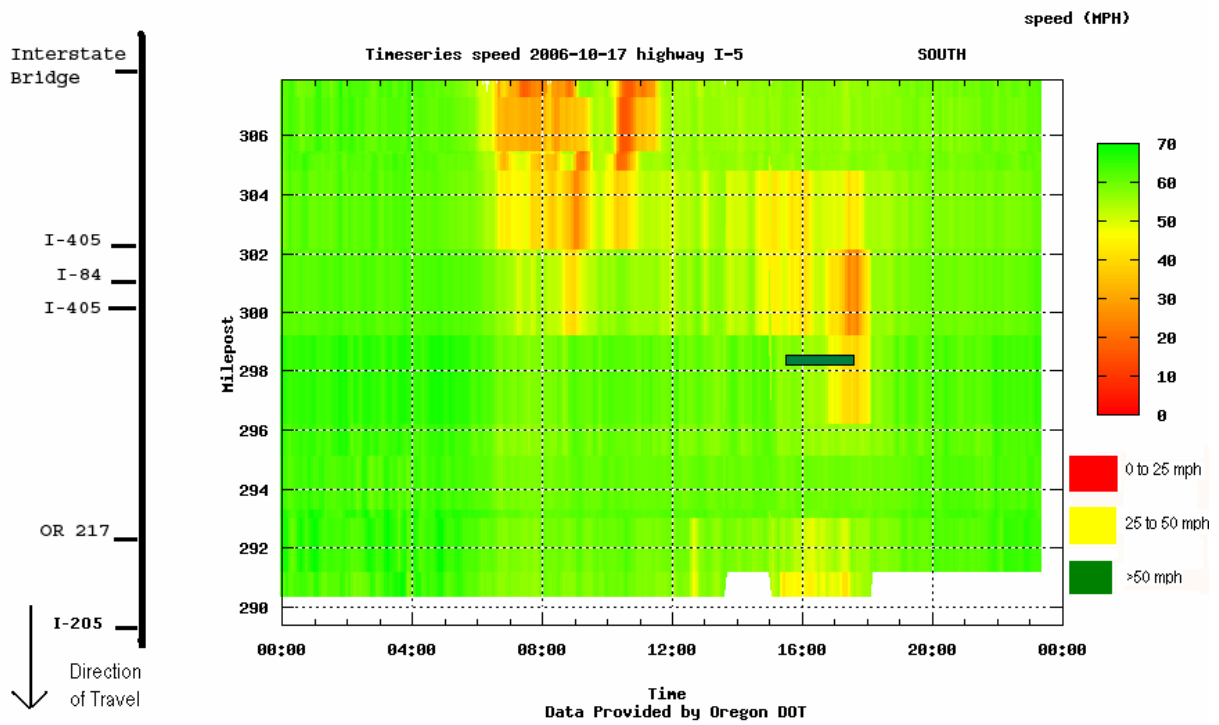


FIGURE 3 Speed contour plot, October 17, 2006, I-5 southbound, with travel time message

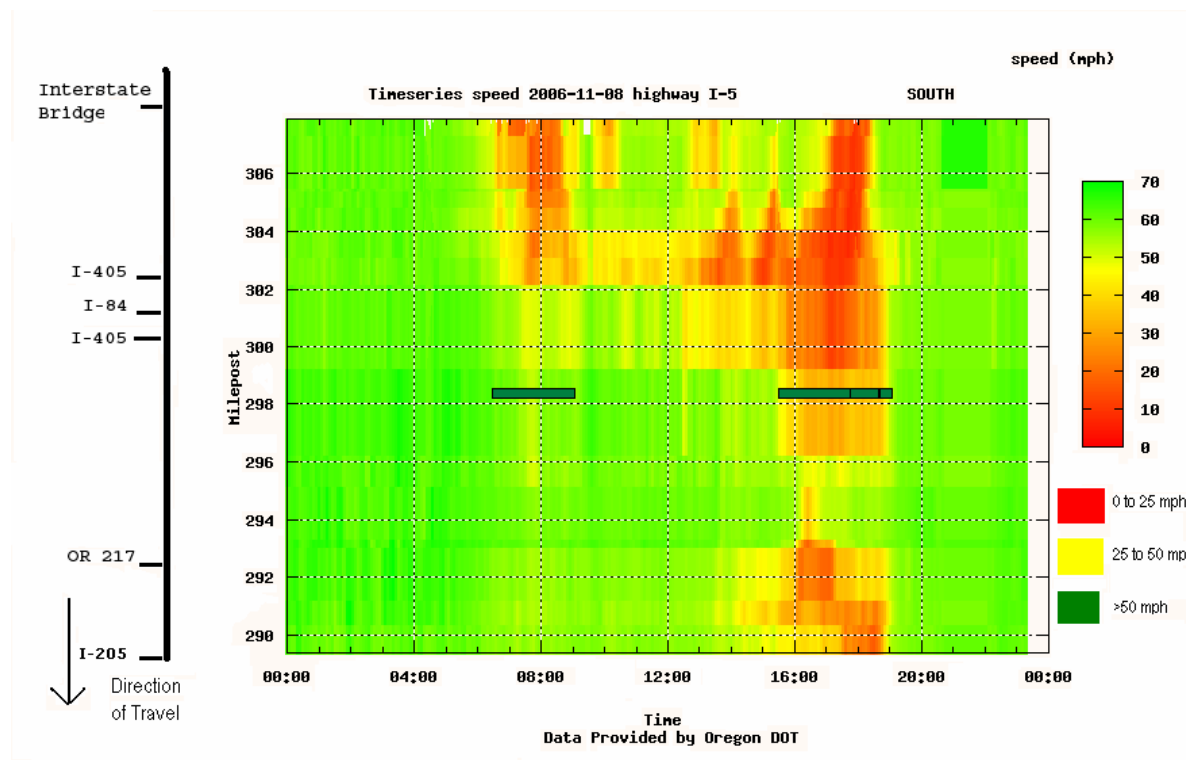


FIGURE 4 Speed contour plot, November 8, 2006, I-5 southbound, with travel time messages and extensions

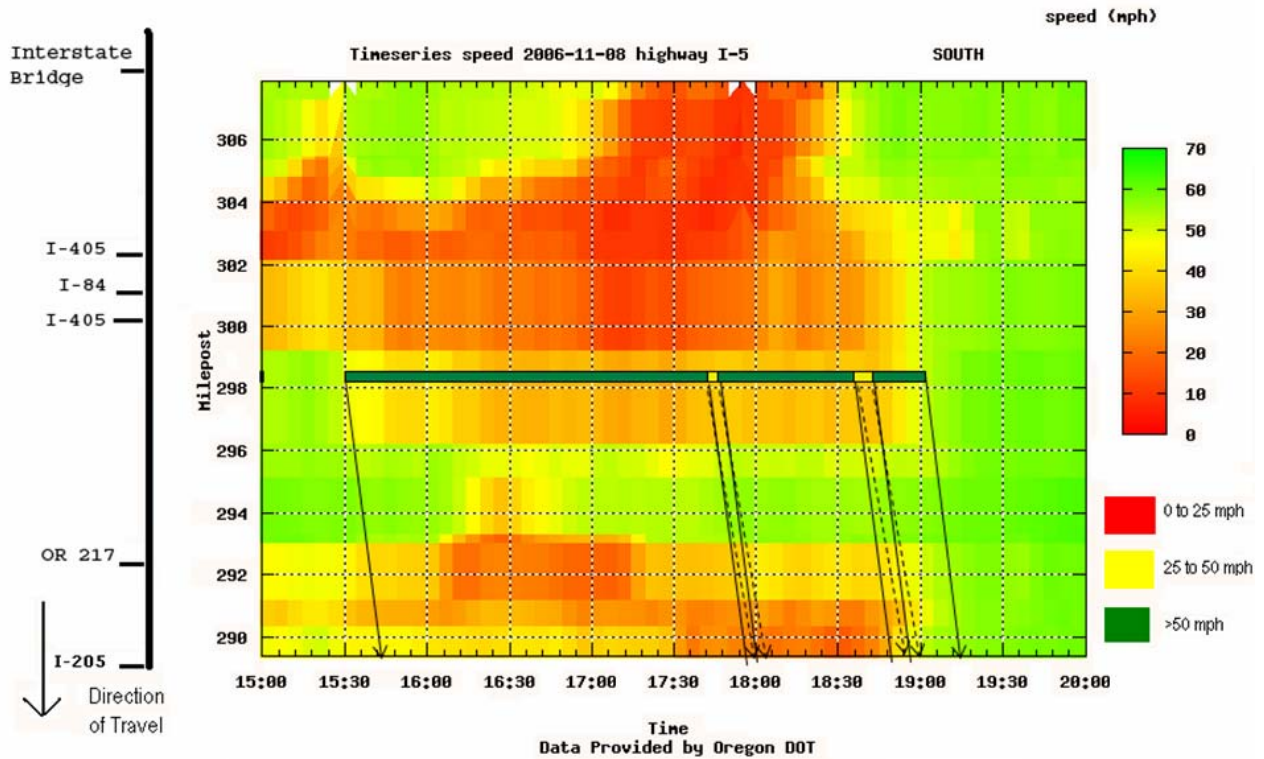


FIGURE 5 Speed contour plot, November 8, 2006, I-5 southbound, 3PM-8PM

Informational Messages

In addition to travel time message, a similar plotting method can be used to show other types of messages. As with the travel time messages, the sign id is translated into a milepost and highway id using a lookup table allowing the message to be located on the highway. Informational DMS messages are overlaid on the speed plot using a + sign which indicates the time and location of the displayed message. Figure 6 shows a sample speed plot for northbound I-5 on September 21, 2006 with 5 DMS messages overlaid on that particular plot. Each DMS message is identified with a number which serves as an index into a list of DMS messages that is displayed within PORTAL along with the plot. Table 5 shows the DMS messages that correspond to those displayed on the plot in Figure 6. The PORTAL data archive also includes data on incidents that can be shown on the same plot. These data add additional relevance to the speed contour plot as well as measurement of freeway performance.

TABLE 5 DMS Messages Displayed On September 21, 2006

SI No	Time Stamp	Milepost	Message Displayed on Sign Board
1	2006-09-21 05:59:20	298	Accident I-5 NB 3 min of I-84 Left Lane Closed
3	2006-09-21 10:43:54	291	Stall on I-5 NB 3 Miles Ahead Expect Delays
4	2006-09-21 16:51:42	305	Bridge Work Ahead Expect Loud Noises
5	2006-09-21 19:29:27	291	Road Work Right Lane Closed 5 Miles Ahead

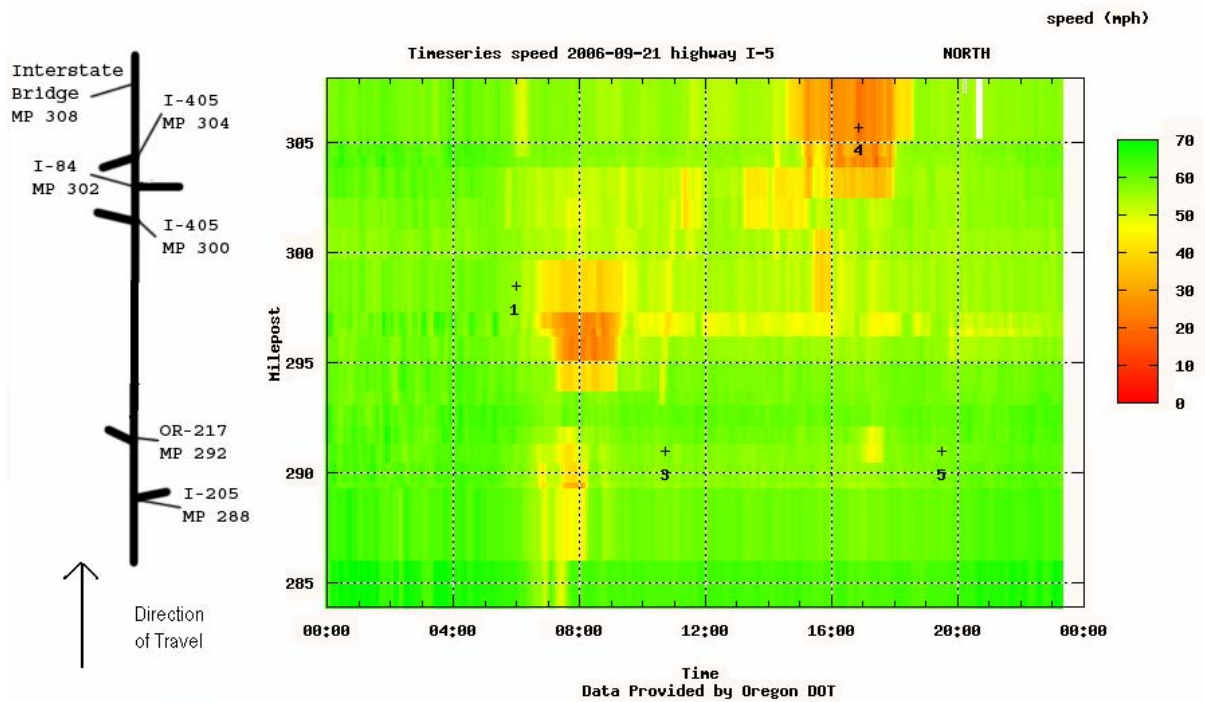


FIGURE 6 Speed contour plot, September 21, 2006, I-5 north, with location of messages in the time-space plane.

CONCLUSION

The development of a graphical display of DMS messages overlaid on speed contour plots has been described. In this display, travel time and informational DMS messages are plotted on highway speed plots. Travel time messages are shown as color-coded boxes and Information messages are marked with + signs. In both cases, the location and time of the message is indicated by the position of the box or marker on the speed plot. The maps are dynamically generated based on DMS messages stored in the database. While not as robust as probe vehicle comparison, overlaying travel time messages on speed plots provides a straightforward method for comparing DMS messages to actual freeway travel conditions.

In the future it is hoped that the ODOT ATMS system will be improved so that the export of DMS messages can be stored in the PORTAL database more readily. In addition, efforts are underway at present to transfer the DMS messages to PORTAL in real time which will facilitate an on-line tool for assessing DMS message accuracy by ODOT operations staff. This is only part of a comprehensive program to improve traffic operations on freeways and arterials in the Portland metropolitan region.

ACKNOWLEDGEMENTS

The authors acknowledge the Oregon Department of Transportation for providing the data and the National Science Foundation for funding under Grant No. 0236567.

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