Evolution and Usage of the Portal Data Archive

10-Year Retrospective

Kristin A. Tufte, Robert L. Bertini, and Morgan Harvey

The Portal transportation data archive (http://portal.its.pdx.edu/) was begun in June 2004 in collaboration with the Oregon Department of Transportation, with a single data source: freeway loop detector data. In 10 years, Portal has grown to contain approximately 3 TB of transportation-related data from a wide variety of systems and sources, including freeway data, arterial signal data, travel times from Bluetooth detection systems, transit data, and bicycle count data. Over its 10-year existence, Portal has expanded both in the type of data that it receives and in the geographic regions from which it gets data. This paper discusses the evolution of Portal. The paper describes the new data, new regions, and new systems that have been added and how those changes have affected the archive. The paper concludes with a section on the uses of Portal that provides several examples of how Portal data have been used by regional partners, with a focus on measuring the performance of the multimodal transportation system, but also including educational elements and research.

In the mid-1990s, the transportation community recognized the potential value of archiving and preserving data from intelligent transportation systems (ITS). The community realized that ITS data had many possible uses, including evaluation, planning, and performance measurement. In 1998, the FHWA issued an addendum to the ITS Program Plan describing the Archived Data User Service (ADUS) vision and communicating the need to collect, retain, and distribute ITS data (*1*). Portal was created in response to this need. In 2005, TransPort, the Portland, Oregon, regional coordinating committee for system management, adopted Portland State University (PSU) as the region's official archiving entity in the region's ITS architecture.

Portal is the official ADUS transportation data archive of the Portland, Oregon–Vancouver, Washington, metropolitan region (http://portal.its.pdx.edu/) and is housed at PSU. The archive began in 2004 with one freeway data feed from the Oregon Department of Transportation (DOT) and a limited number of transportation performance measurement tools. Today Portal contains data or data samples from all modes of transportation, including freeway speeds and volumes, arterial counts, arterial signal cycle data, Bluetooth arterial travel times, transit ridership and on-time performance, and bicycle and pedestrian counts. Portal is one of several existing transportation data archives (*2–4*) and it stands as one of the longest-running archives and is distinguished by being publicly funded and publicly available.

Portal now contains data from three regions of Oregon and Washington, including data from two arterial signal systems, travel times from two Bluetooth detection systems, transit performance data from a single automatic vehicle location (AVL) and automatic passenger counter (APC) system, and freeway data from two DOTs. All these data sources have standard import processes and are imported on a regular basis at their original high-temporal resolution. Work is in progress to add data from the new variable speed limit system in Portland, weigh-in-motion data, and a second transit system and to expand Portal beyond the Portland–Vancouver metropolitan area to include smaller metropolitan planning organizations (MPOs) and jurisdictions in the Northwest that are just beginning to add sensor-based data collection.

BACKGROUND

Three leading transportation data archives in the United States are iPeMS, RITIS, and DRIVENet. These data archives archive a wide variety of transportation data and provide varied performance measures and visualizations.

The IterisPeMS performance management system (iPeMS) is a commercial system for measuring and managing transportation networks (*2*). The iPeMS system provides performance metrics and visualizations for freeway, arterial, and transit data as well as archiving facilities for weigh-in-motion data and count data. Standard performance metrics including vehicle miles traveled, vehicle hours traveled, delay, level of service, and density are supported. Travel time, including arterial travel time, bottleneck identification, and detector health analysis are also supported as well as transit status and route-line analysis and incident data analysis.

The Regional Integrated Transportation Information System (RITIS) from the Center for Advanced Transportation Technology Laboratory at the University of Maryland (*3*) supports the I-95 Corridor Coalition by archiving data from freeways, transit, and arterial signals. Real-time data feeds, situational awareness tools, archive analysis tools, and data download are all supported. Data visualization and analysis tools are provided; however, these tools are available only to public safety or DOT employees. These tools allow users to analyze data and performance measures in the RITIS archive.

DRIVENet is the transportation data archive under development for the Washington State DOT by the STAR Lab at the University

K. A. Tufte, Department of Computer Science and Department of Civil and Environmental Engineering, and M. Harvey, Department of Civil and Environmental Engineering, Portland State University, P.O. Box 751, Portland, OR 97207-0751. R. L. Bertini, Department of Civil and Environmental Engineering, College of Engineering, California Polytechnic State University, Building 192, Room 301, San Luis Obisbo, CA 93407. Corresponding author: K. A. Tufte, tufte@pdx.edu.

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of Washington (*4*). DRIVENet provides real-time and historical data and is designed to store arterial, freeway, and related data. In addition, DRIVENet provides planning-level safety performance evaluation tools and an emissions map. The goals of DRIVENet are to gather data, facilitate scientific explorations in transportation research, and get data into the hands of researchers.

In addition, the University of Tokyo has proposed the development of ITDb, an international traffic database that would house openly available traffic data from a wide variety of countries (*5*).

PORTAL EVOLUTION

Since Portal's inception in 2004, the world of archiving transportation data has changed immensely. The sources, availability, and resolution of transportation data have significantly increased. Bluetooth travel time capture, relatively unheard of in 2004, is now commonplace. Transportation data sensing systems were mostly located in large MPOs; now smaller MPOs are adding sensing systems. Bicycle–pedestrian data collection was predominantly performed manually in 2004; now, automated bicycle–pedestrian detectors are being installed across the country. Even on freeways, where high-resolution data collection was common in 2004, high-definition radar (and other) sensors are now coming into favor and being added to or replacing existing loop detection systems. All of these changes have affected Portal in various ways. Additionally, new ventures such as Inrix are aggregating traffic data from multiple fixed-sensor and probe vehicle sources and packaging the results as travel time data.

From the beginning, Portal data have been used for a wide range of research, including projects related to freeway travel time estimation, incident response evaluation, bottleneck identification, congestion cost calculation, regional transportation system performance report production, and more. As the data available in Portal have expanded over the years, the uses have also expanded. This section covers sections of the Portal interface, discussing at each step how changes have affected the archive in the context of images from the interface. The following section describes usage of the Portal data. The interface discussion begins with the Portal home page.

Portal Home Page

Figure 1 shows the Portal home page as it was originally created in 2005 as well as the original Portal architecture diagram, while Figure 2 shows the current Portal home page (*6*). Both home pages prominently display a map or maps; however, the maps on the home page have changed in several ways.

Development of Portal's Own Map

The original Portal home page simply linked to the Oregon DOT trip check speed map (*7*). The original focus of Portal was on the Portland metropolitan region, under the auspices of Metro, a unique regionally elected government and also the MPO. Portal has since developed its own speed map, providing the ability to display current speeds as well as a comparison to average historical speeds. In Figure 2, the left-hand map shows current speeds; the right-hand map shows 15-min average speeds over the past 5 weekdays.

Geographic Expansion

Another key difference between the maps is that the new map includes the Vancouver region. In 2009, Portal expanded across the Columbia River to Vancouver. Vancouver is a somewhat smaller metropolitan region than Portland, but still sizeable and with an active transportation systems planning organization, Vancouver Area Smart Trek, and significant sensor infrastructure. The expansion to Vancouver had several impacts, a primary one being the need to integrate data from multiple systems. Before the addition of Vancouver data, Portal had one source of freeway data, one source of arterial signal data, and so forth. With the expansion to Vancouver, Portal needed to incorporate data from multiple systems, beginning with combining Vancouver freeway data from the Washington State DOT with the existing Oregon DOT data feed. There were several details that affected the archive:

1. The Washington State DOT feed structure is different from the Oregon DOT feed structure.

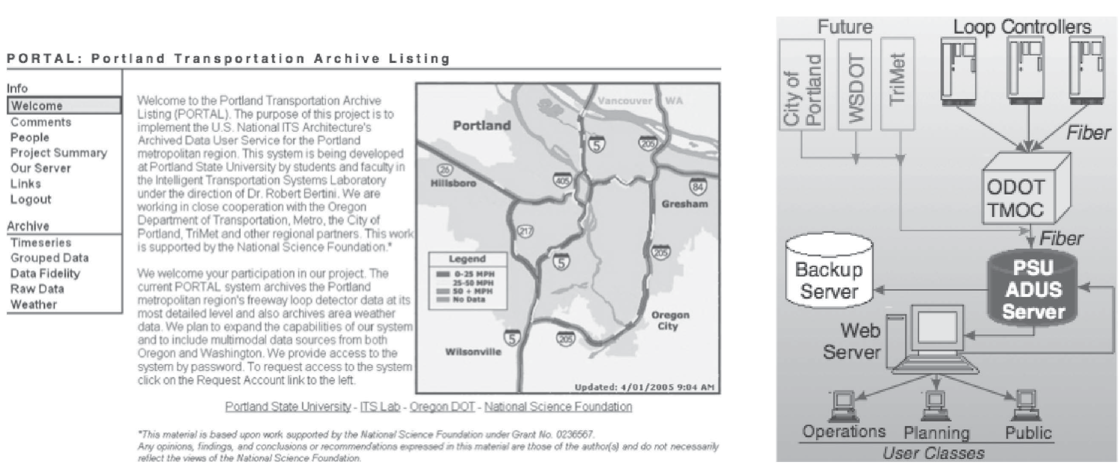


FIGURE 1 Portal home page and system architecture in 2005 (WSDOT = Washington State DOT; ODOT = Oregon Department of Transportation; TMOC = transportation management operations center).

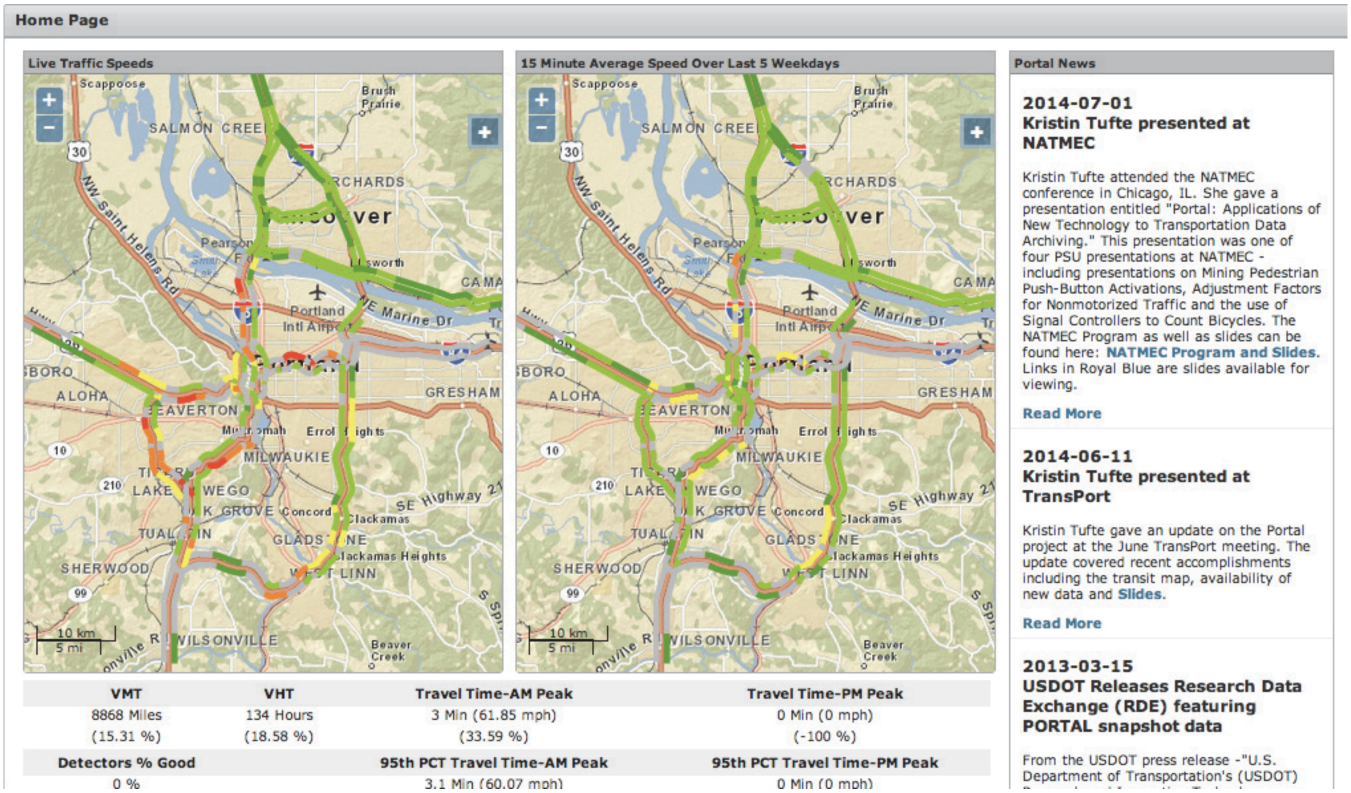


FIGURE 2 Current Portal home page (VMT = vehicles miles traveled; VHT = vehicle hours traveled; PCT = percentile).

2. The Washington State DOT identifies its detectors with strings; the Oregon DOT uses integers.
3. The Washington State DOT originally did not have a 20-s feed (only lower granularity); this feed was added for compatibility with the Oregon DOT data feed.

These differences between feed structure and detector identification were resolved with software and database system meta-data changes. There are at least two broad categories of data integration in transportation systems: first, integrating data from different types of data sources, such as integrating arterial travel time data, transit data, and freeway travel time data, to get a picture of corridor performance; second, integrating "similar" data from multiple systems, such as integrating freeway speed, volume, occupancy data from the Oregon DOT and the Washington State DOT systems, as in the example above. Both types of integration are difficult and this type of integration is the subject of current research at PSU (*8*).

New Oregon Sensors and New Type of Sensing

The Portland region has recently implemented two active traffic management (ATM) projects. These projects were activated in summer 2014 and are described in the section on the uses of Portal. As a part of these systems, approximately 100 new detectors have been installed in the Portland region. There were two significant impacts of the addition of these detectors: segment length changes and having a mix of detector types.

Adding new detectors in the Portland region caused the segment sizes to shrink. Freeway segments associated with detectors changed; the database now needs to handle multiple segment lengths for each station. This support is important to allow consistent comparisons with historical data. The smaller segments can be seen in Figure 2.

The Vancouver region has inductive loop detectors and high-definition radar detectors (Wavetronix) on its freeways. Originally, the Portland area used only inductive loops on its freeways. However, with the addition of the sensors for the ATM projects, which are high-definition radar devices (Wavetronix), Portland now has a mix of sensor types. The impact of mixing data from high-definition radar and loops, which have different sensing characteristics, is unknown and a subject for future research.

New Oregon Data Feed

The Oregon DOT is centralizing data collection into a new data acquisition module (DAC). With this centralization, the Portland freeway data feed has switched from a one-off feed from a single Oregon DOT region to a feed from the DAC. Data from Central Lane County, Oregon, MPO have also been recently added to Portal. Central Lane is a smaller MPO than Portland or Vancouver and thus has a far less well-established sensor infrastructure. Adding data from Central Lane County to Portal was relatively easy because the Oregon DOT had already centralized the data collection through the DAC.

Portal Highways

The original Portal had time series and heat map plots for freeway data. A user could choose the location, lanes, date, time frame, and from seven basic measured or calculated quantities, including count, speed, occupancy, travel time, delay, vehicle miles traveled, and vehicle hours traveled. The original time series plots remain but have been expanded to show two quantities at a time and, in addition, a number of new selectors and download options have been added. Figure 3 shows an original time series volume plot from Portal in 2005; Figure 4 shows the updated version of this plot, including volume and speed, from Portal in 2014. The new system takes advantage of more modern web tools such that hovering with a cursor over the traffic parameter plot reveals the actual value of the curve at that time. Based on user input, the ability to select data based on day of week and the ability to directly navigate to upstream, downstream, and opposite direction stations have been added to the interface (*9*).

Users have the ability to download the data associated with a plot. The idea is for the user to browse through the data, looking for days and times of interest, and then, with a click of a button, download the data for those selections. This ability was first captured in the "generate csv" button in the original Portal interface and continues as the "download data" button in the latest interface. A "download all data" button has been added, which downloads lane-by-lane and ramp data for the selected location and dates. This new button is useful for the bottleneck analysis example discussed in the section on the uses of Portal.

Portal Arterial

In 2005, Portal contained no arterial data; currently Portal contains a variety of arterial data including data from the Clark County, Washington, Wavetronix Signal System, the City of Portland TransSuite Central Signal System, and Bluetooth travel time data from both the City of Portland Bluetooth and the Oregon DOT. Obtaining data from arterial signal systems has been a greater challenge than obtaining data from the state DOT freeway systems, perhaps because the freeway systems were already designed to produce data feeds for speed maps.

Portal currently receives, on a regular, automated basis, Bluetooth travel time data from the City of Portland and the Oregon DOT (Figure 5), the Clark County Wavetronix Signal System (Figure 6), and the City of Portland TransSuite Central Signal System. While all of these feeds are automated and automatically loaded into the Portal database, the four feeds differ in format and transfer mechanism. For Wavetronix, the system receives an automated report dumped once a day and transferred to Portal by file transfer protocol; work is in progress to convert this to an automatic XML feed. TransSuite generates hourly data files, which are transferred to Portal by file transfer protocol. Portal receives and archives a wide variety of data from TransSuite from system count detector data to the measure of effectiveness logs. The system count detector data are visualized in the interface; the other data are archived and work is in progress to develop visualizations.

Bluetooth data are received from the City of Portland and the Oregon DOT. The city sends files of readings on a weekly basis, and matching is done at PSU. The Oregon DOT sends travel time traversals over a real-time XML feed. The Portal arterial multimodal framework is described in a separate paper (*10*).

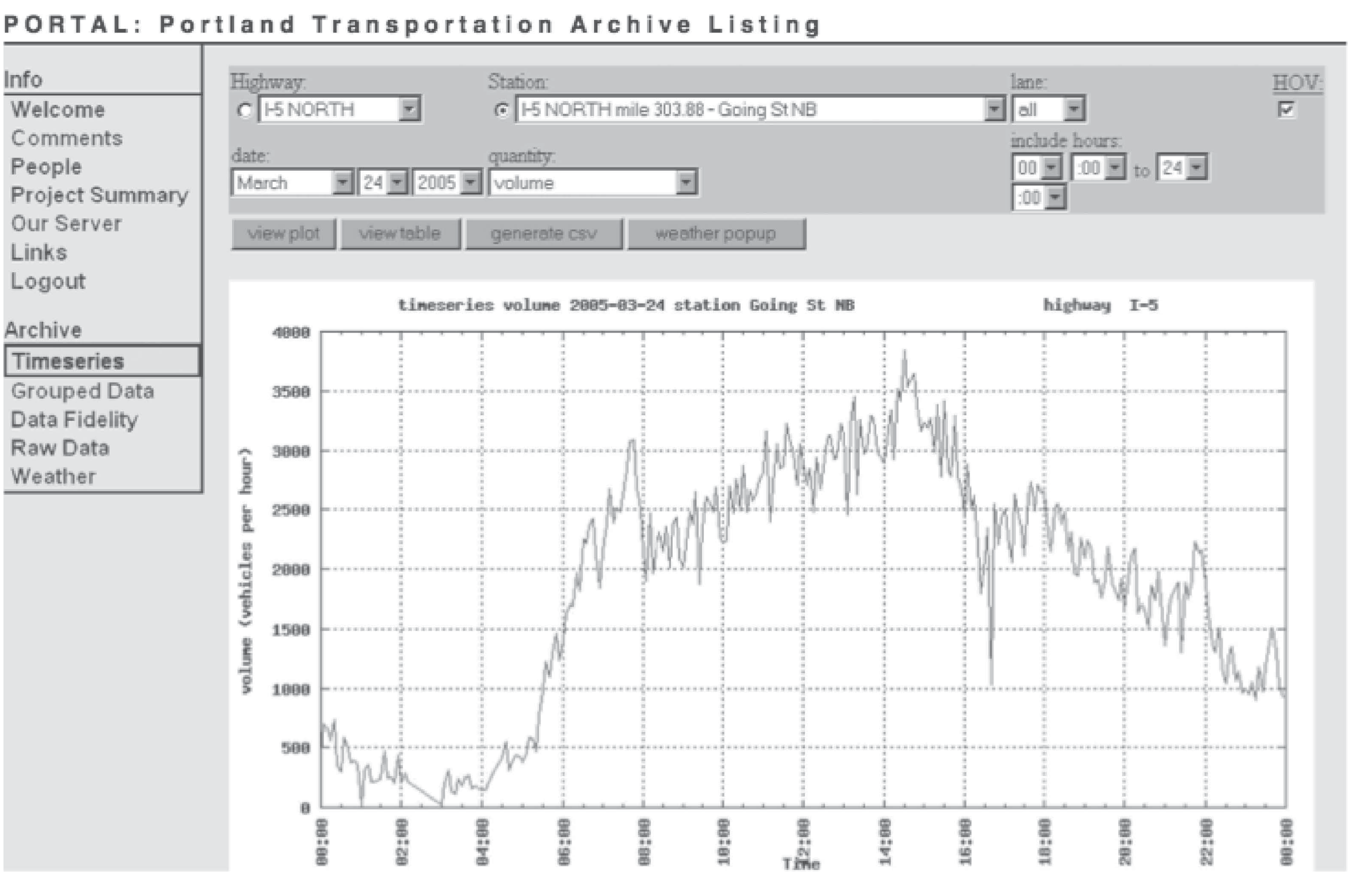


FIGURE 3 Time series volume plot from the original Portal in 2005.

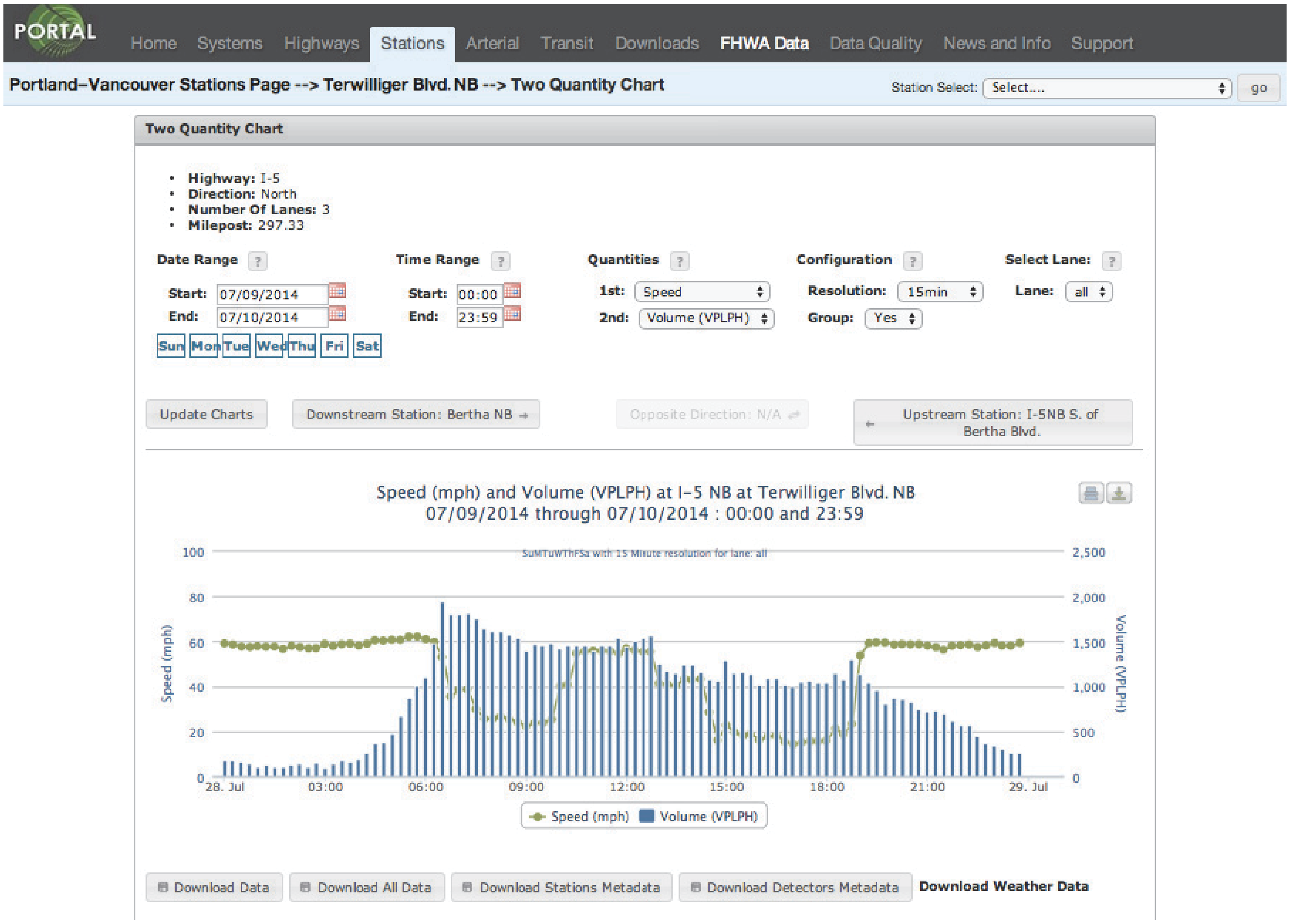


FIGURE 4 Updated time series speed and volume plot from Portal in 2014 (blvd. = boulevard; NB = northbound; S. = south; VPLPH = volume per lane per hour).

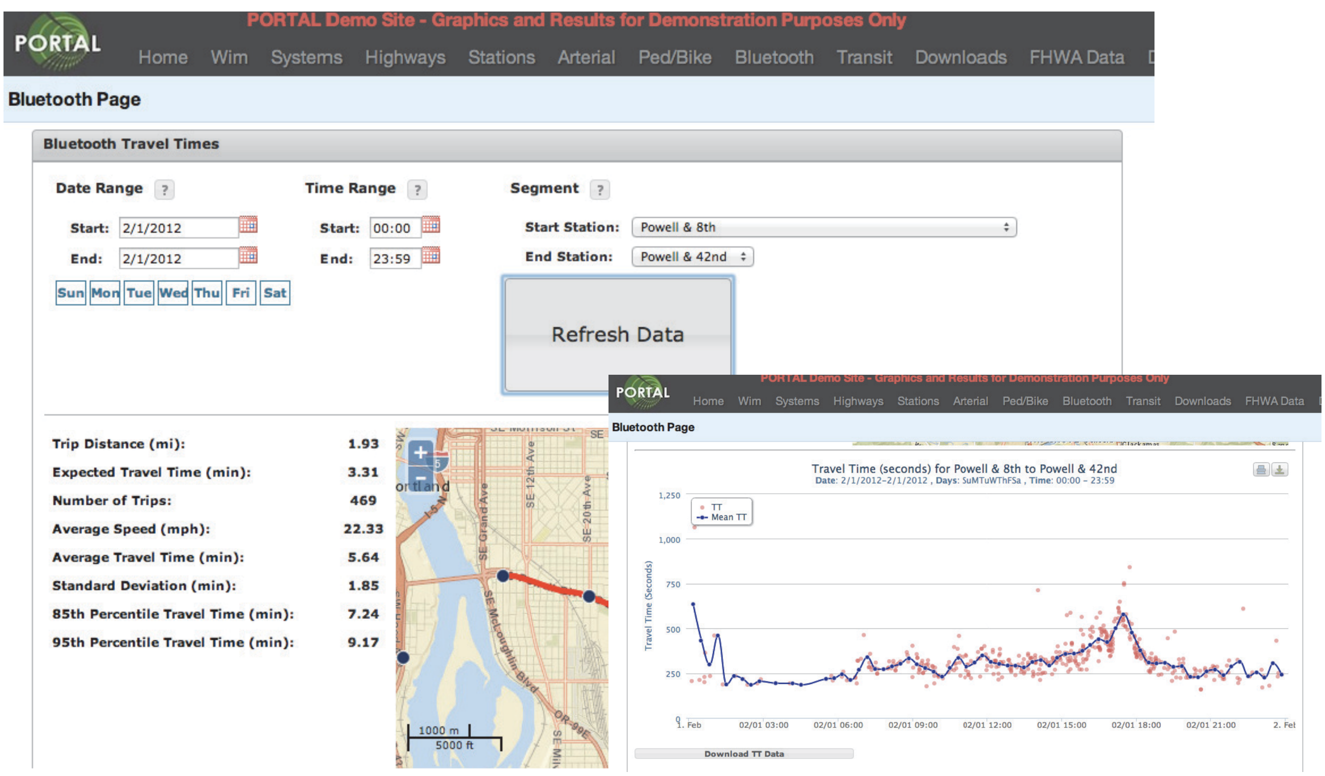


FIGURE 5 Bluetooth map and plots (Wim = weigh in motion).

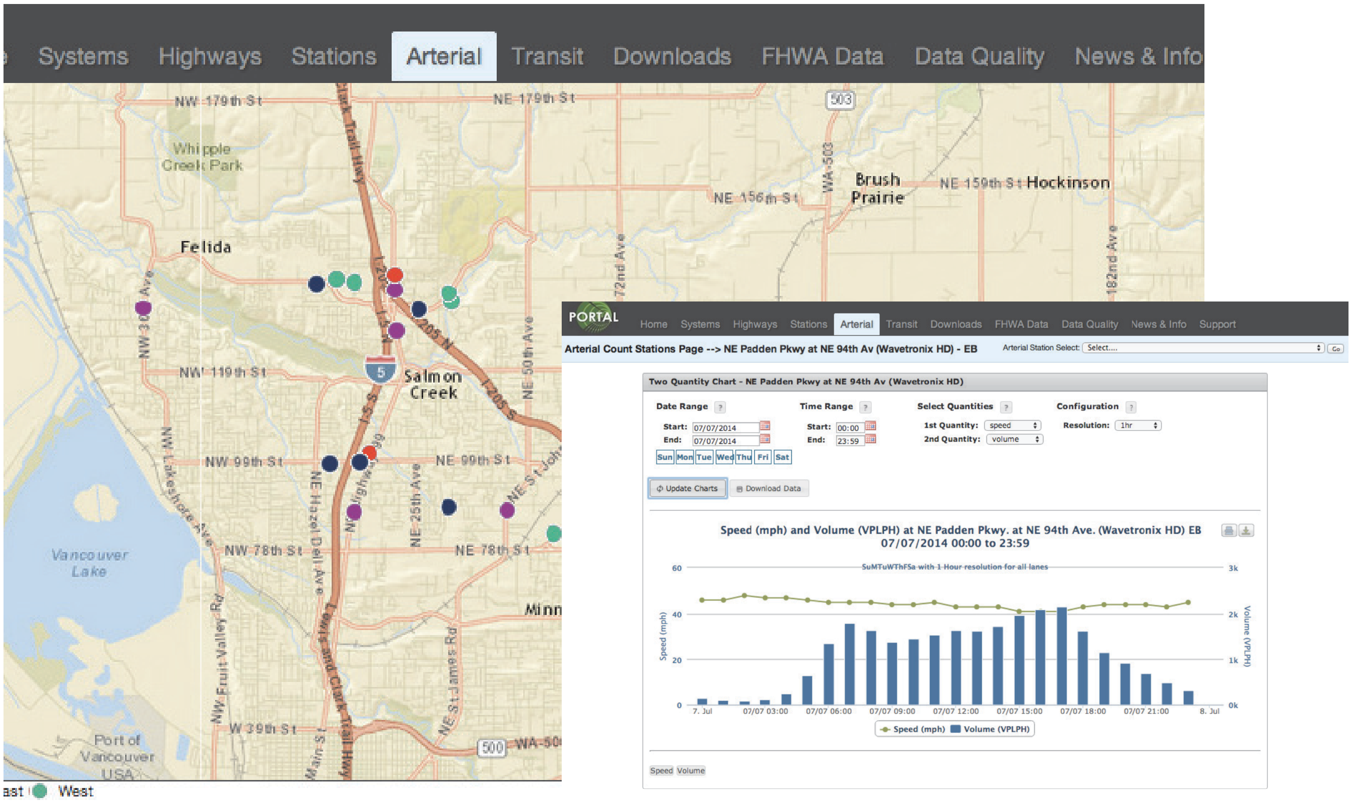
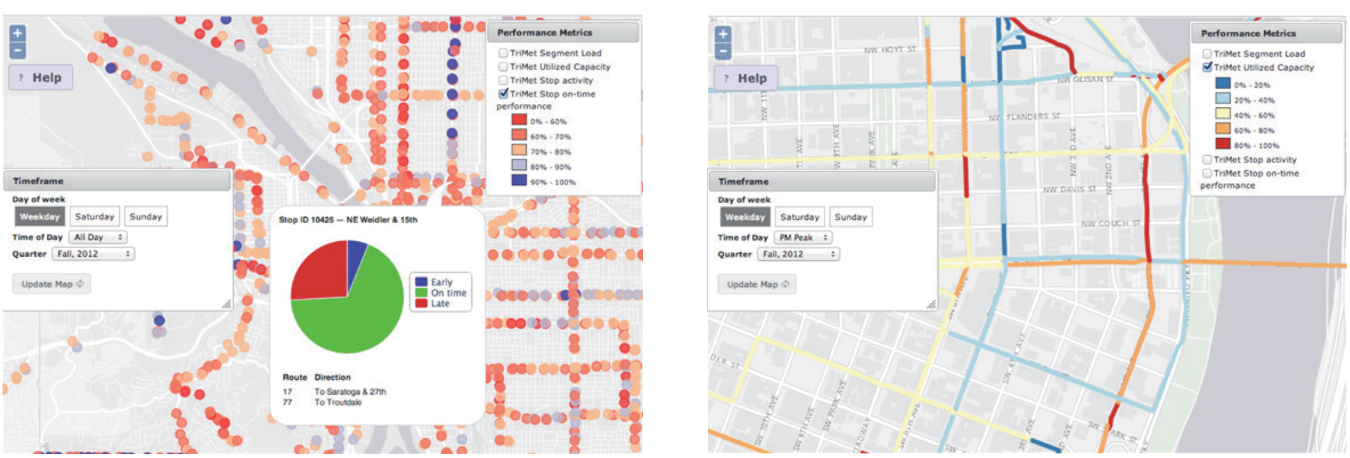


FIGURE 6 Clark County arterial Wavetronix stations and single-day speed–volume plot.

Portal Transit

Portal has also expanded to include transit data. Portal currently receives quarterly passenger census and on-time performance data from TriMet (Figure 7*a*). These data are obtained from TriMet's AVL and APC systems. TriMet creates quarterly summaries from these data, which are provided to Portal. Portal combines these quarterly summaries with schedule information from TriMet's general transit feed specification (GTFS) data. The GTFS is a feed specification promoted by Google, which supports transit schedule and real-time information.

In 2013, a new transit interface was added using the above data (*11*). A key feature of this interface is the ability to produce segment-based maps for transit metrics. The latest version of this map, showing the recently added utilized capacity metric, is in Figure 7*b*. While Portal currently receives transit data from only one agency, TriMet,



(a) (b)

FIGURE 7 TriMet data: (*a*) transit weekday on-time performance and (*b*) utilized capacity.

work is in progress to load data from C-TRAN, the Vancouver transit agency. C-TRAN produces GTFS data and uses the same underlying AVL and APC systems as TriMet.

USES OF PORTAL

Portal is a resource for researchers, practitioners, and even the media. As one measure, there are 93 citations in Google Scholar for portal.its.pdx.edu. This section describes a series of uses of Portal. Each subsection describes a specific documented use of the Portal data, ranging from its use in design of ATM projects to its uses in education, performance measurement, and research.

Advanced Traffic and Incident Management Project Development

The Portland metropolitan region has recently implemented two ATM projects: one on the OR-217 freeway and one in downtown Portland on I-5 and I-405. These projects, which were activated in June 2014, have added a variable advisory speed (VAS) system and variable message signs (VMSs) to display travel times and queue warning messages. The OR-217 system also includes a weather-activated component and a curve warning system. OR-217 is a short three-lane, 7-mi ring connector that connects US-26 and I-5; it has many interchanges and is highly congested. I-5 is the main north–south route through Portland, I-405 is a short 4-mi bypass segment around downtown Portland; and I-405 and I-5 make a loop around Portland and the segments are also highly congested.

In the early planning stages of the OR-217 ATM project, Portal data were used to produce congestion plots to identify the location and activation times of bottlenecks on the system (*12*). An example of such a plot for southbound OR-217 is shown in Figure 8. This figure shows three congestion plots: one each for Tuesdays, Wednesdays, and Thursdays in June 2009. All three plots show a primary bottleneck approximately midway through OR-217, caused by merging and lane changing. The Thursday plot, bottom in the figure, shows the activation of a secondary bottleneck caused by the merge of southbound OR-217 with southbound I-5.

Further on in the design and analysis process, Portal data were used to depict examples of various scenarios using real-world data. Portal data allowed the analysts to step through the day and show how VMS signs and VAS systems would change in response to the traffic conditions, for example, stepping down the advisory speed for traffic approaching a bottleneck. Figure 9 shows an example of

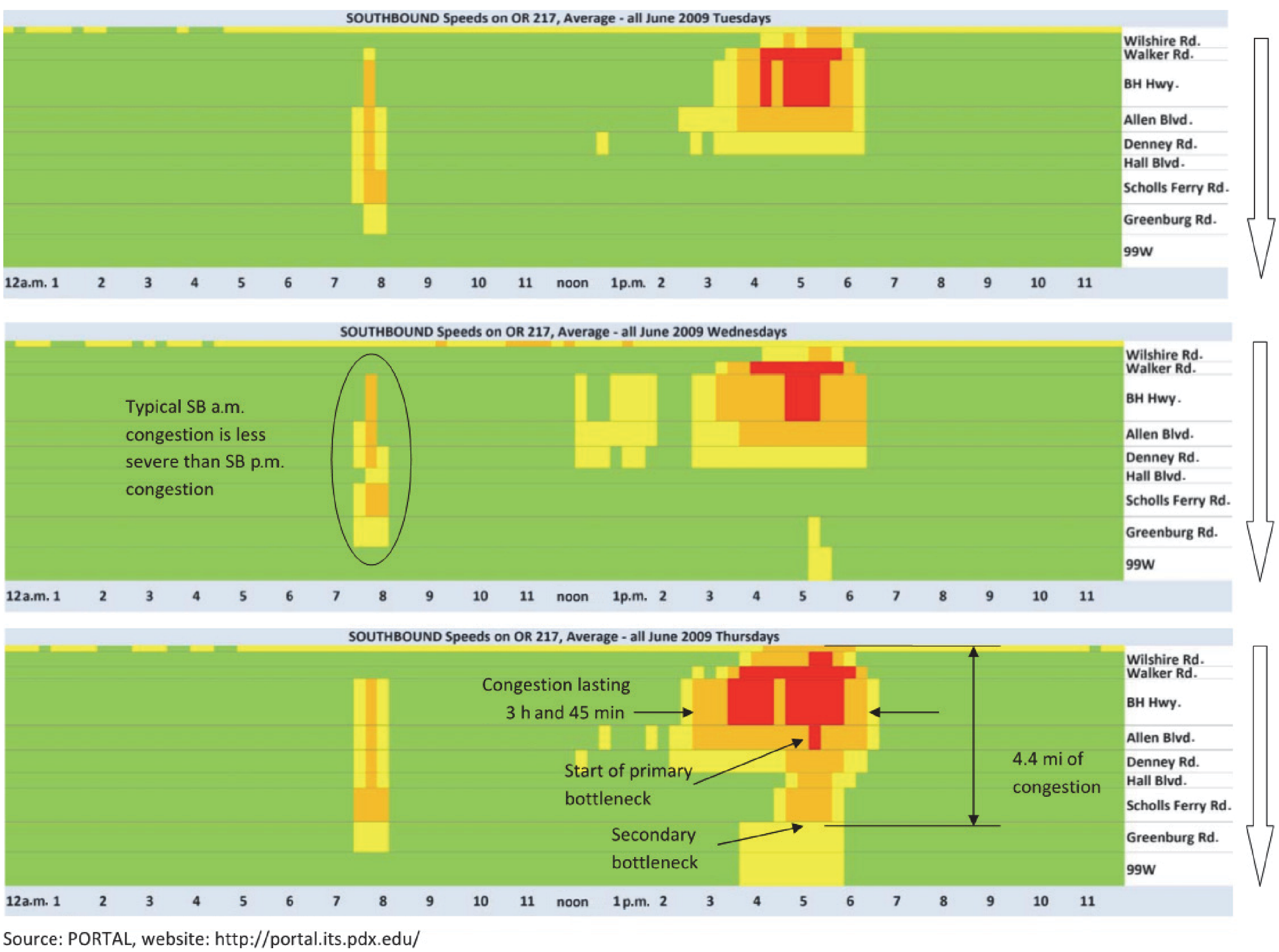
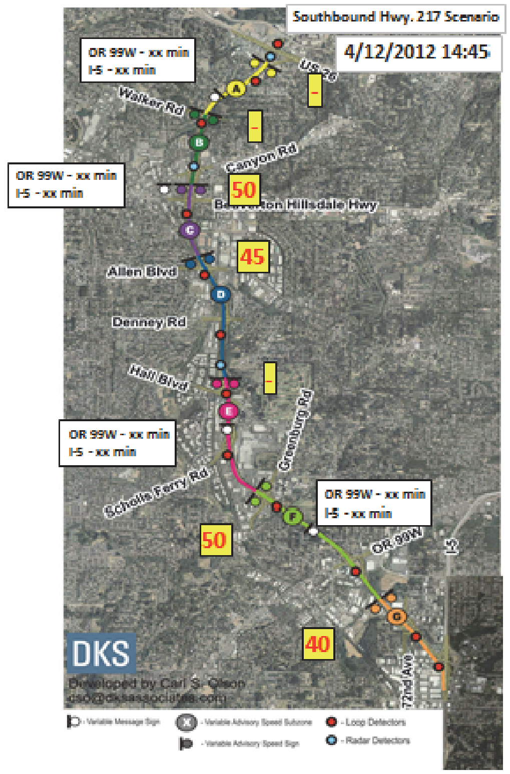


FIGURE 8 Southbound OR-217 congestion plot. (Source: Jennifer Bachman, DKS Associates.)

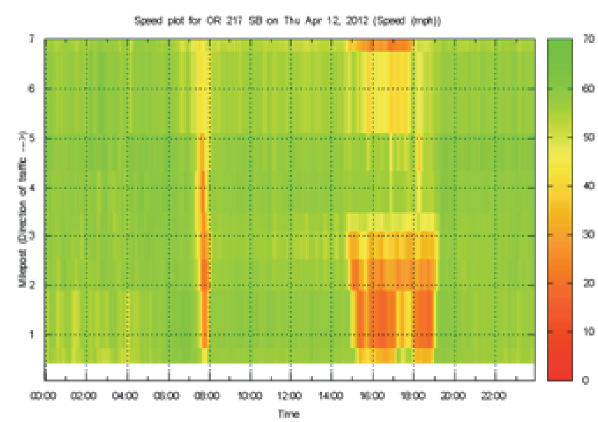
SOUTHBOUND	MPH Step	Distance	VAS Location	Detection Type	Inside Lane Speed	Outside/Center Lane Speed	Outside Lane Speed (if 3 lanes)	Crash Severity (Low = 1, Med = 2, High = 3)
	5	0.73	US 26	Loop	58	53	53	0
			Walker Rd.	Loop	58	59	54	0
	5	0.67		Radar	55	55		0
	5	0.89	BH Hwy.	Loop	60	53		0
			Allen Blvd.	Loop	51	42		0
				Loop	42	35		0
	10	1.36		Radar	55	55		0
			Hall Blvd.	Loop	61	54		0
	5	1.11		Loop	60	54		0
			Greenburg	Loop	56	53		0
	10	1.39		Loop	55	55		0
			72nd Ave.	Loop	56	52	47	0
				Loop	32	43		0



Date/Time	4/12/2012 14:45
Row La	**Average of Speed**
1081	31.6
1082	43.2
1551	57.5
1552	59.4
1553	54.4
1559	60.3
1560	53.3
1566	51.3
1567	42.1
1573	41.6
1574	34.9
1580	60.6
1581	53.8
1587	60.4
1588	54.0
1594	56.0
1595	52.8
1608	56.1
1609	51.9
1610	47.1
1789	57.7
1790	52.7
1791	53.3
1813	42.4
1814	40.1
Grand Tota	**50.7**

Minimum Slow Speed
25

Speed	Message
0	Slow
5	Slow
10	Slow
15	Slow
20	Slow
25	30
30	35
35	40
40	45
45	50
50	-



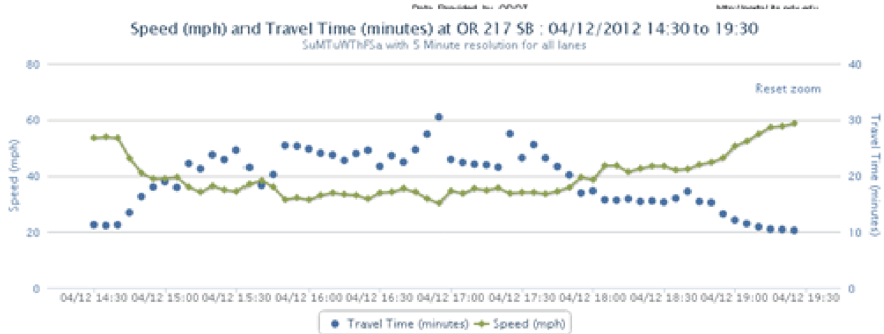


FIGURE 9 OR-217 ATM scenario using Portal data. (Source: Carl S. Olson, DKS Associates.)

a scenario from the OR-217 ATM project. The map in the middle of Figure 9 shows what VAS and VMS messages would be displayed for a given set of conditions. The yellow signs with red lettering represent VAS signs; the white signs with black lettering represent the VMS. Tables showing speed detail by lane and location are shown on either side of the map. Below the map are two plots, a congestion plot as described above and a speed–volume plot captured from the Portal website. Without the availability of the Portal system, it would have been difficult for designers to match the ATM components with the actual traffic features occurring on the ground.

Portal data were used in a similar fashion for the I-5/I-405 advanced traffic and incident management project, but looking at specific locations instead of the entire corridor. This project investigated and designed variable speed signs to help reduce congestion and incidents on the I-5 and I-405 freeways, which traverse downtown Portland. By using the Portal data, analysts were able to simulate how the VAS system would work by using various algorithms and thresholds. They were able to step through each day and show how each algorithm would set the variable speed limits based on the traffic conditions throughout the day.

Connecting the Loop: From Research to Planning to Implementation to Evaluation

The ATM projects also connect the loop from research done with Portal data to a design performed with Portal data, to an implementation that is just going live in the Portland area, to an evaluation of that implementation. In 2007 a study was done on travel time estimation for the Portland area (*13*). When the freeway data collection infrastructure was originally installed, detectors were placed adjacent to each on-ramp, resulting in large sections of freeway without detection. The 2007 study used Portal data and probe vehicle data to evaluate the accuracy of travel time estimation for Portland-area freeways and concluded that addition of detectors, particularly in the long sections without detection (especially those that are also highly congested), was required for the display of accurate travel times. In part in response to this study and as part of the development of ATM and advanced traffic and incident management systems, detectors were recently installed at approximately 100 new locations in the Portland metropolitan area. In conjunction with the previously installed detectors, these new detectors feed the new travel time, queue warning, and variable speed signs. These new detectors dramatically improve Oregon DOT's ability to compute and report travel times over freeway segments to users by VMS and other means.

This process is now continuing through a comprehensive evaluation process. A VAS system was recently activated on OR-217 in Portland, one of the most congested freeways in the state. The corridor is now the subject of a "before and after" evaluation study to determine what effects the system has on both the performance and safety of OR-217, and Portal data play a very important role in this study. Two key areas of interest for the evaluation are distribution of speeds and flows between adjacent lanes and travel time reliability. Currently, a large speed differential between lanes often exists, incentivizing excessive and unnecessary lane changing, which in turn leads to poor corridor performance. Additionally, travel times are highly unreliable during peak demand times, with significant gaps existing between 95th percentile and average travel times. The VAS system is intended to help mitigate both of these issues, and the 20-s loop and radar detector data fed into Portal will allow for direct analysis of these values before and after the system is turned on. Weather and incident data provided by Portal will also be a valuable resource for the evaluation.

Educational Use

The Portal data are used in several courses at PSU.

Cloud Data Management

The Portal data were used as the basis of a project in a cloud data management class at PSU (*14*). In this class, students used a 2-month set of freeway loop detector data to calculate several travel time measures over that data using a cloud data management system of their choice. Having this data set available allowed the students to get invaluable experience implementing a realistic application in an existing cloud system. The data and documentation used for the project was from a data capture project done by PSU for the U.S. DOT Real-Time Data Capture and Management Program (*15, 16*).

Civil and Environmental Engineering Curriculum

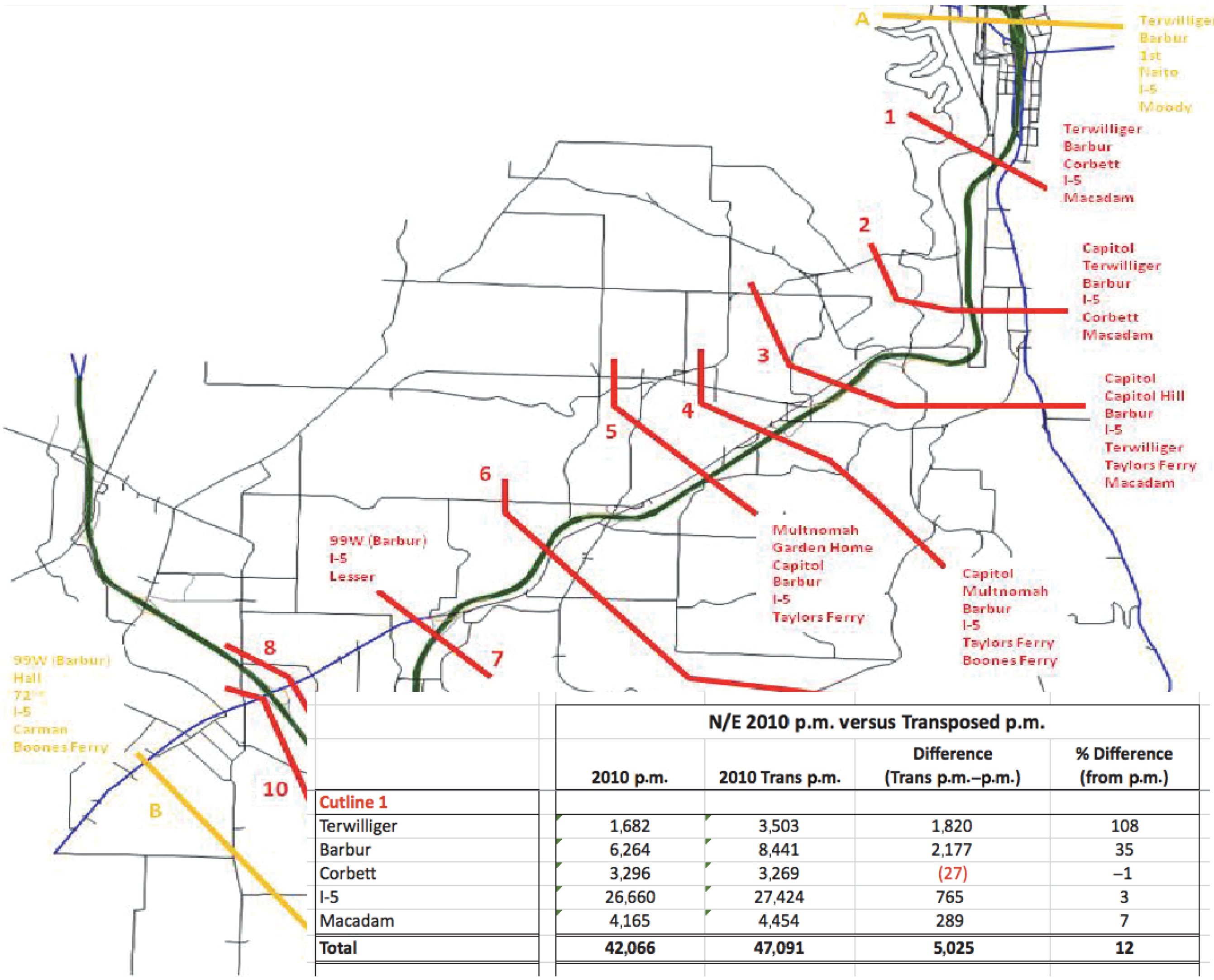
The Portal data are used in several lectures on performance measures and are the focus of a homework assignment in the required undergraduate transportation course, Urban Transportation Systems, at PSU (*17*). In the homework, students select and analyze the detector data to reinforce traffic flow theory concepts. In a graduate-level course, Introduction to Multimodal Transportation Engineering Data Analysis, a book, *Understanding and Communicating Multimodal Transportation Data,* was written using the Portal data and the course is based on that book (*18*). In the course, the students complete a project that requires data preparation, analysis, and report production. The availability of the Portal data makes such a course project possible.

Agency Performance Reporting

Portal data are used to calculate average annual travel reliability for Portland-area freeways for the *Metro Performance Measures Report*, which is produced every other year (*19*). In particular, the Portal data are used to populate a table that shows peak period travel time reliability for Portland area travel corridors. Measures provided include average travel time for each corridor and average congested travel time. In addition, the Vancouver region has plans to incorporate Portal data into their congestion management process reports.

Travel Model Usage: Base-Year Network Assignments for Travel Demand Modeling

The Metro Transportation Research and Modeling Services section uses Portal data when validating base-year network assignments for its travel demand model. Portal freeway count data are typically used in conjunction with arterial count data (usually collected by pneumatic tubes by the local jurisdictions). The counts are analyzed as



	N/E 2010 p.m. versus Transposed p.m.			
	2010 p.m.	2010 Trans p.m.	Difference (Trans p.m.–p.m.)	% Difference (from p.m.)
Cutline 1				
Terwilliger	1,682	3,503	1,820	108
Barbur	6,264	8,441	2,177	35
Corbett	3,296	3,269	(27)	–1
I-5	26,660	27,424	765	3
Macadam	4,165	4,454	289	7
Total	**42,066**	**47,091**	**5,025**	**12**

FIGURE 10 Cutline analysis for traffic demand modeling (N/E = northeast; trans = transposed). (Source: Peter Bosa, Metro.)

cutlines so as to look at the total movement of traffic across multiple parallel facilities to ensure that the overall magnitude and direction of flow through an entire corridor is correct. Figure 10 shows an example of the cutlines for I-5 northbound and associated data for one cutline that is an example of the type of data and analysis used to validate a travel demand model run. Portal data are also occasionally used to help develop traffic flow models for some of the section's more advanced modeling tools.

Oregon DOT Bottleneck Analysis

Corridor Bottleneck Operations Study

The Oregon DOT undertook the Corridor Bottleneck Operations Study in 2009 to identify recurring congestion chokepoints and to seek operational and low-cost "fixes" at spot-specific locations. The study methodology relied on Portal freeway data to make an initial screening for bottlenecks. Ultimately, the project identified and prioritized investments of less than $20 million (per location) that offered mobility and safety benefits. In 2013, the Oregon DOT published Project Atlas: Corridor Bottleneck Operations Study with detailed information about all 21 recommended investments that emerged from the study (*20*).

Bottleneck Analysis

Analysts at the Oregon DOT regularly use Portal data to evaluate and diagnose bottleneck locations, in conjunction with the dynamic ramp metering system that is in place. The analysts retrieve lane-by-lane ramp volume and main-line speed and volume data from Portal. These data are used to help understand how congestion affects flow and throughput as well as speed.

Summary of Uses of Portal

In its 10-year existence, Portal has been used for research, education, analysis, project development, and much more. Included in this section was a selection of recent uses of Portal that demonstrate the variety and depth of usage of the archive data.

CONCLUSION

The Portal transportation data archive was created 10 years ago in response to a forward-looking vision for archiving ITS data, including operational data. The vision was that these data would be useful for planning, analysis, and research. The paper describes how Portal has changed over the years and gives examples of how Portal has been used for project planning, research, performance measurement, and analysis. Over the next years, Portal is expected to continue to expand geographically; work is already in progress to expand to additional smaller MPOs in Oregon. In addition, the types of data housed in Portal are expected to grow as well as the diversity of sources and systems from which the data are derived; work is also in progress on this expansion. Finally, particularly with the advent of MAP-21 (Moving Ahead for Progress in the 21st Century), which was signed into law in July 2012, it is expected that Portal and its data will be increasingly used as a basis for performance measurement.

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