

Experience Implementing a User Service for Archived Intelligent Transportation Systems Data

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In cooperation with the Oregon Department of Transportation (ODOT) and other regional partners, the Portland regional intelligent transportation systems (ITSs) data archive was recently inaugurated via a direct fiber-optic connection between ODOT and Portland State University (PSU). In July 2004, the Portland Regional Transportation Archive Listing was activated; it received 20-s data from the 436 inductive loop detectors composing the Portland area's advanced traffic management system. PSU is designated as the region's official data archiving entity, consistent with the ITS architecture being developed. This paper discusses the steps taken for successful implementation of the Portland region's functional ITS data archive and plans for development and expansion. Included is a discussion of the archive structure, data storage, data processing, and user interface. An experiment involving Metro, the Portland region's metropolitan planning organization, demonstrates that archived loop detector data can be used to improve travel demand forecasts for the Portland region. The data archive will expand to include transit data, freeway incident data, city traffic signal data, and truck weigh-in-motion data.

Data archiving for intelligent transportation systems (ITSs) refers to the systematic retention and reuse of operational ITS data. Though the original and primary purpose of generating these data is often for real-time management of transportation systems, archiving these otherwise discarded data offers a rich source of information to various entities and agencies with a heightening need to evaluate system performance and characteristics on a continuing basis (1). Once retained, the vast amount of ITS-generated data can be used in transportation planning, administration, and research by key stakeholders including metropolitan planning organizations (MPOs), state transportation planners, traffic management operators, transit operators, and transportation researchers (2).

ITS data may be used to supplement or replace conventional data sources that are both time consuming and costly to implement, and the high level of spatial and temporal detail found in ITS-generated data lends itself to novel methods of analysis (2). Cost-effectiveness of the existing data collection infrastructure is maximized, sampling bias is reduced as a result of the continuous collection of data, and a better understanding of variability in system performance and response can be achieved (2). For example, transportation agencies

often invest large sums in manual traffic count programs that collect data at a limited number of sites on only a few days per year. In contrast, often ITS data are available at multiple locations on a 24-h basis, 365 days a year. The key challenge is to document and retain the ITS data so that future users can understand the limitations and capabilities of these data. Use of archived data can also assist in diagnosing defective ITS components and aid in maintenance programming.

To encourage the retention and use of ITS-generated data in these areas, the U.S. Department of Transportation (USDOT) revised the National ITS Architecture in 1999 to include the archived data user service (ADUS), envisioning "the unambiguous interchange and reuse of data and information throughout all functional areas" (3). ADUS requires that data from ITS systems be collected and archived for historical, secondary, and non-real-time uses and that these data be made readily available to users (3). The addition of ADUS to the ITS architecture in 1997 substantially increased national interest and guided the implementation of archiving projects, and in 2000, a 5-year ADUS Program Plan was implemented, beginning major federal activities to promote ADUS deployment.

In cooperation with the Oregon Department of Transportation (ODOT) and other regional partners, the Portland Regional Transportation Archive Listing (PORTAL, located at portal.its.pdx.edu) was recently inaugurated via a direct fiber-optic connection between Oregon DOT and Portland State University (PSU). In July 2004, the data archive was activated, receiving 20-s data from the 436 inductive loop detectors composing the Portland area's advanced traffic management system (ATMS). This paper discusses the steps taken for successful implementing of this functional ITS data archive in the Portland region and future expansion plans. First is a discussion of the archive structure, data storage, and data processing. Second is a discussion of the user interface. The third section describes an experiment conducted with Metro, the Portland region's metropolitan planning organization, to improve volume delay functions using archived loop detector data. The paper concludes by discussing additional features, including other data sources currently under development.

DATA STORAGE AND PROCESSING FOR PORTAL

The Oregon DOT Region 1 transportation management operations center (TMOC) gathers data from 436 inductive loop detectors that compose the Portland region's ATMS. These detectors have been implemented as part of the comprehensive ramp metering system, so dual mainline loops (also known as speed traps) are located just

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upstream of on-ramp locations, and the on-ramps themselves are also instrumented. Recently, additional detection has been installed at several locations on a major freeway that includes a very long segment without ramps. These data (count, occupancy, and speed) are used in the day-to-day management of the transportation system to identify congested areas and incidents and to dispatch incident response or emergency vehicles to the appropriate locations. Drivers can be alerted to problems and rerouted by using variable message signs and television and Internet-based traveler information systems (www.tripcheck.com). As ODOT upgrades its current pretimed ramp metering system to one that is dynamic in nature, the quality of these data is increasingly important for real-time operations.

At 20-s intervals, each loop detector records vehicle count, average speed of these vehicles, and occupancy, or percentage of the sample period when a vehicle was over the detector. ODOT currently archives 15-min aggregate data for operations control purposes. Before implementation of the Portland data archive, the raw 20-s data were retained for only a short time before being discarded. Now, permitted users can access and query the archived data through a web interface. The overall structure of the Portland ADUS is shown in Figure 1. The data are sent from the ODOT TMOC to PSU in XML format. A script on the PSU server parses the XML data as they are sent every 20 s. The data are stored and accessed using a PostgreSQL relational database management system (RDBMS) running on a Linux platform.

The RDBMS stores data physically on a redundant array of independent disks (RAID), providing both high-speed access and increased reliability through redundancy in the event of hardware failure. The web-based user interface is provided by the Apache web server, with database connectivity and additional processing by the PHP hypertext preprocessor module. Detector locations in the database have been geocoded for interoperability with geographic information systems.

This archive implements a data warehousing strategy in that it retains large amounts of raw operational data for analysis and decision-making processes, and in that these data are stored independently of their operational sources, allowing the execution of time-consuming queries with no impact on critical operations uses.

Data security is a key component of the data archive. Toward that end, the working copy of the database maintained on the primary server is replicated in a compressed format at a remote site. These daily backups ensure that if one copy of the database is lost, the archive service can be rapidly returned to operation with no significant loss of data. Both the primary database server and the backup storage are located in climate-controlled machine rooms with uninterruptible power supplies and generator backup power, preventing data loss or gaps in data availability due to power outages. The working copy of the database is stored on a RAID device, providing error detection, redundancy, and ability to rebuild missing data upon device failures. Finally, hardware maintenance and security updates are provided for all computer systems by experienced systems administration personnel.

NATIONAL ITS ARCHITECTURE

In September 1999, ADUS was formally incorporated into the National ITS Architecture (2). In the development of the Portland ADUS, significant attention was placed on ensuring that the archive adhered to the recommendations of the National ITS Architecture. The archive fulfills five distinct processing functions, in accordance with the National ITS Architecture ADUS addendum to the ITS Program Plan (3):

1. Store data in the same format as received from ITS subsystems.
2. Accommodate levels of aggregation and reduction of data flows, depending on the type of data represented.
3. Sample raw data flows for permanent storage in accordance with user specifications. Permanent storage of the sampled data should be online, off-line, or both.
4. Apply quality control procedures to the data, including the flagging of suspect data and the editing of data.
5. Distinguish between the following data types: unprocessed (raw), edited, aggregated, and transformed.

Raw Data Storage

As loop detector data are transferred from the ODOT TMOC to the PSU relational database, they are archived with no loss of resolution. Volume, speed, and occupancy data are archived indefinitely at 20-s intervals. Before ODOT had discarded the 20-s data.

Data Aggregation

At this time the archive accommodates levels of aggregation appropriate to the type of data being recorded. Daily at 3 a.m. the 20-s data are aggregated to 5-min data. These data are appended to a table for the relevant month. The data are also aggregated to 1 h and appended to a table that contains data for an entire year. Future plans call for other levels of aggregation as the need is demonstrated.

In addition to total volume, average occupancy, and average speed, the 5-min and 1-h tables include calculated values of vehicle miles traveled (VMT), vehicle hours traveled (VHT), delay, and travel time. These calculations depend on the highway segment length associated with each loop detector. These segments, or loop detector influence areas, are defined as the segment of the freeway extending halfway to the next upstream station and the segment extending halfway to the next downstream station. Where

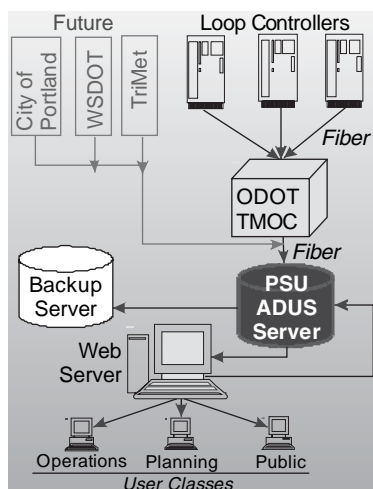


FIGURE 1 Portland metropolitan area ADUS data flows.

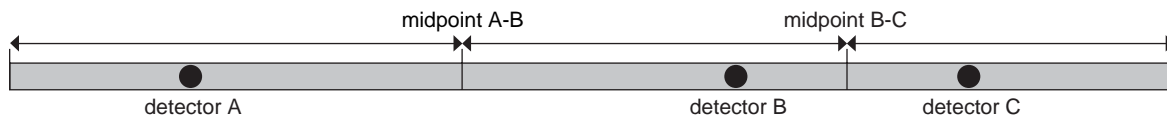


FIGURE 2 Loop detector influence area lengths.

no next station existed, the detector's influence extended to the end of the highway. That is shown in Figure 2. Calculations are as follows:

$$\text{VMT} = \text{segment length} \times \text{volume} \quad (1)$$

$$\text{VHT} = \frac{\text{VMT}}{\text{average speed}} \quad (2)$$

$$\text{delay} = \text{VMT} \times \left[\frac{1}{\text{average speed}} - \frac{1}{V} \right] \quad (3)$$

In Equation 3, V is the target speed. Currently, 60 mph is being used to test the delay calculation. It is envisioned that in the future the user could specify a desired value of target speed so that results could be compared.

$$\text{travel time} = \frac{\text{segment length}}{\text{average speed}} \quad (4)$$

Sampling Data

Users have the ability to sample raw data flows and store data permanently in accordance with their specifications, including aggregation of the data at desired resolutions. These data can either be output on the screen, plotted on a relevant graph, or downloaded in comma separated value (CSV) format for permanent offline storage.

Quality Control

As with all ITS data, data quality issues are experienced. When dealing with huge volumes of data, that is to be expected. Fortunately, PSU has been the first organization to carefully examine and validate the ODOT 20-s loop detector data. As a result, ODOT has been implementing improvements to its system to remove several systematic errors that were discovered.

Quality control procedures are applied to identify and mark suspect or erroneous data. The daily statistics algorithm (DSA) used in the California PeMS database has been implemented (4). DSA flags four error types:

- Type 1. Primarily zero occupancy and flow,
- Type 2. Nonzero occupancy and zero flow,
- Type 3. Very high occupancy, and
- Type 4. Constant occupancy and flow.

DSA uses samples only between 5 a.m. and 10 p.m. Outside that time period, distinguishing between good and bad data becomes more difficult. For example, in the case of a Type 1 error, zero values of occupancy and flow are more likely to be correct owing to low demand.

The Portland ADUS uses the same thresholds as PeMS to flag each error type. In PeMS, a loop is given a Type 1 error if more than 1,200 of 2,040 observations (58.8%) have occupancy and flow values of zero. If more than 50 observations (2.45%) show a nonzero occupancy with zero flow, then the loop is bad because of a Type 2 error. If more than 200 observations (9.8%) have occupancies greater than 0.35, then the loop is bad because of a Type 3 error. In PeMS, data are stored at 30-s intervals. In PORTAL, data are stored at 20-s intervals, and therefore there are 50% more total observations for the sampling period. The number of observations required to flag one of the first three error types is 50% above the thresholds used in PeMS, rather than the 20-s data in PORTAL, and therefore there are 50% more total observations for the 5 a.m. to 10 p.m. time period. PORTAL uses the same percentage thresholds as the PeMS database. Therefore, the number of observations needed to cause each of the first three error types is 50% above the thresholds for PeMS, but the intent is to develop improved quality control measures in the future. The fourth diagnostic measures randomness of occupancy and flow. If a loop records constant occupancy values, this diagnostic will flag a Type 4 error. If any of the four error types occur, that loop is determined to be bad for the day.

Distinguish Between Data Types

The final data processing requirement outlined in the national ITS architecture ADUS addendum is that distinctions be maintained between raw, edited, aggregated, and transformed data. The ADUS user can query the data in three distinct areas of the web interface—raw data, time series, and grouped data. These areas are discussed further in the next section. In each case, the user knows whether the query being performed is using raw or aggregated data.

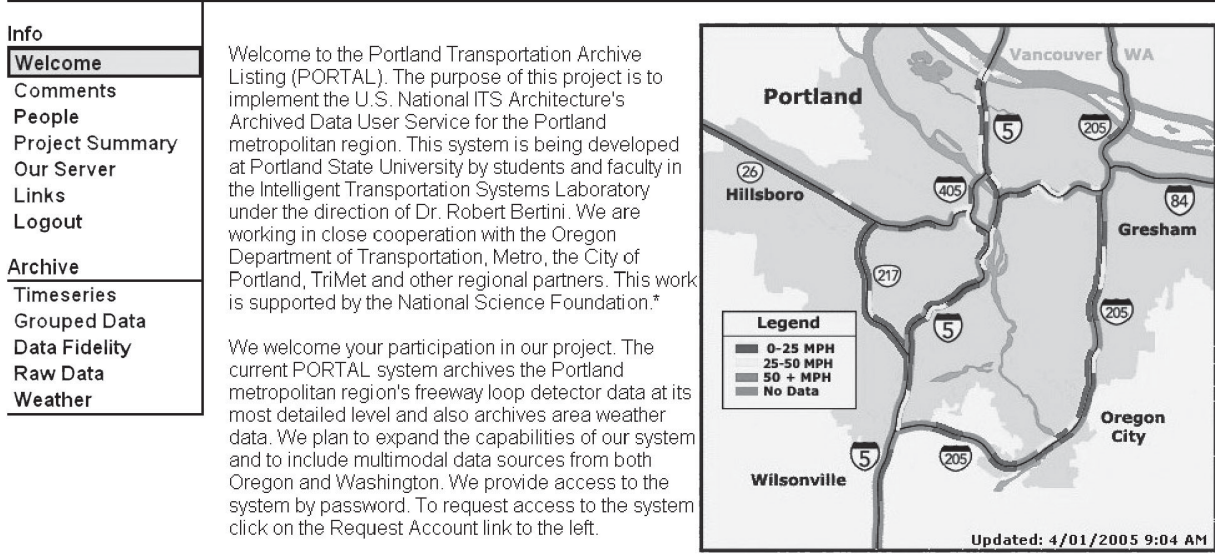
DATA RETRIEVAL

Figure 3 shows the current PORTAL user interface. The map shows an example of how ODOT currently uses loop detector data in real time. The highways are color coded to indicate the current traffic speed on each road segment. The map, maintained by ODOT, is updated every 20 s when the loop detectors record average speed for the time period. This map is also available on ODOT's website—www.tripcheck.com—along with detailed information on road conditions.

The welcome screen gives the user the following options for querying archived data, as indicated by the menu tabs near the top of the screen:

- Time series,
- Grouped data,
- Data fidelity,
- Raw data, and
- Weather.

PORTAL: Portland Transportation Archive Listing



Portland State University - ITS Lab - Oregon DOT - National Science Foundation

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FIGURE 3 PORTAL home page.

Time Series

The time series tab allows the user to perform the queries on the 5-min aggregated data to extract volume, speed, occupancy, VMT, VHT, travel time, and delay. The user can specify a specific loop detector station as well as a full highway segment. In addition, the user can choose the time period and specific travel lanes. The user has the option of either plotting the data, viewing the numbers in a table on the screen, or exporting the data as a CSV file. Figure 4 shows a plot of volume for one station along I-5 North for March 24, 2005. Figure 5 shows a speed contour plot for I-5 North on March 16, 2005.

Grouped Data

The grouped data section allows the user to display summaries of data from multiple days. The data can be grouped by hour of day, day of week, or week of year. Users can also determine the statistics they wish to see, including mean, minimum value, maximum value, and standard deviation. As in the time series section, the user has the choice of plotting the data, displaying a table, or downloading a CSV data file.

Data Fidelity

The data fidelity section allows the user to determine whether the loops queried were determined to be good according to the DSA algorithm discussed above. Users can either obtain information on the health of a specific detector or find out the percentage of healthy loops on a specified highway section. Table 1 is an example of the detector health information available. It has been useful for assisting Oregon DOT with the upgrade of some of its traffic management

system software and in updating some of its ramp meter controller hardware. The plan is to continue to refine this component by soliciting input from TMOC staff.

Raw Data

The user currently has the option of downloading raw 20-s data in CSV format for specific detector stations or highway segments.

Weather

When traffic studies are conducted in the future, it will be important to know what weather conditions were like on the days analyzed. For example, previous studies in Oregon have found substantial differences in the number of crashes on rainy days as compared with dry days (5). To provide at least a minimal amount of weather data to future analysts, PORTAL collects and stores METAR weather observations from the National Oceanic and Atmospheric Administration (NOAA). Weather observations are collected from three points in the Portland region: Portland International Airport and the suburbs of Hillsboro and Troutdale, located west and east, respectively, of the city of Portland. A script written in Python collects and processes the weather data. The Python module pyMETAR provides easy access to NOAA's weather reports (6). Users can query the database to find out about the weather conditions for a specified time period. There is a table in the database that indicates which weather station is geographically closest to each loop detector. Users have the option of extracting data from all three weather stations or the station that is nearest to a particular loop detector.

Roadway weather information system data are also collected from several locations in the region. In the future these data will also be archived in PORTAL.

PORTAL: Portland Transportation Archive Listing

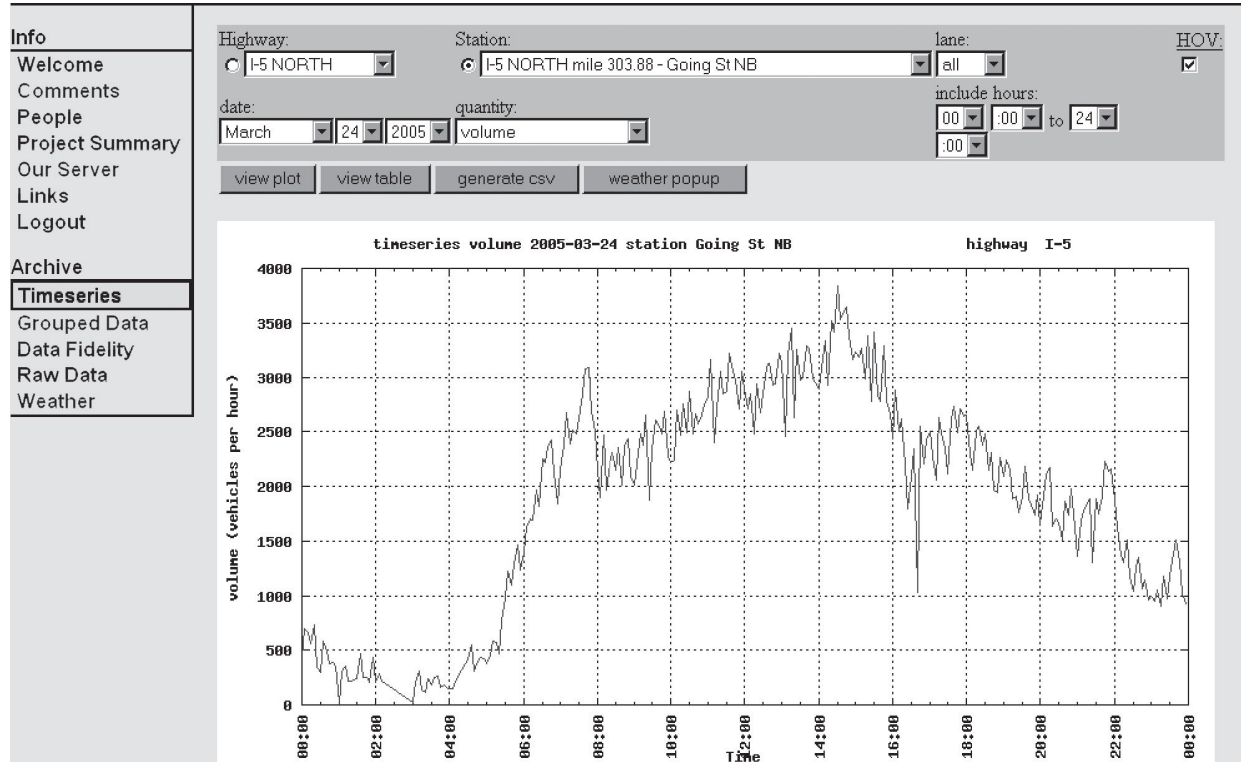


FIGURE 4 Sample volume plot for I-5 North Going Street loop detector station, March 24, 2005.

PORTAL: Portland Transportation Archive Listing

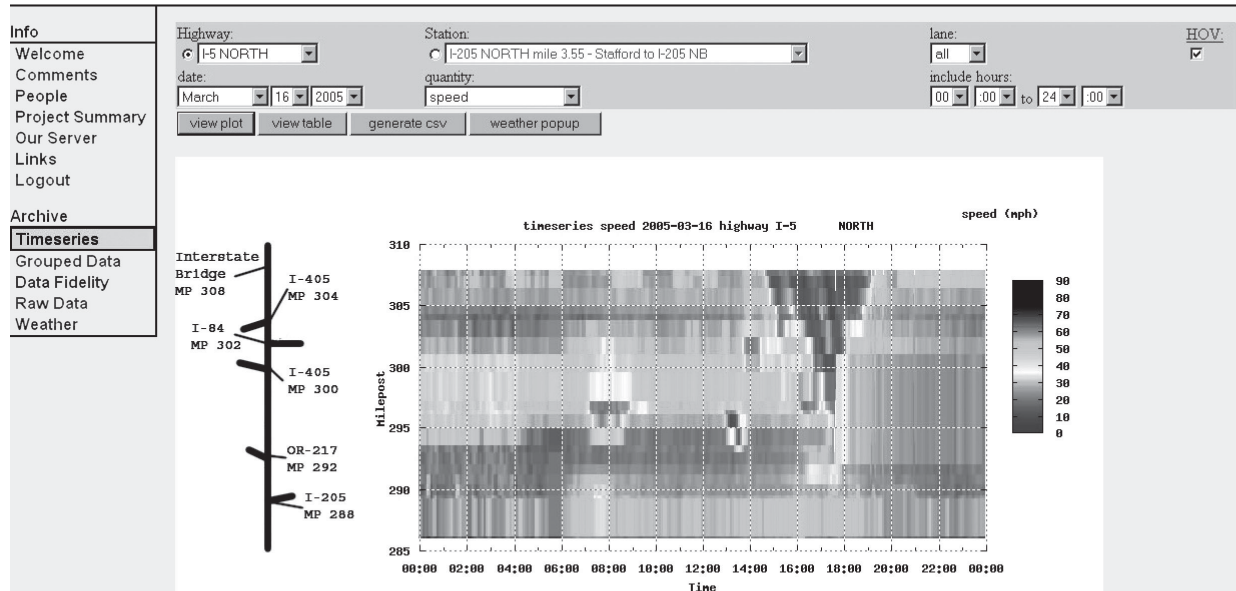


FIGURE 5 Sample speed contour plot for I-5 North, March 16, 2005.

TABLE 1 Loop Detector Health for I-205 South, July 15–July 20, 2004

| Day | healthy_ratio |
|------------|---------------|
| 2004-07-15 | 90.24% |
| 2004-07-16 | 92.68% |
| 2004-07-17 | 87.80% |
| 2004-07-18 | 90.24% |
| 2004-07-19 | 92.68% |
| 2004-07-20 | 92.68% |

TRAVEL DEMAND MODELING CASE STUDY

In early, 2004 the PSU ITS lab worked with Metro, the MPO for the Portland metropolitan area, to improve its travel demand forecasting. This experiment focused on OR-217. ODOT provided 1 week of loop detector data from April 14, 2002, to April 20, 2002, for this experiment.

Metro uses a typical four-step model: trip generation, trip distribution, mode choice, and trip assignment. In the final step, the trips are iteratively distributed over the available transportation links until equilibrium is established. The trip assignment process relies on a volume delay function, which is a specified relationship between the volume of vehicles on a link and the expected amount of time required to traverse that link. Metro worked closely with PSU researchers to use archived loop detector data to improve the accuracy of the volume delay functions used for OR-217 in the regional travel demand model.

Previous Volume Delay Function for OR-217

The volume delay functions used in Metro's travel demand model are a modification of the function in the Bureau of Public Roads' (BPR) *Traffic Assignment Manual* (7, 8). The generalized BPR function has the following form:

$$f_{\text{BPR}}(x) = 1 + (x)^\alpha \quad (5)$$

where

$$x = \frac{v}{c},$$

v = volume, and
 c = capacity.

Metro uses a slightly modified version of the BPR congestion function in its EMME/2 model:

$$f_{\text{EMME2}}(x) = 1 + 0.15 \left(\frac{v}{0.75c} \right)^\alpha \quad (6)$$

Setting Equation 5 equal to Equation 6 and solving for x results in

$$x = \sqrt[\alpha]{0.15 \left(\frac{1}{0.75} \right) \left(\frac{v}{c} \right)} \quad (7)$$

where α and β are unspecified parameters. Metro uses an α value of 7 to represent freeway segments in the model. When $\alpha = 7$, solving for x in Equation 7 results in

$$x = 1.0168 \left(\frac{v}{c} \right) \quad (8)$$

Equation 6 adequately represents the relationship between travel time and volume when the volume–capacity ratio is between 0 and 1. Realistically, volumes should not exceed the actual capacity of the road for an extended amount of time. However, during the trip assignment process, the function values for volume–capacity ratios of 5 or greater are sometimes necessary in calculations to converge to an equilibrium trip assignment. With an α value of 7, Equation 6 increases rapidly where the volume–capacity ratio is above 1. That causes inefficiencies in model convergence.

To address that inefficiency in model convergence, Metro uses a conical volume delay function:

$$f_{\text{CONICAL}}(x) = 2 + \sqrt{\alpha^2(1-x)^2 + \beta^2} - \alpha(1-x) - \beta \quad (9)$$

where

$$\beta = \frac{2\alpha - 1}{2\alpha - 2} \quad (\text{when } \alpha = 7, \beta = \frac{13}{12} = 1.0833)$$

Inserting $\beta = 1.0833$ and $x = 1.0168 \left(\frac{v}{c} \right)$ into Equation 9 results in

$$f_{\text{CONICAL}}(x) = 2 + \sqrt{49 \left(1 - 1.0168 \frac{v}{c} \right)^2 + 1.1735} - 7.1176 \left(\frac{v}{c} \right) - 8.0833 \quad (10)$$

When volume–capacity is between 0 and 1, the conical function represented by Equation 10 is very similar to the BPR function in Equation 6. This similarity is shown in Figure 6. However, for values above 1, the BPR function increases much more rapidly. The conical function is superior because it has the desirable characteristics when the volume–capacity ratio is near and below 1, but has the advantage of converging more efficiently owing to the characteristics when volume–capacity > 1 .

Revised Volume Delay Function for OR-217

Although the use of a conical volume delay function improves convergence times of trip assignment, it does not necessarily accurately represent traffic characteristics on OR-217. There may be regional variations in highway performance that are not accounted for, and it is reasonable to assume that the characteristics of automobiles and the behavior of drivers have changed significantly since the BPR functions were devised. Metro therefore wanted to employ the use of ATMS data to create volume delay functions that more accurately reflect actual road conditions.

The first step in the process was to validate the volume counts from the data archive. Metro compared these volume counts with separate ground counts performed by ODOT. The counts from the database fell within 10% of the ODOT counts. Metro determined that that was within an acceptable range for validation (K. Hauger, Metro Travel Forecasting, e-mail correspondence, Oct. 29, 2004).

The volume figures were then converted to passenger car equivalents (PCE). Although it is technically possible to classify vehicles by length using the existing inductive loop detectors in the Portland region, they are not yet set up to perform that function. The study used the PCE of 1.2, from the *Highway Capacity Manual* for trucks traveling on level terrain (9). The ODOT *State Highway Inventory*

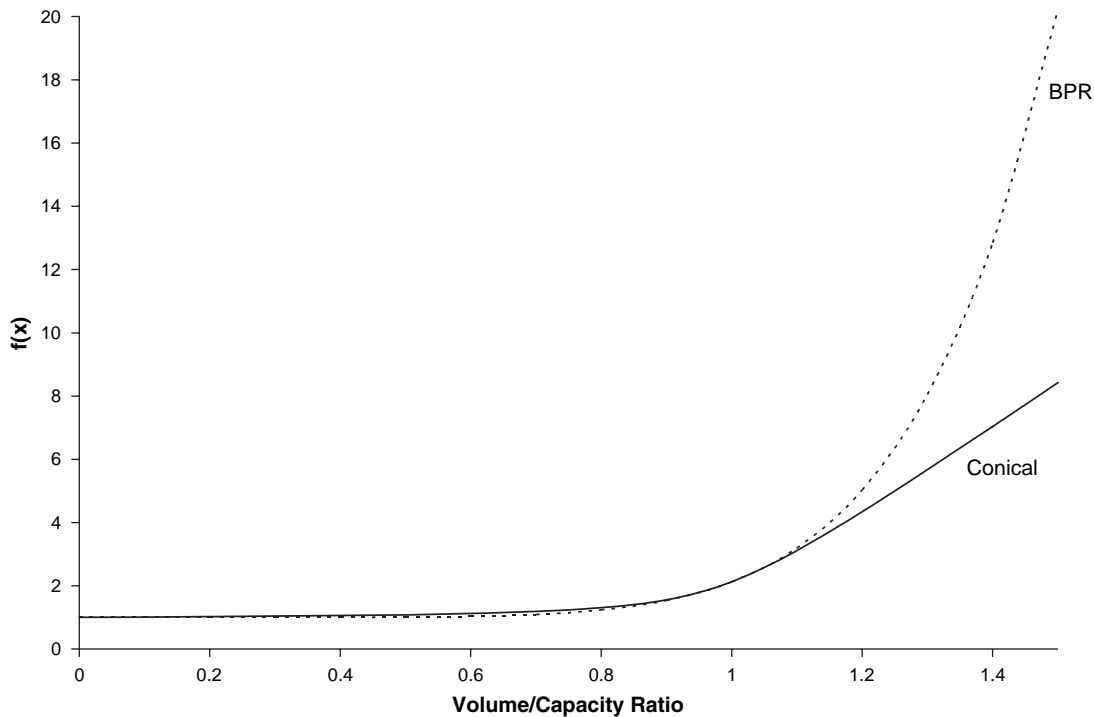


FIGURE 6 Conical versus BPR volume delay functions.

Report gave a percentage of 7.83% heavy vehicles traveling on OR-217 (10). The overall heavy vehicle correction factor (f_{HV}) is

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1)} \quad (11)$$

where

P_T = proportion of trucks (combinations plus single units) from inventory, expressed as a decimal, and

E_T = passenger car equivalents.

This equation gives a correction factor of 1.016. All vehicle counts in the data set were multiplied by f_{HV} for consistency with other portions of the demand model.

The capacity of each segment was taken to be the maximum 15-min flow on each segment. There is some question that these values should be referred to as “capacities” because this word has a strong preestablished meaning. However, results of this process appear to be the maximum sustainable volume of traffic on a particular segment, beyond which a breakdown in flow occurs.

The resulting travel time versus flow pairs are then sorted into bins based on different hourly flows. For each of these bins, the average and standard deviation of the reported travel times were calculated and plotted. At that point, flows were divided by an hourly capacity to allow presentation of the data in a form similar to that required by the demand model. Figure 7 shows a plot of these data for a single detector on OR-217. After these data were plotted for each segment, Metro determined that there was some variation between the segments studied. It was therefore decided to develop two third-degree polynomial functions: a high- and a low-volume delay function. The resulting best-fit functions have the following forms:

$$f_{HIGH} = 0.9664 + 1.2812x - 2.52x^2 + 2.5694x^3 \quad (12)$$

$$f_{LOW} = 0.9711 + 1.0624x - 2.8213x^2 + 2.6339x^3 \quad (13)$$

Figure 8 shows the functions above compared with the conical function described previously.

Feedback from Metro

Metro was pleased with results of the travel modeling experiment and is currently using data extracted from PORTAL to improve volume delay functions for other freeway segments. In addition to the experiment mentioned above, Metro is interested in using the data archive to create performance measures. Partly on the basis of feedback from Metro, PSU researchers are in the process of developing daily and monthly summary pages that will aid decision makers at both Metro and ODOT.

Cumulative Curves Methodology

As stated above, some uncertainty exists when maximum 15-min flow is used as segment capacity. The *Highway Capacity Manual* has traditionally defined this as the capacity of a highway segment, and this is widely accepted in practice. However, the archived loop data can be used to more accurately determine the true capacity of a freeway segment by examining actual flows from day to day, in combination with occupancy and speed data. In addition, previous research has shown the advantages of using plots of cumulative vehicle count and cumulative lane occupancy constructed from high-resolution loop detector data for diagnosing bottleneck activation and examining important bottleneck features (11). With the use of a simple oblique plotting technique, these curves can aid the transportation student or

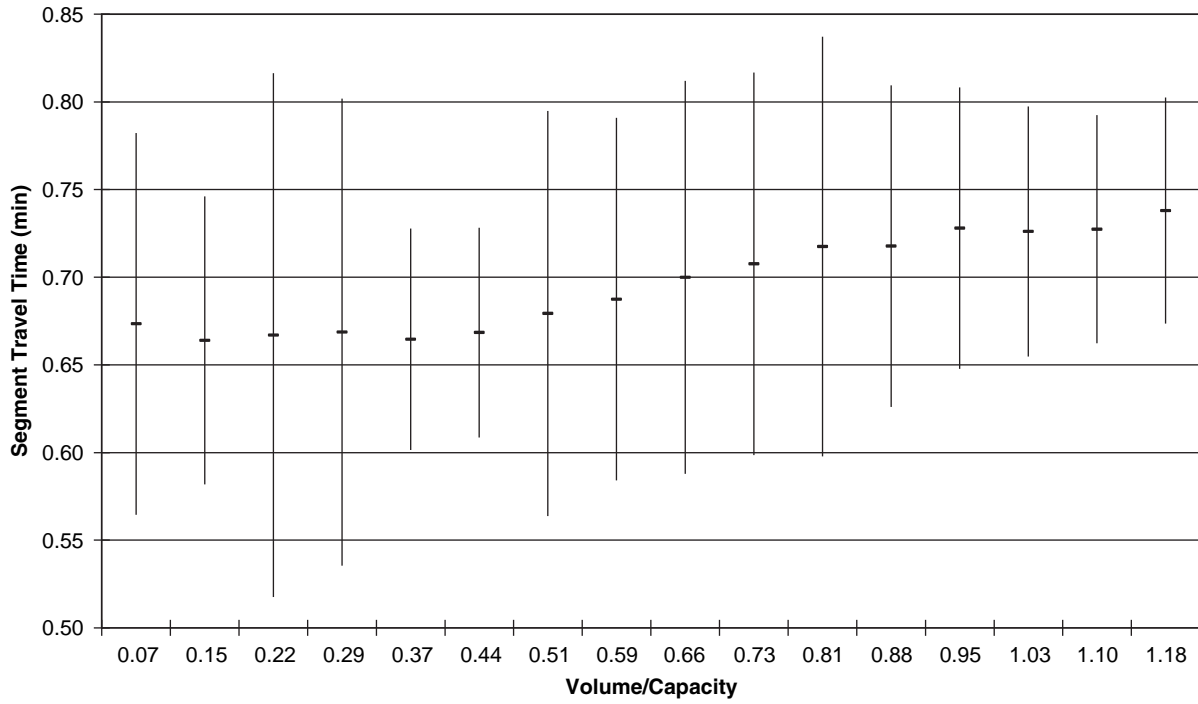


FIGURE 7 Mean and standard deviation of travel time versus volume–capacity ratio.

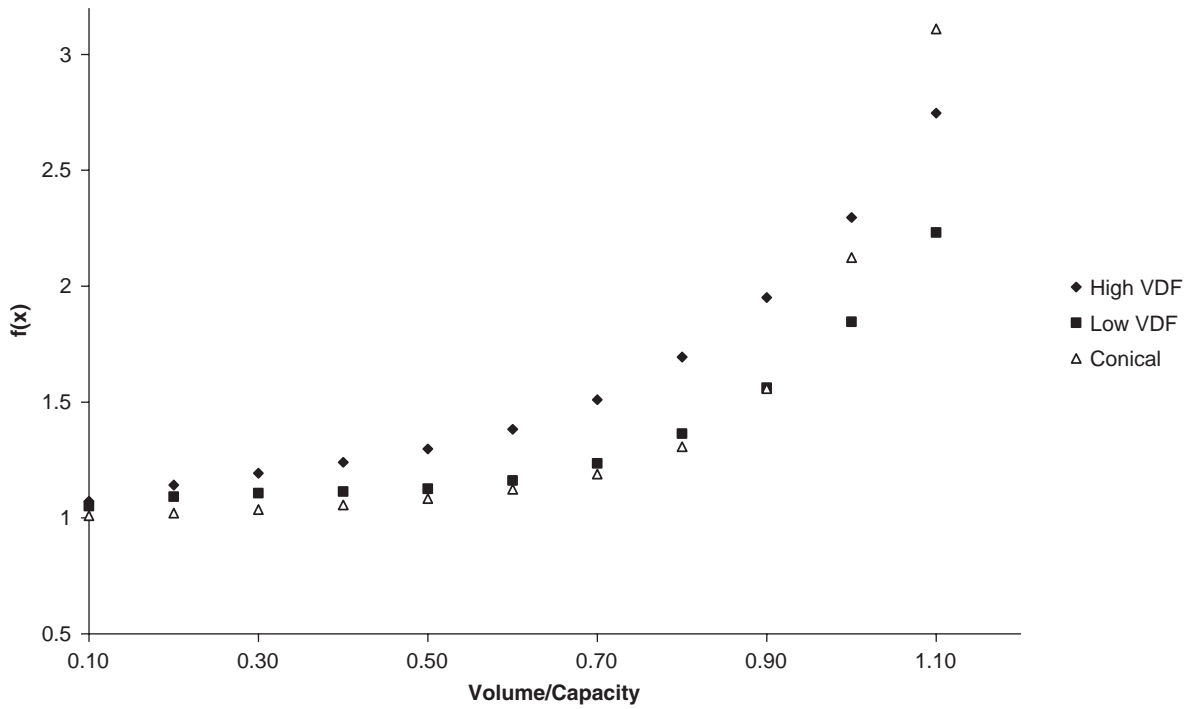


FIGURE 8 Comparison of high- and low-volume delay functions (VDF) with conical function.

researcher in understanding the dynamics of traffic flow. The Portland archive will include automated capabilities for constructing these curves with user input and will aid in the ongoing efforts to locate and diagnose bottlenecks on the Portland freeway system.

FUTURE ARCHIVED DATA

Research across industries indicates that effective data archiving systems start as small prototypes with a single data source. Studies consistently indicate that detector data are the most useful archived data (1), and for that reason the choice was made to first archive these data. The Portland region has a wealth of additional data sources that will be archived at the appropriate time. Two data sources, computer-aided dispatch data and Tri-Met bus data, are discussed below.

Computer-Aided Dispatch Data

Portland's ATMS includes a comprehensive incident management system (5), which in turn generates a large computer-aided dispatch (CAD) database, which then contains information about all recorded incidents on Portland's freeway system. This information includes the type of incident, the lanes that were blocked as a result of the incident, and the start and end time of the incident. The TMOC can record the *X-Y* coordinates of an incident, but it is required only if the incident was severe enough to cause significant delay. In 2001 coordinates were recorded for 10% of all incidents (5). The plan is to archive the CAD data so that it can be further used to assess the performance of the incident management program and identify times when and locations where incidents affected traffic flow.

TriMet Bus Data

TriMet is the transit provider for the Portland metropolitan region. As part of its overall operations management system, TriMet has developed a "smart" bus that enables its automated bus dispatch system (BDS). The BDS includes automatic vehicle location via a satellite-based Global Positioning System (GPS) on all buses as well as automatic passenger counters installed on a majority of the existing fleet and all new bus acquisitions. As part of the real-time component of the BDS, each vehicle transmits its location to the transit management center (along with several other data points) periodically (roughly every 1–3 min). These real-time data are currently archived by TriMet.

Each vehicle in the fleet includes an onboard memory card that is preprogrammed with that bus's schedule information. Therefore the bus "knows" where it is located at all times and links that with the schedule, enabling a schedule status (late-early) report to the operator. Further, as part of the archived data component of the BDS, a data record is written to the memory card at each bus stop. These records contain the route number, direction, trip number, date, vehicle number, operator identification, bus stop identification, stop arrival time, stop departure time, boardings, alightings, and passenger load. Also recorded is whether the doors of the bus were opened, whether the lift was used, the dwell time, maximum speed between previous and current stop, and GPS coordinates. The memory card data are downloaded at the end of each day and compiled into a huge database. This information is used by TriMet to measure system performance on an ongoing basis and to aid in the bus route scheduling effort that occurs each quarter.

One major benefit of TriMet's real-time and archived BDS data is that they can be used to extract performance characteristics from the region's arterial system. In the near future, planned testing should begin of both data sources as part of the Portland archive for this purpose.

CONCLUSION

Although there can be many beneficiaries, data archiving has historically been and continues to be the domain of a single user group (i.e., researchers and planners) (1). The mostly informal arrangements for data archiving with researchers and planners have occurred as a result of the inaccessibility and difficulty in using the large data sets. With the development of new data management and processing tools, and the expansion of web-based services, that is now changing. In the Portland metropolitan area, regional agencies across two states, including cities, counties, MPOs, transit operators, a port, a university, and state DOTs, cooperate by means of TransPort, the regional ITS coordinating organization. The region's ITS architecture has been developed under the auspices of TransPort.

It can be difficult to determine who should bear the responsibility and cost of maintaining an ITS data archive because the organizations that produce the data are frequently different from those who benefit from retention of the data. In cooperation with Oregon DOT, TriMet, and the city of Portland, PSU is a major user of regional ITS data for transportation research. Other recent uses of ITS data by ADUS stakeholders such as Metro, the Portland regional planning organization, have been encouraged and facilitated by PSU researchers already familiar with manipulating these types of data.

As a result, PSU is in an ideal position to host transportation data, and its Intelligent Transportation Systems Laboratory (www.its.pdx.edu) has been designated as the regional archiving site for ITS data from Portland and adjacent areas of southwestern Washington State. The design and implementation of this archive are being carried out in accordance with the functional requirements for ADUS set forth in the national ITS architecture, while also taking into account experiences and suggestions from other systems that are being developed in larger, more populous states and regions (1–3, 12).

This paper has sought to document the experience thus far in implementing PORTAL so that other regions around the country can benefit from this experience. By openly sharing algorithms and experiences, in the spirit of the PeMS system, all regions can benefit from past experiences. In Portland, the emphasis is on the development of a multimodal resource that is benefiting all transportation agencies via a unique collaborative environment established by the TransPort committee.

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