Arterial Network Performance Measures Software

Stanley E. Young, Dennis So Ting Fong

Arterial Network Performance Measures Software

Stanley E. Young
Traffax, Inc.

Dennis So Ting Fong
Traffax, Inc.

SBIR Phase 3 Joint Transportation Research Project
Traffax, Inc.
Purdue University

April 4, 2017

Deliverable Reference:	D2.6 Report on Arterial Network Performance Measures Software
Project Name:	Sensor Fusion and MOE Development for Off-Line Traffic Analysis of Real Time Data
Contractor:	Traffax Inc
Contract Number:	DTFH61-14-C-00035
Contract Term Start	9/4/2014
Contract Term End	9/4/2017
Key Personnel	Stan Young, Darcy Bullock, Dennis So Ting Fong

Recommended Citation

Young, S. E., and D. S. T. Fong. *Arterial Network Performance Measures Software*. Purdue University, West Lafayette, Indiana, 2017. <https://doi.org/10.5703/1288284316570>

Acknowledgments

This work was supported by Traffax/USDOT SBIR DTFH6114C00035. The contents of this paper reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein, and do not necessarily reflect the official views or policies of the sponsoring organizations. These contents do not constitute a standard, specification, or regulation.

Table of Contents

1	Introduction.....	2
2	Structure of the Network Performance Measure Software	3
3	Notes on Software.....	6
	Bibliography	7

1 Introduction

This report provides details of the software implementation for generation of network performance measures from re-identification data as outlined in an earlier project report entitled, “*Network Performance Measures for Arterials – a Systematic Level Perspective*” [1]. The performance measures discussed in that report have been programmed and included in VPXplore open source software as reported and documented in the project report entitled, “*Arterial Performance Measures Software*”, [2]. The Network Performance Measures software implementation is an extension of the VPXplore program, so also, this report is intended as an addendum to the previous Arterial Performance Measures Software report [2], which the reader is encouraged to review if further context or direction is needed with respect to the VPXplore open-source software. Similarly, the reader is referred to the Network Performance Measures report [1] if additional background and application of network performance measures beyond that reviewed herein is needed.

Overview of Network Performance Measures for Arterials -

Network Performance Measures for Arterials - a Systematic Level Perspective [1] introduces a framework for arterial network performance measures and management. The architecture is patterned off of other infrastructure management systems, and the report proposes four key condition performance measures as the basis for developing network performance measures. These four condition performance measures are based on either re-identification data or high-resolution controller data. These four measures are briefly described below.

- ***Median Travel Time – measured in minutes per mile, or miles per hour***
Travel Time, or equivalent space mean speed, directly measures the user experience on the roadway. Poor signal timing, inadequate green time, or other issues on the roadway ultimately increase travel time. Travel Time, when normalized to the length of the roadway, is often expressed in units of minutes per mile. However, the inverse measurement, speed expressed in MPH, may be more familiar to a broader audience. The median, defined as the 50th percentile normalized travel time, is the recommended measure of central tendency due to the prevalence of outliers in directly sampled re-identification data.
- ***Travel Time Reliability – difference in the 15th and 85th percentile normalized travel times***
Similar to Travel Time, Reliability measures the variability of travel time experienced by travelers throughout the day, or during non-recurring congestion events. Travel Time Reliability is measured with respect to the median travel time. The ratio is the difference between the 85th and 15th percentile travel time divided by the median travel time. Again, percentiles measures are used to avoid instabilities associated with the prevalence of outliers in continuously sampled re-identification data, particularly on mid and lower level facilities.
- ***Signal Coordination – minimum percent of traffic that progresses along a corridor on green***
This metric is based on the arrival and green time data contained in high-resolution controllers which have the ability to measure arriving traffic with appropriately located vehicle detectors. This data is used to generate the Purdue Coordination Diagram. This metric, called “percent on green” (POG), measures the minimum percentage of traffic that is able to successfully progress

along a corridor on the green phase. A simple implementation assesses this percentage in the direction of the dominant movement for the peak period. An alternative, though a more complex methodology, would be to use a weighted score considering bi-directional traffic, with the weighting factors based on volume.

- **Capacity Evaluation – percentage of cycle with a split failure**

This measure is the number of cycles during which the queues are not fully discharged by the green interval within an individual signal cycle. This number is determined by analysis of the occupancy of vehicle detectors located near the stop bar relative to the signal state using high-resolution controller data. Split failures are defined by an occurrence when the Green Occupancy Ratio (GOR) and the Red Occupancy Ratio (ROR) are both greater than 80%. This indicates that the green interval was fully utilized (high GOR), and that there was a standing queue after the end of green (high ROR).

Of the four measures above, two (Median Travel Time and Travel Time Reliability) are assessed with re-identification data. These two measures have been integrated into the VPXplore program, augmenting the previously reported work [2]. As with all other code in VPXplore, the network performance measures software is intended to be open-source, serving as a reference implementation to encourage uniformity and consistency in practice in the industry.

2 Structure of the Network Performance Measure Software

The network performance measure software is built upon the VPXplore software architecture, leveraging the integration of the CWS5200 standard data format for segment level re-identification data. The implementation of VPXplore required two additional software development efforts, referred to as modules. The first module, Analytics Processing, implements the specific performance measures from the CWS5200 data structure. The second module, Visualization Engine, is the visualization page, which provides a more in-depth view customized to the performance measures and time periods for arterial network performance. These two modules are illustrated in Figure 2.1 below.

Figure 2.1 Augmentation of VPX Software for Network Performance Measures

Analytics Processing, as originally described beginning on page 18 of the earlier report [2], was augmented to calculate and store travel time percentile measures for specific periods of the day. The processing is similar to the method used to create the existing *cfid* matrix which contains the travel time percentiles for each hour of the day. Recall the format of the *cfid* matrix:

cfid This is a 25 row by 19 column matrix of travel time percentiles. Each row number represents an hour of the day. Row 1 is from midnight to 1 AM. Row 2 is from 1 AM to 2 AM ... Row 24 is from 11 PM to midnight. The last row, row 25, represents data from all 24 hours. Each column is a percentile. The first column is the 5th percentile travel time, the second column the 10th percentile, and so on up to the last column (the 19th column) being the 95th percentile travel time. The 19 entries in row one contain the 5th, 10th, 15th, 90th, 95th percentile travel time for all trips between midnight and 1 AM for the segment.

Rather than data for each hour of the day, a matrix is created specific to four distinct periods as described in Table 1. This matrix is referenced as *period_cfid*, and is explicitly defined below.

Table 1 Defined Periods and Their Defaults

Period	Description	Default Timeframe
AM	Morning Rush Hour	6 AM to 9 AM
Midday	Midday Travel Period	10 AM to 2 PM
PM	Evening Rush Hour	4 PM to 7 PM
Custom	Any User Defined Time Period	---

Default values of the AM, Midday, and PM time period may be altered through the visualization tool. A custom time period may also be initialized through the visualization tool.

period_cfid This is a 4 row by 19 column matrix of travel time percentiles. Each row number represents a period of the day, either the AM, Midday, PM or Custom time period. Row 1 contains the percentiles for the AM period. Row 2 for the Midday period. Row 3 for the PM period. Row 4 contains the percentiles for the custom defined period. As with the '*cfid*' matrix, each column is a percentile. The first column is the 5th percentile travel time, the second column the 10th percentile, and so on up to the last column (the 19th column) being the 95th percentile travel time.

At the current time, the period specific percentiles and the corresponding arterial network performance measures that utilize them are defined only for CWS5200 data sets within the VPX software.

A corresponding visualization graphic was created. A sample of this graphic is shown in Figure 2.2 and described below:

- An additional overlay plot is shown in the lower left axes, with the AM, Midday, and PM time periods highlighted in blue, green, and red respectively.
- The upper left axes contain the standard hourly overlay plot as originally described in the earlier software report [2]. Its functionality remains the same, and the user can toggle through the various hours of the data.

- The upper right axes provide a CFD view of the data. In addition to the hourly ensemble of CDF curves, the AM, Midday and PM curves are also overlaid in their corresponding colors.
- The lower right table contains both the set of performance measures as introduced in the earlier software report [2], as well as the network performance measures recommended in earlier network report [1] that are based on re-identification data. These performance measures are calculated for the three standard periods of the day.

Figure 2.2 Visualization of the Network Performance Measures

Additionally, a custom time frame can be defined as illustrated in Figure 2.3 below. In this instance, a custom period from 9 PM to Midnight is defined and the corresponding graphics and performance measures are also calculated. Also, note that the beginning and ending time periods for the AM, Midday and PM periods may be altered through the menu structure in the visualization.

Figure 2.3 Example of Custom Period analysis from 10 PM to Midnight

3 Notes on Software

The implementation of the Network Performance Measures algorithms was built on VPX software as documented in the earlier software report [2] and excerpted below:

The source code for VPXplore is provided for technical personnel to access critical sub-routines that provide either the implementation of the CWS5200 data standard, or reference implementation for the scatter plot, overlay charts, or cumulative frequency diagrams (CFDs). The current version of VPXplore was developed on Matlab 2013b. Sample output included in this document is from the current version (1.22) at the time of writing. This is a constantly evolving open source code set used primarily for validation activities. Along with the code, a data set is also distributed to exercise the software.

With the update to include Network Performance Measures as described above, the current version of VPXplore is 1.25, and is posted to the shared site available at:

<https://www.dropbox.com/sh/ywg2s8alor40ixb/AACgQJmgswElFueqt-StFTpa?dl=0>

Bibliography

- [1] D. S. T. F. Stanley E. Young, "Network Performance Measures for Arterials - a Systematic Level Perspective," SBIR Phase 3 Federal Highway Administration Project "Sensor Fusion and MOE Development for Off-Line Traffic Analysis of Real Time Data, June 3, 2016.
- [2] D. S. T. F. Stanley E. Young, "Arterial Performance Measures Software," SBIR Phase 3 Federal Highway Administration Project "Sensor Fusion and MOE Development for Off-Line Traffic Analysis of Real Time Data, February 13, 2017.
- [3] N. Spiller, "Federal Highway Administration, Office of Operations, Access Management Principles Presentation," [Online]. Available: http://www.ops.fhwa.dot.gov/access_mgmt/presentations/am_principles_intro/index.htm. [Accessed 5 July 2016].
- [4] A. Brooks, "State of Alaska Fairview Loop Rehabilitation FAQs," Brooks & Associates, [Online]. Available: <http://www.brooks-alaska.com/fairviewloop/faqs.htm>. [Accessed 5 July 2016].
- [5] M. Spack, "The Dos and Don'ts of Access Management," Mike On Traffic - Musings of a Professional Engineer, [Online]. Available: <http://www.mikeontraffic.com/dos-donts-access-management/>. [Accessed 5 July 2016].
- [6] S. Young, M. Hamed, E. Sharifi, R. Morris-Juster, K. Kaushik and S. Eshragh, "I-95 Corridor Coalition Vehicle Probe Project Validation of Arterial Probe Data," July 2015. [Online]. Available: http://i95coalition.org/wp-content/uploads/2015/02/I-95_Arterial_Validation_Report_July2015-FINAL.pdf?dd650d.
- [7] C. M. Day and D. M. Bullock, "Performance Measures of Interrupted-Flow Roadways using Re-Identification and Signal Controller Data," FHWA SBIR 3, 2015.

Report Sponsor

The “Small Business Innovation Development Act of 1982” (Pub. L. No. 97-219), along with reauthorizing legislation (Pub. L. No. 99-443 and Pub. L. No. 102-564, the “Small Business Research and Development Enhancement Act of 1992”), seeks to encourage the initiative of the private sector and to use small business effectively to meet federal research and development objectives. To comply with statutory obligations of the Act, the U.S. Department of Transportation established the Small Business Innovation Research (SBIR) Program, which conforms to the guidelines and regulations provided by the Small Business Administration. Annually, small businesses are solicited to submit innovative research proposals that address the high-priority requirements of the U.S. Department of Transportation and that have potential for commercialization.

This report was developed through a partnership between Traffax, Inc., and Purdue University with funding from a Phase III SBIR contract (DTFH6114C00035) with the Federal Highway Administration. The project, entitled “Sensor Fusion and MOE Development for Off-Line Traffic Analysis of Real Time Data,” created and refined methods and tools for the characterization of performance along arterial corridors.

Publication

This report is part of a series of reports published in collaboration with USDOT, Traffax, Inc., and Purdue University. The full report series is available for download at <http://docs.lib.purdue.edu/apmtp/>.

Open Access and Collaboration with Purdue University

The Indiana legislature established the Joint Highway Research Project in 1937. In 1997, this collaborative venture between the Indiana Department of Transportation and Purdue University was renamed as the Joint Transportation Research Program (JTRP) to reflect state and national efforts to integrate the management and operation of various transportation modes. Since 1937, the JTRP program has published over 1,600 technical reports. In 2010, the JTRP partnered with the Purdue University Libraries to incorporate these technical reports in the University’s open access digital repository and to develop production processes for rapidly disseminating new research reports via this repository. Affiliated publications have also recently been added to the collection. As of 2017, the JTRP collection had over 1.5 million downloads, with some particularly popular reports having over 20,000 downloads.