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January 2003

WSDOT Intermodal Data Linkages Freight ITS Operational Test Evaluation

Final Report

Part 2: Freight ITS Traffic Data Evaluation

U.S. Department of Transportation

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FREIGHT & ITS WEB RESOURCES

USDOT ITS Joint Program Office:
http://www.its.dot.gov

USDOT Office of Intermodalism
http://www.dot.gov/intermodal/freight.html

FHWA Office of Freight Management
http://ops.fhwa.dot.gov/freight/

ITS Cooperative Deployment Network (ICDN):
http://www.nawgits.com/jpo/icdn.html

ITS Electronic Document Library (EDL):
http://www.its.fhwa.dot.gov/cyberdocs/welcome.htm

USDOT ITS Joint Program Office
USDOT Office of Intermodalism (OST)
FHWA Office of Freight Management and Operations

U.S. Department of Transportation
Federal Highway Administration Operations Unit
400 7th Street, S.W., HOP
Washington, DC 20590
Toll-Free "Help Line" (866) 367-7487

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16. Abstract

In mid-1999, in response to the U.S. Department of Transportation's (USDOT) request for participation in the Intelligent Transportation Systems (ITS) Intermodal Freight Field Operational Test (FOT) Program, the Washington State Department of Transportation (WSDOT) entered into a partnership with public and private organizations to test and evaluate the following two freight traffic data ITS projects as part of its overall "Intermodal Data Linkages ITS Operational Test":

- Freight ITS Congestion Management System. This test included an examination of a queue detection system and variable message sign on I-5 approaching the Port of Tacoma, as well an Internet-based camera system installed at three port terminal roadway approaches at the Port of Seattle to monitor gateway and access road queues.

- Freight ITS Data Collection. This test looked at vehicle transponders and wireless GPS devices as tools for detailed data collection of regional freight traffic flows.

These two tests were conducted in tandem with 17 public and private sector participants. SAIC served as the "Independent Evaluator" for this test. Additionally, TRAC served as the primary research team for the examination of the use of GPS devices and transponders to support freight traffic data collection. The results of these assessments, along with corresponding conclusions and recommendations, are detailed in this report. Two key conclusions are summarized as follows:

- The three Port of Seattle cameras experienced approximately 2,000 hits on each camera in July of 2002. These three cameras have become an integrated component of the overall traffic management system in the greater Seattle region.

- Despite significant data analysis challenges, the use of real-time GPS and transponder data collected from trucks and state systems does show promise as a means for MPOs to collection regional freight transportation data; however, further research and system tests will be needed to develop appropriate methods and tools.

This report is Part 2 of two reports. A first volume of this report entitled, “Part 1: Electronic Container Seals Evaluation,” is being published separately. Part 1 covers the separate evaluation effort of the E-seal project, which was the primary focus of the WSDOT Intermodal Data Linkages FOT; it should be noted that the two traffic data projects evaluated in this Part 2 report are not technically related to or integrated with the E-seal project evaluated in the Part 1 report.

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ABBREVIATIONS

ADT	Average Daily Traffic
APL	American Presidents Line
ATIS	Advanced Traveler Information System
AVI	Automatic Vehicle Identification
CB	Citizen's Band (radio)
COTR	Contracting Officers Technical Representative
CSI	Cambridge Systematics, Inc.
CVISN	Commercial Vehicle Information System and Networks
DDHV	Directional Design Hour Volumes
DSRC	Dedicated Short-Range Communication
FLOW	Freeway Surveillance System
FOT	Field Operational Test
GIS	Geographic Information System
GPS	Global Positioning System
ISP	Internet Service Provider
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
MPOs	Metropolitan Planning Organizations
NB	Northbound
PSRC	Puget Sound Regional Council
SAIC	Science Applications International Corporation
SSA	Stevedoring Services of America
TCC	Traffic Control Centers
TMDA	Time Division Multiple Access (cellular phone information standard)
TMC	Traffic Management Center
TRAC	Transportation Research and Analysis Center
USDA	United States Department of Agriculture
USDOT	United States Department of Transportation
USCS	United States Custom Service
VMS	Variable Message Signs
WIM	Weigh-in-Motion
WSDOT	Washington State Department of Transportation

EXECUTIVE SUMMARY

INTRODUCTION

Based on its successful grant application in 1999, the United States Department of Transportation (USDOT) selected a Washington State Department of Transportation (WSDOT)-led team to deploy and test several intermodal freight ITS technologies in the Puget Sound region. The primary purpose of this "WSDOT Intermodal Data Linkages Field Operational Test (FOT)" was to demonstrate the use of electronic seals (E-seals) on containers to track movements and monitor the security of containerized freight moving in-bond through the United States and across the Canadian border. The results of this E-seal test were provided in Part 1 of this report, which was published in December 2002. A secondary purpose of this FOT was to conduct two small-scale tests within the following two emerging Intelligent Transportation Systems (ITS) freight traffic systems areas:

(1) Congestion Management Systems. There were two parts of this test. The first portion deployed a traffic-measuring device at the first of two exits off of I-5 near the Port of Tacoma that would connect with a beacon sign installed upstream on I-5. This connection provided messages displayed in real-time to truck drivers regarding the level of congestion on that off-ramp. This early notification could give truck drivers the alternative of exiting off of the second Port of Tacoma exit on I-5 to avoid the congestion present at the first exit. The second portion of this test involved the installation of video cameras at several Port of Seattle terminal roadway approaches where congestion frequently occurred. The video feeds were made available to trucking companies and the public in real time through the WSDOT traffic conditions Website.

(2) Freight Traffic Data Integration. The were two parts of this test, where both portions had the goal of examining new methods of providing truck travel data to support State and regional freight transportation planning efforts. The first portion examined the utility of data developed from on-truck GPS/wireless broadcast devices, which could measure a truck's location in real time. The second portion of this test examined the utility of data developed from dedicated short-range communication (DSRC)-based truck transponder networks, including Washington State's Commercial Vehicle Information System and Networks (CVISN) transponder network, and also its port-to-border crossing "TransCorridor" transponder network. These transponder networks were utilized in this test to provide periodic measurements of truck locations as trucks passed under reader antennas at certain weigh stations, port terminal gates, and border crossings.

This report presents the findings from the independent assessment of the above two system tests that was conducted by the SAIC Evaluation Team for the USDOT. The Evaluation Team employed a case study technical approach for these two tests, which provides a descriptive and "lessons learned" evaluation research approach. The remainder of this Executive Summary is divided into two sections based on the findings of the case studies for each of these two tests, and is then succeeded by a final section highlighting the most critical recommendations of the Evaluation Team from conducting these case studies.

CONGESTION MANAGEMENT SYSTEMS EVALUATION CASE STUDY

The congestion management systems test consisted of two separate deployments of different technologies to facilitate access to and from the Ports of Seattle and Tacoma. The goal was to use Advanced Traveler Information System (ATIS)-based data to alleviate congestion at the ports' gates and access routes by providing real-time traffic information to the trucking industry. These two tests represent actual deployments in the region's advanced ATIS infrastructure. Table ES-1provides a listing of the public and private stakeholders involved in these tests.

Table ES-1. Congestion Management Systems Test Participants

PARTNER	ROLE						
	Project Management	System Development	System Deployment	Participant Recruitment/ Outreach	System Participant	Evaluation	Project Oversight
Public Sector Partners:							
USDOT							?
WSDOT/TRAC	?	?	?	?			
Port of Tacoma (Tacoma)		?					
Port of Seattle (Seattle)		?		?			
Olympic Regional TMC (Tacoma)		?	?		?		
Private Sector Partners:							
Traficon (Tacoma)		?	?				
Kargor (Tacoma)		?	?				
West Coast Trucking (Seattle)					?		
Lion Trucking (Seattle)					?		
Regional motor carriers					?		
SAIC and CSI						?	

Port of Tacoma Test Case Study

Despite the significant increases seen in recent years in the numbers of automobiles and trucks traveling on I-5 in the Tacoma region, the Port of Tacoma has worked to improve access to the port terminals. As a result, this system was developed and located to help achieve this goal by providing truck drivers serving the Port of Tacoma with the ability to change their route based on the dissemination of current traffic conditions. WSDOT deployed an automated sign/alarm system at the primary I-5 exit for the Port of Tacoma in the southbound direction (from Seattle). This system consisted of a queue detection system on the off ramp and a beacon sign north of the exit. When the queue detection system is triggered, indicating sufficient ramp queuing, an alarm is activated at the local WSDOT traffic operations center. The monitoring staff views the traffic at the Portland Avenue exit (the next southbound exit) via available cameras to verify sufficient capacity exists. When sufficient capacity does exist, the beacon sign is activated and trucks are notified to use the Portland Avenue exit to access the port terminals. Once the beacon has been activated, traffic conditions are monitored and once the congestion has been eliminated, the beacon is turned off.

At the same time that this system was being deployed, the reconstruction of the interchange off of the same off-ramp was completed. Currently, both the highway improvement and the congestion notification system are in place and operating. Since this system has become operational, the historic recurring traffic congestion has not occurred, resulting in insufficient congestion to trigger the system. However, recently the system was activated when a truck rolled over on the off ramp causing immediate back ups. In this instance, the system was used for incident management directing trucks to another exit.

The evaluation effort focused on determining the potential need for the system in the future based on current and forecast traffic levels, as well as identifying the available capacity of the roadway. Some of the conclusions from this evaluation are highlighted as follows:

- **Successful Development and Deployment.** This congestion queue detection and beacon messaging system was successfully developed, deployed, and tested, thus validating the technical proof-of-concept for this type of real-time truck driver congestion information system. The Port of Tacoma and WSDOT closely coordinated to define the appropriate location and design for this system.

- **System Usefulness Limited.** The change in traffic conditions has limited usefulness of the system to date. Since the deployment of this system, the alarm was only triggered once, due to an overturned truck on the off ramp. The recurring traffic congestion that the system was developed to address has been alleviated in the short term by reconstruction of the Port of Tacoma Road and Rt. 509 interchange, and by the decrease in traffic levels from 2000 to 2002.

- **Traffic Growth Supports ITS System.** Traffic growth projections support this type of ITS system development. Over the last 12 years, total traffic on the southbound I-5 off ramp has grown by over 92 percent. In addition, traffic forecasts call for 52 percent growth between 1998 and 2018. Therefore, the improvement in traffic conditions created by the Port of Tacoma Road/Rt. 509 project will be temporary and it is expected that the use of this system will likely increase in the coming years.

<u>Port of Seattle Test Case Study</u>

At the Port of Seattle, traffic congestion at terminal roadway approaches and terminal ramps has been a significant problem over the past decade. The objective of this test was to provide trucking companies with the ability to dispatch drayage trucks based on real-time traffic information for port terminal access. An Internet-based camera system was installed at three locations on terminal access routes to monitor gateway and access road queues. The locations for these cameras were determined by a collaborative effort of local stakeholders, including Port of Seattle staff. These cameras add to an extensive network of cameras already in use in Puget Sound region, but they represent the first cameras deployed specifically to help freight operations. Static photo images are provided via the Internet for each of these cameras, and are updated every 4 minutes on the WSDOT traffic conditions web site.

These cameras provide information on public rights of way and were expected to complement the privately available terminal cameras, such as those provided by the APL and SSA terminals to communicate terminal operations. The test consisted of monitoring traffic flows and the real-time dissemination of information to trucks accessing the Port of Seattle. This test was deployed over a period of time, one camera at a time. Each camera system required coordination with the right of way owners, and also close coordination with the utility providers. In addition, after the camera locations had been selected, one of the affected terminals relocated the site of its access point to improve traffic flow. As a result of these factors, the camera system came on line slowly over the last year.

The evaluation case study effort focused on reviewing the Web page hits to date and meeting with system users (trucking companies) to identify benefits and possible improvement/expansion opportunities. Some of the conclusions from this evaluation are highlighted as follows:

- **Successful Development and Deployment.** The three cameras were successfully deployed and integrated into the existing regional traffic Website, and the usage of this system was greater than expected considering the limited customer set (trucking companies and terminals) and very limited outreach activities. For example, there were approximately 2,000 hits on each camera in July of 2002.

- **Preliminary Positive Feedback from Industry, but Limited Outreach Effort.** The camera system was advertised informally to regional trucking companies that attend the quarterly port truckers' group meetings. Preliminary feedback from the freight industry through these meetings was positive. In general, truckers believe the more information they have access to, the better their operations will function. However, plans for a more formalized outreach effort, including the preparation and distribution of descriptive brochures has not yet occurred.

- **Integration into Operations is Complicated.** Dispatchers use multiple information sources for their dispatch decision-making activities. Adding another resource is complicated as their time is limited. In addition, specific company operations impact the usefulness of a congestion management system, as many trucking companies don't have the luxury of delaying pickups to avoid congestion.

- **Cameras Provide Secondary Benefits.** In addition to providing traffic conditions, the cameras provide the ability of both motor carriers and shippers/receivers to investigate reasons for delay. These cameras provide a mechanism to these participants to check up and confirm reported conditions, as well as identify reasons for delay without direct communication with drivers.

FREIGHT TRAFFIC DATA INTEGRATION EVALUATION CASE STUDY

The Evaluation Team performed a case study of the WSDOT Transportation Research and Analysis Center (TRAC) effort over the past 2 years to test the utilization of freight traffic information obtained from the regionally deployed CVISN and border truck transponder systems (i.e., AVI and DSRC technology), and also from a small test of wireless GPS devices mounted in five drayage trucks that continually traveled throughout the region. This case study is based significantly on documentation and preliminary results provided to the Evaluation Team from TRAC. Table ES-2 provides a listing of the public and private stakeholders involved in these tests.

Table ES-2. Regional Freight Data Collection Participants

PARTNER	ROLE						
	Project Management	Project Participants	Data Collection	Data Analysis	System Participant	Evaluation	Project Oversight
Public Sector Partners:							
USDOT							?
WSDOT/TRAC	?	?	?	?		?	
WSDOT/CVISN		?					
Private Sector Partners:							
PSRC		?					
Air-Trak					?		
Puget Sound Freight Lines					?		
TransCore			?				
CVISN-Equipped Trucks					?		
SAIC and CSI						?	

The freight information developed from the Puget Sound region's ITS devices potentially can be used as the foundation to support local and regional freight transportation planning by organizations such as the Puget Sound Regional Council (PSRC) and WSDOT. Freight-oriented travel data are needed by these organizations to identify freight movement bottlenecks, to explore the reliability of freight movements, and to determine the frequency and costs of nonrecurring events such accidents and weather. Such information justifies the development of freight-oriented highway construction and ITS projects. This information can also assist in identifying and modifying the impacts of activities such as port gate closures, border crossing delays, and major public events.

GPS/Wireless Devices Case Study

Five Air-Trak GPS/wireless devices were deployed at two trucking companies (CSX and Puget Sound Freight Lines) that agreed to allow TRAC install these devices in their trucks. Several truck drivers also received a short training session on how to turn the device on and off. TRAC paid the wireless charges. The purpose of this deployment was to test this technology to determine its applicability for regional freight data collection. The GPS devices were used for 1 year, resulting in 98,000 location reports. The devices were used with various airtime plan configurations to relate the cost of the plan to usefulness of the resulting data. The costs for the wireless charges for 4,500 positions a month were $60.00 per vehicle. Each additional 500 positions cost $7.00 a month per vehicle.

Each time the GPS device reported its location, data was collected on that vehicle's current performance and location. Thus, the data provided vehicle specific speed as well as time and location information. This, in turn, provided point estimates of roadway speed as well as the ability to compute roadway travel time. This information also allowed the TRAC research team to explore "facility performance" based on periodic reports of instantaneous vehicle speed, versus direct measurement of vehicle trips along specific roadway segments.

The evaluation case study effort focused on examining the utility of this data to provide accurate measurements of truck locations and travel times to support regional and state freight transportation data collection efforts. The conclusions from this evaluation are highlighted as follows:

- **Test of On-Truck GPS Showed Significant Limitations.** While the use of GPS units to determine truck travel patterns and estimates of travel times showed promise, the analysis identified several limitations of this technology. The difficulties of integration with GIS systems, the significant cost required to collect the data, the high variability of the GPS data, and the number of units that would be required across a major metropolitan region would restrict the usefulness of this technology. Additionally, significant investment in recurring communications costs, and further research to develop accepted methodologies and automated GPS-to-GIS translations tools would be required to deploy this system in a major metropolitan area.

- **Comparisons of GPS Data to Freeway Loop Data Provided Some Interesting Results.** The instantaneous truck speeds from the GPS device truthfully showed the performance of the trucks, but tended to under estimate actual roadway performance, as many cars will pass slower moving vehicles given the opportunity. If GPS spot speeds from trucks are used to predict "congestion", they also tend to paint an overly "poor" image of roadway performance (even if they represent actual truck performance.) The GPS data appear to frequently report the minor slow downs that result from merge/diverge traffic. These disruptions are significant for trucks during time periods of high volume, but they have lesser effects on the flow of automobiles.

Use of Transponders Case Study

WSDOT already has deployed two truck transponder networks based on the 915 MHz DSRC standard – the statewide CVISN transponder weigh-in-motion (WIM) system, which has transponders on 20,000 registered trucks, and the much smaller TransCorridor system used by trucking companies for improved U.S. Customs (USCS) processing of in-bond movements between the Seattle/Tacoma ports and the Canadian border. These AVI transponders are short-range communication devices that are mounted on the inside of the vehicle's windshield and used to electronically identify the truck, much like an electronic license plate. The transponder reader antennas are placed on poles over the roadway or at elevation at facility entrances, and communicate electronically to verify a trucks transponder identification (ID) number, and then to correlate this number with a records database for state enforcement data for CVISN or USCS in-bond shipment data for the TransCorridor system.

With these networks deployed, archived data on these trucks movements are readily available for regional and state freight planners to utilize. For this project, TRAC acquired several years' worth of data for almost one million tag reads. The evaluation case study effort focused on examining the utility of this data to provide accurate measurements of truck locations and travel times to support regional and state freight transportation data collection efforts. Some of the conclusions from this evaluation are highlighted as follows:

- **Transponder Data is Effective for Calculating Travel Times if Data is Available.** The analysis successfully showed that truck transponders can be used to calculate average truck speed/travel time for a given segment if adequate reporting frequency is available. Transponders can also be used to determine specific time/day congestion points if adequate reporting frequency is available. Transponders cannot be used to determine the specific locations that congestion occurs due to the sparse sensor density (i.e., the typical long distances between deployed transponder reader antennas).

- **Transponder Data Accuracy Was Limited by the Size and Density of the Deployed Transponder Reader Network**. The long segments traveled by these interstate carriers, combined with the low sensor density (limited number of AVI readers), created many opportunities for routes that restricted the number of matched tag reads. Data show that the greater the distance between readers, the less number of matches. This factor limits the usefulness of the data set, as at least two points are required for a travel time calculation. In these cases, additional readers would need to be deployed between current reader segments to improve the accuracy of the data. In addition, it was found that the usability of the data may vary by time of day, week, and year.

RECOMMENDATIONS

The following highlight some of the recommendations that have been developed as a result of the evaluation case studies presented in this report:

- **Future Expansion of the Congestion Management System at the Port of Tacoma.** Ideas have been circulated about a complete port access management system. Based on renewed communication with the Port of Tacoma, future deployments of congestion management technologies should be reviewed by a partnership including the Port of Tacoma, WSDOT, and the Puget Sound Regional Council to identify possible expansions of the existing system.

- **Develop and Conduct an Outreach Program to Promote Port of Seattle Camera Congestion Management System Use.** With the three cameras up and functioning, WSDOT should make a concerted effort to notify as many trucking companies as possible about the congestion management system. Initial suggestions included handing out brochures at port terminal gates.

- **GPS/Wireless In-Truck Systems to Support Freight Transportation Planning Efforts Should Not Be Deployed Yet.** Based on the findings of this analysis, the costs (nonrecurring and recurring) of this technology are too high, and the suite of analysis tools that would allow for successful management and manipulation of the data are not mature. Planning agencies should adopt a “wait-and-see” approach to this technology to monitor future cost reductions and analysis tools development.

- **When the Technologies and Software Mature and the Costs Decrease, Conduct a Large-Scale Test of GPS Data Devices**. In the next several years, as wireless communications and GPS data devices costs continue to drop, investigate the utility of conducting a significantly more comprehensive test of GPS on-truck data devices in a major metropolitan region. This test should also include further research into improving the accuracy of the data, development of automated processes for GPS-to-GIS data mapping, and development of data mining tools for managing the huge data files that would be archived daily under this test.

- **Incorporate CVISN Transponder Data into Freight Planning Efforts.** This test proved the viability of using existing transponder data already provided by a state’s CVISN system to measure truck travel times between transponder reader segments on freeways. Since this data is already available and “free”, state DOT’s and metropolitan planning organizations (MPOs) should work with their state’s CVISN enforcement personnel to gain access to archives of such data to develop appropriate freight travel time statistics which could prove valuable in a variety of transportation modeling and planning efforts.

1. INTRODUCTION

In mid-1999, the U.S. Department of Transportation (USDOT) awarded funding for an Intermodal ITS Field Operational Test (FOT) to a regional consortium led by the Washington State DOT (WSDOT). The main purpose of this “WSDOT Intermodal Data Linkages FOT” was to demonstrate the use of electronic seals (E-seals) on containers to track movements and monitor the security of containerized freight moving in-bond through the United States and across the Canadian border. The results of this test were provided in Part 1 of this report, which was published in December 2002.[1]

A secondary purpose of this FOT was to test new methods of ITS freight traffic systems, including: (1) congestion management systems, and (2) the utility of DSRC transponders and GPS/wireless technologies to support state and regional freight planning efforts. The evaluation of these two test elements is the focus of this report, which is Part 2 of the WSDOT Intermodal Data Linkages Evaluation Final Report.

For the Congestion Management System Test, Internet-based video of access roads to port gates was demonstrated to provide truck drivers/dispatchers with real-time information on traffic congestion, specifically around the Port of Seattle. A traffic sensor and beacon warning sign system was also tested for access to the Port of Tacoma (a Congestion Notification System).

For the Freight Traffic Data Integration Test, in support of the USDOT’s desire to leverage ITS research to support metropolitan planning organizations (MPOs), this test attempted to demonstrate the potential use of trucks equipped with transponders, and other trucks equipped with wireless global positioning system (GPS) devices, to both augment and reduce the resources associated with transportation data collection on regional freight movements.

In support of the USDOT’s Intermodal Freight ITS Program, an Evaluation Team led by SAIC, under the direction of the USDOT Joint Program Office (JPO), was selected in January 2000 to develop and implement an evaluation of the WSDOT Intermodal FOT. With regard to this report, the ultimate goal of this evaluation is to identify “lessons learned” with respect to implementing intermodal ITS technologies for the above two distinct tests of congestion management systems and freight traffic data integration.

For the evaluation of these two tests, given that they were not the primary focus of the FOT (i.e., the E-Seal deployment was the main focus – see the Part 1 report), the Evaluation Team employed a case study technical approach for this analysis. An evaluation case study approach is geared towards a more descriptive and lessons learned evaluation research approach as compared to a more rigorous and quantitative standard ITS evaluation approach. However, it is important to note that the two case study evaluations detailed here do present some significant quantitative data and results that are atypical of traditional ITS case studies.

[1] See “WSDOT Intermodal Data Linkages Freight ITS Operational Test Evaluation Final Report – Part 1: Electronic Container Seals Evaluation”, prepared by SAIC for the USDOT, December 2002.

While the evaluation case study of the Congestion Management System Test was conducted solely by the SAIC Evaluation Team, the case study of the Freight Traffic Data Integration Test was conducted largely by TRAC, with oversight, observations, and the development of conclusions and recommendations being provided the SAIC Evaluation Team. In this regard, the Team would like to recognize the significant contributions from Mr. Mark Hallenbeck at TRAC to the Freight Traffic Data Integration Test evaluation case study.

The succeeding portions of this draft final report document are organized as follows:

- **Section 2. Congestion Management System Evaluation Case Study**. This section describes the ITS technologies deployed to improve truck access to the Ports of Seattle and Tacoma; system use and impact; and the resulting findings, conclusions, and recommendations regarding participant satisfaction and institutional issues.

- **Section 3. Freight Traffic Data Integration Evaluation Case Study**. This section describes the data collection activities conducted by WSDOT to evaluate the usefulness of both GPS and transponder technologies and data sources for estimating truck travel times in the region. Additionally, this section presents the resulting findings, conclusions, and recommendations regarding the collection and use of regional freight data based on these technologies.

This final report document was developed by the SAIC Independent Evaluation Team, which includes Science Applications International Corporation (SAIC) and Cambridge Systematics, Inc. (CSI).

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2. CONGESTION MANAGEMENT SYSTEM EVALUATION CASE STUDY

2.1 INTRODUCTION

The Evaluation Team performed a case study of two different congestion management systems – one based on the use of video cameras (with Internet view access) deployed at port terminal approaches, and the other employing traffic counting and variable message signs at a terminal approach interstate off-ramp with the goal of warning truck drivers of potential port access traffic congestion. This case study is presented below in the following sections:

- 2.1 Description of Technology and Deployments
- 2.2 Technical Approach
- 2.3 Data Summary and Analysis
- 2.4 Findings, Conclusions, and Recommendations

2.2 DESCRIPTION OF TECHNOLOGY AND DEPLOYMENTS

The congestion management test consisted of two separate deployments of different technologies to facilitate access to/from the Ports of Seattle and Tacoma. The goal was to use ATIS-based data to alleviate congestion at the ports' gates and access routes by providing real-time traffic information to the trucking industry. These two tests represent actual deployments in the region's advanced ATIS infrastructure. The goal of the evaluation was to document their impact on traffic operations.

2.2.1 Congestion Notification System at Port of Tacoma

At the Port of Tacoma, a beacon sign-based system was installed along I-5 southbound just north of the off ramp for Port of Tacoma Road. This exit is one of three major interchanges off I-5 that provides access to the Port of Tacoma. Historically, this off ramp has experienced significant traffic queues resulting from several closely spaced traffic signals, and an at-grade rail crossing.

Based on conversations with representatives from the Port of Tacoma, WSDOT identified the most viable placement location for the automated sign/alarm system. This system consists of a queue detection system on the off ramp and a beacon sign north of the exit. The queue detection system consists of a camera and software system that monitors the activity on the off ramp. As depicted in a series of illustrations and photographs in Figures 2-1 through 2-5, Figure 2-1 illustrates the anticipated impact this system might have on port traffic. Figure 2-1 also shows the change in route selection based on available real-time traffic information. Figure 2-2 shows the beacon sign located just north of the exit ramp. Figure 2-3 shows the off-ramp sign where the camera system is installed.

Figure 2-4 shows the view from the camera. The camera monitors a defined area or zone on the ramp looking at two separate variables. These consist of zone occupancy and flow speed. The zone occupancy refers to the percentage of the window that is occupied and the flow speed refers to the vehicle speed (at the time the zone is occupied). Each of these parameters has been set at predetermined levels that have been determined to indicate congestion. Each of these variables must be triggered simultaneously for the alarm to be activated.

When both of these variables are triggered, indicating sufficient ramp queuing, an alarm is activated at the traffic-monitoring center (TMC). The monitoring staff then views the traffic at the Portland Avenue exit (the next southbound exit) via available cameras to verify sufficient capacity exists. When sufficient capacity is verified, the beacon sign is activated and trucks are notified to use the Portland Avenue exit to access the port terminals. Once the beacon has been activated, traffic conditions are monitored and once the congestion has been eliminated, the beacon is turned off.

Figure 2-5 shows the Olympic Region TMC where the monitoring and control takes place. Since deploying this system, the alarm has not been triggered. Possible explanations may include a reduction in port traffic due to the economy and a significant highway construction project that separated two major roadways and a rail line. The objective of this deployment was to provide truck drivers serving the Port of Tacoma with the ability to change their route based on the dissemination of current traffic conditions.

The Port of Tacoma had been working for years to improve access to the port terminals. As a result, this system was developed and located to achieve this goal. In the interim, another project was also initiated – the reconstruction of the Port of Tacoma Road and Rt. 509 interchange just downstream from the I-5 off ramp. This project, in the planning since the early 1990s, was completed between the beacon system design and deployment.

Currently, both the highway improvement and the beacon sign system are in place and operating. From the time the beacon sign system became operational, the historic recurring traffic congestion has not occurred, resulting in insufficient congestion to trigger the system. The system was recently activated when a truck rolled over on the off ramp, causing immediate traffic backups. In this instance, the system was used for incident management directing trucks to the Portland Avenue exit. The evaluation effort has focused on determining the potential need for the system in the future based on current and forecast traffic levels, as well as identifying the available capacity of the roadway.

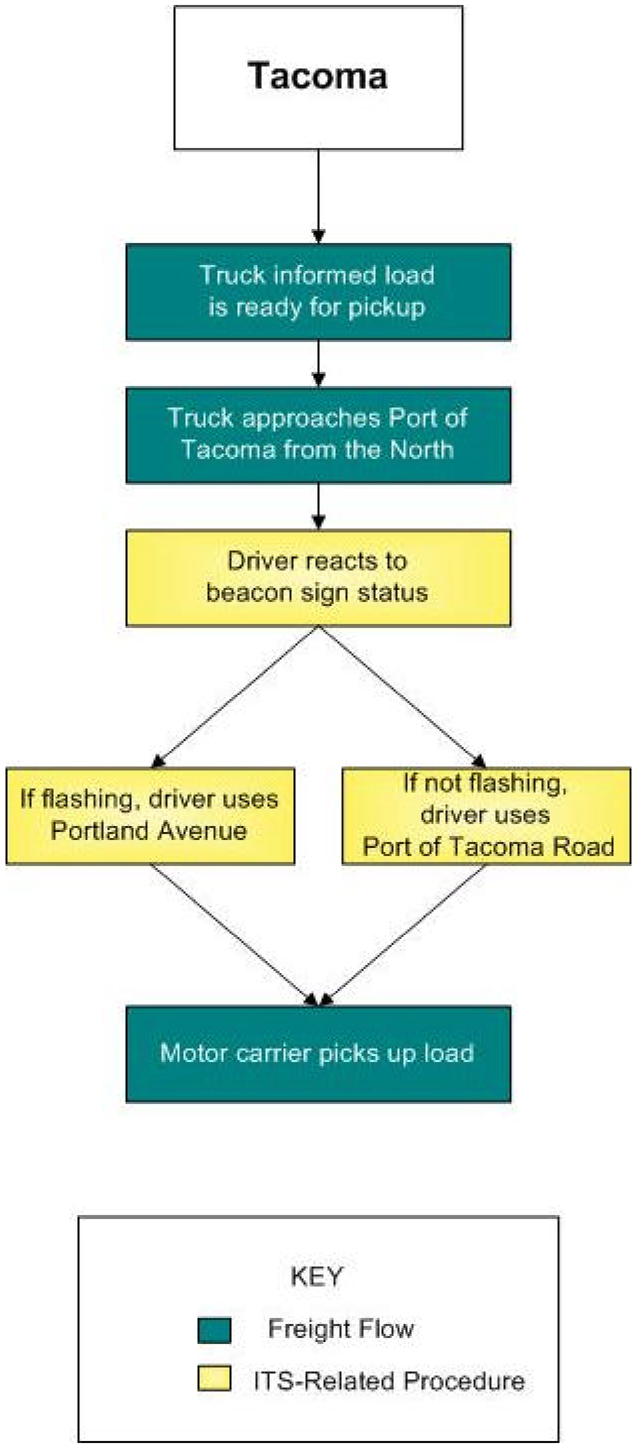

Figure 2-1. Impact of Camera Queue Detection System at Port of Tacoma.

Figure 2-2. Port of Tacoma Road Exit Beacon Sign.

Figure 2-3. Port of Tacoma Road Exit Sign with Camera.

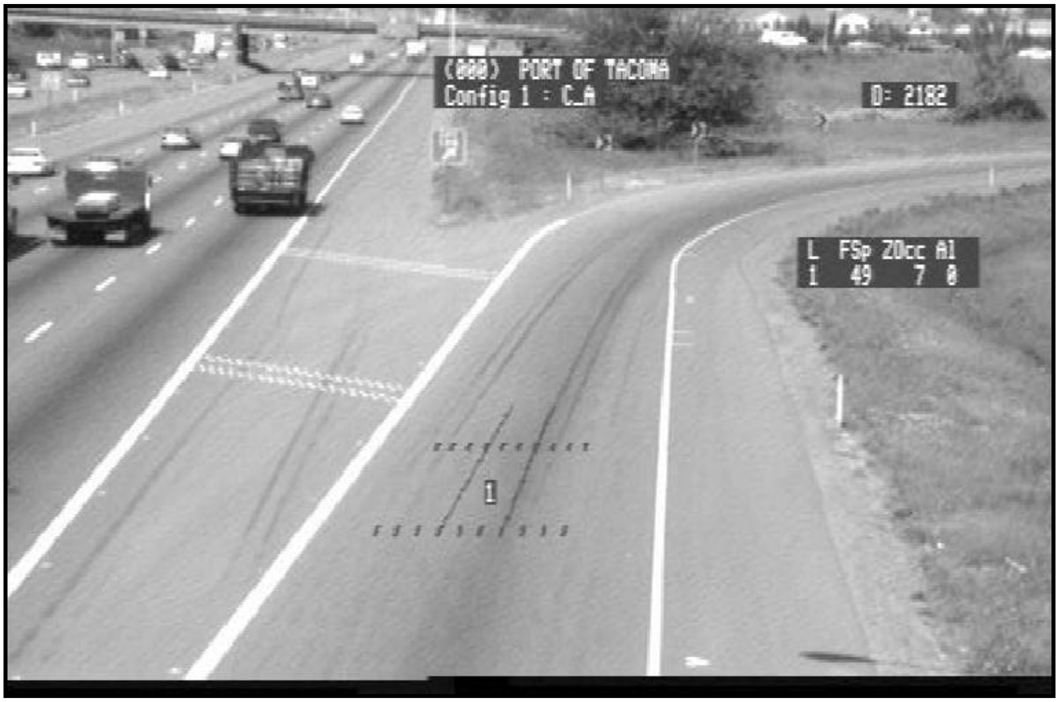

Figure 2-4. Port of Tacoma Road Ramp View from Camera Queue Detector.

Figure 2-5. Olympic Region TMC, Tacoma.

2.2.2 Congestion Management System at the Port of Seattle

At the Port of Seattle, an Internet-based camera system was installed at three locations on terminal access routes to monitor gateway and access road queues. The locations for these cameras were determined by a collaborative effort of local stakeholders, including Port of Seattle staff. These cameras add to an extensive network of cameras already in use in Puget Sound region, and they represent the first cameras deployed specifically to help freight operations.

Static photo images provided via the Internet for each of these cameras are updated every 4 minutes. These cameras provide information on public rights of way and were expected to complement the privately available terminal cameras, such as those provided by American Presidents Line (APL) and SSA to communicate terminal operations.

Figure 2-6 illustrates the impact this system was anticipated to have on port traffic, and shows the change in route selection based on available real-time traffic information. This differs from the Port of Tacoma system in that it requires a trucking company to visit the Website and make a decision, as opposed to responding to a field traffic management system. Figure 2-7 shows the Web page from where the cameras can be accessed.

Figures 2-8 through 2-13 show the actual cameras and the views they provide at each of three locations. In addition to the three cameras, WSDOT has plans to integrate privately available terminal cameras, such as those provided by APL and SSA. This test consisted of monitoring traffic flows and the real-time dissemination of information to trucks accessing the Port of Seattle. The objective of this test was to provide motor carriers with the ability to dispatch port-related trucks based on real-time traffic information for port terminal access.

This test was deployed over a period of time, one camera at a time. Each camera system required coordinating efforts with the right of way owners, as well as with the utility providers. In addition, after the camera locations were selected, one of the affected terminals relocated the location of its access point to improve traffic flow. As a result of these factors, the camera system came on line slowly over the last year. The evaluation effort has focused on reviewing the Web page hits to date and meeting with system users (trucking companies) to identify benefits and possible improvement/expansion opportunities.

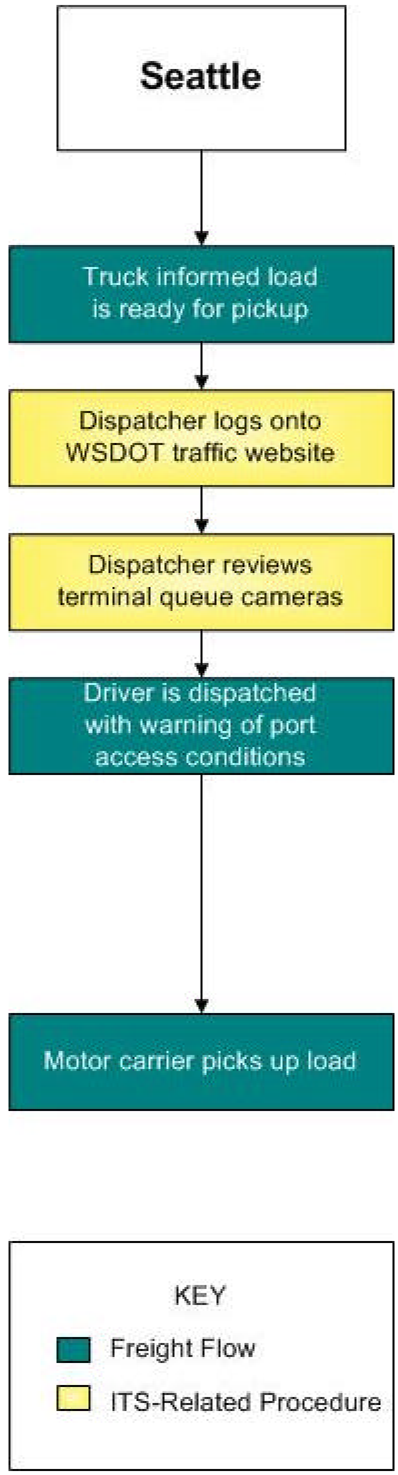

Figure 2-6. Impact of the Internet Traffic Cameras at the Port of Seattle.

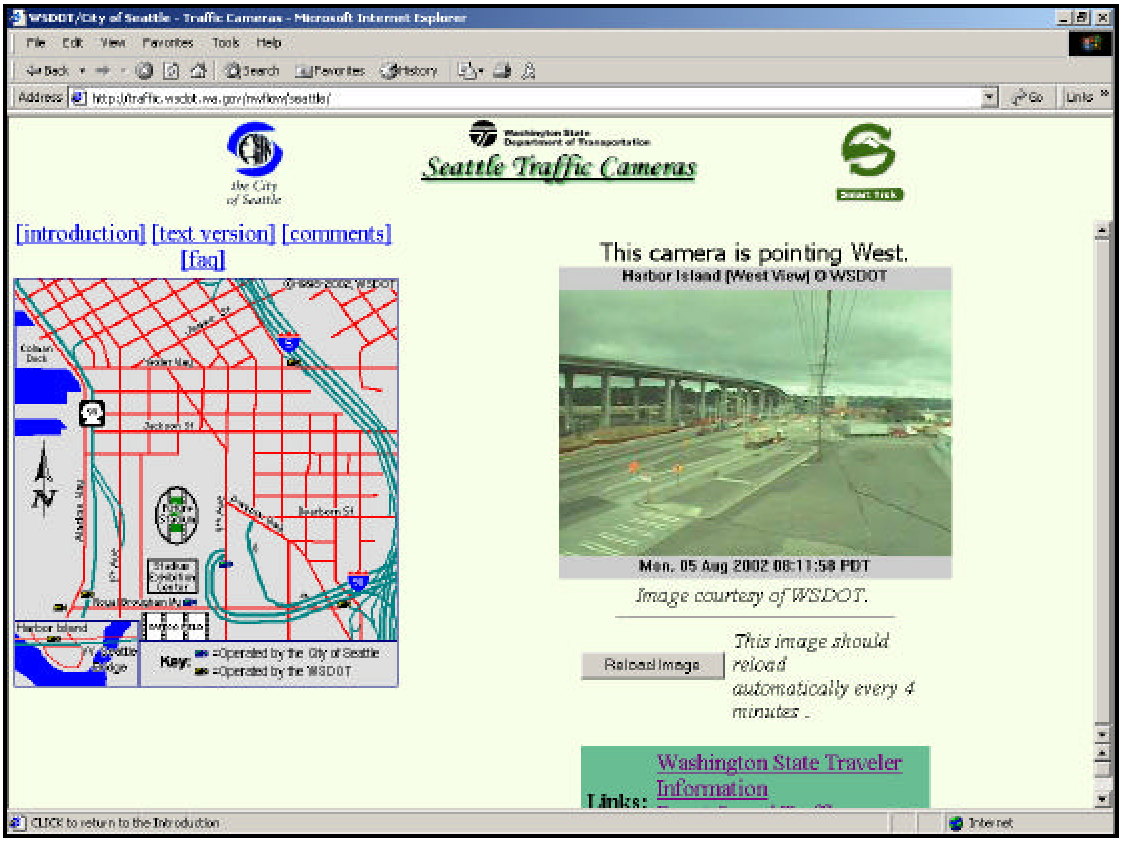

Figure 2-7. Seattle Traffic Cameras Viewed from the WSDOT Website.

Figure 2-8. Camera Located on Harbor Island at Spokane Street (Terminal 22)

Figure 2-9. View from Harbor Island at Spokane Street Camera (Terminal 22).

Figure 2-10. Camera Located on Alaskan Way at Royal Brougham (Terminal 37).

Figure 2-11. View from Alaskan Way at Royal Brougham Camera (Terminal 37).

Figure 2-12. Camera Located on Alaskan Way (Terminal 42).

Figure 2-13. View from Alaskan Way Camera (Terminal 42).

2.3 TECHNICAL APPROACH

The objective of this test was to better manage truck access to the Ports of Tacoma and Seattle by providing real-time traffic information to trucking companies. This test identified key access bottlenecks and developed systems to notify motor carriers of congested traffic conditions. The systems were designed to provide WSDOT and local traffic management agencies with the ability to better utilize available capacity, while providing the freight industry with tools to improve their operations. Additional benefits were to include improved traffic conditions for general traffic, and streamlined operations for the steam ship terminals.

To execute the technical approach, data were collected from the participants. For the Seattle camera deployment, data collection consisted of interviews with the developers and deployers, interviews with representative motor carriers, site visits to observe the deployed technologies, and a review of Website hits for each camera. For the Tacoma queue detection system, data collection consisted of interviews with the system developers and deployers, site visits to observe the deployed technologies, and a review of available traffic data for the region.

2.4 SUMMARY OF DATA AND ANALYSIS

This section presents the data collected and analyzed in support of the evaluation. It describes the participants involved, summarizes the data analysis, and presents key findings and recommendations as outlined in the following sections:

- 2.3.1 Description of Participants
- 2.3.2 Summary of System Performance
- 2.3.3 Congestion Detection System at Port of Tacoma

2.4.1 Description of Participants

The following provides a list of the test participants and their involvement for each congestion management system.

- **WSDOT.** WSDOT was the champion of this FOT, providing ongoing leadership and direction. WSDOT was responsible for recruiting, developing, and deploying the systems.
- **Port of Seattle.** The Port of Seattle was involved in the site selection for the three cameras in Seattle and facilitated outreach to the trucking industry. Staff were also involved in the identification of locations for additional deployments in the future.
- **Port of Tacoma.** The Port of Tacoma was involved in the site selection and development of the beacon-based sign system in Tacoma. Based on historic efforts to improve port access, Port staff were a key proponent for the system.

- **Olympic Region TMC.** The Olympic Region TMC was responsible for deploying and operating the beacon-based sign system in Tacoma.
- **Traficon.** Traficon was responsible for developing the beacon-based sign system, focusing on the camera queue detection hardware and software.
- **Kargor.** Kargor was also responsible for developing the beacon-based sign system, focusing on the camera queue detection hardware and software.
- **Regional Motor Carriers.** Regional motor carriers (West Coast Trucking, Lion Trucking, etc.) were involved in both Tacoma and Seattle, based on the impact the systems had on their operations. For example, the Port of Seattle has an established motor carrier group that brings industry representatives together, such as West Coast Trucking and Lion Trucking.

2.4.2 Summary of System Performance

The system performance data for each test was limited. For the Seattle camera system test, the system was evaluated based on interview data and Website hits. For the Tacoma sign system test, the evaluation was based on discussions with the deployers and a review of available traffic data, given that the system has not been subjected to heavy congestion. The following subsections summarize the results of these data.

2.4.2.1 Congestion Management System at the Port of Seattle

- **Key Camera Placement.** WSDOT and the Port of Seattle worked together to locate the three cameras based on key bottlenecks and the locations of existing private cameras. For example, the camera installed on Spokane Street was located to record the public street because SSA had its own camera that monitored its gate queues.
- **Port Access Issues Discussion Group.** The Port of Seattle sponsors a port-related truck group that meets quarterly to discuss port access issues. The cameras were discussed regularly with this group.
- **Truckers Desire Cameras.** In general, truckers were supportive of cameras; they are anxious for a complete system.
- **Administrative Challenges.** Although the camera technology was relatively inexpensive, the main challenges involved the administrative hurdles that had to be overcome to deploy the cameras. These hurdles included rights of way issues requiring fees and permits; lack of phone lines in the area; and coordination of all these factors to successfully complete the installation. The cameras were installed on existing light poles by WSDOT staff.
- **Website Valuable.** Carrier feedback and Website hits were considered by all stakeholders to be the only way to conduct an evaluation. Since the camera system does not archive the photo images, there is no queue data available.

- **Outreach Desired.** Outreach to the trucking community was planned following installation of the third camera. This has not occurred yet. At a minimum, it was envisioned that outreach activities would consist of handing out brochures to introduce the system at all port terminal gates. The only outreach activity to date were the efforts undertaken by the Port of Seattle at its quarterly truckers' meetings. Through this mechanism, participating trucking companies were made aware of these new cameras.

- **Simplified Website Desired.** WSDOT's traffic Website is considered too large to easily maneuver to access these three cameras. Stakeholders would like a simple Website that has all relevant cameras on it. There were discussions within WSDOT and the Port of Seattle staff about finding a third party, such as the Washington Motor Carrier Association, to host all relevant freight Web cameras, but this has not yet been accomplished.

- **Traffic Cameras Well Received.** WSDOT historically has found traffic cameras to be useful and well received. WSDOT staff are hopeful that the freight industry will similarly find a way to incorporate this tool into their operations.

- **Viability of Camera Option.** Cameras that provide queue information make it possible to schedule arrival times at specific terminals. However, industry representatives suggested this tool is only a real option for long haul loads because short dray operations are based on making the most turns possible in a day. This does not lend itself easily to delaying a pick up time to avoid traffic. Some drivers are currently making six or more turns a day at the Port of Seattle. They have strict delivery appointment times and cannot easily reschedule because a queue exists at a terminal.

- **Cameras Confirmation Actions.** Cameras keep people honest. They provide motor carriers with the ability to check up on their drivers, and shippers/receivers can check up on their carriers. Cameras allow confirmation of problems that historically have been reported by drivers via CB radio.

- **Carriers Question Need for Queue.** Carriers would like to know the reason for a queue in addition to the fact that there is one. This provides them with the ability to provide better customer service. Drivers provide this function today via use of CB radios and Nextel wireless communications.

- **Drivers Distrust ITS VMS Messages.** Drivers in general are distrustful of ITS information such as VMS messages. There is a heavy reliance on word of mouth via CB radios.

- **Cameras Desirable if Cost Effective.** Cameras are of value to the industry if the cost is low. There is not a firm belief that the system provides enough benefits to justify a significant investment; however, the more information available, the better.

- **System is Useful.** Some carriers are using the system regularly and find it useful.

- **Additional Cameras Desirable.** Additional cameras at key locations would be useful. For example, cameras that covered the BNSF intermodal yard and gate would be helpful as historically there are a lot of delays at this location and cameras would help determine if it was congestion or inefficiencies. Figures 2-14 and 2-15 show the roadway and terminal gate for this facility.

- **Locate Cameras at Decision Points.** Cameras should be located at decision points for carriers. After the decision point has passed, congestion information is not useful.

- **Less Congestion at Port of Seattle.** In general, the Port of Seattle does not have long periods of congestion compared to other major ports; there may be a bad Monday morning or Friday afternoon, but it never lasts that long.

- **Cameras in Dispatch Operations Challenging.** Integrating the use of cameras into a dispatcher's operation is the real challenge. Dispatchers cannot be overloaded with additional tasks, and regular viewing of these Websites may be too much for them to incorporate.

Figure 2-14. Recommended Location for Additional Camera, BNSF Intermodal Gateway.

Figure 2-15. Recommended Location for Additional Camera, BNSF Intermodal Terminal Access Road.

Each of the three cameras was consistently used over the last several months in 2002[2], with a peak in August, as illustrated in Table 2-1.

Table 2-1. Monthly Website Hits by Camera

Camera Location	July 2002	August 2002	October 2002	November 2002
Alaskan Way (Terminal 42)	2,070	2,973	2,221	2,353
Alaskan Way at Royal Brougham Way (Terminal 37)	2,025	3,276	2,159	2,259
Harbor Island at Spokane Street (Terminal 22)	1,911	2,156	1,746	1,778

2.4.3 Congestion Detection System at Port of Tacoma

- **Queue Detection System Deployed.** The queue detection system was developed, deployed, and tested, but congestion no longer appears to be a chronic condition on the I-5 southbound exit ramp.

[2] Data for September 2002 were not available.

- **System Works as Designed.** The system was triggered once since deployed due to a truck roll over on the off-ramp. The system worked as designed and functioned effectively as an incident management tool.

- **Ramp Traffic Levels Decreased after Installation of the Queue Detection System.** Traffic levels on the off ramp have increased by over 85 percent in the AM and PM peak periods between 1990 and 2002[3]. This trend holds true for total daily traffic as well. However, since the reconstruction of Rt. 509 and the queue detection system came on line, the traffic volumes have decreased. Table 2-2 illustrates the growth in traffic on this ramp over the last 12 years.

Table 2-2. I-5 Southbound Off-Ramp Traffic Volumes

Year	AM Peak	PM Peak	Average Daily Traffic[4]
1990	230	200	2,596
2000	495	466	5,588
2002	425	463	4,975
Projected Growth: 1990 to 2000	85%	131%	92%

Traffic forecasts for this region, and specifically for Port of Tacoma Road, suggest that there will be an increase of almost 52 percent in average daily traffic (ADT) from 13,500 in 1998 to 20,500 in 2018. This increase in traffic, tied to increases in activity at the Port of Tacoma will increase the demand for a system of this type. Table 2-3 illustrates this growth by peak period and daily traffic.

Table 2-3. Port of Tacoma Road Eastbound/Westbound Traffic Volumes

Year	Bi-Directional Peak Period[5]	Average Daily Traffic
1998	1,350	13,500
2018	1,950	20,500
Projected Growth: 1998 to 2018	44%	52%

The system is based on two criteria: zone occupancy and flow speed. These values are calculated continuously and trigger the alarm if both values exceed their defined parameters. The system currently is programmed to generate an alarm if the zone

[3] Traffic volumes for these 3 years represent the actual data collected and have not been adjusted for seasonal impacts.

[4] ADT was not available for 1990. This estimate was calculated based on the peak number averaged from projected growth from 1990 – 2000.

[5] Peak period numbers are based on the addition of east and westbound Directional Design Hour Volumes (DDHV).

occupancy exceeds 35 percent. In order to verify that the system was working as programmed and to determine how close the system was to being triggered, a data collection effort was undertaken to measure the zone occupancy scores over a 1-week period. This data collection took place between September 26 and October 3, 2002. The results of this effort show that the system was operating as designed, and that the current zone occupancy fell well below the alarm threshold.

For the weekdays, the peak zone occupancy ranged from 12 to 15 percent, falling to 6 and 7 percent on weekend days. Figure 2-16 illustrates the zone occupancy scores for Friday, September 27, 2002, which represents the highest scores for this time period.

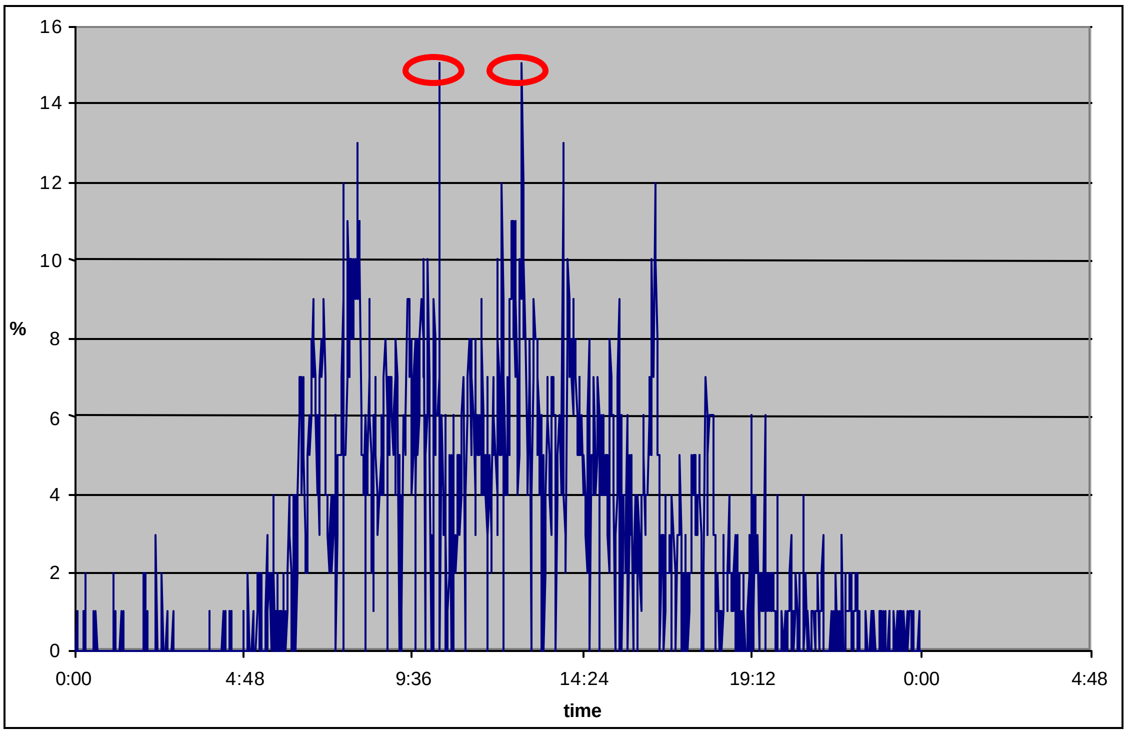

Figure 2-16. Zone Occupancy Scores for September 27, 2002

As the system was developed and deployed to address an existing traffic bottleneck, this evaluation attempted to explain why the system was not being triggered. Three reasons were identified from this analysis. First, the reconstruction of Rt. 509 alleviated the congestion downstream from this ramp, resulting in better overall traffic management. Second, due to a slowdown in the economy, the traffic volumes on this ramp decreased from 2000 to 2002, thereby reducing the need for this system at this time. And third, these data were collected during a time when many ports were experiencing labor issues (strikes) that may have affected the level of traffic during this week. Traficon staff recommended that WSDOT staff continue to monitor the ramp traffic and even consider repeating the data collection exercise once traffic levels were sufficiently recovered to provide additional insights to determine if the 35 percent setting is appropriate.

Even with these explanations, future forecasts call for continued growth in traffic in this region, which will make effective use of this system at some future date. The system did prove to be useful, on at least one instance, as an incident management tool. In addition, the Port of Tacoma and the Olympic Region TMC have discussed one concept to expand the system to cover 54th Street and Portland Avenue (the north and south exits on either side of Port of Tacoma Road). A second concept under consideration is to develop a component to provide truckers with highway conditions at the port terminals to assist them in selecting a port departure route. Therefore, this initial system is seen as one component in an overall port traffic management system.

2.5 CONCLUSIONS AND RECOMMENDATIONS

2.5.1 Conclusions

The conclusions developed from this evaluation are based on qualitative data obtained from personal interviews, and limited available quantitative data. The following provides the conclusions for each of the tests.

2.5.1.1 Congestion Management System at the Port of Seattle

- **Successful development and deployment.** The three cameras were deployed and integrated into the existing regional traffic Website. There were approximately 2,000 hits on each camera in July of 2002.

- **Close Coordination.** The Port of Seattle and WSDOT closely coordinated to select the appropriate locations for each camera. In addition, WSDOT staff worked effectively to overcome institutional barriers to achieve deployment of the technologies.

- **Limited Outreach Activities.** The camera system was advertised informally to regional trucking companies that attend the quarterly port truckers' group meetings. However, plans for a more formalized outreach effort, including the preparation and distribution of descriptive brochures has not yet occurred.

- **Positive Feedback from Industry.** Preliminary feedback from the freight industry through the Port of Seattle's outreach efforts was positive. In general, truckers believe the more information they have access to, the better their operations will function.

- **Low Expectations for Benefits.** Both WSDOT staff and the freight community had relatively low expectations for significant quantitative benefits from these deployments. To date, these expectations appear to have been exceeded.

- **Deployments Part of Regional ITS.** These three cameras became an integrated component of the overall traffic management system in the greater Seattle region.

- **Integration into Operations is Complicated.** Dispatchers use multiple information sources for their dispatch decision-making activities. Adding another resource is complicated as their time is limited. In addition, specific company operations impact the usefulness of a congestion management system, as many trucking companies don't have the luxury of delaying pickups to avoid congestion.

- **Cameras Provide Secondary Benefits.** In addition to providing traffic conditions, the cameras provide the ability of both motor carriers and shippers/receivers to investigate reasons for delay. These cameras provide a mechanism to these participants to check up and confirm reported conditions, as well as identify reasons for delay without direct communication with drivers.

2.5.1.2 Congestion Notification System at Port of Tacoma

- **Successful Development and Deployment.** The congestion queue detection system was successfully developed, deployed, and tested.

- **Close coordination.** The Port of Tacoma and WSDOT closely coordinated to define the appropriate location and design for this system.

- **System Usefulness Limited.** Change in traffic conditions limited usefulness of the system to date. Since the deployment of this system, the alarm was only triggered once, due to an overturned truck on the off ramp. In this instance, the system worked effectively as an incident management system. However, the recurring traffic congestion that the system was developed to address has been alleviated in the short term by reconstruction of the Port of Tacoma Road and Rt. 509 interchange, and by the decrease in traffic levels from 2000 to 2002.

- **Deployment Part of Regional ITS.** This system was integrated into the Olympic Region TMC's daily operations. System use procedures exist and discussions occurred for overall port congestion management system expansion.

- **Traffic Growth Supports ITS System.** Traffic growth projections support this type of ITS system development. Over the last 12 years, total traffic on the southbound I-5 off ramp has grown by over 92 percent. In addition, traffic forecasts call for 52 percent growth between 1998 and 2018. Therefore, the improvement in traffic conditions created by the Port of Tacoma Road/Rt. 509 project will be temporary and it is expected that the use of this system will likely increase in the coming years.

2.5.2 Recommendations

The recommendations developed for these two tests focus on future data collection activities to further measure the benefits of these systems, and to define future opportunities for improvements and expansions.

2.5.2.1 Congestion Management System at the Port of Seattle

- **Develop and Conduct Outreach Program to Promote Camera Use.** With the three cameras up and functioning, WSDOT should make a concerted effort to notify as many trucking companies as possible about the congestion management system. Initial suggestions included handing out brochures at port terminal gates.

- **Developed Centralized Location for Freight Camera Access.** Develop centralized location for all freight-related cameras to facilitate access and use. The idea of a centralized clearinghouse for all freight-related traffic cameras was discussed over the course of this test. There are many private and public cameras that facilitate traffic flows in the Seattle region and north at the border. Making all these available at one location would facilitate their usefulness to the freight industry.

- **Participate in Quarterly Trucker's Group Meetings.** Participate in quarterly meetings of the port truckers' group to communicate changes for the system and to provide the freight industry with a mechanism to provide ongoing feedback on the system. WSDOT staff should attend the quarterly meetings to provide updates on the cameras and to solicit feedback on their usefulness. This will provide an opportunity to continuously promote and improve upon the system's use.

- **Track Web Activity.** Continue to track Web activity on a monthly basis to develop trend information on use of the cameras. WSDOT staff should track the Web activity (number of hits) for these cameras on a monthly basis to track acceptance of the system. This would provide confirmation that the system is being used and help support efforts to expand the system.

- **Prepare Expansion Plan.** Based on feedback from users, prepare an expansion plan to develop a more complete traffic management system for the Port of Seattle. Many early participants have provided positive feedback on the three-camera system. However, discussions focused more on where else users would like to see additional cameras. WSDOT should consider these suggestions and look at the feasibility of expanding the system.

2.5.2.2 Congestion Notification System at Port of Tacoma

- **Conduct Additional Data Collection.** Conduct data collection as necessary to explain the reduction in congestion on the I-5 Port of Tacoma Road off ramp. Current data were collected for the I-5 off ramp that revealed a recent decrease in traffic. However, a system-wide analysis would be required to determine if the traffic is being diverted to other port access roads, or if it truly is indicative of a reduction in traffic.

- **Conduct Capacity Analysis.** Conduct capacity analysis to determine future usefulness of the system at this location. In addition to the data collection activities identified above, a capacity analysis should be conducted to determine the current level of service and identify at what point in the future the system will be heavily utilized.

- **Develop Ongoing Evaluation/Testing Program.** Develop ongoing data collection program to periodically evaluate the system to verify it is functioning. The queue detection system has the ability to generate a log of zone occupancy scores as previously reported. The log will show how close the system is to being triggered. WSDOT should develop a process for collecting this data on a regular basis (perhaps quarterly) to evaluate the ramp operations. In addition, with the system being triggered sporadically, WSDOT staff should continue their practice of testing the system on a regular basis. This corresponds to the recommendation by Traficon that additional data be collected at a later date to validate the system parameters.

- **Communicate/Coordinate Activities**. Communicate/coordinate with Port of Tacoma staff to determine additional traffic management needs. WSDOT staff worked closely with Port of Tacoma staff in the original development of this system. Outreach efforts should be made to determine what additional access constraints exist and to evaluate the impact that this system and the Port of Tacoma Road/Rt. 509 reconstruction had on port access.

- **Refine current ideas on system expansion based on discussions with the Port of Tacoma.** Ideas have been circulated about a complete port access management system. Based on renewed communication with the Port of Tacoma, future deployments of congestion management technologies should be reviewed to identify possible expansions of the existing system.

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3. FREIGHT TRAFFIC DATA INTEGRATION EVALUATION CASE STUDY

3.1 INTRODUCTION

As an additional element of this Freight ITS Traffic Data Evaluation effort, the Evaluation Team performed a case study of the WSDOT Transportation Research and Analysis Center (TRAC) effort over the past 2 years to test the utilization of freight traffic information obtained from the regionally deployed AVI Commercial Vehicle Information System and Networks (CVISN) and border transponder system (i.e., dedicated short-range communication [DSRC] technology), and also from a small test of wireless GPS devices mounted in five drayage trucks that continually traveled throughout the region.

It should be noted that the case study approach applied here is not intended to be a comprehensive and detailed independent evaluation of these deployments; rather this case study presents a summary-level overview of the detailed analysis that was conducted by the TRAC, and is based largely on the results provided to the Evaluation Team from TRAC, augmented by various interviews and discussions that the Evaluation Team has had with TRAC on this case study over the past two years. The conclusions and recommendations provided in this case study were developed solely by the Evaluation Team based on the results of this effort.

3.2 OVERVIEW

The freight information developed from the Puget Sound region's ITS devices potentially can be used as the foundation to support local and regional freight transportation planning by organizations such as the Puget Sound Regional Council (PSRC) and WSDOT. Freight-oriented travel data are needed by these organizations to identify freight movement bottlenecks, to explore the reliability of freight movements, and to determine the frequency and costs of nonrecurring events such accidents and weather. Such information justifies the development of freight-oriented highway construction and ITS projects. This information can also assist in identifying and modifying the impacts of activities such as port gate closures, border crossing delays, and major public events.

At a basic level, this ITS-derived data could provide a convenient picture of urban freight movements. At a project level, this data could provide transportation agency staff with the tools to correlate existing and predicted roadway conditions with changes in freight movements. Such a process will mean that roadway construction projects could more effectively address concerns about regional freight mobility. On a regional level, this data could provide a tool to help transportation agency staff address many questions centered on freight mobility and economic growth. Using indicators developed from such data, agency staff will be better able to discuss the impacts of increased regional congestion on truck flows and freight mobility. This, in turn, may help answer basic policy questions.

Regional ITS that could be used to collect freight data include Washington's CVISN system that provides more than 20,000 windshield-mounted truck transponders used for a freeway speed weigh-in-motion (WIM) system. A related but separate system is WSDOT's Custom's in-bond container system that uses the same transponders for container tracking and a border pre-arrival system. As part of both these transponder systems, public and private agencies have placed readers at weigh stations, ports, along freeways, and at the Washington/British Columbia border. By using software to link these readers, it will be possible to anonymously track individual tag-equipped trucks to determine regional and corridor travel times and patterns.

In the greater Puget Sound region, WSDOT has an extensive loop-based freeway management system known as the freeway surveillance and control system (FLOW). This system includes 200 loop locations that offer information about freeway volume and speeds, and in limited cases, truck volume data. Additionally, the use of "floating car runs" has also been applied by WSDOT in the past to measure traffic flow.

As part of this research, five GPS devices designed to be used as part of a truck fleet management system were tested as data collection devices. These systems used GPS-mounted devices in a truck's cab that used a cellular connection to report the truck position and other information. Such a device potential could offer information about travel times and freeway speeds.

A overview of these four potential methods for freight traffic data collection as implemented or tested by WSDOT is presented in Figure 3-1. A detailed summary of the use of the two new methods tested by TRAC during this FOT, the AVI CVISN/border transponder system data and the use of in-truck wireless GPS device data, is the subject of this case study. The purpose of this effort by TRAC was to test the utilization of these technologies for freight data collection. The test was conducted using TRAC-developed methods and tools, which would enable meaningful freight traffic flow measures to be created from the archived freight ITS data. This effort was not intended to provide a significant data set for analysis, but rather a proof of concept for the utilization of these technologies to support freight traffic data collection.

The following overview identifies the participants involved in these regional freight traffic data collection and analysis activities:

- **WSDOT/TRAC.** WSDOT was the lead for all data collection activities and was responsible for leadership, coordination, data collection, and data analysis.

- **WSDOT/CVISN.** The CVISN program within WSDOT was indirectly involved in these efforts as the CVISN transponder-equipped vehicles served as the pool of trucks used in the transponder data collection and analysis.

- **TransCore.** TransCore provided WSDOT with the transponder data for the port and Blaine border crossing AVI reads via the TransCorridor system.

- **AVI CVISN/TransCorridor-Equipped Trucks.** All trucks operating in the region that were equipped with CVISN or TransCorridor system transponders participated in the transponder analysis by default, as all data available from these systems were utilized.

- **Air-Trak.** Air-Trak was the vendor that provided the wireless GPS units for use in the data collection effort.
- **CSX.** CSX was one of the two trucking companies that agreed to test the GPS units in its fleet.
- **Puget Sound Freight Lines.** Puget Sound Freight Lines was one of the two trucking companies that agreed to test the GPS units in its fleet.

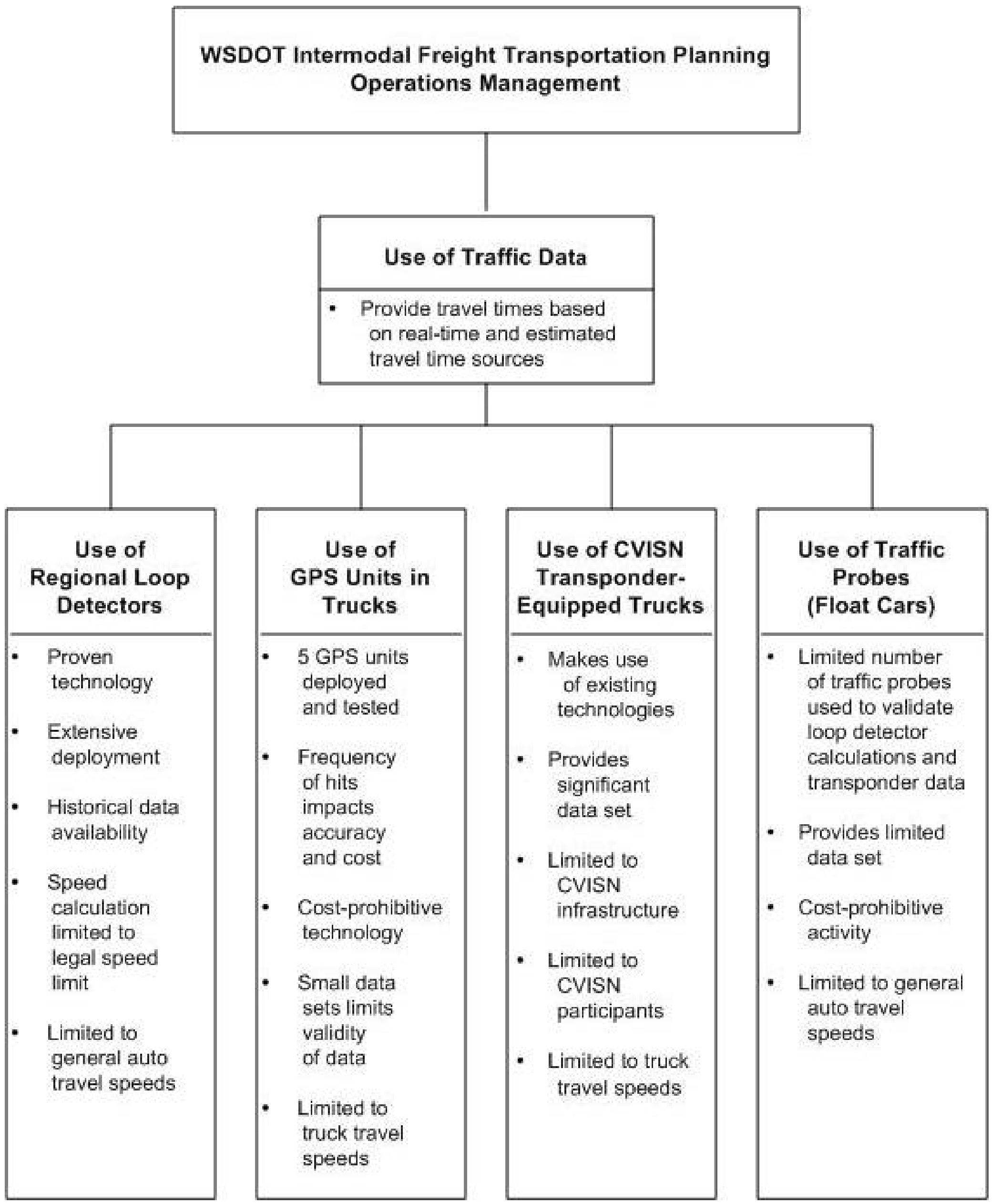

Figure 3-1. Potential Sources for Regional Freight Traffic Data.

3.3 USE OF WIRELESS GPS DEVICES DATA

This portion of the TRAC research explored the use of data obtained from wireless GPS devices installed in trucks. The devices were developed by AirTrak for commercial vehicular fleet management and used GPS technology combined with a cellular reporting feature. The devices were designed to allow commercial vehicle operators to monitor the location of a truck or other assets and communicate back to those assets. This research used five borrowed devices for about a year. They were installed in five trucks that operated mainly in the Puget Sound region. The devices were installed on two trucks based out of Seattle (Puget Sound Truck Lines) and three based out of Tacoma (two with CSX drayage and one with Puget Sound Truck Lines). This process included installing the GPS device and antenna in the trucks, and installing the tracking software at TRAC and at Puget Sound Freight Lines. The drivers of several of the trucks also received a short training session on how to turn the device on and off. TRAC paid the wireless charges. Figure 3-2 shows a sample truck-mounted wireless GPS device used during the test.

Figure 3-2. Truck-Mounted Wireless GPS Device.

The GPS devices were used for a year, resulting in 98,000 location reports. The devices were used with various airtime plan configurations (meaning location reports were obtained every 30 seconds, 60 seconds, whenever the vehicle made a 45-degree heading change, and a combination of time intervals and heading changes). This was done in order to relate the cost of the plan to usefulness of the resulting data. The costs for the wireless charges for 4,500 positions a month were $60.00 per vehicle. Each additional 500 positions cost $7.00 a month per vehicle.

Wireless GPS Analysis

Each time the GPS device reported its location, data was collected on that vehicle's current performance and location. Thus, the data provided vehicle specific speed as well as time and location information. This, in turn, provided point estimates of roadway speed as well as the ability to compute roadway travel time. This information also allowed the research team to explore "facility performance" based on periodic reports of instantaneous vehicle speed, versus direct measurement of vehicle trips along specific roadway segments.

Typically, GPS devices can signal errors due to GPS satellite limitations, atmospheric distortion, and GPS device limitations. The errors from GPS devices used in this project were manifested in several ways. For example, errors that could be attributed to satellite limitations and atmospheric distortions showed up as truck movement (jitter) even when the truck had a speed of zero. This jitter also complicated map matching.

Missing reads and/or lack of GPS location reports tended to be less of a problem for this project than jitter. Other areas within the United States with many tall buildings or natural terrain conditions that limit GPS satellite observation or device communications might experience more frequent problems with GPS signal loss. Signal loss was rarely a problem in this test because the test vehicles travel was often on open freeways and other roadways void of building or natural terrain conditions, thus yielding good GPS signal reception.

In order to make the GPS data useful, it must first be tied to the earth surface using a Geographic Information System (GIS). The lack of knowledge about the location and direction of any given truck at any given time caused the analysis of GPS data to be considerably more difficult than it would be if the test vehicles were traveling known routes. For example, the fact that a vehicle location did not match to a roadway segment could not be immediately traced to poor correlation between GPS and GIS location referencing systems. One reason for this was that during the test, when a GPS location was "off network," the truck could easily be in a parking lot waiting to unload cargo. As a result, it was not possible to simply assign those points to the nearest roadway segment.

Additionally, in some cases, the location errors caused by the combination of GPS signal distortion and GIS map inaccuracy resulted in a vehicle location mid-way between two "plausible" roadways (e.g., between a freeway and a major parallel arterial serving an industrial area.) In another case, the Evaluation Team discovered that two roadway segments could occupy the same latitude/longitude position, leading to confusion over on which road the vehicle was actually traveling.

The result of these location-related problems was that the process of "snapping" GPS locations to the PSRC's GIS network was more difficult than anticipated. After considerable experimentation and a thorough review of the available literature, the final "snapping" process involved a combination of manual steps, automated procedures, and a reduced highway network.The final cleaned data sets were then manipulated using the GIS model commands to link them to other data stored within the GIS, allowing their use for the remainder of the TRAC analysis.

Figure 3-3 shows how GPS data attributes selected for a specific vehicle are mapped to a GIS model.

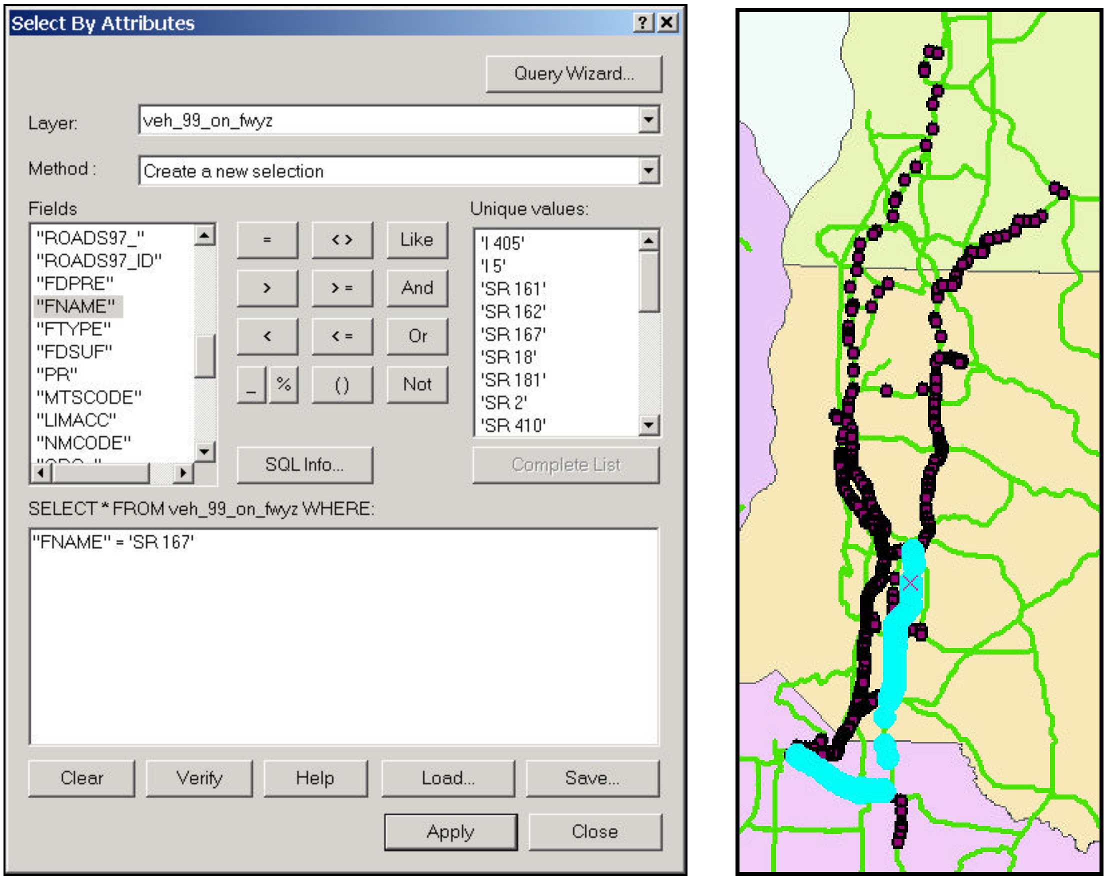

Figure 3-3. Example of Mapping GPS data to GIS Model.

Analytical Output Using the GPS Data

Because of the size of the GPS dataset collected and the need to perform considerable manual data manipulation, it was necessary to limit how much data was actually used in the development of roadway performance statistics within this project. Consequently, data were only processed by TRAC for only three of the five trucks monitored. In addition, only 9 months of data were reviewed. The sample used for analysis included all trips for the three trucks for the 9-month period from July 17, 2000 through April 23, 2001. To limit the data processing problems previously described, only trips segments that occurred on state highways were analyzed.

Data from these trips were used to attempt to produce performance statistics similar to those produced using WSDOT's freeway surveillance system loop data. These statistics include:

- Average and 90th percentile travel times for specific roadway segments and corridors.
- How frequently congestion occurs on specific roadway segments.
- Images of the geographic spread of congestion by time of day.

While the project was able to develop performance reports that were similar in style to those developed from the surveillance data, the results were somewhat less than satisfactory. In large part, this was due to a lack of data that resulted from having only three instrumented vehicles and the fact that those vehicles divided their time between a wide variety of roads in the urban area. (The three trucks analyzed were those operating frequently around the Seattle freeway system, rather than the trucks working drayage operations to/from the Port of Tacoma.)

Individual vehicle movements are shown below in Figure 3-4, which shows the northbound data collected from the GPS from the three instrumented trucks – this figure shows clearly these "trajectories" of individual truck movements as measured by the GPS. This figure contains all of the I-405 trips made by instrumented trucks on this freeway segment during the 9 months included as part of the analyzed portion of the TRAC project test.

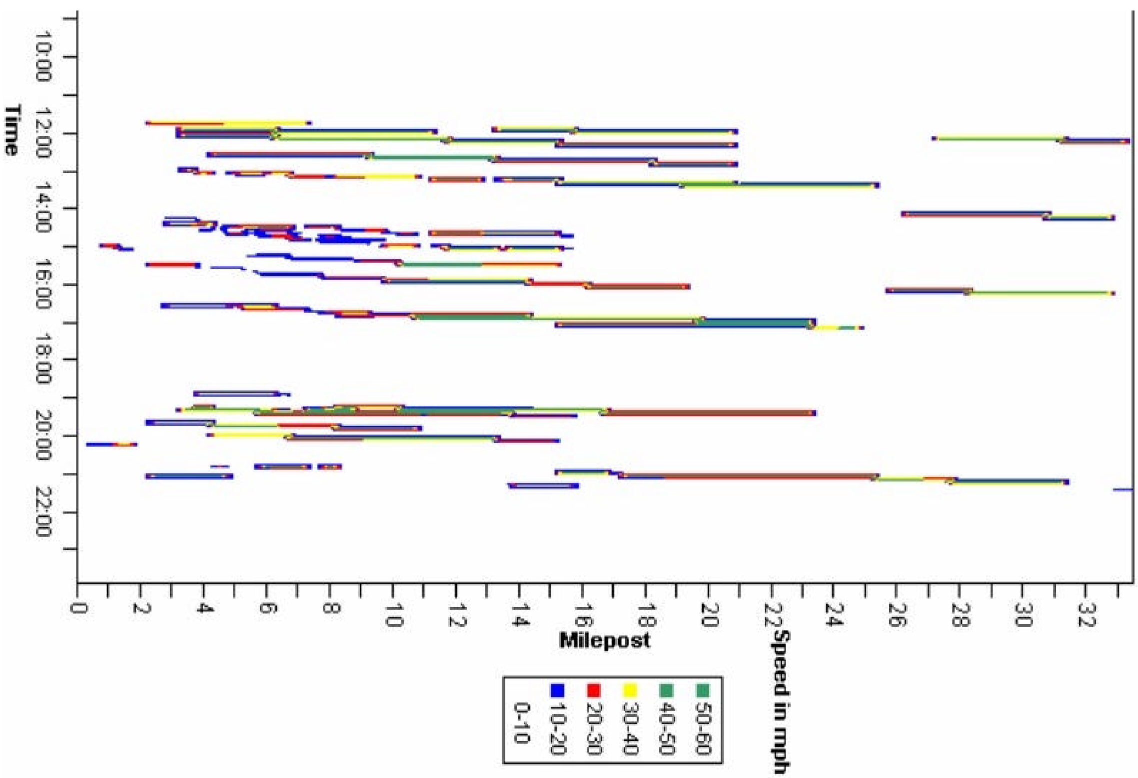

Figure 3-4. Congestion Contour Graphic For Northbound I-405 From GPS Data.

If sufficient data existed, the GPS data could produce statistics and graphics similar to those produced periodically based on WSDOT freeway surveillance data. However, even with nine months of data, there are relatively few vehicle trips on I-405, and most of those trips are in the afternoon in the southern half of the corridor. The fact that most of the trips were in the afternoon is useful from a policy perspective in that it indicates that at least for the instrumented trucks, the key I-405 movement is southbound in the late afternoon. However, the lack of data during the morning peak period raises concerns about the use of commercial trucks as probe data collection devices for obtaining general roadway performance information.

As highlighted in Table 3-1, about one-third of the data collected were from trips taking place in the PM peak periods. The rest of the data were generally collected during the mid-day and early evening nonpeak periods. This analysis confirmed that little of the monitored travel occurred during the AM peak. While this may simply be a function of the trucks that were selected for tracking, it does raise the issue that the time-of-day distribution of commercial truck travel in urban areas is different from passenger vehicles. This resultemphasizes a need to broaden the vehicle tracking program to include other types of vehicles (i.e., in addition to commercial trucks), if general roadway performance is desired, and not just roadway performance as it relates to freight movements.

Table 3-1. Data Distribution (North or Westbound Directions)

Attributes	Vehicle #59	Vehicle #60	Vehicle #61
Total Number of Data Points Measured	1398	2079	1409
Percentage of Data Points during PM Peak	33 %	31 %	43 %
Percentage of Data Points on I-5	45 %	23 %	44 %
Percentage of Data Points on I-405	44 %	24 %	10 %
Percentage of Data Points on SR-167	N/A	23 %	13 %

These comparisons showed that the directly measured “current” speeds reported by the GPS device along with position and time data were indeed more variable than either the freeway surveillance data or the calculated segment speeds based on the time and position information. Table 3-2 illustrates this variability by showing GPS-reported speed data, with the segment data reported by the freeway surveillance system’s 5-minute data archive, as well as data from selected individual loop locations using the available 20-second archive. In addition, the average speed for the monitored truck for the entire trip on I-405 is shown at the bottom of the table.

Table 3-2. Comparison of GPS-Derived Performance Data and Freeway Surveillance Data on a "Congested Day" (7/28/2000)

Facility	Mile Post	Time	GPS Reported Speed	5-Minute Loop Data Reported Speed	20-Second Loop Data Reported Speed [6]
I-405	2.69	14:28	49.5	60	
I-405	3.61	14:29	57.7	60	
I-405	4.51	14:30	55.1	60	
I-405	5.81	14:31	56.1	60	
I-405	6.67	14:32	51.3	60	
I-405	6.78	14:33	42.8	60	
I-405	8.00	14:34	15.3	59	26
I-405	8.06	14:35	14.5	60	
I-405	8.47	14:36	37.8	60	
I-405	9.19	14:38	23.9	60	45
I-405	9.52	14:39	21.0	60	
I-405	9.84	14:40	43.2	60	
I-405	10.38	14:41	25.1	60	39
I-405	10.99	14:42	50.3	60	
I-405	11.66	14:43	50.7	60	43
Average Speed For Total Trip			38.4	60	

While variation in speeds within segments that make up a trip was expected, the presence of several very slow reported speeds from the GPS device was surprising. These speeds were considerably slower than the average 5-minute speeds reported by the freeway surveillance system. Total trip times reported by the GPS-equipped trucks were also slower than computed using the freeway surveillance data, but to a much smaller extent.

Further investigation by TRAC was undertaken to explain these results. The investigation included performing test runs in a car equipped with a GPS run, but staying in the far right lane to mimic the performance of a fully loaded truck. In addition, historical freeway performance data were extracted for individual freeway lanes at 20-second interval levels to look at speed and volume variations on the freeway that may have been lost in the 5-minute aggregation process.

From these two sets of analyses, two primary issues become clear:

[6] Only the 20-second loop average closest to the GPS data point are shown in this table. Also note that GPS data do not correspond directly to loop locations and reporting periods.

1. Freeway performance is much more complex than illustrated in the 5-minute freeway surveillance data.

2. Complexity is apparent in the GPS data.

It is difficult to determine which is the “more accurate” view of roadway performance. The instantaneous truck speeds from the GPS device truthfully show the performance of the trucks, but tend to under estimate actual roadway performance, as many cars will pass slower moving vehicles given the opportunity. Essentially, when monitoring a heavy loaded truck in urban conditions, this analysis frequently monitored the “slowest expected” vehicle. These vehicles are the most constrained by local roadway conditions because of their inability to accelerate, decelerate, or change lanes easily in moderate to heavy congestion. On the other hand, the use of aggregated freeway operations data does not represent actual travel times experienced by heavy commercial vehicles.

If GPS spot speeds from trucks are used to predict “congestion”, they also tend to paint an overly “poor” image of roadway performance (even if they represent actual truck performance.) The GPS data appear to frequently report the minor slow downs that result from merge/diverge traffic. These disruptions are significant for trucks during time periods of high volume, but they have lesser effects on the flow of automobiles.

3.4 USE OF TRANSPONDER DATA

Washington State has deployed two DSRC-based 915 MHz in-vehicle AVI transponder systems (also called tags). One system, CVISN, uses the transponders for a freeway speed WIM bypass system for truck regulatory enforcement by the Washington State Patrol. The other uses the transponders as part of the TransCorridor port-to-border system, in cooperation with U.S. Customs, to allow for expedited movement and tracking of in-bond containers on trucks moving between the Puget Sound ports and Canada. As part of both of these systems, there is a network of stationary roadside AVI readers deployed throughout the region.

This TRAC freight data project attempted to convert transponder reads from these readers into meaningful data while analyzing the data’s limitations and potential rather than simply focusing on how to determine the average travel time for trucks. More specifically, on the basis of available truck tags, the project tried to determine if truck travel times are being lengthened by congestion.. This same congestion will slow down passenger car travel times, but to a different extent than truck travel times. In addition, truck travel times are slower than passenger car travel times, since the speed limits and acceleration profiles for these two sets of vehicles are different. Truck travel can be used as an adequate measure of the presence of congestion, but not as a direct measure of how long it will take the average person to drive from point to point.

Due to minimal data overlap, this TRAC project analyzed the CVISN and TransCorridor system transponder reads separately. The analysis of each is covered in the following sections.

3.4.1 CVISN Transponder Analysis

The transponder used as part Washington's WIM systems are designed to promote the safe and legal movement of commercial vehicle traffic both in Washington and through out the country. Washington was one of the original CVISN states and has a relatively well developed, and growing CVISN based WIM system. The CVISN transponder program allows trucks to bypass WIM-imbedded weigh stations by electronically verifying a truck's weight and credentials as the truck continues traveling down the road at freeway speeds. The WIM system uses the transponder to identify the truck to a system that automatically checks the status of the motor carrier's safety rating, credentials, and weight. The transponder is a short-range communication device specifically assigned to a vehicle and mounted on the inside of the vehicle's windshield and used to electronically identify the truck, much like an electronic license plate. The WIM system is imbedded in the roadway about a half-mile ahead of the weigh station and weighs the truck as it passes over it. At the same time, the AVI device communicates electronically to verify each transponder-equipped truck's weight, size, carrier registration, and safety record while the truck continues moving.

One reason why TRAC used the truck tags in this study by TRAC is because they are readily available. CVISN truck tag reads can be obtained for either single or both directions (depending on the location) from WIM facilities at Ridgefield, Fort Lewis, Stanwood Bryant, Bow Hill, and Cle Elum. For this project, TRAC acquired 4 years' worth of data from the WIM AVI readers at these sites. This included almost one million tag reads. The number of reads will increase each year as more truck drivers buy tags and more planned WIM sites are activated.

Analysis

The CVISN truck tags provided regional facility performance such as travel time for long segment on major interstates. This included heavily traveled segments such as:

- Portland – Olympia
- Olympia – Seattle
- Seattle – Canadian Border

The usefulness of the CVISN transponder data depended on having enough transponder reads. Since the segments were defined by the location of WIM freight facilities, the location of these segments are not necessarily what would be selected for a data program and some segments might not be useful. Accuracy of the reads is also a concern. In addition, it was found that the usability of the data may vary by time of day, week, and year.

Because CVISN truck transponder data typically involve longer distance travel, the estimated travel time from point to point may include stop times. Since the time spent stopped is not part of roadway performance, the CVISN truck tags can only better represent the roads performance if those trips with stops are not included in the estimation. Therefore, to accurately estimate truck travel time using CVISN truck tags, a methodology is needed to identify and remove those trips where the driver stopped between readers.

The analysis process extracted useful truck travel time data (later converted to average speed) from the CVISN truck transponders. This extracted information was later used for developing relevant performance measures. The analysis also examined how the nature of the truck sensor network, including sensor density and how frequent trucks were observed at consecutive reader locations, can affect the ability to filter unwanted data.

Transponder Data Processing

Converting truck tag travel time information into meaningful data is not simply a matter of averaging the measured travel times. First, not all truck tags observed at consecutive reader locations can be used for computing travel time, because a truck can exit before reaching the next reader or a truck can appear in the middle of the segment thus not recorded by the first reader. The other concern here was that the Evaluation Team was measuring long distance travel (typically greater than 100 miles between consecutive readers); however when traveling long distances, drivers frequently stop for a variety of reasons (e.g., for a rest break or to drop off or pick up cargo.) Secondly, given the long distances involved, a considerable difference can exist in travel time from one vehicle to the next, simply as a result of minor variations in how fast individual drivers choose to drive on a free-flow roadway.

Consequently, the "average travel time" measured by truck tags does not really make a very good estimate of either "how long it should take" to drive this distance, or how well the road is really performing. Therefore, those vehicles that have stopped need to be removed from the "facility performance analysis." The algorithm develop by TRAC for this project identified outliers in travel times that have similar start times on the freeway segment being monitored (e.g., those tags with travel times far longer than tags which passed the first reader at a similar start time).

3.4.2 TransCorridor Transponder Analysis

The TransCorridor transponder system is designed to facilitate the movement of participating commercial vehicles over the Washington/British Columbia border by providing commercial vehicle operators, shipping lines, and border enforcement agencies with electronic information about vehicles and there cargo. Part of this system is designed to monitor and facilitate the movement of northbound trucks carrying containerized in-bond freight over the Washington/British Columbia border. This effort used the CVISN transponder technology to monitor the container and eventually record the container crossing into Canada and automatically clear out the bond. A similar system is being developed that use transponder on truck hauling container southbound out of British Columbia into Washington. As a result of these systems, there are AVI readers at the exit gate at the APL terminal at the Port of Seattle, the Maresk terminal at the Port of Tacoma, and south and north bound at the Blaine Customs station at the Washington/British Columbia border.

Analysis

As with the CVISN tags, not all TransCorridor system truck tags observed at consecutive reader locations can be used for computing travel time. Again, because a truck can exit before reaching the next reader or a truck can appear in the middle of the segment, some truck tags were not recorded by the first reader. Therefore, usable data needs to be identified by analyzing time duration between two readers as are computed from the matched tags using time of arrival at two locations as a function of trip start time. Table 3-3 presents an example of this process.

Table 3-3. Example Calculation of Travel Time from Border Transponder Data

Tag ID	Site ID	Time	Time Duration
20801077	Blaine approach	12:35:31	00:00:55
20801077	Blaine exit	12:36:26	
2088CD25	Port of Tacoma	19:50:28	03:45:29
2088CD25	Blaine approach	23:35:57	

The result is a preliminary data set that consists of all trucks that were detected at both readers of a given segment. Trucks that were not detected at both readers of a segment are therefore taken out of the data set. This was done for each applicable freeway segment containing two consecutive readers.

Processing

This TRAC study showed that only the tag reads collected at the Blaine border can be used for further analysis. The reads from the ports could not be used because problems with spatial and temporal data coverage – these issues will be detailed later.

Figure 3-5 shows an example of the truck tag reads converted into time durations for traveling northbound on a half-mile segment from H Street (e.g., approaching the border) to the Duty Free shop (e.g., near the end of freeway leading to the Canada Customs). The duration information could potentially be used to gauge delay conditions near the border area prior to Canada Customs. However, because the truck travel patterns can include one of the following: (1) heading directly to Canada Customs without stopping or (2) stopping in the nearby parking lot to process U.S. brokerage paperwork first and then proceed to Canada Customs, a prolonged time duration may be recorded. The prolonged time duration may be further interpreted as a result of "border delay" (e.g., due to vehicle volumes and processing rate at the booth) and/or time taken to process U.S. brokerage paperwork.

To some extent, if there are adequate data points, sudden significant changes in segment travel time between trucks that are traveling on the same freeway segment can be identified. The assumption here is that freeway performance ordinarily changes in a relatively smooth manner within a short time period (defined roughly as = 20 minutes); therefore, the travel times of trucks traveling on the same segment but only minutes apart should not be significantly different. A significant difference would indicate that the truck made a stop to process U.S. brokerage paper, thus adding to its trip time.

For example, if Truck X with a start time of 20:30 (during a typical day as shown in Figure 3-5) is significantly slower than other trucks that start within 20 minutes before and after Truck X (e.g., 50 minutes versus less than 30 minutes), it is determined that Truck X made a stop before it entered the Canada Customs.

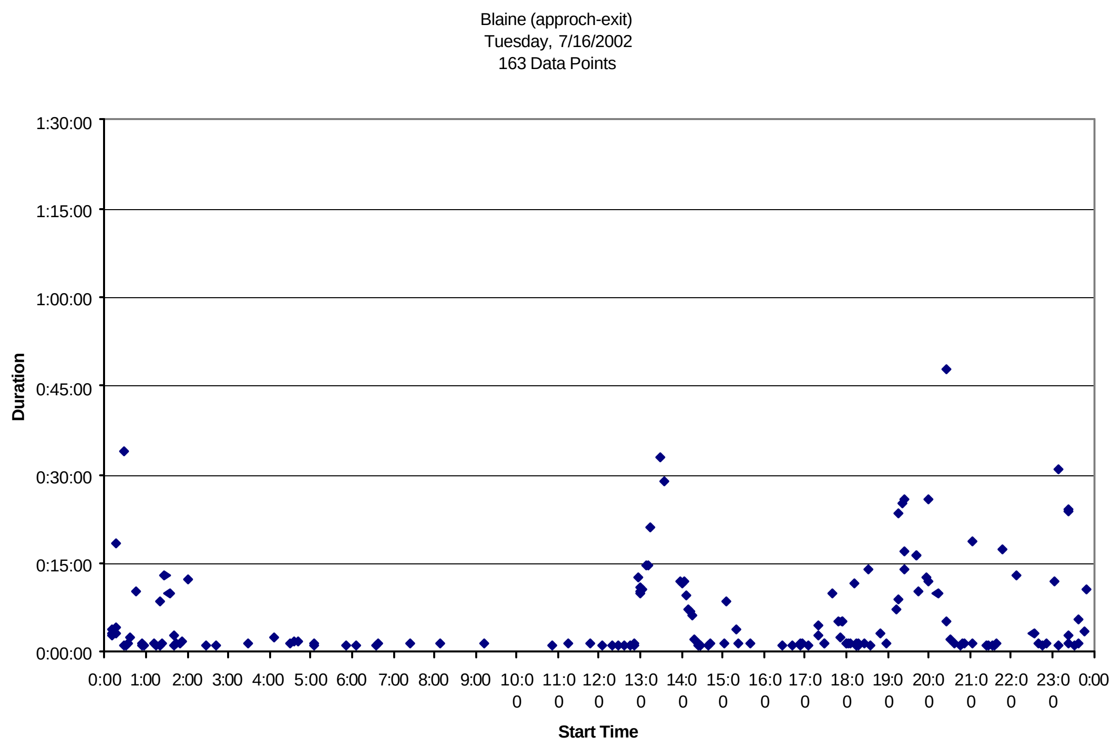

Figure 3-5. A Typical Day of Transponder Reads at the Blaine Border Crossing.

<u>Data Limitations</u>

Unlike traffic management system data that covers a much smaller geographic urban area and have more dense sensor network (e.g., loop data at about a one-half mile interval), the truck tags usually represent long segments (e.g., 100 or more miles per segment) that traverse both urban and rural areas. For example, the distance between the truck border and the Port of Seattle is about 114 miles, and approximately 142 miles between the truck border and the Port of Tacoma. Less information is obtainable with low sensor density on longer routes. Route diversion may occur more frequently on long segments, resulting in fewer matched tag reads.

Although there are relatively frequent tag reads at the border, not many of them are available for tracking from either the Port of Seattle or the Port of Tacoma. Less than 5 percent of the truck tags identified at the border come from either ports. As highlighted in Table 3-4, a 1-week sample indicates two problems for the route from the ports to the border: low data frequency and wide data gap. It is impossible to perform a valid analysis given the limited amount of the data points on the I-5 and SR 543 corridors from Port of Tacoma and Seattle to the Blaine truck border.

Table 3-4. Frequency of Data Points

Sample Week	Number of Data Points		
	Border Crossing	Port of Seattle to the Truck Border in Blaine	Port of Tacoma to the Truck Border in Blaine
Monday	133	2	1
Tuesday	163	6	4
Wednesday	184	1	5
Thursday	158	2	1
Friday	184	4	2
Saturday	88	0	0
Sunday	16	0	0

With long-distance travel, the estimated travel time from point to point most likely may include stop times. When adequate amount of data is available, data can be processed to identify and remove those trips where the driver stopped between readers. For example, if several trucks that leave within 10 minutes from each other and all have similar travel time, this provides more information to support that the delay is more likely due to traffic congestion. However, if data points are sparse, then it is difficult to determine whether a data point in question is usable.

For example, a truck, leaving from the Port of Seattle around 5:30 p.m. on 7/19/2002 (see Figure 3-6) takes 2 hours and 35 minutes to get to the border (which is equivalent to an average trip speed of 44 mph as illustrated in Figure 3-7). This trip takes about one-half hour longer than traveling under a free flow condition (the trip should take about 2 hours or less). Since Figure 3-7 shows that the closest data point is a truck that left 1hour ago and there are no other data points available, it is not possible to distinguish whether the half-hour delay is caused by a rest stop or traffic congestion.

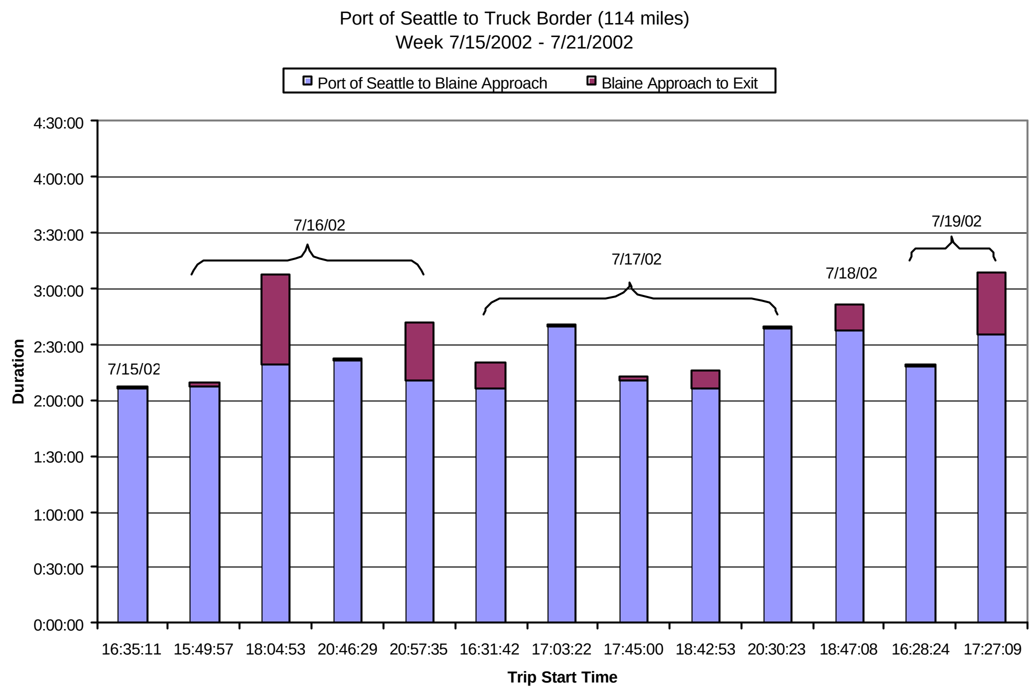

Figure 3-6. Port of Seattle to Truck Border: Sample Travel Time.

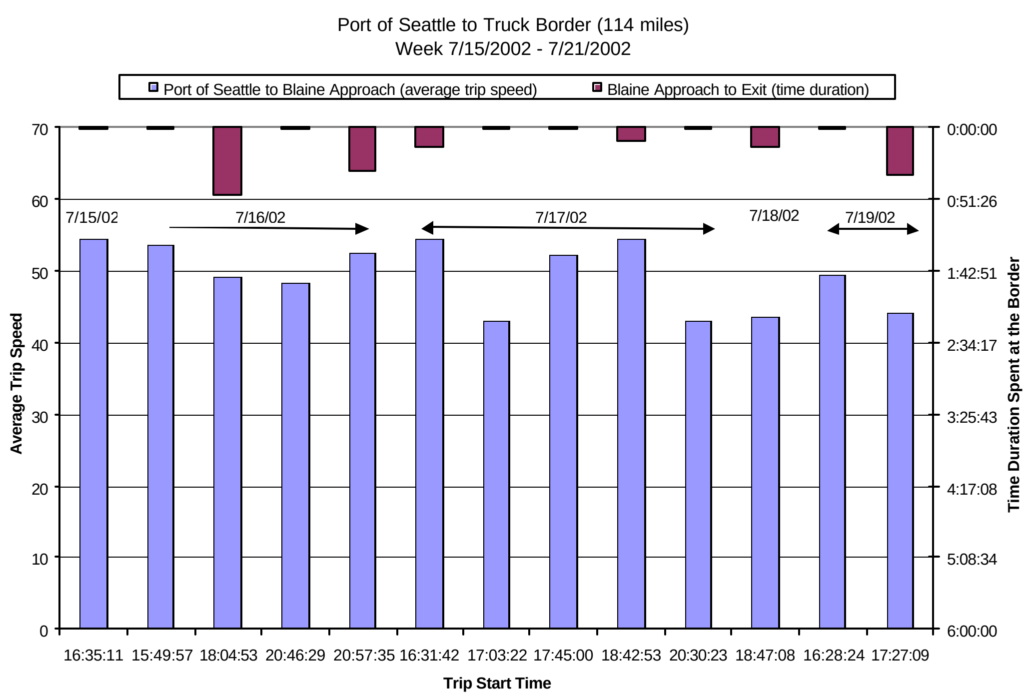

Figure 3-7. Port of Seattle to Truck Border: Sample Speed.

It is important to have adequate number of data points between readers for identifying non-congestion related stops. The definition of “adequate” calls for reasonable judgment (e.g., queue length at the border can have a significant change within 20 minutes, whether it is due to change in vehicle volume or service rate at the border). If adequate reporting frequency is available, the truck tag data collected at the border can potentially have various applications, such as estimating border delay for understanding border travel conditions (e.g., queuing patterns as a function of time), as well as acting as one of the input values in calibrating queuing analysis tool.

3.5 CONCLUSIONS AND RECOMMENDATIONS

Following are the conclusions and recommendations relating to the TRAC case study regarding freight traffic information obtained from the regionally deployed CVISN and border transponder system, and the truck-mounted wireless GPS devices.

3.5.1 Conclusions

- **Test of On-Truck GPS Showed Significant Limitations.** While the use of GPS units to determine truck travel patterns and estimates of travel times showed promise, the analysis identified several limitations of this technology. The difficulties of integration with GIS systems, the significant cost required to collect the data, the high variability of the GPS data, and the number of units that would be required across a major metropolitan region would restrict the usefulness of this technology. Additionally, significant investment in recurring communications costs, and further research to develop accepted methodologies and automated GPS-to-GIS translations tools would be required to deploy this system in a major metropolitan area.

- **Comparisons of GPS Data to Freeway Loop Data Provided Some Interesting Results.** The instantaneous truck speeds from the GPS device truthfully show the performance of the trucks, but tend to underestimate actual roadway performance, as many cars will pass slower moving vehicles given the opportunity. If GPS spot speeds from trucks are used to predict “congestion”, they also tend to paint an overly “poor” image of roadway performance (even if they represent actual truck performance). The GPS data appear to frequently report the minor slow downs that result from merge/diverge traffic. These disruptions are significant for trucks during time periods of high volume, but they have lesser effects on the flow of automobiles.

- **Transponder Data is Effective for Calculating Travel Times if Data is Available.** The analysis successfully showed that truck transponders can be used to calculate average truck speed/travel time for a given segment if adequate reporting frequency is available. Transponders can be used to determine specific time/day congestion points if adequate reporting frequency is available. Transponders cannot be used to determine the specific locations that congestion occurs due to the sparse sensor density (i.e., the typical long distances between deployed transponder reader antennas).

- **Transponder Data Accuracy Was Limited by the Size and Density of the Deployed Transponder Reader Network**. The long segments traveled by these interstate carriers, combined with the low sensor density (limited number of AVI readers), created many opportunities for routes that restricted the number of matched tag reads. Data show that the greater the distance between readers, the less number of matches. This factor limits the usefulness of the data set, as at least two points are required for a travel time calculation. In these cases, additional readers would need to be deployed between current reader segments to improve the accuracy of the data. In addition, it was found that the usability of the data may vary by time of day, week, and year.

- **Border System Transponder Data Can Support Freight Transportation Planning Applications.** If adequate reporting frequency is available, the truck tag data collected at the border can potentially have various applications. These may include estimating border delay for understanding border travel conditions, and also acting as one of the input values in calibrating the queuing analysis tool for transportation modeling efforts of cross-border freight movements.

- **A Filtering Method is Required to Address Truck Stops.** The long distance trip length for CVISN and border system transponder-equipped carriers creates a data set that includes stops between reads. The driver may be stopping to make a delivery, to rest or eat, etc. As a result, in order to use this data, a filtering/cleaning methodology is required to accurately reflect travel times.

3.5.2 Recommendations

- **Examine Data Integration Further For Both GPS/Wireless and Transponders.** State and regional planning bodies should take further steps to investigate opportunities to integrate these data with other available transportation data such as loop detector and video counting systems. It is accepted that individual technologies will not provide complete truck travel patterns; however, the combination of multiple resources could be combined to build a regional profile in many metropolitan areas and border regions.

- **GPS/Wireless In-Truck Systems to Support Freight Transportation Planning Efforts Should Not Be Deployed Yet.** Based on the findings of this analysis, the costs (nonrecurring and recurring) of this technology are too high, and the suite of analysis tools that would allow for successful management and manipulation of the data are not mature. Planning agencies should adopt a "wait-and-see" approach to this technology to monitor future cost reductions and analysis tools development.

- **When the Technologies and Software Mature and the Costs Decrease, Conduct a Large-Scale Test of GPS Data Devices**. This very small test of five devices showed that currently the GPS/wireless technology is too expensive to deploy for region-wide freight data collection, and technical issues also require further development. In the next several years, as wireless communications costs and GPS data devices costs continue to drop, investigate the utility of conducting a significantly more comprehensive test of GPS on-truck data devices in a major metropolitan region, perhaps including several hundred deployed units. This test should also include further research into improving the accuracy of the data, development of automated processes for GPS-to-GIS data mapping, and development of data mining tools for managing the huge data files that would be archived daily under this test.

- **Incorporate CVISN Transponder Data into Freight Planning Efforts.** This test proved the viability of using existing transponder data already provided by a state's CVISN system to measure truck travel times between transponder reader segments on freeways. Since this data is already available and "free", states and MPOs should work with their state's CVISN enforcement personnel to gain access to archives of such data to develop appropriate freight travel time statistics, which could prove valuable in a variety of transportation modeling and planning efforts. This data should also be "sanitized" to ensure data privacy for the trucking industry and private state contracted CVISN transponder system operators such as HELP Incorporated, which operates the PrePass system in many states.

- **Expand Size and Density of Transponder Reader Network.** If truck transponder travel time data is desired by a regional or statewide planning body such as WSDOT or the Puget Sound Regional Council, then at a minimum, an examination should be conducted to assess the potential of deploying additional AVI readers in "traffic-strategic" locations to generate additional data sets and more accurate data sets.

- **Develop Ways of Displaying or Providing Truck Travel Times to Users.** WSDOT should explore methods for displaying the transponder data to the affected stakeholders. Methods could include providing VMS signs that truck drivers could view at border crossings or weigh stations in real-time (e.g., "your travel time today from the border to this weigh station was 67 minutes") as well as available information on the WSDOT Smart Trek Website, which truck dispatchers and trucking companies might find as a useful tool for monitoring vehicle locations and travel time.

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