Transportation Northwest at the University of Washington
Research Project Descriptions
Year 18: September 1, 2005-August 31, 2006

Identifying Number	61-2392
Project Title	Backbone Infrastructure 2005
Principle Investigator	Daniel J. Dailey
Institution	University of Washington
PI's telephone number	206-543-2493
PI's E-mail address	dan@its.washington.edu
External project contact, address, telephone number	Pete Briglia University of Washington Box 354802 Seattle, WA 98195 206-543-3331
Project Objective	The goal for this project is to provide support for the ongoing ITS Backbone. The ITS Backbone, operated at the UW, provides a variety of data resources used by investigators at the UW and researchers at universities and companies around the US. In particular, a number of past and present TransNow projects

Abstract:
Previously projects funded by TransNow, WSDOT, and other Washington State partners have invested in the development of a Puget Sound ITS Backbone architecture and infrastructure that is being used to obtain, fuse, and deliver traffic and traveler information. The ITS Backbone provides a widely available common interface to data from several agencies; it also provides a common public interface to the finest granularity of WSDOT inductance loop data. The Backbone extracts data from a variety of remote agencies and makes it available to engineers in the NW Region Traffic Management System. In the upcoming biennium it will be augmented to include data from Lynwood, Bellevue, virtual speed and travel time sensors on King county arterials, and non-recurring traffic congestion predictions based on weather information.

Task Descriptions and Milestones:

Project Start and End Dates	September 1, 2005 - August 31, 2006
Current year budget	$5,000
For two-year project, total budget and start and end	
Modal orientation of the project	Multi-modal
Student involvement (thesis, assistantship, paid employments)	None

Relationship to Other Projects:

Previously projects funded by TransNow, WSDOT, and other Washington State partners have invested in the development of a Puget Sound ITS Backbone architecture and infrastructure that is being used to obtain, fuse, and deliver traffic and traveler information. The ITS Backbone provides a widely available common interface to data from several agencies; it also provides a common public interface to the finest granularity of WSDOT inductance loop data. The Backbone extracts data from a variety of remote agencies and makes it available to engineers in the NW Region Traffic Management System. In the upcoming biennium it will be augmented to include data from Lynwood, Bellevue, virtual speed and travel time sensors on King county arterials, and non-recurring traffic congestion predictions based on weather information.

Technology Transfer Activities:

1) Maintain hardware and software for existing Backbone infrastructure. This addresses the maintenance of the backbone infrastructure resulting from the SmartTrek project.

2) Expand Backbone data services to include incidents, weather, and parking information.

3) A third activity will interface with data from Lynnwood's traffic management system and make it available to the existing TMS. The real-time Lynnwood data will also be available on the Backbone.

4) Probe vehicle data will be made available through the existing TMS to provide data on roadways for which there is limited instrumentation in the right-of-way. In cooperation with a research project, the probe vehicle travel time for selected corridors will be validated and this data made available in the TMS.

5) The recently updated traffic channel, potentially reaching 431,000 households, will be supported by the Backbone activities.

The following ongoing projects are supported by the Backbone:

1) TrafficTV
2) Real-Time Switched Roadway Video available at the UW
3) Probe vehicle speed and travel time estimates
4) TransNow/WSDOT sponsored research
5) TDAD

6) Lynnwood data integration
7) Bellevue data integration
8) Integration of external data sources into Traffic Management Systems
9) Multi-modal transportation and transit projects
10) Public/private data access
11) NSATMS

Potential Benefits of the Project:

The backbone continues to provide support for a variety of ITS applications that benefit the traveling public in Washington, local public and private sector organizations, traffic management personnel, and university research.

The applications and some use numbers include:

(1) TrafficTV – 430,900 households
(2) Travel Information – 58,388,000 uses
(3) Probe vehicles – 22,812 uses
(4) SDD Data streams – 133,372 uses
(5) TDAD
(6) Multi-modal transportation – 57,272 uses
(7) Public/private data access through SDD toolkit
(8) TRAC/TransNow sponsored research
(9) Lynnwood data integration
(10) Bellevue data integration
(11) Integration of external data sources into Traffic Management Systems
(12) NSATMS
(13) Research at a variety of Universities
(14) Research at local companies such as Microsoft
(15) MyBus – 295 M uses over the lifetime
(16) Busview – 1.3 M uses over the lifetime

TRB Keywords:

Traffic management, virtual sensors, probe vehicles, speed, arterial, transit, freeway, traffic map

Identifying Number	61-2391
Project Title	Deployment of a Virtual Sensor System Based on Transit Probes
Principle Investigator	Daniel J. Dailey
Institution	University of Washington
PI's telephone number	206-543-2493
PI's E-mail address	dan@its.washington.edu
External project contact, address, telephone number	Pete Briglia University of Washington Box 354802 Seattle, WA 98195 206-543-3331
Project objective	The goal for this project is to facilitate the use of virtual sensors based on transit probe vehicles in an active traffic management scenario at WSDOT's traffic management center.

Abstract:
A few agencies have adopted the use of real-time probe vehicles for traffic surveillance. The UW has developed technology to reliably create virtual sensors to augment those installed by WSDOT. However, real-time probe vehicle technology has not been accepted into any large traffic management agency. This project will work in coordination with WSDOT to expand the existing trial of transit based, probe vehicle, virtual sensors. There are both technological and institutional issues to be addressed. For example, on the technology side issues such as threshold values for traffic information displays, using virtual sensors, acceptable to traffic management personnel need to be validated in real world application. On the institutional side, the researchers will need to work with the agency to design guidance for operations personnel when using virtual sensors for traffic management. This will allow WSDOT to expand their surveillance capabilities without the expense of installing inductance loop equipment in the roadways, and without the communications infrastructure expense.

Task Descriptions and Milestones:

Project Start and End Dates	September 1, 2005 - August 31, 2006
Current year budget	$75,000
For two-year project, total budget and start and end dates	
Modal orientation of the project	Multi-modal
Student involvement (thesis, assistantships, paid	TBD

employment)	

Relationship to Other Projects:

Previously funded joint TransNow/WSDOT projects began the development of technology and software to track Metro's AVL-equipped fleet and to use them as a set of probe vehicles on both freeways and arterials. Those projects created the ability to capture AVL data from the roadways, estimate individual vehicle speed, estimate individual transit vehicle travel times as well as estimating corridor travel times, and make prototype virtual sensor web pages. In past work, several techniques and technologies have been used to estimate travel time, each of which has various strengths and limitations. This project takes the next logical steps and provides the probe vehicle data to the WSDOT traffic management center's Traffic Management System (TMS). The data flow to the TMS is from sites selected by UW and WSDOT traffic management personnel such that some are at locations that can be directly compared to existing sensors, typically along I5, SR520, I90 and some are at locations where there are no existing sensors, particularly along SR99.

Technology Transfer Activities:

The following products will result from this project:

1. An algorithm that uses Metro AVL data received over the ITS backbone to estimate speed and travel time of transit vehicles on validated arterial roadways.
2. An SDD Transmitter that can provide real-time speed information on a variety of roadways using Metro Transit vehicles as probes.
3. A graphical display of the speed on a variety of freeway and arterial roadway links.
4. Software to create a connection to the WSDOT NW Region TMS to deliver virtual speed sensor data to the TMS.
5. A set of virtual sensors that meet the needs of the traffic management personnel and augment the existing inductance loop system.
6. A report that:
    a) describes the AVL speed/travel-time algorithm
    b) describes comparative analysis of various estimates and measurements
    c) recommends methodologies for data fusion of various estimates and measurements
    d) recommends future ITS development strategies to make travel times and speeds more available, accurate, and useful.
7. A paper to be submitted for presentation at the TRB'06/07 Annual Meeting and a manuscript to be submitted to a peer-reviewed journal.

This project will be implemented by:

1. providing a real-time data stream of probe vehicle based speed estimates and traffic conditions
2. implementing virtual speed sensors in NW Region's TMS

Potential Benefits of the Project:

The groups who will benefit from this work will range from DOT operations personnel to planners and transit operators. DOT operations personnel will benefit from the creation of a new sensor to measure traffic conditions on both freeways and arterials. Planners will benefit from the availability of corridor information for both reporting and planning. In addition, transit operators will benefit from increased ability to monitor the impact of congestion on schedules. This project's numerous benefits include:

1. leveraging additional key benefits from Metro/WSDOT/TransNow's existing investment in both ITS Backbone and AVL related research projects
2. increasing the effectiveness of performance monitoring efforts by:

a)enhancing the accuracy of estimated travel times and speeds

b)creating the technology for a new tool that can be used to do performance evaluation

3. making available better travel time and speed estimates for a variety of ITS applications by fusing two different travel-time data sources
4. making current travel-time and speed data available for archiving and manipulating
5. creating algorithms for travel time and speed estimation that can be used with any methodology that collects sets of positions as a function of time (e.g., GPS-equipped vehicles)
6. implementing virtual speed sensors for use by the NW Region
7. producing a report that describes the algorithms and statistics of travel time and speed estimates when using probe transit vehicles for performance monitoring.

This project will allow WSDOT to expand their surveillance capabilities without the expense of installing inductance loop equipment in the roadways, and without the communications infrastructure expense.

TRB Keywords:
Traffic management, virtual sensors, probe vehicles, speed, arterial, transit, freeway, traffic map

Identifying Number	61-2475
Project Title	Managing Pedestrian Safety
Principle Investigator	Anne Vernez Moudon
Institution	University of Washington
PI's telephone number	206-685-4057
PI's E-mail address	moudon@u.washington.edu
External project contact, address, telephone number	Paula Reeves WSDOT Highways and Local Programs 360-705-7258
Project objective	The first goal of the project is to examine correlations between pedestrian motor vehicle collision locations (PMVC) and bus ridership, road characteristics, vehicular traffic conditions, and land use features along state roadways. Models will measure the odds of future PMVC to occur, based on specific environmental conditions. Such predictive power will in turn serve the second goal of the project: to identify locations and road characteristics associated with high risk of PMVC, for the purpose of targeting pedestrian safety improvement programs, and developing treatments and countermeasures

Abstract:
The first goal of the project is to examine correlations between pedestrian motor vehicle collision locations (PMVC) and bus ridership, road characteristics, vehicular traffic conditions, and land use features along state roadways. These models will help predict the likelihood of future PMVC based on specific environmental conditions. Such predictive power will in turn serve the second goal of the project: to identify locations and road characteristics associated with high risk of PMVC, to target pedestrian safety improvement programs, and to develop treatments and countermeasures
The study will tie PMVC frequency (number of PMVCs), and severity (societal costs and fatalities) to road and neighborhood characteristics and will model project the impact of changes in these characteristics (specifically transit ridership, vehicular traffic patterns, road design, and activity generators and attractors along the roads).
This project is a continuation of previous Washington State DOT projects on Pedestrian Safety and Transit Corridors and Pedestrian Safety Treatment and Countermeasures.We will use the newly completed WSDOT collision data base and parcel-level GIS land use data.

Project Start and End Dates	September 1, 2005 – August 31, 2006
Current year budget	$29,110
For two-year project, total budget and start and end	

dates	
Modal orientation of the project	Multi-modal
Student involvement (thesis, assistantships, paid employment)	2 PhD RAs

Relationship to Other Projects:

This work continues previous and on-going Washington State DOT projects on (1) Pedestrian Safety and Transit Corridors (Hess, Moudon et al. 2003) and (2) Pedestrian Safety Treatment and Countermeasures (Nee and Hallenbeck 2003). We will use the newly completed WSDOT collision data base and state-of-the-art parcel-level GIS land use data.

Over the last decade, the Principal Investigator has worked with WSDOT and other national, regional, and local agencies to improve pedestrian safety (Hess, Moudon et al. 2001; Hess 1999; Koepsell, McCloskey et al. 2002; Moudon, Hess et al. 2002; Moudon, Hess et al. 1997). Recent research expanded this work to the study of associations between bicycling travel and land use (Moudon, Lee et al. in press).

Technology Transfer Activities:

A final report will be submitted to TransNow, TRAC, and WSDOT. In addition, papers will be prepared for and presented at the Transportation Research Board and the Association of Collegiate Schools of Planning. We will also prepare project findings summaries for TransNow and TRAC publications.

Based on WSDOT Project Officer and Technical Committee's recommendations, workshops will be held for state and local jurisdictions, so they benefit directly from the project and use the methods to identify locations and road characteristics associated with high risk of PMVC; to target pedestrian safety improvement programs; and to develop treatments and countermeasures.

Potential Benefits of the Project:

In the short term, the project will provide a strategic focus for on-going WSDOT projects focusing on Pedestrian Safety Treatment and Countermeasures (Insurance Institute for Highway Safety 2004)

In the medium and long ranges, experience in Florida and other states show that projects similar to the one proposed provide evidence for increasing public and institutional awareness of pedestrian safety needs, with the effect of increasing the scope and

effectiveness of safety enhancement projects directed at pedestrians. The project will guide the forging of more effective collaborative ties between transit agencies and WSDOT, to ensure the safety of the bus riding public, as well as to direct the implementation of traffic control measures and road designs that decrease the risk of PMVC. Being able to identify the locational characteristics associated with PMVCs will enable WSDOT, policy makers, local jurisdictions, and transit agencies to effectively target pedestrian safety programs in areas where safety and improvement investments can yield the highest return.

TRB Keywords:
Pedestrian safety, transit corridors, crash data, GIS

Identifying Number	61-2307
Project Title	Optimization-based Methods for Image Registration
Principle Investigator	George Turkiyyah
Institution	University of Washington
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PI's E-mail address	george@ce.washington.edu
External project contact, address, telephone number	Sivaneswaran Nadarajah WSDOT PO Box 47365 Olympia, WA 98504-7365 360-709-5475
Project objective	The goal of this project is to develop and implement methods for comparing digital image data of transportation facilities to assess change in their condition over time. The main challenge in this problem is the ability to register image sequences, taken at different times, perhaps with different cameras, and in different environmental conditions. Registration is a nonlinear transformation that produces correspondence between image features to allow their metrics to be directly compared. Our demonstration application is the monitoring of distress evolution in concrete pavements.

Abstract:

Image registration is one of today's challenging problems in image interpretation. Image registration is the problem of aligning points and features in one image/view to corresponding points and features in another image/view of the same or another object, or a template object. It involves deforming an image/template to best fit another one. Image registration is essential whenever images obtained at different times, devices, lighting conditions, perspectives, etc, need to be compared and integrated in some fashion. In most problems, especially-planted markers to help with the registration do not exist. Image data and perhaps some a-priori information about the content of the images is the only information available.

One motivating problem is the automatic evaluation of distress on roads. WA State, as many other states, scans the complete highway system every year using cameras mounted on a special van that travels the state highways. The images, while covering every inch of road, are naturally never taken at the exact same locations nor with the same lighting conditions, etc. So the comparison of images to assess the increase in cracking and distress between scans is not possible without registration. Currently human operators have to look painstakingly at the massive amounts of image data to make these assessments. This is time-consuming, expensive, error-prone and perhaps not the most

effective way to collect useful information for the data. Automated methods for registration and comparison can assist engineers in condition evaluation, or at least in prioritizing the areas that seem to be showing most increase in distress.

The image registration problem may be formulated as a large scale optimization problem where the objective is to minimize a distance metric between the two images. The unknown of the problem is a discretization of a non-rigid displacement field that distorts one image into another. The formulation is generally ill-posed and needs to be regularized, and constraints from a-priori problem information may be included. Techniques from finite element methods in elasticity may be used in the dicretization and the resulting problem consists a large scale nonlinear algebraic optimization problem. Multigrid methods can significantly speed up the computations necessary for solving these problems. Despite the challenging nature of this problem, significant algorithmic progress has been made on it recently. Most of the advances have been fueled by medical image registration problems, and made practical and affordable by the massive amount of computational power now available in most offices/departments.

While our motivating problem is the condition evaluation of pavements, the numerical methods proposed will find broad application in the analysis of traffic video data and similar problems.

Task Descriptions and Milestones:

Project Start and End Dates	September 1, 2005 – August 31, 2007
Current year budget	$45,000
For two-year project, total budget and start and end dates	$90,000
Modal orientation of the project	Highway
Student involvement (thesis, assistantships, paid employment)	None listed

Relationship to Other Projects:

The proposed project builds on several previous and ongoing projects in the area of digital image collection, archiving and interpretation:

- The WSDOT web-based Pavement management System. Over the last year, we have developed a web-based version of the WSDOT PMS system. In this version, we have incorporated access to multi terabyte-sized data sets that represent video images of the interstate system in the State of Washington. The data is collected

by a van driving the interstate system annually (rightmost lane). We have made that data accessible through a map-based web interface allowing users to "drive" a road segment and examine its conditions.

• We have recently started a project funded by NSF to look at extracting strain field data from x-ray tomography images of structural concrete specimens under loading. We seek to get a sequence of images taken at different load levels, and develop methods to be able to identify the damage and its evolution at increasing load levels. The proposed project directly complements and contributes to these two efforts. The WSDOT video database of the interstate highway system represents a wealth of data that can be used to help maintain the highway system in very efficient manner. Computer tools that can help in the interpretation of that data are important in this task, because a strictly manual effort for the interpretation of the whole data set is prohibitively expensive. The second project listed above shares some common methodology with the proposed project and the methods and algorithms developed there will form some of the building blocks that we propose to use for this project. We also believe that video data collection is becoming more prevalent as the cost involved in high quality image acquisition and storage drops. The methods we propose to develop are likely to find application in many other transportation areas where there is a need for interpreting temporal image sequences.

Technology Transfer Activities:

The implementation plan involves testing the proposed methods on the WSDOT video database of concrete pavements. The database currently contains detailed 03 and 04 data and in the next couple of months will have 05 data. 06 data will also be available during the course of this study. This set of data provides a sufficiently long duration and some sections of the interstate system may show detectable deterioration that requires WSDOT engineers to look at in further detail. The implementation will be done in two phases. The first phase implementation, which will be in Year 2 of the project, will allow a user through a web-based map interface to select a section of highway in a given year, and obtain the raw and the registered images for that same section of road from prior or subsequent years. The visual interface will show users (who at this stage will likely be WSDOT engineers and managers) how the system is matching the images from road sections in different years, and will allow them to give us some feedback on the reliability of the system in various conditions. In the final phase, towards the end of the project, the system will quantify the change in conditions (increased areas of cracked regions, increased length or width of linear cracks, etc.) and show this information to the user through the web-based map interface. Although the final road condition evaluation and assessment will naturally be made by WSDOT engineers and managers, the implementation of an image registration system will allow them to focus their efforts on the regions that are of most interest (essentially using the results of the system as a "first cut").

Potential Benefits of the Project:

The direct project benefit will come from the specific focus application. The implemented methods will allow personnel in Transportation agencies to better interpret the wealth of road condition video data that they collect. More broadly, in many areas of condition assessment, tracking performance, etc. the need to register image sequences is a critical task. The development of successful methods and implementations of these ideas in concrete pavement condition monitoring could open the doors for other application areas.

TRB Keywords:
Imaging, video, pavements

Identifying Number	61-2306
Project Title	Evaluation of Virtual Pavement Construction Simulations
Principle Investigator	George Turkiyyah
Institution	University of Washington
PI's telephone number	206-543-8741
PI's E-mail address	george@ce.washington.edu
External project contact, address, telephone number	David Newcomb National Asphalt Pavement Association 5100 Forbes Blvd. Lanham, MD 20706-4413 301-731-4748
Project objective	The objectives of this project are twofold. Building on our previous work on the development of a virtual hotmix construction site, we propose to perform a formal evaluation of its effectiveness and usability with contractors and in the classroom. In order to perform this evaluation, a secondary objective is to enhance the current version of the simulator to include non-uniform initial hotmix temperatures, effect of secondary mixing devices, density models of hotmix, the ability to sample a finished job as would occur with an actual construction contract. We will also create additional paving scenarios, based on feedback from contractors, in order to provide paving situations that are problematic and where training is most needed. The addition of these features is a relatively simple task because of the framework and architecture of the existing simulator.

Abstract:
The objectives of this project are twofold. Building on our previous work on the development of a virtual hotmix construction site, we propose to perform a formal evaluation of its effectiveness and usability with contractors and in the classroom. In order to perform this evaluation, a secondary objective is to enhance the current version of the simulator to include non-uniform initial hotmix temperatures, effect of secondary mixing devices, density models of hotmix, the ability to sample a finished job as would occur with an actual construction contract. We will also create additional paving scenarios, based on feedback from contractors, in order to provide paving situations that are problematic and where training is most needed. The addition of these features is a relatively simple task because of the framework and architecture of the existing simulator.

Task Descriptions and Milestones:

Project Start and End Dates	September 1, 2005 – August 31, 2006
Current year budget	$30,000
For two-year project, total budget and start and end dates	
Modal orientation of the project	Highway
Student involvement (thesis, assistantships, paid employment)	None

Relationship to Other Projects:
The proposed project builds on knowledge and data from several related ongoing projects:
• **The WSDOT *Pavement Guide Interactive***. A multimedia CD-ROM based document whose primary purpose is to provide a wide range of pavement information covering aspects from materials to design to construction to maintenance. This has won two national learning awards and has been well-received by the profession. (http://hotmix.ce.washington.edu/wsdot_web)
• **The Virtual Superpave Laboratory (VSL)**. A computer-based learning tool used for training engineering students, practicing engineers, and technicians in the laboratory procedures and data analysis of HMA testing. This project is funded by the National Asphalt Pavement Association (NAPA) and is on-going with expected completion in January 2005. (http://hotmix.ce.washington.edu/vsl)
• **HMA View**. A computer application that collects and relates design, construction, and performance data for hot mix asphalt pavements in a Web-accessible format. There are over 100 completed HMA construction projects already archived in HMA View; each one with detailed construction and manufacturing data. (http://hotmix.ce.washington.edu/hma)
These tools, along with the roller compactor simulator, provide a set of tools that can be used in training.

Technology Transfer Activities:
Following this phase, the implementation plan for the project involves distributing it widely to a national audience. As mentioned above, equipment manufacturers and a number of contractors have expressed their interest in deploying the system. NAPA is the likely vehicle for a national dissemination of the resulting software. We also expect the tool to be used in the classroom to illustrate quality of paving issues, and will make it available to our colleagues at various institutions.

Potential Benefits of the Project:
The paving simulator addresses issues related to the construction of HMA pavements.

This will help fill an immediate need in the HMA industry – a more knowledgeable cadre of personnel in agencies and contracting companies. The simulator will provide cost-effective training to field personnel. It will help to make them aware of some of the issues essential to the success of paving projects. This will assist in educating students about the systems and processes of pavement construction in a compelling, visually rich, interactive, "game-like" environment.

TRB Keywords:
Simulation, pavements, construction, software.

Identifying Number	61-2393
Project Title	Estimation of Incident-Induced Travel Delays on Freeways
Principal Investigator	Yinhai Wang
Institution	University of Washington
PI's telephone number	206-616-2696
PI's E-mail address	Yinhai@u.washington.edu
External project contact, address, telephone number	Pete Briglia 1107 NE 45th St, Suite 535 University of Washington Seattle, WA 98195 206-543-3331
Project objective	The objective of this study is to develop an algorithm for quantifying incident-induced travel delay on freeways using archived loop detector data and incident log data. The algorithm will be automated in a computer program to facilitate the application.

Abstract:

The Greater Seattle area has consistently been ranked as one of the most congested areas in the U.S. Traffic congestion on Seattle's major roadway network costs each commuter an average of $759 annually in wasted time and fuel. The increased travel cost has seriously degraded the economic competition capability of business entities in King County.

In order to solve the congestion problems, a better understanding of congestion causes and impacts is essential. On freeways, it is generally believed that more than 50% of congestion is the result of incidents. Particular attention should be paid to travel delays caused by non-recurrent congestion due to the fact that non-recurrent congestion may be effectively alleviated by cost-effective solutions through traffic management, control, and incident response. In this study, a queuing diagram-based algorithm will be developed for calculating the total travel delays caused by incidents using historical loop detector data and incident data. A computer system implementing this algorithm will also be built to automate the process. This proposed algorithm does not require choosing the reference speeds or other ambiguous thresholds for delay calculation. Therefore, it is easy to understand and implement. The accuracy of the proposed algorithm can be tested using the VISSIM simulation tool.

Task Descriptions and Milestones:

Project Start and End Dates	September 1, 2005 - August 31, 2007
Current year budget	$45,000
For two-year project, total	$90,000

budget and start and end dates	
Modal orientation of the project	Highway
Student involvement (thesis, assistantships, paid employment)	Ryan Avery (PhD), Jianyang Zheng (PhD) - RAs

Relationship to Other Projects:

This proposed project takes advantage of several funded projects recently conducted by the research team at the University of Washington, including "Measurement of Recurring Versus Non-Recurring Congestion," "Identification of Congestionn Causes," "ITS Backbone Infrastructure," and "Improving Dual-Loop Truck (and Speed) Data: Quick Detection of Malfunctioning Loops and Calculation of Required Adjustments." Findings of these projects and the established databases through previous studies can be directly applied to this research.

Technology Transfer Activities:

The estimated travel delays caused by incidents of different types are important inputs for the WSDOT to allocate the limited funding resource against incident-induced congestions on freeways. These results also provide a better understanding on the portion of delay caused by recurrent congestion or non-recurrent congestions at a specific roadway section and, therefore, help to price congestion properly. The queuing diagram-based algorithm developed in this study will be implemented in a computer program to facilitate the application.

A final report detailing the achievements of the proposed project will be written and submitted to TransNow and to the WSDOT for review and distribution. The results of this research project will also be documented in at least one paper for possible publication in *Transportation Research Record* or the *ASCE Journal of Transportation Engineering*.

Potential Benefits of the Project:

Direct benefits from this proposed research project are as follows:

- A better understanding of incident delays that helps to choose incident response strategies and congestion countermeasures;
- A queuing diagram-based algorithm and its computer implementation for incident delay estimation on freeways; and
- A study database with incident and traffic data for further studies on freeway incidents.

TRB Keywords:
Freeway, congestion, incident, delay

Identifying Number	61-2394
Project Title	Cost-Effective Safety Improvements for Two-Lane Rural Roads
Principle Investigator	Yinhai Wang
Institution	University of Washington
PI's telephone number	206-616-2696
PI's E-mail address	Yinhai@u.washington.edu
External project contact, address, telephone number	Dave Olsen WSDOT PO Box 47329 Olympia, WA 98504-7329
Project objective	The objective of this study is to better understand rural roadway accident causes in Washington State and to help find cost-effective solutions for reducing the frequency and severity of crashes on rural two-lane roadways.

Abstract

Accidents on Washington State roadways cost about $5.6 billion dollars in 2002, or $930 per person in Washington State. About 56 percent of fatal and disabling accidents occurred on two-lane rural roads each year, although these roads account for only less than a quarter of the total yearly miles traveled in Washington. The fatal and disabling injury collision risk on two-lane rural roads is 2.4 times as high as that on urban roads. Cost effective safety improvements for two-lane rural roads are urgently needed.

This study aims at identifying accident causal factors on two-lane rural roads and making quantitative evaluations on possible countermeasures. There are three major steps in this study: 1) Roadway geometry data, accident data, traffic volumes, and control devices will be plotted in a GIS system for intuitive comparison and hazardous location identification; 2) Accident-prone locations will be selected for further study to identify major causal factors to traffic accidents; and 3) An econometric model will be developed to quantify the impact of each causal factor on accident risk and identify the cost-effectiveness safety improvement plans. Findings from this study may help decision makers to understand the collision causations better and select more effective countermeasures against two-lane rural roadway accidents.

Task Descriptions and Milestones

Project Start and End Dates	September 1, 2005 - August 31, 2007
Current year budget	$30,000
For two-year project, total budget and start and end dates	$45,000

Modal orientation of the project	Highway
Student involvement (thesis, assistantships, paid employment)	Guohui Zhang (PhD), Patikhom Cheevarunothai (PhD) – RAs

Relationship to Other Projects

This proposed project will conduct follow-up research from two previous research projects entitled "Modeling Vehicle-to-Vehicle Accident Risks at Signalized Intersections" and "A Numerical Examination of Freeway Rear-End Accidents Considering the Mechanism of Accident Occurrence," respectively. The modeling approach used in those two projects can be applied to this study. Our experiences and findings from these two projects will make the proposed project start at a higher level.

Technology Transfer Activities

The rural two-lane road accident database developed for this study can also be used for future safety studies at WSDOT. Results from the statistical analyses will help WSDOT to better understand rural two-lane roadway safety issues and identify locations with higher accident risks. The accident risk models developed for quantifying the relationships between major accident types and causal factors can also be used for evaluating the effectiveness of safety improvement plans on rural two-lane roadways.

A final report detailing the achievements of the proposed project will be written and submitted to TransNow and to the WSDOT for review and distribution. The results of this research project will also be documented in at least two papers, which will be submitted for publication in the *Transportation Research Record* or the *Accident Analysis and Prevention*.

Potential Benefits of the Project

Direct benefits from this proposed research project are as follows:

- Better understanding of accidents occurring on rural two-lane roads in Washington;
- Accident risk models that can be used to evaluate the potential effectiveness of countermeasures against accidents on rural two-lane roadways; and
- Identified accident-prone locations and possible countermeasures to support optimized funding allocations for rural two-lane roadways.

TRB Keywords
Two-lane road, accident, countermeasure, traffic safety

Identifying Number	145836-1
Project Title	A Feasibility Study of Evaluating Transportation Security Systems and Associated Multi-Modal Efficiency Impacts
Principle Investigator	Eric Jessup
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Project objective	The overall purpose of this research project is to conduct a feasibility study and development of a general methodology to determine the impacts on multi-modal and system efficiency of alternative freight security measures. The methodology to be examined will be developed by applying it in several case study scenarios in the Pacific Northwest. To achieve this overall purpose of the research project, the following objectives will be achieved: 1) Inventory and develop structural information on alternative freight security measures under current consideration and implementation by appropriate authorities. 2) Work with institutional and agency sponsors to determine security program detail as to form, status, funding, coverage, etc. 3) Determine costs of implementation of alternative freight security measures. Costs include initial costs of physical implementation, but will also involve consideration of system costs such as delayed movement through port facilities, increased operational cost, lost connectivity to multi-modal facilities, increased pressure and constraints (at specific time intervals) on land based transportation systems, risk and uncertainty in both seamless logistic performance and highway planning/investment performance. 4) Evaluate several programs/measures (applied to northwest ports and Washington border crossings) in a cost/benefit framework including evaluation of who bears the cost of the security measures and what are the impacts on the overall system efficiency.

	5) Develop, summarize and report on a general methodology developed from the above analysis and the feasibility of applying that methodology in real time.

Abstract

The heightened security risks presented by freight cargo movements in the post-9/11 era has necessitated the testing of several different freight security measures to be adopted and implemented at ocean ports throughout the U.S. and world. These measures are designed to minimize the risk of future terrorists' attacks through cargo and container freight moving through the 361 sea and river ports across the U.S. Admittedly the potential threat is quite high given the 21,000 containers that enter a U.S. port daily and the current ability to verify the contents of roughly 5 percent of these shipments.

The outcome and relative success of the different port security demonstration projects underway will lead the way for a uniform security standard to be adopted and implemented by all U.S. ports. However, the focus of each of these demonstration projects is focused on physical implementation issues and the degree to which security risks are minimized. Lacking in these analyses is the impact upon transportation cost efficiency from each of these security measures and the potential disruption of current freight movements, by mode and freight corridor. In order for the state and region to adequately prepare for these altered freight traffic movements and prioritize investment needs accordingly, an assessment and evaluation of the efficiency impacts is needed.

This research project will begin by specifically detailing and outlining these different freight and port security initiatives underway. These may include those initiatives by the U.S. Customs, the Bureau of Customs and Border Protection, MARAD and the U.S. Coast Guard. The three primary demonstration projects being led by the Port of Seattle include, 1) Operation Safe Commerce, 2) Smart and Secure Trade-Lanes and 3) STAR-BEST. The two pilot programs being tested by U.S. Customs involves the testing of smart containers (C-TPAT) and freight trucks crossing the U.S.-Mexico Border in the FAST lane.

Each of these pilot projects will be evaluated in a cost/benefit framework, including the physical and operational cost of implementation, but additionally incorporating the efficiency losses realized as a result of each approach. These costs include delayed movement through port facilities, increased operational cost, lost connectivity to multi-modal facilities, increased pressure and constraints (at specific time intervals) on land base transportation systems, risk and uncertainty in both seamless logistic performance and highway planning/investment performance.

These findings will then be applied to one of the Pacific Northwest Ocean Port operations to determine impacts of improved efficiencies. Suggestions as to priority security

measures (based on both efficiency and physical impacts) will be offered. The state will be better equipped to focus transportation infrastructure investments, to address security concerns system-wide, including both land and maritime movements.
Technology transfer will be a primary focus and include publication in scholarly journals (Transportation Research Record, Transportation Quarterly, Journal of the Transportation Research Forum, etc.), presentations at professional conferences and regional association meetings and state planning meetings.

Task Descriptions and Milestones

Project Start and End Dates	September 1, 2005 - August 31, 2006
Current year budget	$42,000
For two-year project, total budget and start and end dates	
Modal orientation of the project	Multi-modal
Student involvement (thesis, assistantships, paid employment)	Grant Monson (MS) - RA

Relationship to Other Projects

This research project is very timely because it will build on another project that is currently under way, lead by these same two Principal Investigators. The overall goal of that project is to consider the impact of security measures on the international trade competitive situation for products coming into and out of the state, region and nation. The preliminary findings of that study will serve to inform and shorten the necessary literature and study review that is the logical first step of a good research effort.

That research effort is focused on the impact on trade competitiveness of alternative security constructs; this project is broader and is focused on developing an evaluative methodology to be used in differing studies with alternative goals.

Other studies may be under way but the current literature base does not reveal work done on the impacts, which is the focus of this study. The closest might be the beginning work at the George Washington University in "Developing a Framework for Economically Sustainable Port Security. These Principal Investigators and their research team have been in contact with that beginning effort.

Technology Transfer Activities

The initial output of this research effort will be a report detailing the general methodology developed from the preliminary analysis undertaken and an assessment of

the feasibility of implementation. Its strengths and weaknesses, its applicability in differing circumstances and the results of the case studies/demonstration projects will be identified. This report will be publicly available (PDF file format) on the TransNow home page, the WSDOT/TEP, the WSU/SFTA websites, as well as in printed form from the TransNow Center.

Second, because the research team will be working closely with ports, federal and state agencies, modes, and shippers, as well as with relevant state DOTs, a degree of results dissemination and implementation will be constantly forthcoming. The principal investigators have a history and currency of working with the Washington State Transportation Plan, the Port Authorities and other policy makers in the state and nation and will be interacting throughout this project.

Third, research results will be produced and presented to appropriate bodies and decision-makers, as decided in collaboration with Trans Now and WSDOT personnel. Finally, these principal investigators have a proven record of scholarly publications. Papers and presentations at regional and national transportation of economic/planning conferences (PNWREC, TRB, TRF, AASHTO, and scholarly publications in Journals are expected, given the timeliness and scope of this unique research effort. Seminars within the Universities of the TransNow consortium are expected as well as faculty conferences in those and other academic outlets.

Potential Benefits of the Project

This project will have provided and described a preliminary general methodology to predict the impacts of freight security measures and assessed the feasibility of implementation. It will allow decision makers dealing with the security issue to broaden their perspective of what the overall goals are and just how expensive is the last ten percent of risk decrease in a security context. It will provide understanding to those who are impacted by the security measures, and at least a general sense of the magnitude of those impacts, thereby informing the policy debate about who benefits, who carries the costs and why.

Decision makers at all levels should find this general tool and the applied case studies useful in their deliberation, whether it is the United States arguing with the European Union, or ports trying to show the Federal government what the security measures are costing them. Informed discussion is better discussion, even in a highly charged security debate.

Since the literature on the specific impacts of security measures in inter-modal/port facilities or cross border flows is very sparse, this analysis and methodology contribution from the state of Washington would be a major contribution to the very general literature that does exist.

TRB Keywords
Security, port infrastructure, modeling, planning