Transportation Northwest at the University of Washington
Research Project Descriptions
Year 17: September 1, 2004-August 31, 2005

Identifying Number	61-0744
Project Title	The Use of Weather and Weather Model Data to Predict Non-recurring Traffic Congestion
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 Washington State DOT University of Washington Box 352802 Seattle, WA 98195-4802
Project objective	1. Refine the methodology to automatically use transit coaches as probe vehicles to estimate freeway and arterial speed and travel time for traffic and traveler information, traffic management, as well as performance monitoring. 2. Deploy a set of components to provide real-time travel time and speed measures widely available to researchers nationwide. 3. Improve public access to virtual sensors over a large geographical area of metropolitan King County by improving the user interface for a web application. 4. Publish peer-reviewed results describing the effectiveness and confidence levels of data created using a transit fleet management system to create virtual sensors.

Abstract:

This project will demonstrate the quantitative relationship between weather patterns and surface traffic conditions. The aviation and maritime industries use weather measurements and predictions as a normal part of operations and this can be extended to surface transportation. While it is generally asserted that there is a causal relationship between weather and transportation systems delays, this relationship has not been quantified in a way that allows the effect on surface transportation systems to be predicted. This research has the potential to accomplish two very important things: (1) prediction of non-recurring traffic congestion and (2) prediction of conditions under which incidents or accidents can have a significant impact on the freeway system. This linkage of weather to traffic may be one of the only non-recurring congestion phenomena that can be accurately predicted. This work will create algorithms and implementations to correlate weather with traffic-congestion. Further, it may provide a means for traffic management to place resources proactively to clear incidents.

Transportation Northwest at the University of Washington
Research Project Descriptions
Year 17: September 1, 2004-August 31, 2005

Task Descriptions and Milestones:

Project Start and End Dates	September 1, 2004 – August 31, 2005
Current year budget	$35,000
For two-year project, total budget and start and end	
Modal orientation of the project	Highway
Student involvement (thesis, assistantship, paid employments)	Graduate

Relationship to Other Projects:

This research will use the Traffic Data Acquisition and Distribution (TDAD) database as a data-mine to obtain spatial and temporal traffic data for the metropolitan Seattle. The TDAD data mine in turn depends upon the ITS Backbone project, which is sponsored by WSDOT. A data-mine of Doppler radar information from the Department of Atmospheric Sciences at the University of Washington will be used to extract weather conditions such as wind speeds, droplet size, and surface precipitation.

Technology Transfer Activities:

a) Creating an algorithm that can correlate weather and congestion data and produce confidence intervals for the causality of non-recurring congestion as predicted by Doppler radar data.

b) Creating an algorithm to correlate the output of the Mesoscale weather model operated by Atmospheric Sciences with non-recurring congestion.

c) Describing a prediction methodology for using weather and weather prediction data to predict non-recurring traffic congestion on the freeway.

d) Demonstrating this experimental congestion prediction system to WSDOT using freeway data.

e) Submitting a paper for presentation at the TRB'05 Annual Meeting and submitting a manuscript to a peer review journal.

Potential Benefits of the Project:

This project will benefit WSDOT by a proof of principle demonstration of predicting non-recurring congestion. It will further benefit WSDOT by allowing them to predict the need for incident response equipment and by providing a dynamic means to plan the deployment of incident response vehicles. It will eventually benefit the traveling public by speeding WSDOT clearing of incidents due to warning of possible future incidents. It will also

benefit the public if it is made part of the traveler information systems deployed to inform the public about congestion, recurring and non-recurring. It will benefit the research community by publishing quantitative relationships between weather measurements/predictions and non-recurring congestion on freeways.

TRB Keywords:

Data-Mine, Weather, Model, Prediction, Traffic, Freeway, Doppler Radar

Identifying Number	61-0801
Project Title	Road Construction Project Simulator
Principle Investigator	George Turkiyyah
Institution	University of Washington
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External project contact, address, telephone number	David Newcomb National Asphalt Pavement Association 5100 Forbes Blvd Lanham, MD 20706-4413 (301) 731-4748
Project objective	This project seeks to enhance student understanding of the entire hot mix asphalt (HMA) construction process through use of interactive, entertaining and realistic computer simulations. A high-level computer simulation of the HMA manufacturing and construction process will be developed to give users a better understanding of the overall HMA road construction process. In particular, this simulation will help users appreciate and evaluate the various roles and tasks that need to be managed, time and resource constraints, material variability, cost and the influence of these factors on the quality of the finished product. Models will be developed using actual manufacturing and construction data, while the user interface will be highly graphical, intuitive and entertaining. This research will produce a prototype HMA manufacturing and construction computer simulator.

Abstract:

The goal of this project is to produce a software simulation that enables the user to manage a road construction project from the hot mix asphalt plant operation to the finished paved road.
Throughout the simulation, the user is provided with the resources needed to complete a specified road construction task. These resources include raw materials for hot mix production, trucks for transportation of the hot mix asphalt from the plant to the site, equipment to lay, roll, and finish the pavement. In addition, the simulation will include a virtual crew that can be directed to execute the road construction tasks.

Built into the simulator is a set of models that emulate real-world constraints on hot mix asphalt construction. These include models of mix design properties, temperature-dependent mix characteristics, resource management to balance production and laydown rates, rolling and compaction, and deployment of available man-hour resources.

Computer graphics technology will be used to give the user an omniscient, third-person perspective on the virtual world. Interaction with the visually rich world enables the user to zoom in and examine the individual processes and locations in the simulation or pull back and have a macro view in order to manage the inter-process relationships. From the third-person vantage point, the user can start and stop tasks in order to synchronize dependent tasks or to verify the quality of work.

Using a game metaphor, feedback mechanisms will be in place to inform the user of the success of the construction task. This simulator will be useful for training students and workers in the road construction industry, highlighting the necessity of quality control, task coordination, and resource management.

Task Descriptions and Milestones:

Project Start and End Dates	September 1, 2004 - August 31, 2005
Current year budget	$35,000
For two-year project, total budget and start and end dates	
Modal orientation of the project	Highway
Student involvement (thesis, assistantships, paid employment)	Thesis/RA

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)
- **Xpactor**. A virtual hot mix compactor simulation that is designed to allow users to experience hot mix rolling. It also provides a realistic simulation of hot mix cooling physics through the use of the MultiCool software. The current implementation of the project enables multi-user simulations on a network.
- **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)

The proposed project builds on the technology, expertise and data contained in these projects. The WSDOT *Pavement Guide Interactive* and VSL provide a rich knowledge base of HMA material properties, manufacturing and construction knowledge; HMA View provides a large set of existing construction data from which models can be made; and the Xpactor provides a framework for graphical simulation of a paving task on a micro-level.

Technology Transfer Activities:
The implementation plan contains three elements. Following completion of the prototype road construction simulator, trial implementation will be done within three types of organizations: universities, state DOTs, and a contractor-oriented paving association (NAPA). At the University of Washington, we will introduce the simulator to both senior and graduate students and obtain student feedback on its effectiveness and ability to convey critical field construction operations. State DOTs will be targeted for trial implementation including Washington and Maryland. These states together with California, Minnesota, and Texas have formed a consortium that enables collaboration on pavement-related issues. The research directors and chief pavement engineers for these DOTs meet on a regular basis. They have stated that tools, such as the road construction simulator, are needed for training their personnel, and are motivated to assist with implementation. Finally, NAPA will identify one or more of its member contractors that the research team will collaborate with for trial implementation. With high employee turnover, construction-related training is a constant and critical contractor need.

Potential Benefits of the Project:
The road construction simulator addresses issues related to the manufacture and 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 timing, communication, and safety 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:
pavement, simulation, software, construction

Identifying Number	61-0802
Project Title	Comprehensive Evaluation on Transit Signal Priority System Impacts Using Field Observed Traffic Data
Principle Investigator	Yinhai Wang
Institution	University of Washington
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PI's E-mail address	yinhai@u.washington.edu
External project contact, address, telephone number	Larry Senn. UW Box 354802 Tel: (206) 543-6741
Project objective	The main objectives of this research are: • Quantitatively evaluate the Transit Signal Priority (TSP) benefits for transit operations; • Calculate the overall impacts of the TSP system on local traffic networks; and • Understand how the TSP effects change with traffic conditions and signal control parameters, and recommend optimal system settings.

Abstract:

Transit Signal Priority (TSP) is an operational strategy that facilitates the movement of in-service transit vehicles, either buses or streetcars, through traffic controlled intersections. By reducing the intersection delays of transit vehicles, a TSP system can reduce transit delay and travel time, thereby increasing the quality of service. In the last two decades, TSP systems have been deployed in many cities worldwide. However, enthusiasm for TSP in North America has been tempered with concerns that overall traffic performance may be unduly compromised when signal timing plans intended to optimize traffic flow are overridden to provide a travel advantage to transit vehicles. To quantitatively evaluate the effect of TSP, several studies have been conducted in recent years. While these studies generally agree on the benefits for transit operations, the overall impacts of TSP on local traffic networks remain unclear. Therefore, TSP effects on a particular network need to be evaluated based on specific conditions of the network. This study proposes a sensor-data-based comprehensive evaluation plan for the South Snohomish Regional Transit Signal Priority (SS-RTSP) system. Impacts of the SS-RTSP system on both transit and local traffic operations will be quantitatively evaluated.
Task Descriptions and Milestones:

Project Start and End Dates	September 1, 2004 – August 31, 2005
Current year budget	$35,000
For two-year project, total budget and start and end dates	
Modal orientation of the	Transit and highway

project	
Student involvement (thesis, assistantships, paid employment)	Four students will work on this project as RAs.

Relationship to Other Projects:

In this proposed project, impacts of the South Snohomish Regional Transit Signal Priority (SS-RTSP) system on both transit and local traffic operations will be quantitatively evaluated based on field site data. This project takes advantage of several sensor and safety related studies, sponsored or non-sponsored, recently conducted by the research team at the University of Washington. Also, the traffic data network being established at the Smart Transportation Applications and Research Laboratory (STAR Lab) will provide real-time traffic sensor data and other field observed data for the evaluation. Major sponsors of the STAR Lab traffic data network include the University of Washington, Transportation Northwest (TransNow), and the Washington State Department of Transportation (WSDOT).

Technology Transfer Activities:

This project is an evaluation of an implemented TSP system. The results obtained will help both the traffic management and transit operation agencies to better understand the impact of the TSP system. It may also provide some hints for future TSP implementations elsewhere. While the WSDOT does not directly control the signals involved in the SS-RTSP project, it does operate a number of signal systems for which TSP is being considered for funding. The results of this test will help WSDOT determine the correct initial TSP operating parameters for those locations.

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 *ASCE Journal of Transportation Engineering.*

Potential Benefits of the Project:

- A method for comprehensive evaluation of TSP impact using field observed traffic data;
- Quantitative evaluation results on transit operational benefits from the SS-RTSP project;
- Calculated MOEs that reflect the overall impacts of the TSP system on local traffic networks;
- A transit signal evaluation database that will benefit future researchers; and

- Recommended optimal settings of the traffic control and TSP systems if the secondary MOEs are also calculated.

TRB Keywords:

traffic detection, transit signal priority, intersection delay, intersection signal control

Identifying Number	821528, Task 4
Project Title	Estimating the Impacts of TODs on Travel and Transit Use
Principle Investigator	Jennifer Dill
Institution	Portland State University
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PI's E-mail address	jdill@pdx.edu
External project contact, address, telephone number	Kyung-Hwa Kim Metro 600 NE Grand Ave., Portland OR 97232-2736 503-797-1929 503-797-1773 kimk@metro.dst.or.us
Project objective	• Collect empirical data on travel behavior at transit-oriented developments (TODs) in the Portland region • Estimate the potential of TODs to increase transit ridership • Understand the relationships between people's housing and travel decisions

Abstract:
Many growing regions throughout the United States, including Portland, are turning to transit-oriented development (TOD) to address problems of traffic congestion and suburban sprawl. For example, Metro, Portland's regional government, is relying on TOD concepts in its Region 2040 Growth Concept and is spending several million dollars to financially support new TODs. Similar programs are being adopted in many metropolitan areas that have expanding rail and bus rapid transit systems. Unfortunately, there is limited evidence on the impact of TODs on travel behavior and transit use. Much of the existing research that supports this concept is based upon older, traditional neighborhoods, rather than newly built TODs, such as Orenco Station in Hillsboro, Oregon. While the neighborhoods may include some similar features, households that choose to live in new TODs are likely to differ significantly from those living in older neighborhoods. Therefore, empirical research is necessary to examine the travel behavior of residents of these new TODs. This project will collect such data, using two new TODs in the Portland region: Orenco Station and The Round at Beaverton. The project will involve surveys of residents of these two TODs, as well as control neighborhoods. The surveys will collect information about household characteristics, travel behavior, and attitudes about travel and their neighborhood. The control neighborhoods will include similarly-priced housing. At least one will have similar transit service, but without the TOD design features (mixed uses, good pedestrian access, etc.). Another will include similar land use and design features, but without the light rail transit service. A final control neighborhood will be a typical post-World War II suburb, with limited transit service or mixed uses. The results will help improve public policy-making and planning at many levels. Transit agencies may benefit by learning how to increase ridership via TOD programs. Metropolitan Planning Organizations, like Metro and the Puget Sound

Regional Council, and local governments may be able to use the results to improve modeling and other estimates of the impacts of their polices.

Task Descriptions and Milestones:

Project Start and End Dates	September 15, 2004 – August 31, 2005
Current year budget	$17,885
For two-year project, total budget and start and end dates	
Modal orientation of the project	Multi-modal, focusing on transit
Student involvement (thesis, assistantships, paid employment)	One graduate student research assistant will work on the project. That student could use the project for their field area paper (~thesis) research. The PI will incorporate the project in classes when possible.

Relationship to Other Projects:
In Spring 2003, the PI conducted a survey of residents of Fairview Village, a New Urbanist development in the Portland region, and two control neighborhoods. The survey asked about trips made the previous week, along with information about why the respondent chose their home/neighborhood, how they felt about their neighborhood, and demographic information. This proposal will build on the survey instrument and methodology that the Fairview Village research.

Technology Transfer Activities:
The final report will be available on the PI's web site (web.pdx.edu/~jdill), as well as the Center for Urban Studies site. The PI will prepare at least one academic journal article and a paper for presentation at TRB 2006 based on the research. We will present the results at the PSU Center for Transportation Studies seminar, which is available for viewing on the web, both live and archived. Finally, we will look for additional opportunities to present the results to the professional transportation planning community, including the newsletters of local chapters of the American Planning Association, Women's Transportation Seminar, and ITE. Given our limited travel funds, we can not commit to presenting at the national conferences of these organizations. Finally, we will make a limited number of copies of the final report to distribute to key government agencies in the TransNow area, including the major transit agencies and MPOs.

Potential Benefits of the Project:
The results will help improve public policy-making and planning at many levels. Transit agencies may benefit by learning how to increase ridership via TOD programs. Metropolitan Planning Organizations, like Metro and the Puget Sound Regional Council, and local governments may be able to use the results to improve modeling and other estimates of the impacts of their polices.

TRB Keywords:
Transit-oriented development, transit, travel behavior, mode split

Identifying Number	821528, Task 5
Project Title	Data Visualization as a Tool for Improved Decision Making within Transit Agencies
Principal Investigator	Thomas J. Kimpel
Institution	Portland State University
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PI's E-mail address	kimpelt@pdx.edu
External project contact, address, telephone number	Steve Callas, TriMet 4012 SE 17th Avenue, Portland, OR 97202 (503) 962-7502
Project objective	The proposed project has two principal objectives: 1) to develop visualization methods that serve to reduce the quantity and enhance the quality of the information presented in transit service performance reports and 2) to develop effective communication tools for presenting important findings to decision makers.

Abstract:
The subject of this proposal concerns the visualization of bus performance measures using a geographic information system (GIS) and other graphical techniques for improving decision making capabilities within transit agencies. TriMet, the regional transit provider in the Portland, OR, area has been a leader in bus transit performance monitoring using data collected via automatic vehicle location (AVL) and automatic passenger counter (APC) technologies. A vast amount of information is collected and archived for off-line analysis of transit operations. This information is summarized on regular bases in the form of bus transit performance reports which help inform agency personnel about the status of various parts of the transit system across numerous spatial and temporal dimensions. To date, most of the data presented in performance reports are in tabular format. With the exception of sorting performance measures by either best and worst case examples, a large amount of useful information is not being utilized due to the sheer volume of information available. While the performance reports generated at TriMet have been successful in identifying scheduling and operational issues, a disjuncture exists with respect to the ability to convey important findings to key decision makers including schedulers, service planners, and management personnel. The proposed project has two principal objectives: 1) to develop visualization methods that serve to reduce the quantity and enhance the quality of the information presented in transit service performance reports and 2) to develop effective communication tools for presenting important findings to decision makers.

Task Descriptions and Milestones:

Project Start and End Dates	September 1, 2004 - August 31, 2005
Current year budget	$35,000
For two-year project, total budget and start and end dates	
Modal orientation of the project	Transit
Student involvement (thesis, assistantships, paid employment)	One Graduate Research Assistant

Relationship to Other Projects:
The proposed project builds on previous research by the team that has evaluated the implementation of TriMet's automated bus dispatching system (BDS) and uses of archived AVL-APC data for performance monitoring and analysis. Previous TransNow-sponsored research on this subject includes 1) the development of transit operating performance measures (Strathman et al., 1999); 2) documentation of initial general operating performance improvements following BDS implementation (Strathman et al., 2000); 3) BDS applications to transit operations control (Strathman et al., 2001); and 4) BDS applications to scheduling (Strathman et al.,2002) 4) bus APC validation and NTD sampling (Kimpel et al., 2004); 5) evaluation of transit signal priority effectiveness (Kimpel et al., forthcoming). The proposed project is a logical extension of past research in that it extends previous work in the area of performance monitoring through development of visualization tools for improved decision making within the transit agency.

Technology Transfer Activities:
The research team will submit the findings of the project for presentation at the annual meeting of the Transportation Research Board. Research findings will also be submitted for publication. An interactive website linked to the Center for Urban Studies homepage will be developed highlighting the project findings. The final document will also be made available for download.

Potential Benefits of the Project:
The expected benefits of the project include better utilization of transit service performance data by transit agency personnel, leading to further improvements in service efficiency and service quality.

TRB Keywords:
Transit, Automatic Vehicle Location System, Automatic Passenger Counter, Service Planning, Performance Monitoring, Geographical Information System (GIS)

Identifying Number	821528, Task 6
Project Title	Enhancing the Crash Reporting Process: A Feasibility Assessment
Principle Investigator	Dr. Christopher M. Monsere
Institution	Portland State University
PI's telephone number	503-725-9746
PI's E-mail address	monsere@pdx.edu
External project contact, address, telephone number	Robin Ness Oregon Department of Transportation Transportation Data Section 555 - 13th Street NE Salem, Oregon 97301-4179 (503) 986-4236
Project objective	The objective of this project is to determine the feasibility of deploying an improved system for self-reporting of motor vehicle crashes by citizens. The project will determine acceptance of general public to electronic crash reporting, identify any institutional or legal barriers to implementation, estimate the potential benefits to data managers and users, and make a final recommendation on feasibility. The project will focus on Oregon, since a majority of Oregon motor vehicles crashes are reported by citizens, although there may be applications to other states that require citizen reporting. The objective of the project will be met by completing a comprehensive review of the literature and practice, developing a research strategy to determine common reporting errors made by the public, conducting a survey to determine acceptance of an electronic form, and making a final recommendation of the feasibility of such a system.

Abstract

In most states, police officers and trained investigators complete crash reports for nearly all reportable crashes that occur on public roads. Many states have made significant improvements in the quality and timeliness of their crash data systems by implementing, in addition to other improvements, electronic filing of these reports by police officers. Oregon relies on citizen reports for a majority of their crash data and Washington accepts citizen reports for a small share of their data. In both cases, paper forms must be submitted to the responsible state agency which are then manually coded into the crash data system. Police reports are also paper based. This process limits the improvements that can be made in both the quality and timeliness of data unless enhancements can be made to the reporting process. Washington attempted to implement an optical scanning system for crash reports in the mid 1990s to improve timeliness and ease data entry burden but met with numerous technical challenges. This research would study the feasibility of implementing a web-based system for reporting crashes, with a focus on

citizen reporting and to a lesser extent police reporting. Institutional and legal issues will be identified and a concept framework will be developed. General public and institutional acceptance will also be quantified.

Task Descriptions and Milestones

Project Start and End Dates	September 1, 2004 – August 31, 2005
Current year budget	$20,900
For two-year project, total budget and start and end dates	
Modal orientation of the project	Highway
Student involvement (thesis, assistantships, paid employment)	CE Master's student on assistantship, Undergraduate CE work hours

Relationship to Other Projects

This project will build upon PSU's emerging research focus area of highway safety. Current projects underway for the Oregon Department of Transportation (ODOT) include an effort to update the crash reduction factors used by state engineers when evaluating safety improvement projects and a systematic statewide analysis of speed-related crashes. While this work does not build directly upon any current research efforts, it will serve as a building block for future efforts to improve Oregon's crash reporting system. This work will, however, build upon other efforts such as the work completed to date on the National Model for crash record systems, TraCS, and other similar efforts. In addition, the effort is synergistic with increasing use of e-commerce in government services.

Technology Transfer Activities

We anticipate and call for early and consistent involvement of our external project contact. A letter of support has already been obtained from the program coordinator of the ODOT's statewide crash reporting unit and from the City of Portland's Office of Transportation (see section 6.0). We will work with other members of the technical advisory committee and other external constituents at the City of Portland, ODOT, Association of Oregon Counties, League of Oregon Cities, and Alliance for Community Traffic Safety in Oregon (ACTS Oregon).

The project results will be presented to our external project constituents, as well as being presented at the next Annual Transportation Safety Conference where Dr. Monsere is organizing a crash data users forum. We will also likely be able to present our results at the annual International Forum on Traffic Records and Highway Information Systems and the annual meeting of the Transportation Research Board. In addition, we will make every effort to present at local and statewide meetings of professional organizations such

as Women's Transportation Seminar, Society of Women Engineers, American Society of Civil Engineers and the Institute of Transportation Engineers.

Two months prior to the project end date, the draft of the final report will be forwarded to TransNOW for review and distribution. Results will also be disseminated through appropriate web-based media (e.g., the PSU and ITS Laboratory website). The co-principal investigators and students will develop appropriate paper(s) for submittal to scholarly journals and major regional and national transportation conferences.

Potential Benefits of the Project

The primary benefit of this research will be to answer the question of whether electronic self-reporting of crashes is feasible in the state of Oregon. Public agencies that compile, process, and store crash data will be particularly interested in the results of this feasibility study. Should the feasibility study indicate the system would be appropriate for Oregon additional benefits be realized if the system were fully deployed. Improved data accuracy and accessibility would be possible for engineers, planners, and citizen organizations. The enhanced system would result in easier and more efficient interaction with government and reduced data entry burden for state agencies. Current staff would be available for other tasks that may have much higher returns. If the system were to be extended for use by police agencies, significant reductions in paperwork would result in more time for other public safety duties.

TRB Keywords

Highway safety, Traffic safety, Records management, Information management, Accident records, Crash records