

TRANSPORTATION RESEARCH DIGEST

December 2010

ARIZONA TRANSPORTATION INSTITUTE

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DECEMBER 2010

TO: TRANSPORTATION PROFESSIONALS, MANAGERS, & POLICY MAKERS

FROM: ARIZONA TRANSPORTATION INSTITUTE

The volume of information on transportation issues, policies, technologies, and related topics is huge. Not even the most well-read professional can keep up with everything that might be useful to know. The *Transportation Research Digest* series is designed to expedite the transmission of information by condensing and summarizing significant documents. Busy professionals or managers may quickly obtain the gist of new developments and determine whether they need to see the full document.

The *Transportation Research Digest* is not meant to present definitive resolutions of scientific or policy controversies, but contributions to the pursuit of knowledge and the debate of issues. The intent is to be comprehensive rather than conclusive on the multitude of issues and topics of concern to those working in the field of transportation. Readers are encouraged to obtain the original document summarized in the *Transportation Research Digest* and subject the content to their own judgment.

Transportation professionals who would like to recommend documents to be summarized or submit summaries to be considered for inclusion in this publication are invited to do so. To recommend a document please send a copy (or information indicating how a copy can be obtained) of the research report to be summarized. To be considered, the report must meet the following requirements: (1) it is transportation related, (2) it is no more than two years old, (3) there is enough information in the report to warrant a two page summary. To write a summary, insure that the document being summarized meets the above requirements. The summary should be submitted in an electronic format. This summary should be in the 500 to 800 word range and may include tables and/or simple graphics—all of which must fit within the *Transportation Research Digest's* two-page format. Submissions are subject to editing for clarity and length. We do not guarantee that all submissions will be published.

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Transportation Research Digests from December 1995 to November 2003 are available on request.

A “Topic” code in the Table of Contents will help readers more quickly identify items of interest. The topic codes are explained in the table below.

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AIRP	Airports	PRIV	Privatization
AVIA	Aviation	RAIL	Railroads
BIKE	Bicycles	RDS	Roadside
CON	Construction	ROW	Right-of-Way
ECON	Economics	SAFE	Safety
ENV	Environment	STR	Structures
FIN	Finance	TECH	Technology
INOV	Innovations	TOLL	Toll Roads
MAIN	Maintenance	TRAN	Transit
MISC	Miscellaneous	TRF	Traffic
MVD	Motor Vehicle Dept	TRK	Trucking
PAVE	Pavement	VEH	Vehicles

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Thank you.

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Research on Factors Relating to Density and Climate Change by Kimberly Burnett, *et al.*, Abt Associates Inc., 55 Wheeler Street, Cambridge, MA 02138 (National Association of Home Builders, 1201 15th St., NW, Washington, D.C. 20005; ph. 1-800-368-5242; http://www.nahb.org/fileUpload_details.aspx?contentID=139993) (June 2010)

Highlights

- Urban areas have become more decentralized.
- Pricing may play a more important role in explaining travel behavior than characteristics of the built environment.

The research on the relationship between density and travel is virtually unanimous: after controlling for socioeconomic factors, density directly influences VMT and mode choice. However, the weight of the evidence suggests that the effect of density on travel behavior is modest (roughly 5% reductions in VMT and vehicle trips with a doubling of density). In comparison, large increases in regional accessibility (accessibility to regional centers), are found to have a much larger impact on travel behavior – roughly 20% reductions in VMT. Based on the modest impacts on VMT of increasing density—and the difficulty of achieving that added density—several researchers suggest that it is not an effective policy tool.

Self selection is an important methodological issue that affects all studies of the relationship between travel behavior and the built environment. People who dislike driving may self-select to live in walkable neighborhoods with convenient access to transit, while people who like driving may be more likely to select neighborhoods with good auto accessibility.

An important unresolved question then is the extent to which estimates of impacts on

travel behavior are affected by self selection. The weight of the evidence suggests that self selection and the built environment both have independent effects on travel behavior, but there is little research on the magnitude of the effect of each factor. Regardless, studies that ignore the impact of self selection are likely to overestimate the impact of the built environment on travel behavior. One method for correcting for self selection is to include variables in models of travel behavior that capture people's predispositions to drive or take transit. Most studies that include these variables find that they explain a great deal of the variation in travel behavior, and suggest personality/attitudes toward driving and transit may be more important than characteristics of the built environment.

The size of the potential impact of changes in the built environment may depend in part on whether there is unmet demand for the high-density, walkable neighborhoods that are associated with lower auto ownership and VMT. If there is – perhaps because of local zoning restrictions that tend to encourage low density residential development – then neighborhood choices that better match consumers' preferences could indeed result in sizeable reductions in VMT.

Studies that consider New Urbanism-type street patterns generally find that they have only weak or no impact on auto use. They have more impact on walking and bicycling, as does pedestrian-oriented design.

Demographic and other characteristics such as income, race/ethnicity, and immigrant status affect the degree to which residential density influences travel behavior. Other aspects of the local context – such as the local economy and geography – also affect the relationship between residential density and travel behavior. With so many factors influencing travel behavior it is clear that there is no one-size-fits-all strategy for changing travel behavior.

There are at least three primary factors affecting the relationship between residential density and the climate (via travel behavior). One of these is the trend toward decentralization of employment from city centers. Less than a quarter of jobs are now located in the central business district, compared with nearly half located more than 10 miles from downtown. The trend, which started over half a century ago, indicates that the traditional view of the monocentric city is a poor approximation for the reality of most American cities. Importantly, it weakens the ability of public transit – particularly fixed rail systems – to meet travel needs, and reinforces the need for auto ownership and neighborhoods that accommodate autos.

A second factor is the increasing number of households with two workers who often commute to different locations. The literature is mixed on the implications of this trend, although there is consensus on one point: the research clearly demonstrates that households do not primarily select their residential location in order to minimize their commutes.

A third factor is the recent increase in non-work trips. Understanding trends in non-work trips is important because unlike work trips, non-work trips are often discretionary, and therefore may be more influenced by the

built environment, pricing, and other factors designed to reduce auto trips and their associated greenhouse gas emissions. On the other hand, non-work trips may be less influenced by public transit options because they often involve multiple destinations and are thus less well suited to public transit than work trips. Trends over the past decade also indicate that commercial truck traffic is increasing its share of total VMT, and that this trend is likely to continue in the next decade.

In addition to unresolved questions about the role of self selection, other important questions are left unanswered by the current research on the connection between residential density and the climate. Among others, how difficult would it be to achieve residential densities that are double their current levels across a metro area – that make Atlanta look more like Boston? Experience from Portland, Oregon, an area known for its urban growth boundary, suggests that sizeable increases in density takes decades – at least 30 years. Given that the built environment is long lived, this result is not surprising.

Few studies include the impact of travel cost—either in terms of time or money—on travel behavior, but those that do conclude that pricing may play a more important role in explaining travel behavior than characteristics of the built environment. They conclude that changes in policies that affect the monetary or time cost of car ownership and use—such as increases in gas taxes or the price or availability of parking and the supply of roads—are more effective in changing travel behavior than any other policy. If policy makers find these types of economic incentives to be unpalatable, policies that lead to large-scale changes in land-use are a distant second-best alternative.

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Synthesis of Innovative Contracting Strategies for Routine and Preventive Maintenance Contracts by Cindy L. Menches, Nabeel Khwaja, Juan Chen, Center for Transportation Research, University of Texas at Austin, 1616 Guadalupe, Suite 4.202, Austin, Texas 78701-1255 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; http://www.utexas.edu/research/ctr/pdf_reports/0_6388_1.pdf) (Feb 2010)

Highlights

- This research aimed to identify the innovative maintenance contracting strategies that are being used by other state DOTs or other countries.

An efficient maintenance contracting strategy can help transportation agencies to accomplish their maintenance goals given challenging in-house resources constraints. This research aimed to identify the innovative maintenance contracting strategies that are being used by other state DOTs or other countries that can be implemented by TxDOT. It also aimed to develop a decision method that can aid TxDOT in selecting appropriate contracting strategies for outsourcing various maintenance activities. Major conclusions from this study include the following:

- Three components have been identified that make up a maintenance contracting strategy: delivery method, type of contract specification, and pricing strategy.
- Thirteen (13) delivery methods that are used worldwide for highway maintenance contracting are identified, as well as three types of contract specifications, and three pricing strategies.
- There is no existing standard definition and terminology for various maintenance delivery methods because each state DOT or country tailors a

delivery method to suit its needs or circumstances and names the delivery method accordingly. Hence, this research provides standard definitions that can be used throughout the United States.

- Some delivery methods, such as Multi-Agency Contract Method or Partial Competitive Maintenance Contract Method, are seldom used by DOTs in the United States, and other methods, such as Alliance Contract Method or CREMA Contract Method, are only implemented outside the United States.
- An overall picture of how frequently the thirteen delivery methods are used and who is using them is presented.
- Many factors will affect a transportation agency's ability to select an effective maintenance delivery method. A particular goal that the agency wants to achieve through outsourcing (such as a long-term commitment from contractors), or a particular circumstance (such as lack of equipment or expertise), are just two of the many factors that will impact the decision process.
- A decision tree with eight (8) decision nodes (and associated decision criteria) have been identified through 11 DOT interviews. A Maintenance Contracting Strategy Selection Framework was

developed based on the decision nodes and criteria.

- A selection algorithm has been developed to assist maintenance personnel in selecting appropriate contracting strategy that can help them achieve their particular outsourcing goals and accommodate their specific maintenance circumstances.
- A selection guide provides guidance on the selection and implementation of

innovative maintenance contracting strategies for the outsourcing of maintenance activities.

- Eleven (11) case studies present five (5) delivery methods that are being used within TxDOT or other state DOTs that give the reader a picture of how these delivery methods are implemented in practice.

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Accelerating Transportation Project and Program Delivery: Conception to Completion, NCHRP Report 662 by Dennis Keck, *et al.* (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_662.pdf) (2010)

Highlights

- The case studies in this report highlight some of the best practices that follow a project from the start until ribbon cutting.

The demand for continued infrastructure investments in today's environment places increased pressure on transportation professionals to expedite the delivery of projects and programs. Along with reduced delivery schedules, projects must also maintain high quality while minimizing cost. Environmental issues, community activists, stricter regulations, and variable risks are among the myriad of factors that impact project delivery. The transportation industry is transforming itself as new ways of delivering projects compete with established ones.

Recent advancements have been made in improving project delivery by accelerating critical phases of a project; however, the literature is lacking in documentation of program and project acceleration through innovative holistic methods. This lack has prompted the need to research best practices that provide transportation decision makers at the state level with some options for accelerating their programs and projects holistically.

Eight states were selected for this research. Their best practices are documented in the case studies included in this report. Among the research findings was a pattern of shifts in the way departments of transportation (DOTs) do business. While the technical

aspects of developing a project or program can be considered a constant among all of the agencies, the DOTs of today have a different focus and adhere to a different set of rules.

Trends

In the course of studying these states, it became evident that certain trends and challenges were common to many of them. The identified trends are discussed briefly in the following paragraphs:

Research indicates that state DOTs are increasingly identifying performance measures as one of their most pressing needs. As attainable goals and targets are set and achieved, programs and projects are accelerated. While the traditional project approach placed greater emphases in the design phase, current approaches focus on thoroughly outlining the purpose and need, carefully defining the scope to considerable detail, and clearly outlining the front end of a project even before the feasibility assessment stage.

More state DOTs are beginning to use Project Management Institute philosophies to deliver projects, balancing the quadruple constraints of a project (scope, schedule, budget, and quality), more and more in their management activities. Leadership was found to play a critical role in the efficiency with which programs are executed. Managers and administrators orchestrate the dynamic interplay that occurs between individuals, work teams, agencies, and stakeholders for an initiative to come to fruition. Strong leadership

at the top sets the stage for performance at all other levels.

DOT employees are communicating laterally and vertically, collaborating to reach difficult decisions, and cooperating to meet agreed-upon goals. This effort has led to true partnering with agencies and the public and the creation of trust-based relationships. The successes of high-performance teams, specialized function teams, and self-directed work teams support the finding that a team approach fosters accelerated project delivery. State DOTs have recognized that a supportive team environment drives project performance.

The need to produce more or better services with limited resources and environmental constraints has compelled state DOTs to change their organizational structures, empowering employees to unleash their creative potential and arrive at innovative solutions. Creative realignment—shifting the organization’s culture—has required strategic management of the changes required to adapt to new ways of doing things. Which organizational structure better lends itself to efficient program and project delivery? Research has shown that the hierarchical “silos” of the past are gradually being replaced with flatter organizational models that create opportunities for communication and exchange of knowledge across management lines. Regionalization has often resulted in delivery of better quality products and services. Particularly in large states, regionalization offers district offices the flexibility to operate independently or to draw on the support of a larger regional office when required.

Research has discovered state DOTs moving toward greater levels of transparency—accountability—internally and with the public as well. Linked closely with performance measures, transparency also provides opportunities to establish baselines and set targets.

Challenges

The trends discussed in the following paragraphs have come about in response to a myriad of challenges faced by state DOTs:

- “The Perfect Storm”—The demanding and difficult climate within which today’s DOTs must operate, created by aging infrastructure, financial constraints, increased population and congestion demands, and environmental sensitivity.

- Outsourcing vs. In-house—Striking the right balance of DOT personnel and professional consultant services to meet workload demands, accelerate programs in the best way, and save costs.

- Right-of-Way/Utilities/Railroads—The initial planning and scoping of a project has become more important than ever to expedite perhaps the most difficult project phases to accelerate.

- Setting Baselines and Targets—Critical to developing performance measures and asset management protocols to ensure efficient and expeditious use of limited dollars.

- Context-Sensitive Solutions—An integral step, especially in urban areas with major community concerns. However this strategy may not benefit all projects; used in the wrong setting, it could actually prolong the project schedule.

- Policies—Constant review and revision of state and federal DOT and environmental policies is required to ensure timely project delivery without sacrificing quality or environmental stewardship.

Through applying the listed trends and working through challenges, state DOTs have adapted their strategies and operations to become dynamic, flexible structures where communication and sharing of knowledge aids them in meeting their mission.

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Measuring Transportation Network Performance, NCHRP Report 664 by Cambridge Systematics, et al (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_664.pdf) (2010)

Highlights

- The guidebook has identified three key building blocks needed to support network performance analysis.

Partnerships

The scenarios have been organized around three basic types of partnerships: regional, peer-to-peer, and intra-agency. Regional and intra-agency scenarios are less in need of a separate organization or formal partnership. Even the formal partnerships set up as part of the intra-agency scenario are committees that can be created by directive. Where formal partnerships exist, a range of approaches may apply:

- In the multistate scenario, a strong independent organization focused on multistate objectives led the effort. Project specific steering committees also may be needed to draw in other relevant partners.
- In the megaregional scenario, several organizations contributed important roles, including technical support, partnership facilitation, and others. The regional agencies involved already were familiar with one another.

Performance Measurement Framework

A framework for establishing performance measures is a critical component. The framework helps a set of agencies define the transportation network under consideration, the relevant strategies to evaluate, and the measures to help assess network performance.

The development of a framework is likely to be closely tailored to the specific parties involved and the issues of interest at the time. Each of the scenarios outlined developed unique frameworks for network performance, with different strategies and outcomes.

For example, in the multistate scenario, the performance measurement framework provided a means to consider the appropriate mix of public and private investment in various rail infrastructure projects. In the regional scenarios, the framework was built to help MPOs expand their area of concern to address investments and policy changes such as reliability, land use, pricing, and other nontraditional investments. Network performance analysis helps illustrate the impact of various types of investments and policies on overall system performance.

A framework should provide focused and clearly articulated goals, carried through to the selection of performance measures, to elicit support from participants. A well-stated agenda opens doors to collaboration.

Data/Methodology

Data and tools are a central part of considering network performance. A basic question of network performance is whether or not new measures are required. The research generally suggests that the measures are the same or similar to ones that have been used, but in many cases new or improved data or tools are needed to be able to capture the performance of the network. Examples of data and tools include the following:

- For the regional scenarios, a combination of scenario planning and tackling new issues requires sketch models or other tools that can capture the long-range benefits of reliability, pricing strategies, and land use strategies;
- For the multistate scenario, an economic analysis model helped the states compare strategies across state boundaries;
- For the megaregional scenario, significant work was needed to bind together several independent travel demand models used by the individual MPOs that made up the partnership; and
- For the intraregional scenario, data and tools were generally already available, but individual DOT departments were not necessarily aware of what other departments were using.

Integrating data across departments requires understanding the specific needs and data quality requirements, as well as developing methods to access data for multiple purposes.

Conclusions

- Measuring network performance offers benefits that include understanding the implications of programs and improvements, selecting the best option to improve network mobility, and finding efficiencies through partnerships and data sharing.
- One basic question of this project is, “Are there network performance measures?” Network performance measurement is unique not in the process or measures used but in the partnerships and collaboration required. Working across agencies to establish

common goals and developing methods for measuring those goals is inherently challenging. A range of approaches may be appropriate, depending on the specific agencies involved and their relationship to one another (i.e., peer institutions and existing agreements on cooperation). As such, this research project was organized around a common framework and a set of partnership scenarios.

- As regions expand past the traditional MPO boundaries and travel and economies become interdependent through the formation of megaregions, the importance of network-level performance measurement will increase. More agencies will find these tools and processes critical for addressing the transportation challenges they face.
- As agencies continue to engage in network-level performance measurement, the processes and practices will become more standardized and transferable.

This research project began with a question about measuring performance at a network level. Though clear technical challenges are noted throughout the final report and guidebook, it quickly became clear through the research that a deeper understanding of the partnerships necessary to consider network performance was required. Several partnership models are described here, but future research should take these models further; develop an understanding of the institutional, legal, and other challenges; and develop recommendations to help agencies apply these partnerships in the future, especially for the multistate and megaregional partnerships.

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Driver Workload and Visual Studies by K. Fitzpatrick, S.T. Chrysler, E. Park, A.A. Nelson, J.A. Robertson, V. Iragavarapu, Texas Transportation Institute, The Texas A&M University System, College Station, Texas 77843-3135 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; <ftp://ftp.dot.state.tx.us/pub/txdot-info/rti/psr/5911.pdf>) (Feb 2010)

Highlights

- Simulator studies supported previous research in finding that drivers will steer away from an obstacle in their lane rather than engage in a panic stop situation.
- Reaction time at the 85 mph speed was statistically longer than at the 60 mph speed.
- Performance declines when a driver is multi-tasking at higher speeds.

Geometric design guidance has traditionally existed for speeds ranging from 15 to 80 mph. Potential values for geometric elements designed for 85 to 100 mph speeds were developed in a recent research project conducted for the Texas Department of Transportation (TxDOT) and are now in the TxDOT *Roadway Design Manual*. Because of limited previous research, the project relied upon extrapolating from previous research and using engineering judgment to develop the criteria. One area that was identified as needing additional research was driver workload at higher speeds.

It is possible that driver workload could increase with higher speeds, leading to a slowed reaction time to hazards. In other words, at high speeds it may be that the driver is paying so much attention to the basic task of vehicle control that he or she may be slower in responding to hazards. On the other hand, driver vigilance may increase with higher speeds, leading to equal or faster reaction times. In addition to reaction time, the driver

must be able to see an impending object, both in the daytime and in the nighttime.

The type of object that the driver is likely to encounter is typically another vehicle, one which may be traveling at a slower speed. The rate of change of an image in terms of visual angle is very slow at far distances. The ability to perceive an upcoming target in the visual field—e.g., approaching a slow-moving vehicle from behind—depends on a driver's ability to detect that the image size is changing, which does not occur until fairly close distances. Therefore, at high speeds drivers will not have much time to decelerate or maneuver out of the way.

The project objectives were achieved through a series of research tasks. Within those tasks, researchers explored several methods as part of this project to assist in gaining a better understanding of driver performance at high speeds. This project used the following research studies:

- *Closed-Course Pilot Study* consisted of observing and recording the activities and actions of a series of drivers following a lead vehicle going either 60 or 85 mph.
- *Open-Road Pilot Study* recorded participants driving between Odessa and Pecos, Texas, within 70 mph and 80 mph sections.
- *Simulator Pilot Study* determined driver reactions to an upcoming vehicle (both passenger car and large truck) and also

generated directions for how to conduct the Phase II simulator study.

- *Simulator Phase II Study* collected brake reaction to a vehicle in the driver's view for 50 participants. Conditions varied including initial speed, lead-vehicle type, lead-vehicle deceleration rate, and workload level.
- *Following Distance Study* used data from traffic counters to identify speed and axle gap data on freeways with 60, 70, and 80 mph posted speed limits.
- *Gaps at Passing Study* measured gaps during passing maneuvers for daylight conditions on freeway sections.

The simulator studies supported previous research in finding that drivers will steer away from an obstacle in their lane rather than engage in a panic stop situation. When responding to a vehicle slowing in their lane, the reaction time of drivers in the simulator study at the 85 mph speed was statistically longer than drivers at the 60 mph speed. Drivers took more time at the higher speed to respond to a lead vehicle slowing in their lane. The traffic counter data showed that axle clearance distance was larger for the 80 mph freeway sites as compared to the 60 and 70 mph speed limit sites, both statistically and practically.

The passing gap study found a different result. Drivers used similar passing-gap distances on both 70 mph and 80 mph sections. Drivers passed more closely to the larger

vehicle (recreational vehicle) than the smaller vehicle (sedan). Passing gap increases by 10 ft for each mph increase in speed difference between the lead vehicle and the following vehicle. The faster a driver approaches a vehicle, the greater the passing-gap distance.

In the simulator and test-track studies that directly measured driver performance, evidence is present that performance declines when a driver is multi-tasking at higher speeds. For tasks such as mental arithmetic in the simulator and detecting a peripheral light while changing a CD on the test track, reaction time to lead-vehicle deceleration was longer at the higher speeds. Researchers interpreted this to mean that driving at the higher speed was more challenging. The simulator study, in particular, showed that driving 85 mph required more mental effort than driving 60 mph, leaving less mental capacity free to do the arithmetic problems.

These laboratory and controlled test-track tasks are likely relatively easy compared to the type of multi-tasking drivers may do on actual roads. For safety reasons, this project was not able to overload drivers on the open road and test track by giving them tasks such as cell phone conversations, navigation system interactions, etc. For this reason, the results of these driver performance studies should be taken to be at the low end of a scale of driver distraction. Driving performance may decline even further in situations where drivers are engaging in other physically or mentally distracting tasks.

TRANSPORTATION RESEARCH DIGEST

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Roadway Related Tort Liability and Risk Management by Kenneth Agent, Kentucky Transportation Center, College of Engineering, 176 Raymond Building, University of Kentucky, Lexington, Kentucky 40506-0281; ph. 859.257.4513 (Kentucky Transportation Cabinet, State Office Building, Frankfort, Kentucky 40622; http://www.ktc.uky.edu/Reports/KTC_10_07_SPR_399_10_1F.pdf) (Jun 2010)

Highlights

- A history of claims paid and a list of recommendations for controlling risk are presented.

Conclusions

- The number of claims has not increased over the past several years.
- The dollar amount claimed has not increased over the past several years. The average annual amount of claims is about \$4.3 million. The average annual amount paid (for decided claims) has been about \$575,000. Adding an amount representing an expected payment for unresolved claims would increase this amount to slightly over \$600,000.
- The increase in the allowed claim amount has not resulted in an increase in the average claim amount with the largest average claim amount in 1995.
- The percentage of the claim amount paid is low (about 15 percent).
- 58% of the claims were under \$500.
- While only about 7% of the claims were for \$50,000 or more these 1,035 claims represent about 86% of the total amount claimed.
- Almost one-half of the claims have some payment with the percent paid decreasing dramatically as the amount of the claim increases (from 48% for

claims under \$500 to 12% for claims of \$50,000 or more).

- The increase in the allowed claim amount has not resulted in an increase in the number of large dollar amount claims.
- Considering the larger claim amount (\$50,000 or more), the most common reason relates to an alleged problem relating to traffic signs (about 14% of all reasons with an average claim amount of over slightly over \$100,000).
- The reason for the claim with the largest amount paid was inadequate drainage followed by inadequate or improper signs or markings, crash involving a Cabinet vehicle, shoulder dropoff, and lack of guardrail.

Recommendations

- Provide training related to risk management
- Develop and maintain a detailed database of claims including the reason for each claim and the results
- Provide each highway district with an annual summary and analysis of claims filed in their district
- Develop and maintain a traffic sign inventory
- Identify and investigate high crash locations and document results from all investigations Use road safety audits as a method to evaluate safety features of a

- roadway section Continue to implement a guardrail installation priority program
- Continue to implement the work zone safety and mobility policy
 - Document complaints and their resolution
 - Provide training for personnel involved in installing signs and pavement markings Ensure that the resurfacing program results in proper roadway cross-section and does not result in a shoulder drop-off
 - Review fatal crashes where a roadway feature is listed as a contributing factor Delineate objects such as culvert headwalls in the clear zone
 - Document maintenance activities
 - Review terminology used in agency documents
 - Review standards and policies
 - Document design exceptions
- Document decisions made in the design, construction, and maintenance processes Remove non-crashworthy objects and traffic signs placed by businesses or individuals on state right-of-way
 - Use a consistent policy for the placement of signing at the intersection of state and local roads
 - Establish a sign maintenance program to comply with reflectivity requirements Maintain a roadway inventory system
 - Maintain relationships with police agencies to ensure proper coding of roadway-related contributing factors and notification when the police officer believes the Cabinet should investigate the factors contributing to a crash
 - Continue to investigate all crashes involving a Cabinet vehicle

TRANSPORTATION RESEARCH DIGEST

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From Buses to BRT: Case Studies of Incremental BRT Projects in North America by John Niles & Lisa Callaghan Jerram (Mineta Transportation Institute, College of Business, San José State University, San Jose, CA 95192-0219; 408-924-7560; <http://www.transweb.sjsu.edu/project/2704.html>) (Jun 2010)

Highlights

- BRT enables the allocation of funding to projects that achieve the greatest benefit at the lowest cost.

Bus Rapid Transit (BRT), as illustrated in implementations around North America, comes in many shapes and sizes. The term has been applied to rubber-tire transit lines that use many different combinations of techniques to improve bus service, such as bus-only lanes and roads, pre-boarding fare collection, transit priority at traffic signals, stylish vehicles with extra doors, bus stops that are more like light rail stations, and high frequency service.

This study examines five approaches to BRT systems as implemented by public transit agencies in California, Oregon, and Ontario. The resulting lines and network of lines vary widely, ranging from small changes in a local bus route, to a completely new line in a new mode. On one end of the spectrum, the San José area has frequent arterial bus services with traffic signal priority. On the other end, there is the case of a transit-only, grade-separated busway in Los Angeles County with full-featured stations and special buses that look like no others in the agency. The authors also describe three variations more in the middle of the range of BRT possibility.

The case studies as a group show that BRT, as applied in North America, is a discretionary combination of elements that can be assembled in many different combinations over time. Transit agencies have wide latitude

to determine which combination of elements best serves their needs, given their specific circumstances. Every element incrementally adds to the quality or attractiveness of the service.

This latitude provides transit agencies with many benefits, including the ability to match physical infrastructure with operating requirements. For example, a BRT service can combine operations serving free flowing arterial roads in the fringes of the downtown with dedicated lanes in areas closer to city center where congestion is greatest. Moreover, unlike rail transit, bus transit vehicles can operate both on and off the guide way, extending the corridors in which passengers are offered a one-seat ride with no transfer required. Transit agencies also can select specific BRT components and strategies, such as traffic signal priority and increased stop spacing, and apply them to existing local bus operations as a way to increase bus speeds and reduce operating costs. Indeed, this strategy was used by one of the case study locations—the Los Angeles Metro Rapid system.

This latitude also creates challenges. For example, as shown by the case studies overall, a wide range of systems are labeled as BRT in North America, creating confusion among policymakers and the public regarding the definition of BRT. By contrast, in other parts of the world, such as Latin America and Asia, the term BRT is more frequently understood to be a rail-like rapid transit system with fully dedicated lanes and trunk and feeder

operations. Thus, a basic bisection of BRT implementations into heavy and light is useful, depending on the degree of exclusivity of the guide way. Heavy BRT means the buses are mostly running on lanes separated from other traffic, and light BRT means the buses are mostly operating in mixed traffic.

The wide range of options creates planning challenges. When does the expense and construction time of a dedicated lane or guide way pay off in higher performance and, if so, over what portions of the route should such infrastructure be implemented? If a dedicated guide way is used, will it be used by special buses as a trunk line with stations reached by other modes, or will the guide way be an HOV lane open to other vehicles that can operate off-guide way, including local buses, van pools, taxis, and car pools? Can the overall travel time benefits of a dedicated lane be achieved at substantially lower cost by other means, such as increased station spacing and traffic signal priority, especially if these are applied widely across a bus system, rather than in just a single corridor?

Across the various BRT elements falling into the categories of guideway, stations, vehicles, technology, and operations pattern, the specific elements selected for a BRT route can be implemented all at once, or in incremental stages. Increments can be either or both geographical extensions or additions of features.

This flexibility has substantial policy implications in the expanded choices for transit investment that are available. The transportation sector accounts for nearly one-third of carbon dioxide emissions in the United States. Achieving President Obama's goal of an 80 percent reduction in emissions by 2050 will require fundamental changes in transportation planning and delivery, including ensuring that

many more urban travelers have viable public transit options.

Bus performance improvement offers quick results at a reasonable public cost. For example, as shown by the case studies, the 26 bus lines of the Los Angeles Metro Rapid network were implemented far more quickly and for billions of dollars less than the four L.A. rail lines, yet these enhanced buses are serving 78 percent as many passenger trips as the entire rail system. All of the Metro Rapid lines even cost less to put in place than the single Orange Line BRT line in the same city, and yet the Metro Rapid is providing over three times the gain in daily boardings. These examples suggest that incremental improvements, applied widely to regional bus networks, may be able to achieve significant benefits at a lower cost than substantial infrastructure investments focused upon just one or a few corridors.

As reflected in federal law, the Federal Transit Administration's capital grants program—New Starts—requires corridor-level development, as opposed to system-wide improvements. There is no provision for a jurisdiction to consider, as part of the alternatives analysis process, whether the level of funding for a major corridor-level project could achieve even greater benefits if applied to more modest system-wide improvements.

The case studies in this report show that BRT is not a one-size-fits-all solution, but rather a wide range of strategies that can be deployed in specific corridors or across entire bus systems. The availability of BRT elements in many incremental combinations suggests that an expanded policy framework is warranted: one that enables objective comparison across these options and the allocation of funding to projects that achieve the greatest benefit at the lowest cost.

TRANSPORTATION RESEARCH DIGEST

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Fully Adaptive Detection-Control System for Isolated Intersections by S.R. Sunkari, P. Songchitruksa, H.A. Charara, X. Zeng, Texas Transportation Institute, The Texas A&M University System, College Station, Texas 77843-3135 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; <ftp://ftp.dot.state.tx.us/pub/txdot-info/rti/psr/6029.pdf>) (Feb 2010)

Highlights

- The variable initial module developed in this project determines the appropriate minimum green when stop-bar detectors are not available.
- The module can improve intersection efficiency in real time.

Engineers from the Texas Department of Transportation (TxDOT) use all available strategies to improve operations at signalized intersections. Over the past few years numerous systems like D-CS (Detection-Control System), AWECS (Advance Warning of End of Green System), and PIA (Platoon Identification Accommodation) were developed to improve safety at high-speed intersections. These systems required a pair of advance detectors in each lane. They also required stop bar detectors on all approaches including the major street approaches to improve intersection efficiency. With increases in the cost of installing and maintaining detectors, there is a need to develop strategies that would require fewer detectors and operate satisfactorily even when detectors fail. This project's objective was to develop three modules to improve efficiency not only at traffic signals with D-CS type systems but also at typical fully actuated signalized intersections.

Researchers developed the following three modules to improve the efficiency of fully actuated signalized intersections.

Module 1: Adaptive Variable Initial Module: This module functions similarly to the variable initial feature in traffic signal controllers. Variable initialization is used when an intersection approach has only setback detectors and no stop bar detectors. This module removes the need for stop bar detectors for systems like D-CS and for intersections with dilemma zone detectors. This module is also useful when stop bar detectors fail. The module determines the minimum initial time required to clear the vehicles detected during the non-green portion of the phase. The minimum initial value is then implemented using the phase-hold function.

Module 2: Detector Failure Module: This module monitors the phase utilizations of all phases and builds and maintains a database of phase utilizations for four weeks. This database determines the appropriate phase to be allocated to a particular phase in case of a detector failure. The module monitors the phase utilizations continuously to respond to detector failures. Once a detector failure is identified, the module recommends the appropriate phase time for each phase and implements the phase time using ring force-off function.

Module 3: Variable Delay Module: This module monitors the activity of the left-turn and right-turn detectors for implementing detector delay. Based on the traffic patterns on these detectors and the phase utilizations of the major movements, the module determines the delay to be applied to the detectors. Delay

typically minimizes the unnecessary terminations of the major movements. Use of variable delay can further improve the efficiency of using a static detector delay.

The researchers collected data from two sites in Texas where AWECS was implemented. The number of actuations on the setback detectors for an approach, as well as the time taken to clear the queue for the same approach, is logged in the AWECS data files. These data were used to develop and calibrate the models for the adaptive variable initial module. The database of phase utilization for all phases enabled prediction of the phase durations. Phase utilizations of the major street movements assisted in developing the variable delay models.

Researchers from the Texas Transportation Institute (TTI) implemented the modules at: US 84 and Aviation Parkway in Waco (Module 1, Module 2, and Module 3), SH 21 and Business SH 6 in Bryan (Module 2), and SH 105 and FM 3083 in Conroe (Module 1 and Module 2).

TTI researchers developed models to predict the maximum initial value based on the number of lanes on the approach. Models were developed for single-lane and two-lane approaches. The variable initial model was verified and calibrated in Waco and implemented at the site in Conroe, which has 3 lanes in each direction. The variable initial module in Conroe showed a very strong

correlation to the actual time required to clear a queue as obtained by observing the occupancy of stop bar detectors.

Researchers implemented a model for Module 2 using the rolling average of the phase utilization for the previous four weeks. Input from the project monitoring committee resulted in a more sophisticated prediction model that considered the variances in the average of the phase utilizations. The accuracy of these models depended on the level of activity at the intersections.

Researchers also developed a preliminary module for variable delay and implemented it in Waco. However, this variable delay module was applicable under rare conditions and its benefits were minor, halting its development.

The variable initial module developed in this project determines the appropriate maximum initial value (minimum green) when stop-bar detectors are not available. The module can improve intersection efficiency in real time by considering many factors including the utilization of the left-turn phase. The detector failure module is applicable during detector failures at an intersection. Using this module can significantly improve intersection efficiency until the detector failure is rectified. Both these modules require data that are currently available in signal controllers, making their incorporation into the signal controller firmware very feasible.

TRANSPORTATION RESEARCH DIGEST

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Guidelines for the Use of Pavement Marking Symbols at Freeway Interchanges by B.R. Ullman, S.T. Chrysler, M.D. Finley, N.D. Trout, Texas Transportation Institute, The Texas A&M University System, College Station, Texas 77843-3135 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; <ftp://ftp.dot.state.tx.us/pub/txdot-info/rti/psr/5890.pdf>) (Feb 2010)

Highlights

- There is a benefit to the use of pavement marking symbols at freeway interchanges.
- These benefits translate to both freeway operations and motorist understanding.

Pavement marking technology has advanced to allow the use of large multi-color symbols placed on pavement as a means of providing drivers with another source of information from which they can make good driving decisions. This project focused on the use of such in-lane pavement markings to provide the driver with lane guidance and warning information near freeway interchanges. More specifically, researchers evaluated the design and application issues that are associated with the use of pavement marking symbols.

Researchers approached this project using several different types of evaluations to accomplish their objectives. The first approach was establishing the current state-of-the-practice with regard to the use of pavement marking symbols in Texas. The second approach for this project was conducting two sequential human factors laboratory studies that addressed public comprehension, recognition, and preference with regard to such symbols. Lastly, two different field studies were conducted. The first was a closed-course evaluation of the markings' visibility and the other was a real-world application of markings to identify operational effects.

Based on the information gained through this project, researchers have developed basic recommendations for what information should be placed as in-lane pavement markings near an interchange. The following items list some of the key recommendations identified during this project.

- Shields should be used as opposed to text for highway identification. (See Figure 1.)
- The greatest benefit to motorists is gained through the use of both arrows and shields in the interchange area.
- Simple single-lane exits (particularly traditional right exits) need pavement marking symbols to be placed only in the exit lane.
- If in-lane pavement markings are used at complex interchanges (e.g., optional lanes, multi-lane exits, etc.), they should be applied to all lanes.
- Optional lane symbol pavement markings should provide the same basic information as other lanes at that interchange (i.e., show both highway shields and an optional arrow).
- Order of information in the optional lane should be:
 - arrows preceding the highway route shields,
 - primary (through traffic) highway shield, then
 - exiting route shield last.

- The length of pavement marking symbols recommended for standard freeway interchanges are:
 - shields 15 ft, and
 - arrows 12 ft.
- Markings should be placed after the motorist has passed at least one overhead guide sign for the interchange.
- The pavement marking symbols should be placed far enough upstream of the decision point to allow a motorist to safely change lanes based on the information provided.

Based on the results of this project, researchers believe that there is a benefit to the

use of pavement marking symbols at freeway interchanges. These benefits translate to both freeway operations and motorist understanding. Based on this belief, researchers have developed guidelines for the use of pavement marking symbols in this area.

These guidelines should be considered prior to the application of such markings to ensure that motorists are receiving the best possible benefit from this information. Not only do these guidelines provide basic information concerning the appropriate application of pavement marking symbols at an interchange, but they also include examples in many cases to help illustrate the point.



Figure 1. Example of In-Lane Pavement Marking Shields

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Separation of Vehicles—CMV-Only Lanes, NCHRP Report 649 by Cambridge Systematics, Inc. (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_649.pdf) (2010)

Highlights

- There is substantial recent interest in applications of truck-only lanes.

This study conducted a detailed review of the experience and analysis of truck-only lanes in the United States and internationally. The objectives of the study included the following:

- Develop a compendium of information about the technical and institutional issues associated with applications of truck-only lanes so that practitioners can make better informed judgments and evaluations of potential costs and benefits of truck-only lanes. This compendium was prepared, to a large extent, in the interim report for this study. Key issues and findings of this compendium are summarized in the next section of this chapter, and the entire contents of the compendium are presented in Appendix A of the report.
 - Conduct a performance evaluation of different truck-only lane configurations and applications to assess the potential benefits and performance issues that arise. This performance evaluation was intended to illustrate the key performance metrics and methodologies for conducting the performance evaluation of truck-only lanes and to suggest the configurations and applications in which truck-only lanes are most likely to provide the greatest benefits. In addition, an objective of the study was to evaluate how potential costs of truck-only lanes relate to the benefits, and how these compare against the benefits and costs of other types of highway system investments (such as adding mixed-flow capacity). Chapters 3 and 4 of this report presented the results of the performance evaluations and B-C analyses of truck-only lanes. Since this project did not have the resources to conduct new research, the performance evaluations conducted in Chapter 3 relied on published data primarily from feasibility studies and very limited field observations. Data gathered from these sources also served as key inputs in the B-C analyses of truck-only lanes.
 - Suggest areas of future research to improve understanding of the performance of truck-only lanes in various applications. Clearly, the lack of actual field data from which to draw conclusions is a major obstacle to completing the types of evaluations that would be desirable, and the final section of this chapter provides some ideas on how this issue might be addressed. In addition, this chapter suggests some ideas for future research programs and analyses that go beyond what was feasible in this project.
- This study determined that there is substantial recent interest in applications of

truck-only lanes in the following types of applications:

- Long-haul intercity corridors,
- Major urban corridors with high volumes of truck traffic, and
- Major corridors providing access to ports and intermodal terminals.

As noted several times in this report, there are no actual examples of truck-only lanes in the applications that were identified in the literature review. The closest examples to any of these applications identified are in Rotterdam, Netherlands, where nonseparated and barrier-separated lanes for trucks have been implemented along the A-16 (5.5 km/3.4 mi) and A-20 (2.4 km/1.5 mi) motorways, respectively. These lanes can be considered to be representative of truck-only lane applications along key segments of major urban goods movement corridors. Efforts to obtain any performance data from this roadway were unsuccessful. There are some other limited examples of truck/auto separations providing data to assess the benefits of separating trucks and autos, and these were used to support the analysis in this study. These primarily include truck bypass lanes around interchanges and the

dual-dual roadway sections of the New Jersey Turnpike that include auto-only and mixed-flow lanes. There have also been some experiments with truck lane restrictions, such as those conducted by the North Central Texas Council of Governments (NCTCOG) in a study conducted from 2005 to 2006 that collected data on safety and travel time differences in lanes that were restricted to autos only, as compared to right-hand lanes in which trucks were restricted to travel. These experiments also provide information on approaches that might be used to collect data on operational performance of truck-only lanes in the future. Nonetheless, there continue to be some significant gaps in the data and analyses that have been conducted to date.

These gaps limited the study team's ability to reach definitive conclusions on many aspects of truck-only lane performance and cost-effectiveness. This chapter will draw together the results of the analyses from the previous chapters to establish some general conclusions about truck-only lanes and to suggest particular areas of research that show reasonable prospects for providing answers to critical outstanding questions.