TRANSPORTATION RESEARCH DIGEST

August 2010

ARIZONA TRANSPORTATION INSTITUTE

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AUGUST 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.

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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.

Code	Topic	Code	Topic
ADM	Administration	PLAN	Planning
AIRP	Airports	PRIV	Privatization
AVIA	Aviation	RAIL	Railroads
BIKE	Bicycles	RDSD	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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Characterization of In-Use Emissions from TxDOT's Non-Road Equipment Fleet by J. Zietsman, D. Lee, M. Farzaneh, J.D. Johnson, 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/5955.pdf) (Jan 2010)

Highlights

- Researchers identified three emissions reduction technologies as promising candidates for reducing emissions in non-road equipment: hydrogen enrichment (HE), fuel additives (FA), and selective catalytic reduction (SCR).

The Texas Department of Transportation (TxDOT) operates the largest fleet of non-road equipment in Texas and one of the largest in the United States. TxDOT's non-road fleet consists of construction equipment such as cranes, excavators, loaders, etc., a vast majority of which run on diesel engines. The emissions impact from these units is considerable, but the emissions characteristics are not well understood. Emissions from the equipment—particularly oxides of nitrogen (NOx)—are an issue of concern, especially in non-attainment areas in Texas. The overall goal of this project was to characterize emissions from TxDOT's non-road diesel equipment fleet, assess the effectiveness of using various emissions reduction technologies, and propose appropriate strategies for TxDOT's non-road fleet based on the research findings.

Researchers performed an extensive literature review and investigation to obtain information on emissions reduction technologies, non-road emissions reduction case studies, and non-road emissions resources. Based on results of these activities, researchers identified three emissions reduction technologies as promising candidates for reducing emissions in non-road equipment: hydrogen enrichment (HE), fuel additives (FA), and selective catalytic reduction (SCR).

Researchers analyzed the characteristics of TxDOT's non-road equipment fleet and identified three categories of equipment that contributed the most NOx emissions—graders, rubber-tire loaders, and excavators. The research team developed a protocol for testing non-road equipment emissions using portable emissions measurement systems (PEMS), including duty cycles that replicated the various operational modes of the equipment.

Tests on six graders assessed emissions characteristics before and after installation of the FA and HE technologies. The emissions testing used Texas Transportation Institute's (TTI's) SEMTECH-DS and Axion test units to collect results for NOx, carbon monoxide (CO), particulate matter (PM), hydrocarbons, and carbon dioxide (CO2).

An additional project task involved development of an optimization methodology to identify the best strategies for deployment of emissions reduction technologies on a fixed budget. This approach takes into account information regarding the available budget and the costs and emissions reduction observed for different technologies. The results of the methodology enable a deployment strategy that maximizes benefits in nonattainment and near non-attainment areas, where emissions reduction is of major importance.

Researchers analyzed test results using both average modal emissions rate and fuel-based approaches to compare emissions of the tested graders before and after application of the emissions reduction technologies. Overall, there was a high variability in the measured emissions among the graders and between operational modes. Analysis of the test results showed that neither FA nor HE applications had a significant impact on NOx emissions or CO emissions. Both technologies provided moderate reduction in hydrocarbon and PM emissions. The levels of NOx emissions observed during the in-use testing using PEMS were lower than emissions calculated based on U.S. Environmental Protection Agency (EPA) guidance.

The optimization methodology was applied to demonstrate possible deployment strategies to distribute emissions control equipment among TxDOT's non-road fleet for various budget levels. This exercise demonstrated the flexibility and application of the optimization approach to maximize benefits from emissions reduction technologies.

Due to the variability in the data and relatively few equipment units tested, results should be considered as indicative of the direction of changes achieved in emissions levels, not as conclusive evidence of the effectiveness of either FA or HE technologies.

Since NOx reductions were the primary focus of this study, researchers do not recommend that TxDOT deploy either FA or HE to reduce emissions of the non-road equipment fleet. However, SCR remains a promising option for NOx emissions reductions. While this project did not test with SCR, it is the subject of a separate, ongoing project with TTI and TxDOT under an EPA grant. The optimization methodology developed as a part of this project has future applicability if TxDOT finds suitable technologies (such as SCR) for deployment in the non-road fleet.

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AUGUST 2010

Federal Highway Program Shortchanges Half of the States by Ronald Utt. (Heritage Foundation, 214 Massachusetts Ave NE, Washington DC 20002-4999; phone 202.546.4400; http://www.heritage.org/Contact-Heritage) (April 15, 2010)

Highlights

- There are serious imbalances in how federal highway funds are distributed.

Among the many contentious issues that will confront Congress in the months leading up to reauthorization of the federal highway program (now postponed until December 2010) is the program's inequities relating to the distribution of federal trust fund revenues to the states. Under current law, the federal fuel taxes paid into the trust fund by motorists and truckers are returned to the states by a series of mathematical formulae.

These formulae, however, embody serious flaws that cause many states (called donors) to consistently receive shares that are less than they pay in while others (called donees) consistently receive more. This deficiency exacerbates regional transportation problems because the shortchanged states are typically those with above-average population growth and transportation needs.

Over the past several decades, states that are shortchanged by the program have been concentrated in the Southeast, the Great Lakes region, and California and Arizona. States receiving more than their fair share have been concentrated in the Northeast and Middle Atlantic regions and the sparsely populated Mountain states.

Column 2 of Table 1 provides state-by-state details on winners and losers in 2008 (the latest data available), and column 3 provides state-by-state details for the years since the program's inception in 1956. States with a share ratio less than 1.0 are donors and are receiving a smaller share compared to what they pay in. Those whose share ratio exceeds 1.0 are getting back more than their fair share. As column 3 reveals, many of the losing states in 2008 have been consistent losers since 1956.

One reason that these equity problems persist is that the United States Department of Transportation does not accurately calculate and report state-by-state equity shares and instead measures each state's share by comparing the sum of dollars paid in to the sum of dollars paid out. Because the trust fund in recent years has paid out more than it receives in taxes, this way of measuring performance indicates that all states earn an above-average return on their payments—which, of course, is a mathematical impossibility. This flaw was corrected by the Bush Administration, and accurate numbers were reported for 2007, but the new Obama team has reverted to the incorrect equity calculations.

The current laws governing the federal highway and transit programs expired in September 2009 but have been extended to December 2010 to allow for more time to develop new legislation. While the Obama Administration has yet to release its reauthorization proposal, much of its transportation focus has been on bicycles and passenger rail, and no mention of equity issues has appeared.

State Gains and Losses from Federal Transportation Trust Fund: 2008

	Return Ratio, 2008	Return Ratio, 1956–2008
Alabama	0.965	0.997
Alaska	3.672	5.470
Arizona	0.896	0.935
Arkansas	1.078	0.952
California	0.972	0.891
Colorado	0.929	1.025
Connecticut	1.337	1.486
Delaware	1.570	1.464
District of Columbia	4.907	3.780
Florida	0.789	0.861
Georgia	0.960	0.845
Hawaii	1.609	2.687
Idaho	1.352	1.460
Illinois	0.976	0.959
Indiana	0.912	0.814
Iowa	0.925	0.988
Kansas	0.972	0.992
Kentucky	0.959	0.931
Louisiana	1.053	1.096
Maine	1.006	0.996
Maryland	0.879	1.109
Massachusetts	0.898	1.260
Michigan	0.919	0.840
Minnesota	1.388	1.070
Mississippi	0.951	1.016
Missouri	0.996	0.885
Montana	2.222	2.143
Nebraska	0.995	0.990
Nevada	1.035	1.125
New Hampshire	0.993	1.152
New Jersey	0.909	0.888
New Mexico	1.038	1.130
New York	1.097	1.126
North Carolina	0.884	0.824
North Dakota	1.932	1.902
Ohio	0.918	0.852
Oklahoma	1.038	0.855
Oregon	1.044	1.049
Pennsylvania	1.123	1.079
Rhode Island	2.296	2.104
South Carolina	0.905	0.833
South Dakota	1.904	1.910
Tennessee	0.931	0.882
Texas	0.810	0.801
Utah	0.853	1.162
Vermont	2.359	1.963
Virginia	0.894	0.965
Washington	1.046	1.180
West Virginia	1.791	1.743
Wisconsin	1.027	0.911
Wyoming	1.325	1.528

Source: Author's calculations based on data from the U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 2008, Table FE-221, at *http://www.fhwa.dot.gov/policyinformation/statistics/2008/index.cfm* (April 13, 2010).

Table 1 • WM 2863 heritage.org

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Restoring Trust In the Highway Trust Fund by Robert Poole and Adrian Moore (Reason Foundation, 3415 S. Sepulveda Blvd., Suite 400, Los Angeles, CA 90034; ph. 310/391-2245; http://reason.org/files/restoring_highway_trust_fund.pdf) (Aug 2010)

Recommendations
- Shift non-highway programs either to general revenues or to the states.
- Narrow the federal Highway Trust Fund's focus to rebuilding and modernizing the Interstate system, both urban and inter-city.

Federal surface transportation policy is at a fateful crossroads. Since the completion of the Interstate system, the federal program has lost its focus and its sense of purpose. And the userspay/users-benefit funding mechanism which built that system (dedicated fuel taxes) has gradually been transformed into a public works tax for Congress to spend on its own—rather than highway users'—priorities.

Most proposals to reformulate the federal transportation program would further break faith with highway customers. While appearing to advocate simplification and program consolidation, they would add costly new non-highway programs, increasing highway use taxes but diverting much of the proceeds to still more non-highway programs. Yet it is thanks to these very trends that American taxpayers no longer have trust in the Highway Trust Fund. Instead of welcoming an expanded federal program, most oppose increases in fuel taxes as unlikely to improve their own transportation situations.

The federal transportation program is notoriously politicized, failing to make the best use of existing funds and failing to focus on the most important national transportation goals. Every serious study in recent years has concluded that America is under-investing in highway infrastructure. But rather than simply putting larger sums of money into a seriously flawed process, the better course is to rethink and refocus the federal role, in order to spend more on core federal purposes and less on peripheral concerns. Some reauthorizations have brought big changes to the federal transportation program. This one should as well, not by moving further away from a user-fee funded system designed to improve mobility, but by moving back toward it.

While the federal government may have an interest in a wide range of transportation issues and concerns, direct federal involvement is both unwise and inappropriate. The facilitation of inter-state travel and commerce and international trade are clearly federal responsibilities, so a larger emphasis on inter-state and international transportation should be at the core of a rethought federal role. The Interstate highway system was laid out more than 60 years ago, and begun 50 years ago. Increasing portions of it are reaching the end of their design life and need complete reconstruction. Most urban Interstates need major additions to eliminate bottlenecks and reduce congestion, and many inter-city Interstates need more lanes to handle projected growth in truck traffic.

A major federal effort to rebuild and modernize the Interstate system for the 21st century (Interstate 2.0) would give new focus to the federal highway program. It offers the opportunity to restore the original user-fee nature of highway user taxes. Ever since the ISTEA legislation of 1991, each federal reauthorization has expanded the eligible uses of federal highway user taxes to an ever-larger array of non-highway programs. Indeed, this diversion ultimately goes back to the 1970 PL 91-605, which first permitted Highway Trust Fund monies to be used for transit facilities, undercutting the users-pay/users-benefit principle. Subsequent reauthorizations steadily increased non-highway uses, such that today urban transit, bikeways, scenic trails, "enhancements," and numerous other programs consume about one-quarter of all current federal highway user tax revenues.

Congress could dramatically increase funding to reduce the very large backlog of cost-effective highway projects via two changes: (1) shifting non-highway programs either to general revenues or to the states, and (2) narrowing the federal Highway Trust Fund's focus to rebuilding and modernizing the Interstate system, both urban and inter-city.

This Interstate 2.0 approach would increase federal investment in the nation's most important arteries by nearly $10 billion per year. Refocusing the federal gas tax on rebuilding and modernizing these vital roadways would restore the kind of trust in the Highway Trust Fund that was present during its early years. Making this change is also probably the best hope for gaining political support, not for all-purpose transportation tax increases, but for significantly improving the performance of the nation's most critically important highway infrastructure.

This proposal should be attractive to the traditional highway community, which in recent decades has accepted diversions of highway-user taxes to non-highway purposes in exchange for a larger total program. That trade-off appears to be coming to an end, thanks to strong public opposition to increasing the gas tax.

Friends of mass transit should understand that in today's political climate, it is not necessary to tap into the gradually shrinking pool of petroleum-based highway taxes in order to have high-quality transit systems. State and local jurisdictions, where the benefits from transit occur, have been more willing to invest in transit in recent years. There isn't sufficient national interest or benefit from local transit systems for the federal government to help fund them.

Most states would be better off with the proposal presented in this paper. All would benefit from the major reconstruction and modernization of their most important highways, the Interstates. They would gain new freedom to manage their non-Interstate highways, freed from costly federal requirements and priorities, and instead could focus on their own transportation needs and goals. On the funding side, although they would no longer receive federal funding for non-Interstates, they would gain new freedom to use tolling and public-private partnerships to shore up their programs. If they decided to replace some former federal revenue, states could find savings by aggressive efforts to improve efficiency, prioritizing projects that will produce the largest benefits, and embracing tolling to pay for new roads and improvements to existing ones, preferably via public-private partnerships that shift financing and risk away from taxpayers and onto the private sector.

The urgent need to rebuild and modernize vital Interstate highway infrastructure is bogged down by a system that prioritizes politics and ribbon-cutting. The federal gas tax has become a general-purpose public works tax instead of a true highway user fee. Refocusing the federal program on Interstate 2.0, and restoring the true user fee nature of the federal fuel tax.

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AUGUST 2010

Analysis of Seasonal Strain Measurements in Asphalt Materials under Accelerated Pavement Testing and Comparing Field Performance and Laboratory Measured Binder Tension Properties by Mostafa A. Elseifi (Louisiana Transportation Research Center, 4101 Gourrier Avenue, Baton Rouge, LA 70808; http://www.ltrc.lsu.edu/pdf/2010/fr_444.pdf) (June 2009)

Highlights
- Analysis conducted in this study established the relationship between the binder deformation properties at intermediate and low temperature and mix performance.

Instrument responses in past accelerated loading facility (ALF) experiments were analyzed to quantify the variation of pavement responses with temperature and its relationship to pavement performance. Measurements were also used to determine the effectiveness of stress and strain measurements in past experiments and the use of sensor technology to monitor pavement damage.

Analysis conducted in this study established the relationship between the binder deformation properties at intermediate and low temperature and mix performance. Nine straight binders obtained from two major asphalt suppliers were tested using the ductility test, the direct tensile test, and the multiple stress creep recovery test. All selected binders were classified as PG 64-22 according to the Superpave binder specification system. To assess the results of these tests, selected asphalt binders were evaluated using high pressure gel permeation chromatography, differential scanning calorimetry, and dynamic mechanical analysis. In addition, three binders with contrasting levels of ductility were used to prepare asphalt mixes, which were evaluated using the Indirect Tensile Strength (ITS) test.

Based on the results of this analysis, the following conclusions may be drawn:

- Repeatability of stress and strain measurements was acceptable in most cases.
- Survivability of the gages was deemed acceptable. However, installed pressure cells in the granular layers appeared to tilt during construction or after the loading started. With the increase in the number of passes, signals became noisier, but the peak response could still easily be extracted.
- Pavement responses were strongly influenced by the temperature during testing. An exponential model provided acceptable description of this variation.
- Strain gages were not a reliable indicator of damage development in hot-mix asphalt (HMA).
- Measured vertical stress remained fairly constant with the increase in the number of passes. This observation indicates that the stress applied on the material mainly depends on the magnitude of the external load and not on the level of damage in the material.
- Based on the analysis conducted in this study, a number of modifications to past instrumentation strategies are recommended and were discussed in the analysis section.

Based on the results of laboratory testing conducted in this study, it can be concluded that the measurement of binder ductility is beneficial to the state and correlates well with mix performance at intermediate temperature. This test may not be substituted with the direct tensile test or the multiple stress creep recovery test. In addition, the following conclusions may be drawn:

- An inverse correlation was found between binder ductility at 25°C and the measured failure strain at -12°C. In other words, a binder that provides high ductility at intermediate temperature would be characterized by poor elongation properties at low temperature. This behavior was linked to the binder chemical compositions, which revealed the following:
    - An increase in the binder content of low molecular weight (LMW) results in an increase in its ductility at intermediate temperature.
    - An increase in the binder content of crystallizable LMW results in crystallization of these molecular fractions at low temperature. Due to their crystalline nature, these components are characterized by brittle and stiff physical behavior at low temperatures. In addition, an increase in maltene content results in some of the light components to crystallize at higher temperature as it approaches the glassy region.
- All tested binders lost part of their low molecular weight content during aging resulting in an increase in the asphaltene content in the aged binder. Binders with the same crude oil source lost about 2% of their low molecular weight components in the aging process.
- Performance of the binder can be strongly linked to its chemical constituents. A positive correlation exists between the percentage of LMW in the binder and its rutting resistance as predicted by the criterion of $G^*/\sin\delta$ for the original binder. In contrast, the increase in LMW results in an increase in the binder stiffness at low temperatures.
- Current Superpave specifications failed to differentiate between these binders in terms of performance since they may all be used as PG 64-22 binders and are expected to exhibit similar pavement performance. Since past research has widely established the relationship between asphalt ductility and pavement performance, it would be expected that these binders would not exhibit the same performance in the field.
- There was a positive correlation between the binder ductility and the measured tensile strength of the mixture as well as its strain at failure. Using a binder with a high ductility resulted in a mixture with greater indirect tensile strength and a stronger ability to resist cracking at intermediate temperatures.
- An inverse correlation was found between binder ductility and percentage recovery in the multiple stress creep recovery (MSCR) test. Moreover, a binder with high ductility would be characterized by high nonrecoverable creep compliance. This means that a binder characterized with a high level of ductility would exhibit poor performance in the MSCR test.

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Transportation Impacts of Smart Growth Development in Maine by Andrew Weeks (Transportation Research Center, Farrell Hall, 210 Colchester Avenue, Burlington, VT 05405; http://www.uvm.edu/~transctr/trc_reports/UVM-TRC-09-005.pdf) (Aug 2009)

Highlights
- Targeted smart growth land use controls might reduce VMT by almost one half of one percent.
- Multiple smart growth land use controls might reduce VMT by two-thirds of one percent.

This study evaluates the reductions in average trip lengths, daily vehicle miles traveled (VMT), and daily greenhouse gas (GHG) emissions from on-road automobiles due to smart growth development strategies in two Maine towns, Lisbon in Androscoggin County and Sanford in York County. The future analysis year is 2030 and considers levels of household and employment growth expected in the two towns.

Three growth scenarios are analyzed. The Status Quo Growth scenario considers future growth following historical land use patterns in Lisbon and Sanford, based on linear growth assumptions. The first smart growth scenario, Targeted Smart Growth, redirects a portion of household and employment growth into one dense, mixed-use infill development, within an assumed growth boundary in each town. The second smart growth scenario, Multiple Smart Growth, is a more rigorous version of Targeted Smart Growth by redirecting a greater amount of growth into two smart growth developments in Lisbon and three smart growth developments in Sanford. In Lisbon, 100 households and 101 jobs are redirected for Targeted Smart Growth, and a total of 239 households and 139 jobs are redirected for Multiple Smart Growth. In Sanford, 358 households and 561 jobs are redirected for Targeted Smart Growth, and a total of 859 households and 852 jobs are redirected for Multiple Smart Growth.

Each smart growth scenario is modeled using travel demand forecasting techniques, and the resulting average trip lengths, VMT, and GHG are compared across the three scenarios.

In Lisbon, VMT and GHG emissions estimated for the Targeted Smart Growth scenario were 0.43% and 0.42% lower, respectively, than estimates for the Status Quo scenario. The VMT percent reduction corresponds to 656 fewer vehicle miles traveled daily in the Town of Lisbon. Under the Multiple Smart Growth scenario, the reduction in network-wide VMT and GHG emissions was approximately 0.68% and 0.57%, respectively, compared to Status Quo. The VMT percent reduction corresponds to 1,038 fewer vehicle miles traveled daily.

In Sanford, VMT and GHG emissions estimated for the Targeted Smart Growth scenario dropped by 0.24% and 0.27%, respectively, from the Status Quo scenario. The VMT percent reduction corresponds to 985 fewer vehicle miles traveled daily in the Town of Sanford. Under the Multiple Smart Growth scenario, the reduction in network-wide VMT and GHG emissions was approximately 0.42% and 0.43%, respectively, compared to Status Quo. The VMT percent reduction corresponds to 1,698 fewer vehicle miles traveled daily.

In summary, analysis results for Lisbon and Sanford indicate that:

- The densification and mixing of residential and employment growth as infill developments has a slight observable impact on VMT and average trip lengths.
- The scenario with multiple smart growth developments had greater benefit, in the form or VMT and GHG reductions, than the scenario with one smart growth development.
- Intra-zonal trips tend to increase for smart growth zones, while the number of intrazonal trips for non-smart growth zones decreases, albeit at varying degrees depending on the land use mix of those zones.
- Some roadways in the towns experienced VMT increases, which were offset by greater VMT reductions on other roadways, resulting in net, network-wide VMT reductions.
- The effect of increases in VMT on some roadways to/from the smart growth developments should be considered when performing detailed planning of such developments.
- The smart growth scenarios are limited to the amount of growth expected in Lisbon and Sanford by the year 2030.
- Indicating potential for further research, a general estimation shows that greater reductions in VMT and GHG emissions might be attained through an increased share of daily transit trips by providing new transit service to/from the smart growth developments along existing transportation corridors.

It should be noted that only the location, density, and mix of growth were modified across the planning scenarios in the study. Household characteristics, such as size and auto availability, were held constant so that each scenario had similar numbers of daily trips. Use of alternative transportation modes was also held constant, so that there was equal automobile use in each scenario.

Importantly, the study results do not include the effect of future transit service coupled with the proposed smart growth developments. Consequently, the results indicate that the efficacy of the smart growth scenarios to reduce VMT in Lisbon and Sanford is greatly limited without transit to complement the proposed dense, mixed-use developments. One premise of the smart growth scenarios is that the proposed infill developments would be “transit ready” along existing transportation corridors – Route 196 in Lisbon and Route 109 in Sanford. The smart growth scenarios partially prepare future development for more efficient and viable land use interconnectivity with transit, but transit would also be needed to fully realize this benefit and provide further reductions in daily VMT.

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AUGUST 2010

Economic Development Impacts of High-Speed Rail by David Levinson (University of Minnesota, Department of Civil Engineering, 500 Pillsbury Drive SE, Minneapolis, MN 55455; ph. 612-625-6354; http://nexus.umn.edu/Papers/EconomicDevelopmentImpactsofHSR.pdf) (May 27, 2010)

Highlights
- Noise and vibration costs along the line would be quite significant.
- The local land use effects of HSR are likely to be small to non-existent.
- Improving technologies for airlines and automobiles undermine any potential long term benefits from HSR.

This paper reviewed the state of high-speed rail (HSR) planning in the United States c. 2010. The plans generally call for a set of barely inter-connected hub-and-spoke networks.

- There is sometimes a danger of a planner falling in love with his map. There is no danger here, even the same agencies have random maps. It seems as no one cares where the lines actually go, so long as they are high-speed rail.
- The marketers have also made a mistake, 220 miles per hour sounds a lot slower (and less futuristic) than 350 kilometers per hour.
- The US carries a greater share of freight by rail than Europe. Converting rights-of-way into passenger only (which is required for HSR) may cost some of that freight share.
- Any money spent on HSR cannot be spent on something else. The issue of opportunity costs is seldom mentioned.

The evidence from US transit systems shows that lines have two major impacts. There are positive accessibility benefits near stations, but there are negative nuisance effects along the lines themselves. High speed lines are unlikely to have local accessibility benefits separate from connecting local transit lines because there is little advantage for most people or businesses to locate near a line used infrequently (unlike public transit). However they may have more widespread metropolitan level effects. They will retain, and perhaps worse, have much higher, nuisance effects.

A previous study of the full costs of high-speed rail in California showed that the noise and vibration costs along the line would be quite significant. Some examples are reported here, typical lines may have noise damage costs on the order of $1 billion.

If high-speed rail lines can create larger effective regions, that might affect the distribution of who wins and loses from such infrastructure. The magnitude of agglomeration economies is uncertain (and certainly location-specific), but I think presents the best case that can be made in favor of HSR in the US.

That said, remember that real HSR (not the short term improvements to get to 90 or 110 MPH, which may or may not be a good thing, but are certainly not HSR) is a long term deployment, so it needs to be compared with cars 10 or 20 or 30 years hence, and the air transportation system over the same period. Cars are getting better from both an environmental perspective and from the perspective of automation technologies. The DARPA Urban Challenge vehicles need to be bested to justify HSR. Cars driven by computers, which while sounding far off is technologically quite near, should be able to attain relatively high speeds (though certainly not HSR speeds in mixed traffic). Further they may move less material per passenger than HSR (trains are heavy), and so may net less environmental impact if electrically powered. Aviation is improving as well, both in terms of its environmental impacts and its efficiency. Socially-constructed problems like aviation security or congestion can be solved for far less money than is required for any one high-speed rail line.

The local land use effects of HSR are likely to be small to non-existent. The agglomeration benefits may exist, but there is little grounds for concluding their size.

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AUGUST 2010

Effects of Debris on Bridge Pier Scour, *NCHRP Report 653* by P. F. Lagasse, *et al*. (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_653.pdf) (2010)

Highlights

- This research accomplished its basic objectives of developing guidelines for predicting the size and geometry of debris accumulations at bridge piers and methods for quantifying scour at bridge piers resulting from debris accumulations.

This research accomplished its basic objectives of developing guidelines for predicting the size and geometry of debris accumulations at bridge piers and methods for quantifying scour at bridge piers resulting from debris accumulations. The project produced results on two related problems: (1) predicting the accumulation characteristics of debris from potentially widely varying source areas, in rivers with different geomorphic characteristics, and on bridges with a variety of substructure geometries and (2) developing improved methods for quantifying the depth and extent of scour at bridge piers considering both the accumulation variables and the range of hydraulic factors involved.

Waterborne debris (or drift), composed primarily of tree trunks and limbs, often accumulates on bridges during flood events. Debris accumulations can obstruct, constrict, or redirect flow through bridge openings resulting in flooding, damaging loads, or excessive scour at bridge foundations. The size and shape of debris accumulations vary widely, ranging from a small cluster of debris on a bridge pier to a near complete blockage of a bridge waterway opening. Debris accumulation geometry is dependent on the characteristics and supply of debris transported to bridges, on flow conditions, and on bridge and channel geometry. The effects of debris accumulation can vary from minor flow constrictions to severe flow contraction resulting in significant bridge foundation scour.

Qualitatively, the impacts of debris have been well documented; however, a pressing need remains for state DOTs and other bridge owners to have improved prediction methods for the geometry (size and shape) of typical debris accumulations, the conditions under which debris can be expected to develop, and the resulting depth and extent of scour at bridge piers. Currently, only limited guidance is available on which to base critical public safety decisions during flooding on debris-prone rivers. There is a need for accurate methods of quantifying the effects of debris on scour at bridge pier foundations for use by departments of transportation (DOTs) and other agencies in the design, operation, and maintenance of highway bridges.

The research approach involved the following steps:

1. Completion of a literature review and evaluation of current practice with a survey of state DOTs and other bridge owners.

2. A field pilot study to evaluate instrumentation for obtaining data at debris-prone bridges and costs associated with debris-related field studies.

3. Development of a photographic database (archive) as an alternative to field work for assessing typical debris shapes and geometry relationships, nationally.

4. Development of detailed guidelines and flowcharts for estimating the potential for debris production and delivery to a bridge site, and a case study to illustrate the application of the guidelines.

5. Extensive laboratory testing of the most common debris shapes and geometries to determine the relationships between debris shape and dimensions and the depth and extent of bridge pier scour.

6. Development of methods for predicting the depth, shape, and extent of scour at bridge piers resulting from debris accumulation. Application of the methodology is illustrated with example problems.

7. Discussion of approaches and limitations for incorporating debris in one- and twodimensional hydraulic computer models.

8. Discussion of inspection, monitoring, and maintenance issues at debris-prone bridges.

9. Suggestions for implementation activities to enhance the state of practice for estimating scour at bridge piers under debris loading.

Appraisal of Research Results

As an extension of the original work by Diehl for the Federal Highway Administration (FHWA), guidelines and flowcharts were developed for estimating (1) the potential for debris production and delivery from the contributing watershed of a selected bridge and (2) the potential for accumulation on individual bridge elements. The application of the guidelines is illustrated by a case study of a debris-prone bridge on the South Platte River in Colorado. The case study introduces and illustrates the use of field data sheets for evaluating the potential for debris production and delivery from a given watershed.

As a basis for laboratory testing, the photographic archive introduced in Chapter 2, the field pilot study of debris sites in Kansas, and the South Platte River case study were examined to develop a limited number of debris shapes that would represent the maximum number of configurations found in the field. Simplified, yet realistic, shapes that could be constructed and replicated with a reasonable range of geometric variables were needed for laboratory testing. Rectangular and triangular shapes with varying planform and profile dimensions were selected to represent prototype debris accumulations. To account for additional variables thought to be relevant to debris clusters in the field, a method to simulate both the porosity and roughness of the clusters was developed. However, porosity and roughness were found to be, at most, second order factors in estimating scour at bridge piers under debris loading.

The laboratory testing program included the use of a large indoor flume at Colorado State University and model bridge pier shapes, development of state-of-the-art instrumentation for data acquisition, and a wide range of materials to fabricate the debris clusters. Baseline tests were conducted and results were compared with several pier scour prediction equations. A series of tests under clear-water conditions with the various debris shapes were completed. The results are illustrated with tabular data, photographs, and post-test contour plots.

An appraisal of testing results supported the development of an improved algorithm for predicting the scour anticipated at bridge piers from debris accumulations with rectangular and triangular planforms and varying length, width, and depth geometries. In Chapter 3, application of the methodology is presented to integrate the debris accumulation guidelines with the equation for predicting debris scour at bridge piers using the South Platte River case study as an example.

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AUGUST 2010

The Rideability of a Deflected Bridge Approach Slab by Mark Martinez (Louisiana Transportation Research Center, 4101 Gourrier Avenue, Baton Rouge, LA 70808; http://www.ltrc.lsu.edu/pdf/2010/457_press_revised.pdf) (Nov 2009)

Highlights
- A localized pavement distress index was developed.
- The value of the LRI system lies in its ability to easily locate and rate localized roughness.

It has been recognized that there are inherent limitations associated with the pavement roughness index systems currently in use to locate and quantify certain types of localized pavement distresses found in pavement surface dips and bumps, concrete slab joint faulting, bridge-end bumps, etc. For this reason, a new pavement roughness index for localized pavement distress, herein termed the LRI, was proposed and developed to index such phenomena.

The initial work on developing the LRI was accomplished through the analysis of raw profiler data collected on three different bridges. These bridges were selected to have a wide variety of bridge roughness conditions. This preliminary analysis indicated the squared variance of a high-speed laser profiler's accelerometer output, the LRI, was sufficient to both identify and index bridge-bump type phenomena. Findings show that each of the three tested bridges exhibited a unique speed to LRI relationship that could also be used to rate ride quality ranging from comfortable to unsafe.

The posted speed localized roughness index (LRI_{PS}) was developed as a refinement of the preliminary research. This refinement was implemented to ensure that the LRI, which varies with speed, would be able to index ride quality independently of speed. A profiler runs a series of LRI tests at a given site at various speeds. These resulting LRI scores are regressed and regression equations are developed. The LRI_{PS} score for the site is found by plugging the sites posted speed limit into the regression equation. A series of 11 bridges from the northern half of East Baton Rouge Parish were randomly selected to investigate the viability of the LRI_{PS} indexing system.

The intention for field implementation of the LRI indexing system is that it will require only a single test to be run at the posted speed limit. For this reason, a retest of the 11 bridges was undertaken approximately one year after the initial testing. This testing showed that the retest scores correlated well with the regression based scores (differences were within the margin of error of the regression analysis).

The translational vehicular transfer function (TVTF) circuit was developed to overcome transportability and suspension degradation issues. It accomplishes this by effectively converting the accelerometer signal of a given profiler into the accelerometer signal of any other profiler. Costs to implement the LRI system are expected to be minimal. A retrofit of a relatively inexpensive accelerometer and/or a prototype circuit board along with associated software is all that should be required to become operational. There will be a need to periodically calibrate the prototype by measuring and inputting vehicular characteristics of the rig being retrofitted (suspension system masses, spring constants, and damping factors). The cost of calibration and the difficulty associated with implementation are also expected to be minimal.

It is also expected that operation of the LRI monitoring system will be very easy requiring little setup or operator attention both prior to and during field testing. Neither is it expected that post-processing will be a problem. Plans are in place to design a stand-alone software program that will accept field collected ASCII files on input and will produce LRI scores on output. Program setup and use are expected to be simple and intuitive.

The value of the LRI system lies in its ability to easily locate and rate localized roughness. This should make it invaluable to maintenance and rehabilitation efforts and for construction quality assurance/quality control (QA/QC) since there aren't any current, effective means to accomplish this. It is expected that its use in helping field crews to quickly and easily monitor localized distress will generate savings in terms of time, manpower, and money.

Research showed that profile-based indexing systems like the international roughness index (IRI) and ride number (RN), adequately rate steady-state roughness. But, it was also shown that such systems do have problems rating localized roughness. The LRI_{PS} system, by contrast, has proven itself to be most effective in this area.

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AUGUST 2010

Technology Scan for Electronic Toll Collection by Joseph D. Crabtree, Candice Y. Wallace, and Natasha J. Mamaril, 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_08_15_SPR_359_08_1F.pdf) (Jun 2008)

Highlights

- This report discusses advantages and disadvantages associated with different types of collection and different locations. It also discusses issues related to interoperability with other systems.

Transportation facilities funded by user fees (i.e., tolls) are common throughout the United States and around the world. The purpose of this project was to identify and assess available technologies and methodologies for electronic toll collection (ETC) and to develop recommendations for the best way(s) to implement toll collection in the Louisville metropolitan area.

As a means of raising supplemental revenue, highway tolling offers numerous advantages, as well as some disadvantages. Advantages include the additional revenue generated by the tolls, the ability to assign charges directly to those actually using the facility, the public's willingness to pay direct user charges associated with a specific benefit, the ability to move projects forward more quickly, a continuing source of funds for operations and maintenance, the potential use of tolls to manage travel demand and congestion, and an enhanced opportunity for public-private and public-public partnerships. Disadvantages include the costs associated with collecting the tolls (both direct and indirect), the potential for tolls to be perceived as double taxation, and potential equity issues.

Current technologies for collecting tolls include manual collection, automated cash machines, dedicated short-range communications (DSRC) transponders, optical character recognition (OCR), and others.

DSRC technology, consisting of vehicle-mounted transponders and roadside readers, has been the predominant technology used for ETC for the past 20 years. It provides high traffic throughput, high accuracy, and low collection costs. A key issue in selecting a specific DSRC technology is interoperability with other systems. There are numerous ETC system currently deployed in the United States, and these systems use several different DSRC technologies.

OCR technology uses camera systems and software to read motor vehicle license plates and to assign tolls to vehicles based on their license plate numbers. OCR-based systems can provide reasonable traffic throughput; however, accuracy tends to be low, and collection costs are quite high. As a result, OCR technology is typically used as a secondary collection method and/or an enforcement tool rather than as a primary collection method. In addition to the "proven" technologies, there are other technologies being investigated and or pilot-tested. These include odometer-based tolling, cell-phone-based tolling, and satellite-based tolling.

When compared to manual toll collection, ETC has both economic and environmental benefits. These include: (1)

reductions in transaction and waiting times, (2) faster commutes, (3) reduction in fuel consumption, (4) easing of traffic congestion, (5) reduction in air pollution, (6) reduction in cost of operations, and (7) improved identification of toll evaders.

When considering the implementation of tolls in the Louisville metropolitan area, it is important to consider the type of toll collection to be performed (traditional toll plaza, open-road tolling, or hybrid) and the best location for actually collecting the tolls. This report discusses advantages and disadvantages associated with different types of collection and different locations. It also discusses issues related to interoperability with other systems.

The primary challenge associated with any ETC deployment is this: How should the system deal with those vehicles that are not equipped and enrolled for ETC? The success of any ETC system will depend to a large extent on how well this challenge is addressed. If Kentucky decides to implement ETC, a key question will be whether or not to provide a manual payment option. This will affect the number and types of violators that will be encountered. Effective enforcement must be provided to discourage toll violations and to maintain public confidence in the system. The most common technology used in violation enforcement is automated license plate recognition (LPR) systems. These systems are used to identify violators so that appropriate enforcement actions can be taken.

When ETC systems are deployed, tolls can be varied by time of day in order to manage traffic flow and reduce congestion during peak periods. This report discusses several examples of variable-pricing strategies that have been implemented in various locations throughout the world.

The case studies described in this report are: (1) the Bay Area Bridges in San Francisco, California, (2) Highway 407 in Toronto, Ontario, Canada, and (3) the Indiana Toll Road. For each case study, information is presented on the types of toll collection conducted, the types of technology deployed, the toll rates and variations, violation enforcement, incentives for participating in ETC, collection rates and loss rates, technology reliability, operations and maintenance costs, marketing, and participation rates.

This study resulted in the following conclusions and recommendations: ETC provides substantial advantages over manual toll collection; the use of DSRC for ETC is proven, accurate, and reliable; Kentucky should strongly consider ETC versus manual collection for any proposed implementation of tolls; Kentucky should strongly consider selecting an ETC technology that is interoperable with the E-ZPass system; Kentucky should strongly consider implementing open road tolling whenever possible; a major decision in implementing ETC is determining how to deal with non-equipped, non-enrolled vehicles; and adequate enforcement is critical to the success of any ETC implementation.

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AUGUST 2010

Speed Harmonization and Peak-period Shoulder Use to Manage Urban Freeway Congestion by S. Travis Waller, ManWo Ng, Erin Ferguson, N. Nezamuddin, Dazhi Sun, 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_5913_1.pdf) (Oct 2009)

Highlights

- Variable speed limits (VSL) and shoulder use homogenized traffic stream and resulted in smoother flow of traffic.

Speed harmonization and peak-period shoulder use are promising dynamic traffic management strategies for dealing with the increasing levels of congestion observed around the globe. This report investigated their uses on Texas freeways. To this end, a comprehensive approach was developed to determine the feasibility of these active traffic management strategies. In particular, we presented a multi-resolution simulation framework, developed efficient control algorithms, presented several crash precursors to assess safety, and made recommendations on the ITS devices requirement and enforcement. Potential impediments in their implementations were also discussed. A cost-benefit methodology has been presented to determine economic viability of these strategies. These crucial steps were summarized in a comprehensive operational deployment plan.

Variable speed limits (VSL) and shoulder use were implemented in the test section under four different strategies (offline VSL, online VSL, offline VSL with shoulder use, and online VSL with shoulder use) to assess their impact on traffic operations and safety. The results obtained from the implementation of VSL and shoulder use are summarized here:

- VSL and shoulder use did not have significant impact on throughput of the freeway.
- These strategies homogenized traffic stream and resulted in smoother flow of traffic by reducing the total number of stops per vehicle, stopped delay, and number of lane changing maneuvers.
- In general, traffic stream was further homogenized due to reduction in traffic density and speed variability within and across lanes. This also indicated the potential safety benefits that can be obtained by the use of these strategies on freeways.
- If VSL and shoulder strategies are implemented early on and before the onset of full congestion, then they resulted in greater benefits.
- Shoulder use contributed significantly to traffic homogenization process in the middle of the shoulder-use section. However sudden drop of shoulder use at the section end reduced the capacity of the downstream section by one lane and this led to bottleneck creation and significant speed reduction.
- VSL and shoulder use implementation reduced average speed of traffic in the implementation section, and therefore

they contributed to a small increase in travel time.

In conclusion, VSL and shoulder use homogenized traffic and reduced stop-and-go traffic condition by moving the traffic more steadily. Smoother flow of traffic results in less emission, less fuel consumption, and less wear and tear for vehicles, and leads to safer driving conditions.