Research Digest

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Southwest Region University Transportation Center Reports

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Research Digest

Item 1

Cost-Efficiency of Highway Operations and Maintenance of Public-Private Partnerships

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

CTR SWUTC/14/600451-00086-1 • 2014

While the literature on public-private partnerships (PPPs) argues that the private sector's life-cycle approach to design and construction results in operational cost efficiencies, empirical support is missing. This study explored that issue by conducting a four-prong investigation. First, a literature review searched for evidence of such efficiencies and methodologies to evaluate them: it found no empirical evidence of superior operations and maintenance (O&M) cost-efficiency in PPPs. Second, a simple methodology to evaluate life-cycle cost-efficiency is proposed, but adequate data and assumptions about O&M costs are needed. Third, since PPP projects in the U.S. are recent and currently subject to routine O&M, indicators to compare those costs were proposed as well. Fourth, a case study compared the routine O&M costs of a PPP to those of a system of traditionally delivered toll roads. The results showed that the PPP was more cost-efficient in operating expenditures (OPEX) per mile (-60%) and per lane-mile (-53%). The traditional system was more cost-efficient in OPEX per vehicle miles travelled (97%), toll transactions (332%), and toll revenue (20%). However, those three indicators depend on traffic volumes, which were overwhelmingly greater on the traditional system. While the case study showed cost-efficiency differences between public and private sectors, additional research is needed to empirically test the hypothesis of the private sector's greater efficiency. Understanding the differences in cost-efficiency between publicly and privately managed roads will help decision-makers to minimize the life-cycle cost of their investments.

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http://swutc.tamu.edu/publications/technicalreports/600451-00086-1.pdf

Item 2

Effect of Changing Driving Conditions on Driver Behavior Towards Design of a Safe and Efficient Traffic System

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

TTI SWUTC/13/600451-00103-1 • 2013

This simulation-based study explores the effects of different work zone configurations, varying distances between traffic signs, traffic density and individual differences on drivers' behavior. Conventional Lane Merge (CLM) and Joint Lane Merge (JLM) were modeled in a driving simulator and thirty participants (seven female and 23 male students) navigated through the two configurations with two levels of traffic density and in three different conditions: a) standard sign distance, b) 25% reduction, and c) 25% increase in the distance between traffic signs in the advance warning zone. Information regarding travel time, speed, braking force and location of merge was collected through the simulator. Self-reported measures of mental demand, physical demand, temporal demand, performance, effort, frustration and total workload were recorded from all participants by using the NASA TLX. The results show that, on average, driving through the JLM took 18.8% longer than the CLM. Moreover, no significant difference in speed was found between the two merge configurations. However, the percent maximum braking force was 34% lower in the JLM configuration. The comparison of two merge configurations with respect to the location of changing lanes suggest that overall, the JLM configuration encourages drivers to remain in the closed lane longer. The analysis of self-reported workload ratings shows that participants reported 15.3% lower total workload and 18.8% higher performance when driving through the JLM. Moreover, mental demand, temporal demand, effort and frustration were lower in JLM by 16.4%, 23.4%, 13.7% and 28%, respectively. In terms of self-reported workload, the JLM is more conducive to driving. In conclusion, the JLM outperforms the CLM.

This report is available for free download (1.9 MB):
http://swutc.tamu.edu/publications/technicalreports/600451-00103-1.pdf

Item 3

Enhanced Adaptive Signal Control Using Dedicated Short-Range Communications

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

TTI SWUTC/14/600451-00010-1 • 2014

Connected vehicle technology with dedicated short-range communications can provide traffic information in a spatial domain that conventional fixed-point detectors cannot provide. However, because of low market penetration with this new data source, new measures to obtain other traffic parameters and new methodologies to use these new data for better signal control are needed. Arterial roads with multiple intersections and coordinate systems can benefit from these spatial domain data as it allows vehicles to move without being stopped.

For a heterogeneous traffic flow, multi-class cell transmission (M-CTM) is used to optimize signal timing control. M-CTM should work well in modeling traffic flow with signal coordination along an arterial where the platoon dispersion effect is significant and has to be accounted for in order to achieve accurate modeling results. Furthermore, queue length estimation was developed to use connected vehicle data without relying on a conventional detector. Lastly, an adaptive signal control based on the queue length estimation and connected vehicle technology was developed and compared with the pre-timed signal in various traffic conditions. The results show that the proposed control logic works well in both the free-flow condition and the congested condition, can decrease total delay, and can prevent queue overflow.

This report is available for free download (2.6 MB):
http://swutc.tamu.edu/publications/technicalreports/600451-00010-1.pdf

Item 4

Exploring Sustainable Transportation for Texas Southern University

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

TSU SWUTC/14/600451-00042-1 • 2014

Texas Southern University is a commuter campus with students, faculty, and staff traveling from the Greater Houston area to the university. Over the past few years, the TSU campus has made marked improvements to move towards a "greener" more sustainable campus with less impervious coverage. Despite this commitment, the campus still has not addressed how the university will decrease its carbon footprint and change the way people arrive at the campus. Adopting a multi-facetted approach to commuting where faculty, staff, and students have the sustainable commuting options: i.e. rideshare, transit, drive, and bicycle, as viable alternatives to get to the university. The literature and practices currently in use show these strategies are already working well at other campuses and could prove success at TSU as well.

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http://swutc.tamu.edu/publications/technicalreports/600451-00042-1.pdf

Item 5

The Future of Fully Automated Vehicles: Opportunities for Vehicle- and Ride-Sharing, with Cost and Emissions Savings

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

CTR SWUTC/14/600451-00081-1 • 2014

Fully automated or autonomous vehicles (AVs) hold great promise for the future of transportation. By 2020 Google, auto manufacturers and other technology providers intend to introduce self-driving cars to the public with either limited or fully autonomous capabilities. AVs may be able to save the U.S. economy up to $37.7 billion in comprehensive costs from safety, mobility and parking improvements at the 10% market penetration, and potentially up to $447.1 billion with 90% market penetration. Even with only 10% market share, over 1,000 lives could be saved annually. However, realizing these potential benefits while avoiding potential pitfalls requires more than just technology advancements: significant barriers to a successful rollout include AV costs, liability, security, and privacy.

Once fully self-driving vehicles can safely and legally drive unoccupied on U.S. streets, a new transportation mode for personal travel looks set to arrive. This new mode is the shared automated vehicle (SAV), combining on-demand service with self-driving capabilities. This work simulates a fleet of SAVs operating within the city of Austin, using Austin's transportation network and travel demand flows. This model incorporates dynamic ride-sharing (DRS), allowing two or more travelers with similar origins, destinations and departure times to share a ride.

Model results indicate that each SAV could replace around 10 conventionally-owned household vehicles while serving over 56,000 person-trips. SAVs' ability to relocate while unoccupied between serving one traveler and the next may cause an increase of 4-8% more travel; however, DRS can result in reduced overall VMT, given enough SAV-using travelers willing to ride-share. SAVs should produce favorable emissions outcomes, with an estimated 16% less energy use and 48% lower volatile organic compound (VOC) emissions, per person-trip formerly served by a household vehicle.

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Item 6

Game-Theoretic Analysis of Dynamic Traffic Equilibria

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)
CTR SWUTC/14/600451-00079-1 • 2014

Dynamic traffic assignment has grown steadily in popularity and use since its inception. It has become an important and permanent tool in transportation agencies across the country. However, the exact nature of dynamic traffic equilibrium, including existence and uniqueness results, is not fully known in simulationbased models. Specifically, we discuss the possibilities of unrealistic multiple equilibria that arise out of simplified flow models. We demonstrate this with a simple diverge-merge network and discuss piecewiselinear fundamental diagrams as one possible resolution.

This report is available for free download (740 KB):
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Item 7

A Hot Spot Analysis of Teenage Crashes: An Assessment of Crashes in Houston, Texas

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)
TSU SWUTC/14/161341-1 • 2014

Today, states have enacted laws to ensure that teen drivers are more skilled and drive safely. The result is fewer accidents. However, in previous research, when teen crashes were mapped, certain streets and areas appeared to have more accidents than other areas. The goal of this research is to investigate the “hot spot” locations where teens have accidents and to determine important factors contributing to the concentration of accidents. This research will benefit planners and engineers and help them determine if additional changes are needed at locations with high teen crashes to make these areas safer.

This report is available for free download (3.7 MB):
http://swutc.tamu.edu/publications/technicalreports/161341-1.pdf

Item 8

Performance Measures for Multi-vehicle Allowance Shuttle Transit (MAST) System

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

TTI SWUTC/14/600451-00026-1 • 2014

This study investigates the performance measures for multi-vehicle mobility allowance shuttle transit (MAST) system. Particularly, researchers were primarily concerned with two measures, waiting time and ride time, to evaluate the performance and help design of m-MAST systems. The MAST system is an innovative concept that allows transit vehicles to deviate from a fixed route consisting of a few mandatory checkpoints to serve on-demand customers within a predetermined service area, and thus can be both affordable and convenient enough to attract the general public. For the MAST system, the fixed route can be either a loop or a line between two terminals. The checkpoints are usually located at major transfer stops or high demand zones and are relatively far from each other. Researchers developed analytical results for the waiting time probability distribution and its expected value as well as the expected ride time for different types of customers in terms of the system parameters for both 1-MAST system and multi-vehicle MAST (m-MAST). Researchers also discussed the assumptions behind the estimation. Based on the analytical results, researchers provided the inherent constraints between these parameters and demand.

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Item 9

Policy Implications of Emerging Vehicle and Infrastructure Technology

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

CTR SWUTC/14/600451-00087-1 • 2014

This report considers a broad range of emerging transportation technologies that have potential for enhancing travel on and operations of the Texas transportation system. It provides an overview of technology classifications and assesses the policy implications of emerging vehicle and infrastructure technology classifications—namely, connected, autonomous, and electric vehicle technologies—as well as cloud computing and crowdsourcing in the context of transportation systems and services. The researchers assessed these technologies in terms of their ability to further state and national transportation goals. Also assessed were barriers to adoption and promotion at various development stages. Research is presented on new policies and institutional changes that are being implemented outside of Texas. Finally, policy implications for Texas are discussed.

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Item 10

Real Time Freeway Incident Detection

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

CTR SWUTC/14/600451-00083-1 • 2014

The US Department of Transportation (US-DOT) estimates that over half of all congestion events are caused by highway incidents rather than by rush-hour traffic in big cities. Real-time incident detection on freeways is an important part of any modern traffic control center operation because it offers an opportunity to maximize road system performance. An effective incident detection and management operation cannot prevent incidents, however, it can diminish the impacts of non-recurring congestion problems. The main purpose of real-time incident detection is to reduce delay and the number of secondary accidents, and to improve safety and travel information during unusual traffic conditions. The purpose of this project is to evaluate two recently developed automatic incident detection algorithms. The majority of automatic incident detection algorithms are focused on identifying traffic incident patterns but may not adequately investigate possible similarities in patterns observed under incident-free conditions. When traffic demand exceeds road capacity, the traffic speed decreases significantly and the traffic enters a highly unstable regime often referred to as "stop-and-go" conditions. The most challenging part of real-time incident detection is recognition of traffic pattern changes when incidents happen during stop-and-go conditions. This work describes a case study evaluation of two recently evolved incident detection methods using data from the Dallas, TX traffic control center.

This report is available for free download (1.5 MB):
http://swutc.tamu.edu/publications/technicalreports/600451-00083-1.pdf

Item 11

Real-time Optimization of Passenger Collection for Commuter Rail Systems

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

CTR SWUTC/14/600451-00082-1 • 2014

Commuter rail systems are being introduced into many urban areas as an alternative mode to automobiles for commuting trips. The shift from the auto mode to rail mode is anticipated to greatly help alleviate traffic congestion in urban road networks. However, the right-of-way of many existing commuter rail systems is usually not ideally located. Since the locations of rail systems were typically chosen long ago to serve the needs of freight customers, the majority of current commuter rail passengers have to take a non-walkable connecting trip to reach their final destinations after departing even the most conveniently located rail stations. To make rail a more viable, competitive commuting option, a bus feeder or circulator system is proposed for seamlessly transporting passengers from their departing rail stations to final work destinations. The primary research challenge in modeling such a bus circulator system is to optimally determine a bus route and stop sequence for each circulating tour using the real-time demand information. In this paper, we termed this joint routing and stop optimization problem the circulator service network design problem, the objective of which is to minimize the total tour cost incurred by bus passengers and operators while minimizing the walk time of each individual bus passenger. A bi-level nonlinear mixed integer programming model was constructed and a tabu search method with different local search strategies and neighborhood evaluation methods was then developed to tackle the circulator service network design problem.

This report is available for free download (899 KB):
http://swutc.tamu.edu/publications/technicalreports/600451-00082-1.pdf

Item 12

A Real-time Transit Signal Priority Control System that Considers Stochastic Bus Arrival Times

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

TTI SWUTC/14/600451-00014-1 • 2014

Transit Signal Priority (TSP) is an effective strategy for providing preferential treatment to move transit vehicles through intersections with minimum delay. However, TSP can disrupt traffic on non-priority phases if not properly implemented. To produce a good TSP strategy, advance planning with enough lead time is usually preferred; this means added uncertainty about the bus arrival at the stop bar, which has been difficult to be accounted for. Researchers proposed a stochastic mixed-integer nonlinear model (SMINP) to be used as the core component of a real-time transit signal priority control system. The SMINP was implemented in a simulation evaluation platform. An analysis was performed to compare the proposed control model with the standard check-in/check-out TSP system implemented in the VISSIM Built-in Ring-Barrier Controller (RBC-TSP). The results showed the SMINP produced as much as 30 percent improvement of bus delay from the RBC-TSP in low to medium volume conditions. In high-volume conditions, the SMINP model automatically recognizes the level of congestion of the intersection and gives less priority to the bus so as to maintain a minimum impact to the traffic on its conflicting phases. In the case of multiple conflicting bus lines, a rolling optimization scheme was developed. A comparison indicated the RBC-TSP systems cannot handle a high degree of saturation when there are significant amount of conflicts between bus lines, while the SMINP can automatically give less priority to bus so as to cause much less impact to other traffic.

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http://swutc.tamu.edu/publications/technicalreports/600451-00014-1.pdf

Item 13

Safety Performance for Freeway Weaving Segments

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

TSU SWUTC/14/600451-00045-1 • 2014

The intensive lane change maneuvers at weaving sections often result in safety and operational problems. Various factors, including the design of ramp roadways, use of auxiliary lanes, and continuity of lanes will have significant effects on the level of service and safety performance of the weaving sections. This study investigated the safety performance of freeway weaving sections and developed a quantitative model for predicting the safety impacts of different types of geometric treatments for freeway weaving sections. The results of this study show that weaving sections with longer length will have lower crash frequency per 1000 ft., more required lane changes for diverge vehicles will result in more crashes in the freeway weaving section, increasing merge traffic in the weaving sections will slightly reduce the crash risk at this section, and increasing diverge traffic in the weaving sections will increase the crash risk at this section. In this study, Crash Modification Factors (CMFs) were also developed based on the developed crash prediction model for estimating the impacts of different safety treatments for the freeway weaving sections.

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Item 14

Southwest University Transportation Center Strategic Transportation Finance Clearinghouse

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

TTI SWUTC/14/161305-1 • 2014

Between now and 2030, there will be a significant gap, well in excess of $100 million, between the amount of revenue needed to funded infrastructure projects and the amount of revenue available to fund those projects in Texas. At the same time, there is private capital seeking to invest in infrastructure projects. Despite the need for capital on the part of the public sector and the willingness to supply capital on the part of the private sector, to date, there have been only a limited number of public-private partnership projects. This paper seeks to begin a process to construct an environment in which more projects can be funded with private capital to the benefit of both the public and private sectors.

This report is available for free download (1.3 MB):
http://swutc.tamu.edu/publications/technicalreports/161305-1.pdf

Item 15

Sustainability of Transportation Structures Using Composite Materials to Support Trade and Growth

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

TTI SWUTC/14/600451-00009-1 • 2014

Corrosion-induced deterioration of steel rebar is one of the main reasons for repair and rehabilitation programs for conventional steel-reinforced concrete bridge decks. According to the National Association of Corrosion Engineers (NACE), of all bridges in the United States, over 50 percent are constructed of conventional steel-reinforced or prestressed concrete, and one in three bridges is considered structurally deficient or functionally obsolete due to corrosion of steel reinforcement. NACE has estimated the annual cost of corrosion-related maintenance of highway bridges in the United States at $8.3 billion.

To overcome corrosion-induced structural issues, researchers have introduced and applied fiber-reinforced polymer (FRP) bars, over the past couple of decades, as a corrosion-resistant candidate for either conventional reinforcing steel or prestressing strands. High strength-to-weight ratio, corrosion resistance, and accelerated construction due to ease of placement of the bars and implementation are the special characteristics that make these bars an appealing alternative for either steel-reinforcing bars or prestressing strands.

This report presents the experimental and analytical investigations of structural performance of a full-scale American Association of State Highway and Transportation Officials (AASHTO) I-girder Type I, reinforced and prestressed with aramid-fiber-reinforced polymer (AFRP) bars, where the bridge girder is composite with a topping deck. The major objectives of this research included evaluating (1) the constructability, (2) the load and deformation capacities under either flexure or shear tests, and (3) the structural performance per AASHTO load and resistance factor design (LRFD) criteria.

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Item 16

Use of Containers to Carry Bulk and Break Bulk Commodities and Its Impact on Gulf Region Ports and International Trade

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

SWUTC/14/600451-00105-1 • 2014

The University of New Orleans Transportation Institute was tasked by the Louisiana Transportation Research Center (LTRC) in mid-2012 to assess the use of containers to transport bulk and break bulk commodities and to determine what their impact would be on ports within Louisiana and along the Gulf Coast once the Panama Canal Expansion (PCE) is complete in 2015. LTRC's principal interest was on the impact of the growing container trade in the emerging maritime and international trade world as a result of the PCE and the resultant all-water routes to/from Asia via Gulf Coast and U.S. East Coast ports. They were primarily interested in the impacts of shipping services calling on Gulf ports, specific import and export commodities shipped by container, and the identification of specific commodities shipped by container which can grow and under what circumstances.

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Item 17

Use of Directional Median Openings on Urban Roadways

SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER (SWUTC)

TSU SWUTC/14/161342-1 • 2014

Over the past decades, many states and local transportation agencies have installed directional median openings on divided roadways to improve arterial safety and operational performance. A directional opening is normally used to restrict crossing and left-turn movements from minor streets to help avoid potential conflicts. A series of potential benefits may be achieved by installing directional-median openings, including reduced crash rates, increased traffic capacity, and better operational performance. However, the benefits of directional median openings depend largely on proper implementation and on various factors, including geometric, traffic control, environmental conditions, and the type and placement of the downstream U-turn provisions. The goal of this research is to investigate the safety impacts of installing directional openings on median-divided urban roadways. To achieve this goal, the research : 1) synthesized existing related research; 2) compared the safety performance of directional median openings and full median openings, at subject opening locations and downstream U-turn locations; and 3) analyzed the contributing factors to the crashes occurred at the downstream U-turn locations of a directional median opening.

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