



## Program Progress Performance Report

**Submitted to:** U.S. Department of Transportation  
Research and Innovative Technology Administration (RITA)

**Federal Grant:** #DTRT12-G-UTC06

**Project Title:** Southwest Region University Transportation Center (SWUTC)

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**Recipient Organization:** Texas A&M Transportation Institute  
Texas A&M University System  
3135 TAMU  
College Station, TX 77843-3135

**Recipient Identifying Number:** 600451

**Grant Period:** January 1, 2012 – January 31, 2016

**Reporting Period End Date:** June 30, 2014

**Report Term:** Semi-annual – January 1, 2014 – June 30, 2014

*Melissa S Tooley*

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Melissa Tooley - Director

## 1. Accomplishments:

SWUTC Goals as stated in *SWUTC Prospectus* – to produce research, education and workforce development and technology transfer initiatives that serve the needs of Region 6 and support the five strategic goals of USDOT.

### **SWUTC Goal #1: Research Program**

With this grant, SWUTC's research program will build on historical accomplishments, and make fundamental strides in basic and advanced research that will be implementable by operating agencies responsible for improving accessibility and mobility while reducing congestion in our urban transportation systems; provide infrastructure renewal; harmonize freight movements between Canada, U.S. and Mexico; reduce the bottlenecks while improving the technology and linkages among the freight and passenger modes in the intermodal transportation network; improve the livability of our rural and urban neighborhoods; and contribute to improvements in the overall safety of the transportation enterprise in our region and nation.

### **Completed Research Project Accomplishments/Dissemination of Results for this Reporting Period:**

◆ **SWUTC Project #161304: How Do Travelers Perceive and Value Travel Time Reliability** - The literature on the value of passenger travel time is extensive and well developed, but research attempting to quantify value of travel time reliability (VOR) is relatively new. This research used a novel approach to try to understand travel time reliability using empirical data of travelers from the Katy freeway. The use of empirical data enabled researchers to overcome most of the shortcomings of the existing techniques. This found that the understanding of travel time reliability is far more complex than what has been reported in existing research. Moreover, common measures of variability such as standard deviation of travel are not representative of how travelers perceive travel time reliability.

Research results disseminated through:

- Final Technical Report: Empirical Measurement of Travelers' Value of Reliability, Mark Burris, Santosh Rao Danda, Texas A&M University (TAMU), March 2014, 45 pp.
- Presentations: 2 (citations in Products Section of previous PPPR)
- Future presentation planned to the Transportation Research Board (TRB) Annual Meeting, January 2015.

◆ **SWUTC Project #161305: Strategic Transportation Finance Clearinghouse** - Between now and 2030, there will be a significant gap, well in excess of \$100 million, between the amount of revenue needed to fund 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 research sought 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.

Research results disseminated through:

- Final Technical Report: Strategic Transportation Finance Clearinghouse, Robert Farley, David Ellis, and Allison Weldon, TAMU, May 2014, 44 pp.
- Presentations: 2 (citations in Products Section of this report)

◆ **SWUTC Project #161342: Use of Directional Median Openings on Urban Roadways** - This research investigated the safety impacts of installing directional openings on median-divided urban roadways. The results of this research indicate that, since converting a full median opening to a directional median opening will generate more U-turns at the downstream opening of directional opening, the selection of U-turn location is

critical for the safety performance of directional openings. Diverted left-turn traffic should not be allowed to make U-turns at a closely spaced opening that already have significant U-turns or left-turn volumes.

Research results disseminated through:

- Final Technical Report: Use of Directional Median Openings on Urban Roadways, Yi Qi, Xiaoming Chen, Yubian Wang, Guanqi Liu, and Yan Lu, Texas Southern University (TSU), May 2014, 55 pp.
- Presentation: 1 (citation in Products Section of this report)

♦ SWUTC Project #600451-00009: Sustainability of Transportation Structures Using Composite Materials to Support Growth and Trade – This study 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.

Research results disseminated through:

- Final Technical Report: Sustainability of Transportation Structures Using Composite Materials to Support Trade and Growth, Shobeir Pirayeh Gar, Stefan Hurlebaus, John B. Mander, Wesley Cummings, Michelle J. Prouty, and Monique H. Head, TAMU, June 2014, 126 pp.
- Journal Publication: 1 (citation in Products Section of this report)
- Thesis: 2 (citations in the Products Section of this report)
- Journal Articles in Preparation: Practical Anchorage System for FRP Prestressed Concrete Bridges, W. Cummings, S. Pirayeh Gar, S. Hurlebaus, Texas A&M University, Journal TBD.

♦ SWUTC Project #600451-00010: Enhanced Adaptive Signal Control Using Dedicated Short Range Communications – Queue estimation is an unsolved problem, because traditionally detectors are at fixed locations. Through this research, a model to estimate queue length using Connected Vehicle technology was developed. In addition, market penetration ratio of the technology was also considered.

Research results disseminated through:

- Final Technical Report: Enhanced Adaptive Signal Control Using Dedicated Short-Range Communications, Yunlong Zhang and Kamonthep Tiaprasert, TAMU, May 2014, 84 pp.
- Journal Publication: 1 (citation in Products Section of this report)
- Journal Article Under Review: 1 (citation in Products Section of this report)

♦ SWUTC Project #600451-00014: Novel Transit Signal Priority under Connected Vehicle Framework - This project explored a fundamentally new way to operate traffic signal systems to provide transit signal priority at signalized intersections in urban environments. With current techniques, transit vehicles are serviced on a first-come, first-serve basis, and each intersection is operated independently of the other intersections in the corridor. What frequently occurs in practice is that priority treatment can be given to a transit vehicle that has few riders and/or is less behind schedule than a later transit vehicle which is more in need of priority (i.e., is fuller or is running further behind schedule) than the first vehicle. This approach attempts to optimize when, where, and how transit vehicles are treated in a corridor based upon estimates of their arrival time and level of need.

Research results disseminated through:

- Final Technical Report: A Real-Time Transit Signal Priority Control System the Considers Stochastic Bus Arrival Times, Xiaosi Zeng, Kevin Balke, Praprut Songchitruksa, and Yunlong Zhang, TAMU, October 2013, 93 pp.
- Presentation: 1 (citation in Products Section of this report)
- Journal Publication: 1 (citation in Products Section of this report)
- Journal Articles Accepted for Publication: 1 (citation in Products Section of this report)

◆ SWUTC Project #600451-00028: Sustainability of Bridge Foundations Using Electrical Resistivity and Induced Polarization to Support Transportation Safety - This research explored the feasibility and effectiveness of induced polarization (IP) and electrical resistivity imaging (ERI) for determining the depth of unknown foundations. With budget cuts and deteriorating infrastructure, there is a need to seek alternative solutions for nondestructive structural integrity testing that are more robust to limit bridge failures that hinder transportation safety. With this research, an experimental field study was conducted at a National Geotechnical Experimentation Site (NGES) to identify key parameters for the testing design and setup in order to obtain optimal surveys of bridge foundations. The results showed that IP and ERI can be used in concert with one another to estimate the type and depth of bridge foundations.

Research results disseminated through:

- Final Technical Report: Sustainability of Bridge Foundations Using Electrical Resistivity Imaging and Induced Polarization to Support Transportation Safety, Stefan Hurlebaus, Jean-Louis Briaud, and Stacey Tucker, TAMU, January 2014, 161 pp.
- Presentation: 1 (citation in Products Section of this report)
- Journal Article Submitted for Review: 1 (citation in Products Section of this report)

◆ SWUTC Project #600451-00029: Policy Implications of Automated Vehicles on Texas Highways - Automated vehicles are an emerging technology with the potential to greatly change and disrupt the American transportation system, but may also have significant benefits. This study sought to understand how automated vehicles will change the transportation system, identify implications on state and local transportation providers, determine future research needs, and understand emerging policy issues.

Research results disseminated through:

- Final Technical Report: Automated Vehicles: Policy Implications Scoping Study, Jason Wagner, Trey Baker, Ginger Goodin, and John Maddox, TAMU, January 2014, 64 pp.
- Policy Handbook: Revolutionizing Our Roadways: The Challenges and Benefits of Making Automated Vehicles a Reality. Jason Wagner, Trey Baker, Ginger Goodin, John Maddox, and Chris Pourteau, TAMU, February 2014, 36 pp. Used to present study findings to legislative staff.
- Poster/Slide Presentation: Used to present study findings to legislative staff.

◆ SWUTC Project #600451-00042: Exploring Sustainable Transportation for Texas Southern University - This research reviewed alternative transportation solutions for Texas Southern University to decrease its carbon footprint by changing the way faculty, staff and students arrive at the campus.

Research results disseminated through:

- Final Technical Report: Exploring Sustainable Transportation for Texas Southern University, Gwen Goodwin, Sascha Sabaroche, and Walter Council, TSU, May 2014, 47 pp.

◆ SWUTC Project #600451-00044: Left-Turn Lanes at Unsignalized Median Openings - Due to the frequent presence of median openings in urban arterial settings, the requirements for the deceleration and storage of turning vehicles (e.g. AASHTO Green Book) often exceed the available length between two adjacent openings which leaves traffic engineers to decide whether left-turn lanes, shorter than the standards, can be used or not. The goal of this research was to investigate the minimum required length for left-turn lanes at the unsignalized median openings, and study the safety and operational impacts of such left-turn lanes with substandard lengths.

Research results disseminated through:

- Final Technical Report: Left-Turn Lanes at Unsignalized Median Openings, Yi Qi, Xiaoming Chen, Yubian Wang, and Yan Lu, TSU, March 2014, 61 pp.
- Journal Articles Published: 2 (citations in Products Section of this report and previous PPPR)

- Presentation: 1 (citation in Products Section of previous PPPR)

♦ SWUTC Project #600451-00046: A Case Study of Severe Environmental Justice Communities in the Houston Region - Declining federal subsidies are limiting transportation capacity at the regional and local levels. At the same time, federally funded agencies must comply with Executive Order (EO) 12898, which augments Title VI of the Civil Rights Act of 1964. The EO states that agencies are to identify burdens and benefits to vulnerable populations. Prior to the 2010 demographic and socioeconomic data collected from the decennial census, the American Community Survey (ACS) and the United States Department of Health and Human Services were used to classify environmental justice zones. In the 2010 decennial census, the U.S. Census Bureau eliminated the long-form, which reduced the data available to perform adequate environmental justice analyses. Currently, metropolitan planning organizations (MPOs) use the ACS which provides limited data. MPOs must now develop innovative strategies to determine environmental justice zones.

This research produced information to aid and assist the Houston-Galveston Area Council in their environmental justice analyses.

Research results disseminated through:

- Final Technical Report: An Examination of Severe Environmental Justice Zones in Houston, TX, Gwen Goodwin, Jamaal Schoby and Walter Council, TSU, April 2014, 34 pp.
- Presentation: 1 (citation in Products Section of this report)
- Future presentation planned to the Transportation Research Board (TRB) Annual Meeting, January 2015.

♦ SWUTC Project #600451-00079: Game-theoretic Analysis of Dynamic Traffic Equilibria - Dynamic Traffic Assignment models are used to estimate how many travelers use a roadway link at different times of the day. They are based on an equilibrium principle according to which no traveler between an origin-destination pair can do better by switching to an alternate route. This research focused on issues related to multiple equilibria in such models. Researchers first pointed out the existence of multiple equilibria in dynamic networks and discussed its implications on project selection. Then they discussed how some of the simplified traffic flow models that are used in various DTA software packages can lead to counter-intuitive phenomena in which all feasible flow patterns are at equilibrium, while in practice only one of them is likely to be observed. Modifications to the traffic flow models are proposed to mitigate this phenomenon.

Research results disseminated through:

- Final Technical Report: Game-Theoretic Analysis of Dynamic Traffic Equilibria, Stephen D. Boyles, Christopher Melson, Tarun Rambha, and Jennifer C. Duthie, University of Texas at Austin (UT-Austin), March 2014, 52 pp.
- Presentation: 3 (citations in Products Section of this report)
- Journal Articles Submitted for Review: 1 (citation in Products Section of this report)
- Curriculum Developed: Research findings have been incorporated into a graduate course on Dynamic Traffic Assignment (CE392D) at the UT-Austin.

♦ SWUTC Project #600451-00083: Improving the Reliability of Automated Freeway Incident Detection Using Multiple Real Time Data Sources - Automated incident detection has been studied for over 30 years and most urban traffic control centers have some form of this technology in operation. Most of these techniques are quite accurate when freeway speeds are high and density is low. However, under high density, low speed, stop and go, conditions, undetected incidents and false alarms are common. The technology developed here extends the state of the art providing a new tool that improves reliability under the critical low speed, high density traffic conditions.

Research results disseminated through:

- Final Technical Report: Real Time Freeway Incident Detection, Moggan Motamed and Randy Machemehl, UT-Austin, April 2014, 42 pp.
- Undergraduate and Graduate Curriculum Developed: The methodology developed by this research is being implemented in the curricula for a graduate and an undergraduate traffic engineering course within the UT Transportation Engineering program. Study results have led to new course problem sets and field tests to be performed by the students in the classes.
- Future presentation: A Freeway Incident Detection Algorithm Using Dynamic Time Warping, Motamed, Moggan and Randy Machemehl, paper to be offered for presentation and publication at the Transportation Research Board Meeting, Washington, DC, January 2015.
- Future presentation: Pilot Testing of a Freeway Incident Detection Algorithm Using Dynamic Time Warping, Motamed, Moggan and Randy Machemehl, paper to be offered for presentation and publication at the June 2015 Canadian Society for Civil Engineering Meeting, June 2015.

♦ SWUTC Project #600451-00103: Effects of Changing Driving Conditions on Driver Behavior towards Design of a Safe and Efficient Traffic System - This project was an attempt to improve traffic flow and drivers' safety at work zones. The new work zone layout which was studied in this project proved to perform better, in terms of improving driving safety and traffic flow, compared to the traditional methods of lane closure near work zones.

Research results disseminated through:

- Final Technical Report: Effect of Changing Driving Conditions on Driver Behavior Towards Design of a Safe and Efficient Traffic System, Fereydoun Aghazadeh, Laura Hughes Ikuma and Sherif Ishak, Louisiana State University (LSU), December 2013, 69 pp.
- Presentation: 3 (citations in Products Section of this report and previous PPPR)
- Journal Article Published: 1 (citation in Products Section of this report)
- Publication: The Joint Merge: Improving Work Zone Traffic Flows, UTC Spotlight: University Transportation Centers Program, July 2013.

♦ SWUTC Project #600451-00107: States' Tools for Connecting Transportation and Affordable Housing - With increasing attention on the need to combine affordable housing with mobility options, this research examined which states have incorporated transit proximity into their allocation of low-income housing tax credits. In addition, the research also reviewed to what extent low-income residential patterns are included in federally required, regional transportation planning.

Research results disseminated through:

- Final Technical Report: State and Regional Tools for Coordinating Housing and Transportation, Akul Nishawala, Kate Lowe and Marla Nelson, University of New Orleans (UNO), January 2014, 39 pp.
- Presentation: 1 (citation in Products Section of this report)

**Plans for Next Reporting Period to Accomplish Research Goal:**

- Provide support, guidance and assistance to project Principal Investigators to facilitate the achievement of individual research project objectives in compliance with approved work plans.



## **SWUTC Goal #2: Education and Workforce Development Programs**

With this grant, SWUTC will promote excellence and the preeminent status the education programs at each of the consortium member universities. This consortium nurtures world-class innovators in the education and preparation of transportation leaders for the emerging information-rich economy, through a continuing process of improvement in curriculum, courses and teaching methods.

### **Efforts Active January 1 2014 – June 30, 2014:**

♦ **SWUTC graduate scholarship programs** have the ultimate goal to prepare a highly qualified cadre of new professionals into transportation science. These programs provide financial support to students to participate in classroom and sponsored research activities. In addition, the program provides increased communications skills as students make presentations, participate in debates, and write proposals and reports. Students also participate in technical tours and professional meetings throughout the year. Students in these programs receive tuition, fees and/or stipend support.

#### Current Status:

Transportation Scholars Program at TAMU - Number of students currently in program: 4

Advanced Institute at the UT-Austin – Number of students currently in program: 14

Graduate Stipend Program at Texas Southern University (TSU) – Number of students currently in program: 8

### ♦ **Summer Undergraduate Fellows Programs**

The SWUTC Summer Undergraduate Transportation Scholars (UGTSP) at TAMU continues to be an extremely successful recruiting endeavor, attracting a diverse group of students into the graduate programs in transportation. Each year, the UGTSP recruits juniors and seniors from other universities and from diverse academic backgrounds into a summer-long program in transportation research and education as a first step towards graduate study in transportation. While at TAMU, the students have the opportunity to work with graduate students, faculty members, and researchers and are also exposed to research through meetings with project sponsors and weekly research seminars. Students make field trips to various transportation agencies and attend professional meetings such as the summer meeting of TexITE. At the end of the summer term, the students make presentations on their research and produce a paper for publication. These papers are published annually as a *Compendium of Student Papers* and posted on the SWUTC website.

#### Current Status:

Undergraduate Transportation Scholars Program (UGTSP) at TAMU. 2014 program in progress. Number of students participating: 4.

Publication of 2013 Student Papers: Compendium of Student Papers: 2013 Undergraduate Transportation Engineering Fellows Program, H. Gene Hawkins, editor, Texas A&M University, November 2013, 137 pp. Available online at <http://swutc.tamu.edu/publications/2013-2/>

### ♦ **Ph.D. Candidate Assistantship Program** at TAMU:

This competitive program selects Ph.D. candidates for a maximum of 12 months of salary support while their dissertation is being completed. No tuition or fees are paid. Candidates are chosen based on the quality and value of the proposed research. The goal of this program is to expedite the progress of students to complete doctoral requirements and begin their careers as transportation leaders.

#### Current Status:

##### 2012 PhDCA Program:

Of the six proposals selected for funding in FY12, five are now complete. (Citations in previous PPPRs)

##### 2013 PhDCA Program

Six proposals selected for FY13 funding – all efforts initiated September 1, 2013 and are currently in progress.

♦ **Development of New Collaborative Transportation Statistics and Microsimulation Distance Learning Course** at TAMU and University of Nebraska-Lincoln (UNL). (SWUTC Educational Initiative #600451-00032)

This course development was a collaborative effort between TAMU and UNL to provide a practice-based statistics distance-learning course for transportation engineering students. This course was based on Statistics 658 (TAMU) taught by Distinguished Professor Cliff Spiegelman and CIVE 898-Transportation Microsimulation & Statistics (UNL) taught by Dr. Larry Rilett. The transportation statistics textbook previously developed by the SWUTC and authored by Spiegelman, Park, and Rilett was utilized in the course.

The course covered topics important for transportation engineers that are not usually covered in general engineering statistics courses. Topics included microsimulation, discrete regression, and design of experiments. The focus was on actual transportation problems and utilized a number of case studies based on SWUTC and MATC research. The course was taught jointly at TAMU and UNL via web link during the Spring 2014 semester. During each lecture, Dr. Spiegelman was present in the TAMU classroom, with Dr. Rilett in the UNL classroom.

Students who completed this course will have an improved ability to analyze data, design better experiments, develop better data collection plans, and be able to make more insightful statements about experimental and observed transportation data. Equally important, they will also be able to communicate their results more clearly.

**Current Status:**

Effort complete: course taught during Spring 2014 semester to approximately 10 students at both TAMU and UNL. Student evaluations of the course were extremely favorable with an average of 4.6 on a scale of 1-5.

Course syllabus available online at <http://swutc.tamu.edu/education/>

Materials from this distance-based course will serve as a basis for developing modules targeted to practicing transportation professionals either through on-line applications or through short courses.

**Plans for Next Reporting Period to Accomplish Education and Workforce Development Goal:**

- Continue support of graduate scholarship programs at TAMU, UT-Austin and TSU, and the Ph.D. Candidate Assistantship Program at TAMU.
- Complete the 2014 Undergraduate Transportation Scholars Program at TAMU.

**SWUTC Goal #3: Technology Transfer**

Timely information, delivered to the right people is the desired outcome for SWUTC's technology transfer program. SWUTC supports a varied menu of techniques to transfer SWUTC derived results. These include: continually updating the SWUTC website at <http://swutc.tamu.edu/> with center news and downloadable publications; publishing and distributing research final technical reports to 20 state and national libraries; and support for SWUTC researchers as they present their research results through peer-reviewed publications and professional presentations.

**See complete listing of publications and presentations produced during this reporting period in the following Products Section.**

**Plans for Next Reporting Period to Accomplish Technology Transfer Goal:**

- Continue to update website with recent center activities and accomplishments.
- Publish final technical reports as individual research projects are completed.
- Continue to support researchers as they present their research results through peer-reviewed publications and professional presentations.



## 2. Products:

SWUTC Publications/papers/presentations for this reporting period:

### **Publications Submitted for Review:**

Queue Length Estimation Using Connected Vehicle for Adaptive Signal Control, Yunlong Zhang, TAMU, under review for publication in *IEEE Transaction of Intelligent Transportation System Journal*. (Product of SWUTC Project #600451-00010)

Electrical Resistivity and Induced Polarization Imaging for Unknown Bridge Foundations, S. Tucker, J. –L Briaud, S. Hurlbaas, M.E. Everett, R. Arjwech, TAMU, under review for publication in *ASCE Geotechnical and Geoenvironmental Engineering*. (Product of SWUTC Project #600451-00028)

Real-Time Optimization of Passenger Collection for Commuter Rail Systems, Yao Yu and Randy Machemehl, UT-Austin, under final review for publication in the *Proceedings of the Canadian Society of Civil Engineers 10<sup>th</sup> International Specialty Conference on Transportation*. (Product of SWUTC Project #600451-00068)

Diverge Models and Dynamic Traffic Equilibria, S.D. Boyles, J. Duthie, T. Rambha, and C. Melson, UT-Austin, under review for publication in *Networks and Spatial Economics*. (Product of SWUTC Project #600451-00079)

Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations for Capitalizing on Self-Driven Vehicles, Kara Kockelman, UT-Austin, under review for publication to *Transportation Research Part A*. (Product of SWUTC Project #600451-00081)

Capacity and Federal Program Design: Competing for TIGER Funds, K. Lowe, UNO, under review for publication in *Public Works Management and Policy*. (Product of SWUTC Project #600451-00106)

Capacity or Equity?: Federal Funding Competition between and within Regions, K. Lowe, S. Reckhow and J. Gainsborough, UNO, in final revision for publication in the *Journal of Urban Affairs*. (Product of SWUTC Project #600451-00106)

Selection and Allocation of Manual Traffic Control Points and Personnel During Emergencies, S. Parr, V. Dixit and B. Wolshon, LSU, submitted for publication in the *Journal of Emergency Management*, Special NEC Issue, January 2014. (Product of SWUTC Project #600451-00113)

### **Book/Journal Submissions Published (citations not captured in previous PPPRs):**

Developing a Total Peak Period Travel Time Performance Measure: An Updated Concept Paper, David Schrank and Bill Eisele, TAMU, published in the *Transportation Research Record: Journal of the Transportation Research Board*, 2014. (Product of SWUTC Project #161302)

Greenhouse Gas and Urban Congestion: Incorporating Carbon Dioxide (CO<sub>2</sub>) Emissions and Associated Fuel Consumption into TTI's *Urban Mobility Report*, David Schrank and Bill Eisele, TAMU, published in the *Transportation Research Record: Journal of the Transportation Research Board*, 2014. (Product of SWUTC Project #161302)

Advancing Safety Performance Monitoring at Signalized Intersections Using Connected Vehicle Technology, P. Songchitrukksa and L. Zha, TAMU, published in the *Transportation Research Record: Journal of the Transportation Research Board*, 2014. (Product of SWUTC Project #161303)

Computational Modeling of the Flexural Performance of an AFRP Prestressed Girder with a Composite Bridge Deck, S. Pirayeh Gar, M.H. Head, S. Hurlbaas, TAMU, published in the *ACI Structural Journal*, Vol. 110, No. 6, pp. 965-975, 2013. (Product of SWUTC Project #600451-00009)

A Real-Time Transit Signal Priority Control Model Considering Stochastic Bus Arrival Time, X. Zeng, Y. Zhang, K. N. Balke, K. Yin, TAMU, published in the *IEEE Transactions on Intelligent Transportation Systems*, Volume: PP, Issue: 99, 2014. (Product of SWUTC Project #600451-00014 and 600451-00010)

A Model for Transit Signal Priority Considering Stochastic Bus Arrival Time, Kevin Balke, TAMU, published in the *Transportation Research Record: Journal of the Transportation Research Board*, 2014. (Product of SWUTC Project #600451-00014)

Novel Transit Signal Priority under the Connected Vehicle Framework, Kevin Balke, TAMU, accepted for publication in the *IEEE Transactions on Intelligent Transportation Systems Journal*, 2014. (Product of SWUTC Project #600451-00014)

Safety Impacts of Using Short Left-Turn Lanes at Unsignalized Median Openings, Xiaoming Chen, Yi Qi, Yan Lu, TSU, published in the *Transportation Research Record: Journal of Transportation Research Board*, 2014. (Product of SWUTC Project #600451-00044)

Route Switching Behavior among Austin Commuters, Moggan Motamed and Randy Machemehl, UT-Austin, published in the *Proceedings of the 2013 General Conference of the Canadian Society of Civil Engineers*, Montreal, Canada, June 2013. (Product of SWUTC Project #600451-00068)

Equilibrium Analysis of Low-Conflict Intersection Designs, S. Boyles, T. Ramba and C. Xie, UT-Austin, published in the *Transportation Research Record: Journal of Transportation Research Board*. 2014 (Product of SWUTC Project #600451-00079)

Planning and Management of Transportation Systems for Evacuation, Bryan Wolshon and V.V. Dixit, LSU, Publication – Chapter 8 of the *Handbook of Emergency Response: A Human Factors and Systems Engineering Approach*, ISBN: 978-1-4665-1456-0, Taylor & Francis Publishing Inc., New York, 2013. (Product of SWUTC Project #600451-00101)

Effect of Work Zone Configurations and Traffic Density on Performance Variables and Subjective Workload, Shakouri, M., Ikuma, H. L., Aghazadeh, F., Punniaraj, K., & Ishak, S., LSU, published in *Accident Analysis & Prevention*, 71, 166-176, 2014. (Product of 600451-00103)

Effect of Phased Evacuations in Megaregion Highway Networks, Z. Zhang, K. Spansel and B. Wolshon, LSU, accepted and in press for publication in the *Transportation Research Record: Journal of the Transportation Research Board*, February 2014. (Product of SWUTC Project #600451-00114)

#### **Theses Produced:**

Evaluation of Advanced Construction Materials for Sustainable and Durable Infrastructure, Michelle Prouty, TAMU, MS thesis, 2014 (Product of SWUTC Project #600451-00009)

Aramid Fiber for Prestressed Bridge Girders, Wesley Cummings, TAMU, MS thesis, 2014 (Product of SWUTC Project #600451-00009)

Imparting Electrical Conductivity into Asphalt Composite Using Graphite, A. Baranikumar, TAMU, MS thesis, 2013 (Product of SWUTC Project #600451-00025)

Improvements and Extensions of Dynamic Traffic Assignment in Transportation Planning, Christopher Melson, UT-Austin, MS thesis, 2013 (Product of SWUTC Project #600451-00079)

#### **Presentations (citations not captured in previous PPRs):**

Greenhouse Gas and Urban Congestion: Incorporating Carbon Dioxide (CO<sub>2</sub>) Emissions and Associated Fuel Consumption into TTI's *Urban Mobility Report*, David Schrank and Bill Eisele, TAMU, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, D.C., January, 2014. (Product of SWUTC Project #161302)

Developing a Total Peak Period Travel Time Performance Measure: An Updated Concept Paper, David Schrank and Bill Eisele, TAMU, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, D.C., January, 2014. (Product of SWUTC Project #161302)

Advancing Safety Performance Monitoring at Signalized Intersections Using Connected Vehicle Technology, P. Songchitruksa and L. Zha, TAMU, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, DC, January, 2014. (Product of SWUTC Project #161303)

Texas Transportation Finance Options, David Ellis, TAMU, keynote address presented to over 100 statewide leaders in economic development, San Antonio, Texas, October 2013. (Product of SWUTC Project #161305)

The Role of Public-Private Partnerships in Transportation Finance, David Ellis, TAMU, keynote address at the Bond Buyer's 18th Annual Public Finance Conference, Austin, Texas, February 3, 2014. (Product of SWUTC Project #161305)

Operational and Safety Impacts of Directional Median Opening on Urban Roadways: A Case Study in Houston, TX, Yi Qi, TSU, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, DC, January, 2014. (Product of SWUTC Project #161342)

Development and Validation of a Generalized Viscoplastic Yield Surface Model for Asphalt Concrete, Y. Zhang, R. Luo and R. Lytton, TAMU, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, DC, January 2014. (Product of SWUTC Project #600451-00006)

A Model for Transit Signal Priority Considering Stochastic Bus Arrival Time, Kevin Balke, TAMU, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, DC, January, 2014. (Product of SWUTC Project #600451-00014)

Multifunctional High-Performance Composite Materials for Civil Infrastructures, Phillip Park, TAMU, presented at 2014 Korean-American Scientists and Engineers Association – Southeastern Regional Conference (KSEA-SERC), Atlanta, GA, March, 2014. (Product of SWUTC Project #600451-00025)

Nondestructive Testing of Subsurface Infrastructure Using Induced Polarization and Electrical Resistivity, Stacey Tucker, TAMU, presented at Kansas State University, Manhattan, Kansas, February 11, 2013. (Product of SWUTC Project #600451-00028)

Safety Impacts of Using Short Left-Turn Lanes at Unsignalized Median Openings, Xiaoming Chen, Yi Qi, Yan Lu, TSU, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, DC, January, 2014 (Product of SWUTC Project #600451-00044)

A Case Study of Severe Environmental Justice Communities in the Houston Region, Gwen Goodwin, TSU, presented at the 44<sup>th</sup> Annual Conference of the Urban Affairs Association, San Antonio, TX, March 21, 2014. (Product of SWUTC Project #600451-00046)

A New Spatial Multiple Discrete-Continuous Model for Land Use Change Analysis, S. K. Dubey and C. R. Bhat, UT-Austin, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, DC, January, 2014. (Product of SWUTC Project #600451-00063)

Transportation Systems and the Built Environment: A Life-Cycle Energy Case Study and Analysis, Kara Kockelman, UT-Austin, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, DC, January, 2014. (Product of SWUTC Project #600451-00067)

Establishing the Variation of Dynamic Traffic Assignment Results Using Subnetwork Origin-Destination Matrices, Gemar, Bringardner, Boyles and Machemehl, UT-Austin, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, DC, January, 2014. (Product of SWUTC Project #600451-00079)

Equilibrium Analysis of Low-Conflict Intersection Designs, S. Boyles, T. Ramba and C. Xie, UT-Austin, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, D.C., January, 2014. (Product of SWUTC Project #600451-00079)

Subnetwork Analysis for Dynamic Traffic Assignment Models: A Strategy for Estimating Demand at Subnetwork Boundaries, Gemar, Bringardner, Boyles and Machemehl, UT-Austin, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, DC, January, 2014. (Product of SWUTC Project #600451-00079)

Environmental Implications of Shared Autonomous Vehicles Using an Agent-Based Model, Kara Kockelman, UT-Austin, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, D.C., January, 2014. (Product of SWUTC Project #600451-00081)

Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations for Capitalizing on Self-Driven Vehicles, Kara Kockelman, UT-Austin, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, DC, January, 2014. (Product of SWUTC Project #600451-00081)

Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations for Capitalizing on Self-Driven Vehicles, Kara Kockelman and Joshua Shank (Eno Executive Director), UT-Austin, presented to the U.S. House Subcommittee on Highways and Transit, Washington, DC, January, 2014. (Product of SWUTC Project #600451-00081)

Evaluation of Current Incident Detection Algorithms, Randy Machemehl, UT-Austin, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, DC, January, 2014. (Product of SWUTC Project #600451-00083)

Effect of Aggregate Micro- and Macro-Texture on Pavement Skid Resistance, Prasad Buddhavarapu, UT-Austin, presented at the 4<sup>th</sup> International Safer Roads Conference, Cheltenham, UK, May, 18-21, 2014. (Product of SWUTC Project #600451-00085)

Development and Application of the Gulf Coast Megaregion Evacuation Traffic Model, Bryan Wolshon, LSU, presented at the 2014 National Hurricane Conference, Orlando, FL, April, 2014. (Product of SWUTC Project #600451-00101)

Megaregion Evacuation Analysis, S. Parr, LSU, presentation to the 2013 Conference of Visualization of Big Data, Irvine, CA, October 2013. (Product of SWUTC Project #600451-00101)

Megaregion Evacuation Simulation and Analysis, Bryan Wolshon, LSU, presented at the 2013 Sea Level Rise Summit, Fort Lauderdale, FL, October 2013. (Product of SWUTC Project #600451-00101)

Effects of Varying Work Zone Configurations, Distances Between Traffic Signs and Individual Differences on Drivers' Perceived Workload, M. Shakouri, K. Punniaraj, F. Aghazadeh, L. Ikuma, and S. Ishak, LSU, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, D.C., January, 2014. (Product of SWUTC Project #600451-00103)

Assessment of The Impacts Of Merge Configuration, Traffic Density and The Distance Between Traffic Signs Near Free Way Work Zones on Drivers' Response, K. Punniaraj, M. Shakouri, F. Aghazadeh, L. Ikum, and S. Ishak, LSU, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, D.C., January, 2014. (Product of SWUTC Project #600451-00103)

Beyond Container Volumes: Panama Canal Expansion, Bulk Commodity Exports and the U.S. Gulf Coast, James Amdal, UNO, presented at the 93<sup>rd</sup> TRB Annual Meeting, Washington, DC, January, 2014. (Product of SWUTC Project #600451-00105)

States' Tools for Connecting Transportation and Affordable Housing, Catherine Lowe, UNO, presented at the 2014 American Planning Association Louisiana State Planning Conference, New Orleans, LA, January 29-31, 2014. (Product of SWUTC Project #600451-00107)

Assessing the Mega-Region: Evaluating the Role of Livable Community Patterns in Gulf Coast Mega-Region Planning, Billy Fields, UNO, presented at the National Urban Affairs Association Conference, San Antonio, TX, March 2014. (Product of SWUTC Project #600451-00109)

Operation Characteristics of Manual Traffic Control for Mass Egress, S. Parr and B. Wolshon, LSU, presented at the 2014 National Evacuation Conference, New Orleans, LA, January, 2014. (Product of SWUTC Project #600451-00113)

Effect of Phased Evacuations in Megaregion Highway Networks, B. Wolshon, LSU, presented at the 93<sup>rd</sup> TRB Annual Meeting, Session 814, Washington, D.C., January, 2014. (Product of SWUTC Project #600451-00114)

Websites (other than SWUTC website) and other social media utilized for this reporting period:

Project 161302: <http://mobility.tamu.edu/ums/>

Project 600451-00081: <http://www.caee.utexas.edu/prof/kockelman>

Project 600451-00081: <http://www.enotrans.org/>

Project 600451-00081: <http://www.journals.elsevier.com/transportation-research-part-c-emerging-technologies/>

Project 600451-00082: <http://www.trb.org>

Project 600451-00082: <http://www.lib.ctr.utexas.edu>

Project 600451-00083: <http://www.ascelibrary.org>

Project 600451-00101: <http://www.evaccenter.lsu.edu>

Project 600451-00106: <http://brr.berkeley.edu/wp-content/uploads/2013/05/Lowe-capacity-equity.pdf>

Project 600451-00113: <http://trid.trb.org/view/2013/P/1251599>

Project 600451-00119: <http://www.transpotation.uno.edu>

Project 600451-00119: <http://pbriLA.org>

Technologies or techniques for this reporting period:

◆ **Algorithm Developed** – SWUTC Project #161304 – How do Travelers Perceive and Value Travel Time Reliability developed an algorithm (technique) to identify individual trips and related trip attributes on a freeway using automated vehicle identification (AVI) records and tolling information from the sensors on the freeway. The technique was subsequently used for a study on Atlanta I-85 Express Lanes, which have similar AVI and toll sensors.

◆ **New Technology** – SWUTC Project #600451-00009 – Sustainability of Transportation Structures Using Composite Materials to Support Growth and Trade developed and extensively tested a new anchorage system to improve the gripping capacity and sustainability performance during conventional stressing techniques on aramid-fiber-reinforced polymer (AFRP) bars.

◆ **New Diagnostic Technique** – SWUTC Project #600451-00028 – Sustainability of Bridge Foundations Using Electrical Resistivity and Induced Polarization to Support Transportation Safety produced a new technique utilizing induced polarization and electrical resistivity to determine the depth and shape of unknown bridge foundations.

◆ **Technique to Enhance DTA Software** - SWUTC Project #600451-00079 – Game-Theoretic Analysis of Dynamic Traffic Equilibria produced a new technique to address the problem of multiple equilibrium solutions that may arise in current DTA software packages.

◆ **New Performance Technique** – SWUTC Project #600451-00103 – Effects of Changing Driving Conditions on Driver Behavior towards Design of a Safe and Efficient Traffic System developed a technique to evaluate the performance of a newly proposed merge configuration known as Joint Merge from safety and human factors perspective. The final product proved to be safe and efficient in guiding vehicles through construction zones.

◆ **Crash Modification Factors Developed:** SWUTC Project #600451-00044 – Left-Turn Lanes at Unsignalized Median Openings developed Crash Modification Factors (CMFs) for future applications in projecting the change in crash frequency, given a specific change in left-turn lane length.

Inventions/patent applications/licenses for this reporting period: Nothing to report at this time.



Other Products for this reporting period:

◆ **Curriculum Developed:**

- SWUTC Project 600451-00032 - Development of New Collaborative Transportation Statistics and Microsimulation Distance Learning Course produced a new graduate course available at TAMU and the University of Nebraska-Lincoln.
- Research findings from SWUTC Project #600451-00079 – Game-Theoretic Analysis of Dynamic Traffic Equilibria have been incorporated into a graduate course on Dynamic Traffic Assignment (CE392D) at the University of Texas at Austin.
- Methodology developed by SWUTC Project #600451-00083 – Improving the Reliability of Automated Freeway Incident Detection Using Multiple Real Time Data Sources is being implemented in the curricula for a graduate and an undergraduate traffic engineering course within the University of Texas Transportation Engineering program. Study results have led to new course problem sets and field tests to be performed by the students in the classes.

◆ **Models Developed:**

- SWUTC Project #161342 – Use of Directional Median Openings on Urban Freeways developed a Poisson regression model to investigate the influencing factors on the crashes which occurred at the downstream U-turn locations of directional median openings.
- SWUTC Project #600451-00010 – Enhanced Adaptive Signal Control Using Dedicated Short Range Communications developed a queue estimation model and signal control logic based on estimated queue from Connected Vehicle technologies.
- SWUTC Project #600451-00014 – Novel Transit Signal Priority under the Connected Vehicle Framework developed a model which uses a stochastic mixed-integer nonlinear model (SMINP) as the core component of a real-time transit signal priority control system. The model adopts a novel approach to capture the impacts of the priority operation to other traffic by using the deviations of the phase split times from the optimal background split times. In addition, the model explicitly accounts for the randomness of a bus arrival time to the stop bar, by considering the bus stop dwell time and the delay caused by standing vehicle queues. The SMINP has yielded as much as 30% improvement of bus delay by handling bus priority request much more effectively under congested traffic conditions.
- SWUTC Project #600451-00044 – Left-Turn Lanes at Unsignalized Median Openings produced a new model for estimating the length of left-turn lanes at unsignalized median openings. This is a unique model that can take account of the impacts of u-turn traffic at the median openings. This is an important feature because with the increasing use of directional median openings and indirect left-turns on urban roadways, u-turn traffic will become more prevalent.
- SWUTC Project #600451-00079 – Game-Theoretic Analysis of Dynamic Traffic Equilibria produced new models that can be integrated into existing software for Dynamic Traffic Assignments.
- SWUTC Project #600451-00083 – Improving the Reliability of Automated Freeway Incident Detection Using Multiple Real Time Data Sources developed an incident detection model designed to have significantly better reliability than existing algorithms during very high density, stop-and-go, freeway driving conditions. Ultimately, the technology could significantly improve the response time of emergency and enforcement activities to freeway incidents. This improvement in emergency response to incidents will reduce the number of secondary collisions and generally mean that user time lost in congestion due to incidents will be reduced.

### 3. Participants & Other Collaborating Organizations

Organizations as SWUTC Partners:

See previous PPRs for extensive list of organizations providing in-kind support in the form of personnel who serve as project monitors for active SWUTC research projects.



#### **New partnerships/collaborations for this reporting period:**

Ron Feltz, Marketing Manager, Jebro – Contribution: in-kind support – provided various types of asphalt binder samples for SWUTC Project #600451-00025.

Knife River – Contribution: in-kind support – provided raw materials at no cost for SWUTC Project #600451-00025.

Raymond Butler of Butler Consulting – Contribution: in-kind support – shared data and a cost model for SWUTC Project #600451-00080.

The Eno Center for Transportation – Contribution: in-kind support – helped sponsor and develop the paper titled Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations for Capitalizing on Self-Driven Vehicles which was presented to the U.S. House Subcommittee on Highways and Transit for SWUTC Project #600451-00081.

Capital Area Metropolitan Planning Organization (Austin) – Contribution: in-kind support – providing support for use of its Demographic Allocation Tools that help modeling work for SWUTC Project #600451-00088.

Louisiana Department of Transportation and Development – Contribution: in-kind support - provided roadway data files and historical crash data from 2009 to 2011 to support the analysis and calibration efforts of SWUTC Project #600451-00102.

Texas State University – Dr. William Fields – Contribution – in-kind support - provided faculty time for SWUTC Project #600451-00106.

University of New South Wales, Sydney Australia – Dr. Vinayak Dixit – Contribution: in-kind support – assisted in the development of some components of the research methodology for SWUTC Project #600451-00113.

New Orleans Regional Planning Council – Contribution: in-kind support – provided data for SWUTC Project #600451-00115.

The Greater New Orleans Community Data Center (GNOCDC) – Contribution: in-kind support – provided data for SWUTC Project #600451-00115.

The University of New Orleans – Office of Research and Sponsored Programs – Contribution: financial support - for principal investigator to design and pilot the interview instrument and the purchase of two licenses of NVivo, a software package for managing and analyzing qualitative data utilized for SWUTC Project #600451-00115.

Rutgers University – David Listokin – Contribution: in-kind support - provided faculty time for SWUTC Project #600451-00116.

HRI Properties – Hal Fairbanks, Pres Kabacoff – Contribution: in-kind support and facilities - participated in conference calls and workshop, provided meeting space, contributed to case study research for SWUTC Project #600451-00116.

National Complete Streets Coalition - Contribution: in-kind support - review of draft survey instrument and provided feedback prior to its release for SWUTC Project #600451-00119.

State Smart Transportation Initiative - Contribution: in-kind support - review of draft survey instrument and provided feedback prior to its release for SWUTC Project #600451-00119.

#### **4. Impact**

##### *Impact on the development of the principal disciplines of the program for this reporting period:*

##### **◆ Civil Engineering:**

- Results from SWUTC Project #600451-00010: Enhanced Adaptive Signal Control Using Dedicated Short Range Communications could lead to a new type of adaptive signal control algorithm (based on queue lengths) which could help alleviate congestion by decreasing total delay and preventing queue overflow.
- SWUTC Project #600451-00014: Novel Transit Signal Priority under the Connected Vehicle Framework explored a fundamentally new way to operate traffic signal systems to provide transit signal

priority at signalized intersections in urban environments. The study findings will potentially impact transit system planning and operations. The research also has the potential to impact future development of traffic signal operating systems.

◆ **Civil Engineering/Structures:**

- Results from SWUTC Project #600451-00009: Sustainability of Transportation Structures Using Composite Materials to Support Growth and Trade confirm the strength and deformation capacities of composite girders. Study findings being applied to a new research effort funded by the Association of American Railroads on the application of AFRP bars in railroad concrete ties. This study also developed a new anchorage system to improve the gripping capacity and sustainability performance during conventional stressing tests on aramid-fiber-reinforced polymer (AFRP) bars.
- The results of SWUTC Project #600451-00028: Sustainability of Bridge Foundations Using Electrical Resistivity and Induced Polarization to Support Transportation Safety directly benefit the state of good repair of the nation's bridge inventory. For certain types of bridge foundations, it provides a new, less costly and effective method for determining foundation depth. Researchers also showed that the method can be used for imaging other subsurface structures such as gas lines and other underground utilities.

*Impact on other disciplines for this reporting period:*

◆ **Impacts on Behavioral Economics, Statistics and Econometrics.** The results of SWUTC Project #161304: How do Travelers Perceive and Value Travel Time Reliability borrow concepts from and impact the fields of transportation engineering, behavioral economics, statistics and econometrics. The research identifies the complexities of quantifying behavioral attributes such as the value travelers place on travel time reliability. It also identifies the limitations of some of the statistical modeling techniques and suggests possible ways of improving the models.

◆ **Impacts on Cognitive Psychology and Cognitive Ergonomics.** SWUTC Project #600451-00103: Effects of Changing Driving Conditions on Driver Behavior towards Design of a Safety and Efficient Traffic System studied a new work zone layout and its impact on drivers' workload. Workload, in this context, is the amount of mental and physical stress that a driver experiences when he/she drives in a certain environment. This notion is widely researched in psychology and is perceived as one of the main factors that affects drivers' performance.

*Impact on the transportation workforce development for this reporting period:*

◆ **Provide Opportunities for Students to Participate in SWUTC Research.** SWUTC requires that students be involved in a meaningful way in the conduct of all SWUTC research efforts. During this reporting period, 71 graduate students and 7 undergraduate students were involved in the SWUTC research activities.

◆ **Graduate Scholarships Provided.** The SWUTC graduate scholarship programs provide stipends to students to participate in classroom and sponsored research activities. Graduate students supported this reporting period: 26

◆ **Undergraduate Summer Fellowships Provided.** This program recruits juniors and seniors from other universities and from diverse academic backgrounds into a summer-long program in transportation research and education as a first step towards graduate study in transportation. Undergraduate students supported this reporting period: 4

◆ **Research Results Transferred to the Classroom.**

- Research findings from SWUTC Project #600451-00079 – Game-Theoretic Analysis of Dynamic Traffic Equilibria have been incorporated into a graduate course on Dynamic Traffic Assignment (CE392D) at the University of Texas at Austin.
- Methodology developed by SWUTC Project #600451-00083 – Improving the Reliability of Automated Freeway Incident Detection Using Multiple Real Time Data Sources is being implemented in the curricula

for a graduate and an undergraduate traffic engineering course within the University of Texas Transportation Engineering program. Study results have led to new course problem sets and field tests to be performed by the students in the classes.

◆ **New Graduate Course Developed.** SWUTC Project 600451-00032 - Development of New Collaborative Transportation Statistics and Microsimulation Distance Learning Course produced a new practice-based statistics distance-learning graduate course available at TAMU and the University of Nebraska-Lincoln. This course provides students with an improved ability to analyze data, design better experiments, develop better data collection plans, and be able to make more insightful statements about experimental and observed transportation data, and communicate their results more clearly. Number of students attending Spring 2014 session: 20.

Impact on physical, institutional, and information resources at the university or other partner institutions for this reporting period:

Nothing to report.

Impact of technology transfer for this reporting period:

◆ **Informing the Public and Decision Makers.**

- SWUTC Project #161304: How do Travelers Perceive and Value Travel Time Reliability focused on studying existing travel behavior on a freeway with both tolled and free lanes. The research provides a better understanding of how travelers make decisions and choose between different options. This knowledge can be used to make better-informed infrastructure funding decisions and improve the existing transportation system. On the service provider side, this knowledge can help better price existing infrastructure to reduce overall travel time, (un)reliability and optimize revenue generation. On the consumer (traveler) side, better understanding of the system would enable travelers to make better use of the existing facilities and maximize their own utility. Overall, this would lead to improved social, economic and environmental conditions.
- The principal impact of SWUTC Project #161305: Strategic Transportation Finance Clearinghouse was to increase awareness and understanding of public-private partnership techniques for policy makers and transportation planners seeking a higher degree of information. Over time, this will facilitate better decision making.
- The results of SWUTC Project #161342: Use of Directional Median Openings on Urban Roadways provide guidelines to transportation engineers in appropriately implementing directional median openings. The developed methods, models and major findings of this research can be incorporated into the state or Federal roadway design manuals.
- SWUTC Project #600451-00029: Policy Implications of Automated Vehicles on Texas Highways developed a better understanding of how automated vehicles could affect state and local transportation agencies; it helped to identify areas for future research; it identified emerging policy issues; it furthered the understanding of the economic implications of automation; and it fostered a greater understanding of the automated vehicle industry perspective with regard to regulating automated vehicles. Utilizing the knowledge gained from this research, legislative entities could draft and pass public policies related to automated vehicles. Similarly, it is also possible that governmental entities could make decisions in a non-legislative manner based on the information developed as a result of this research.
- The results of SWUTC Project #600451-00044: Left-Turn Lanes at Unsignalized Median Openings provide guidelines to transportation engineers in implementing appropriate left-turn lanes at unsignalized median openings. The developed methods, tables, and models can be incorporated into the state or Federal roadway design manuals.
- The methodology developed by SWUTC Project #600451-00046: A Case Study of Severe Environmental Justice Communities in the Houston Region to determine justice zones is beneficial to metropolitan planning organizations (MPOs) trying to more accurately identify these areas. Specifically, the results from this research can impact the planning and decision making policies for the Houston-Galveston Area

Council (H-GAC) MPO. The agency is interested in knowing how their planning policies impact EJ communities. While the study revealed that the most extreme tracts still maintained good access to public transit, H-GAC can ensure that future policies and capital expenditures benefit or enhance livability and access in and around these identified EJ zones.

- Results from SWUTC Project #600451-00079: Game-Theoretic Analysis of Dynamic Traffic Equilibria has direct implications on policy making in transportation as all planning models use traffic assignment to evaluate the impacts of improvement strategies on congestion. However, when multiple equilibria exist, it becomes difficult to make policy decisions as different results could favor the selection of different projects. While current modeling practices have been oblivious to the problem of multiple equilibria, the researchers point out its occurrence and importance and propose ways to model it.

The research team had conversations with modelers at the Capital Area Metropolitan Planning Organization discussing the research results. While the research results have not yet been implemented these conversations have laid the ground for future research.

This research can also be applied to other areas in that the problem is similar in many ways to routing in telecommunication networks and equilibrium in queuing systems.

- SWUTC Project #600451-00103: Effects of Changing Driving Conditions on Driver Behavior towards Design of a Safe and Efficient Traffic System - Many people, such as drivers, workers and transportation authorities can benefit from the improvements suggested by this project's findings. Using Joint Lane Merge can reduce the number of accidents and fatalities and improve driving flow which results in less time in traffic and consequently less fuel consumption. The results from this research could impact DOT's guidelines for road closure.
- Findings from SWUTC Project #600451-00107: States' Tools for Connecting Transportation and Affordable Housing can serve as a resource for transportation agencies (especially MPOs) and housing agencies (especially those responsible for allocating low-income housing tax credit). It is part of the ongoing effort by many policy actors to better tie transportation to issues – like housing.

Impact on society beyond science and technology for this reporting period:

- ◆ **Reduced Crash Rates.** SWUTC Project #161342: Use of Directional Median Openings on Urban Roadways investigated the safety impacts of installing directional openings on median-divided urban roadways. The results of this research indicate that, since converting a full median opening to a directional median opening will generate more U-turns at the downstream opening of directional opening, the selection of U-turn location is critical for the safety performance of directional openings. The results of this research will reduce the crash rates related to the use of directional median openings. Thereby, it will reduce social and environmental cost associated with the traffic accidents.
- ◆ **Increasing Transit Ridership.** SWUTC Project #600451-00014: Novel Transit Signal Priority under the Connected Vehicle Framework developed a fundamentally new way to operate traffic signal systems to provide transit signal priority at signalized intersections in urban environments. This new system will greatly improve bus delay and likely change the public's attitude about the effectiveness of transit as an alternative mode of transportation for relieving congestion.
- ◆ **Improved Traffic and Parking on TSU Campus.** SWUTC Project #600451-00042: Exploring Sustainable Transportation for Texas Southern University reviewed alternative transportation solutions for Texas Southern University to decrease its carbon footprint by changing the way faculty, staff and students arrive at the campus. By utilizing environmentally friendly transportation options, such as carpools/vanpools or rideshare programs, users would see economic savings in gas, time, car maintenance and repair.
- ◆ **Improving Incident Response Time.** SWUTC Project #600451-00083: Improving the Reliability of Automated Freeway Incident Detection Using Multiple Real Time Data Sources developed an incident detection model designed to have significantly better reliability than existing algorithms during very high density, stop-and-go, freeway driving conditions. The new technology will enable control centers to detect the problem essentially as it happens and greatly impress those involved with the responsiveness reducing user time loss,

secondary collisions and positively impacting the opinions of travelers. The research team is currently working with the Texas Department of Transportation to implement the new technology in traffic control center operations.

## **5. Changes/Problems**

Nothing to report.