Program Progress Performance Report

Submitted to:	U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology
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Project Title:	Data-Supported Transportation Operations and Planning (D-STOP) Center
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Signature:	

1. ACCOMPLISHMENTS

What are the major goals of the program?

The Data-Supported Transportation Operations and Planning (D-STOP) Center's vision is to be a national and international multimodal and multidisciplinary center of excellence that promotes the integration of cutting-edge developments in wireless sensor networks and communications technology with transportation systems to improve the United States' economic competitiveness. This vision will be implemented through a research mission, an education and workforce development mission, and a technology transfer mission.

D-STOP's *research mission* is to develop fundamentally new methodologies to better harness traditional and recent data sources, and potentially develop new sources, in seeking to improve models for transportation planning and traffic operations. D-STOP research will occur in three areas: operations, planning, and technology, with significant priority placed on work that cuts across these areas.

The *education and workforce development (EWD) mission* is to build a transportation workforce that is able to use multi-disciplinary approaches to address multi-dimensional complex problems, through an emphasis on real-time data analysis and processing, the study of the dynamics underlying human activity-travel decision-making, and training on the effective use of information technology innovations.

D-STOP's *technology transfer (TT) mission* is to disseminate information on research activities and findings, and actively promote the utilization and implementation of research products/findings through demonstrations on small-scale networks (in collaboration with industry and public agency partners).

What was accomplished under these goals?

Research Program Accomplishments
D-STOP's research activities focus on harnessing innovative technologies and data sources to develop architectures and systems for data collection and analysis. The research will foster economic competitiveness through its focus on gathering and analyzing data to support effective and efficient decision-making. The major research accomplishment during this reporting period was the continued development of the research agenda in coordination with D-STOP faculty and researchers. A total of 16 projects were pursued with partial or full funding support from D-STOP. Of these, five projects were completed during this reporting period. Currently, 11 projects are underway.

Completed Projects

1. **Transit Demand and Routing after Autonomous Vehicle Availability**
   (PI: Stephen Boyles); End date: December 31, 2015

2. **Coherence Time and Beam Alignment for mmWave Vehicular Communications**
   (PI: Robert Heath); End date: October 31, 2015

3. **Infrastructure-Informed Travel Sheds**
   (PI: Jennifer Duthie); End date: December 31, 2015

4. **A Comprehensive Dwelling Unit Choice Model Accommodating Psychological Constructs Within A Search Strategy for Consideration Set Formation**
   (PI: Chandra Bhat); End date: December 31, 2015

5. **On Accommodating Spatial Interactions in a Generalized Heterogeneous Data Model (GHDM) of Mixed Types of Dependent Variables**
   (PI: Chandra Bhat); End date: December 31, 2015

Ongoing Projects

1. **Semi-Autonomous Parking for Enhanced Safety and Efficiency**
   (PI: Sriram Vishwanath); Anticipated end date: April 1, 2016

2. **Combining Millimeter-Wave Radar and Communication Paradigms for Automotive Applications: A Signal Processing Approach**
   (Co-PI: Robert Heath and Chandra Bhat); Anticipated end date: May 31, 2016

3. **Improved Traffic Operations through Real-Time Data Collection and Control**
   (Co-PIs: Stephen Boyles and Sanjay Shakkottai); Anticipated end date: May 31, 2016

4. **Models for High Dimensional Mixed Regression**
   (Co-PIs: Constantine Caramanis and Chandra Bhat); Anticipated end date: September 30, 2016

5. **Streaming PCA with Many Missing Entries**
   (PI: Constantine Caramanis); Anticipated end date: September 30, 2016

6. **Greedy Subspace Clustering**
   (PI: Constantine Caramanis); Anticipated end date: September 30, 2016

7. **High-precision GPS Vehicle Tracking to Improve Safety**
   (Co-PIs: Jennifer Duthie and Todd Humphreys); Anticipated end date: April 30, 2016

8. **The Formulation and Estimation of a Spatial Skew-Normal Generalized Ordered-Response Model**
   (PI: Chandra Bhat); Anticipated end date: June 30, 2016

9. **A Latent Class Multiple Constraint Multiple Discrete-Continuous Extreme Value Model of Time Use and Goods Consumption**
   (PI: Chandra Bhat); Anticipated end date: June 30, 2016

10. **Transportation Data Discovery Environment**
    (PI: Jennifer Duthie); Anticipated end date: August 31, 2018
    The aim of this proposal is to develop a microeconomic time-use framework that (a) accommodates technological relationships between time allocated to activities and goods consumption, and (b) proposed a discrete distribution for the response coefficients. This latent class model will be able to identify different segments of the population, each one of them with different effects of the exogenous variables on time allocation, activity participation, and goods consumption. This endogenous segmentation will be compared in a comprehensive fashion with the typical segmented estimation of microeconomic time use models (of the type discussed in the first paragraph of this abstract) from a theoretical, conceptual, and empirical data fit standpoint. The empirical analysis will be pursued using a 2012 Dutch data set on weekly time use and good expenditure.

11. **Travel Modeling in an Era of Connected and Automated Transportation Systems: An Investigation in the Dallas-Fort Worth Area**
    Joint Project with North Central Texas Council of Governments (NCTCOG)
    (PI: Chandra Bhat; Researchers: Natalia Ruiz Juri, James Kuhr, Mason Gemar, Jen Duthie); Anticipated end date: December 31, 2016
    There is substantial anticipation and excitement in the area of connected/automated vehicles (CAVs) and transportation systems in terms of their potential to improve transportation safety and enhance mobility and accessibility. CAVs can have a substantial impact on travel patterns and roadway performance, and on mobile source-emissions, fundamentally altering strategic planning decision. Within this context, and given that metropolitan planning organizations (MPOs) incorporate a multi-decade (20 or more years) planning horizon in their long-term planning process, it is important that NCTCOG considers the implications of CAVs early on.

Research Results Disseminated: Thirteen papers were published and nineteen papers are forthcoming in refereed journals based on the research projects associated with D-STOP. Several other papers are in the review process. Thirty-four presentations were made at conferences and meetings.

Plans for Next Reporting Period to Accomplish Research Goal: Provide support, guidance, and assistance to project Principal Investigators so individual research project objectives can be achieved. Undertake supporting research funded through the Texas Department of Transportation.

Education and Workforce Development Accomplishments

The research projects outlined above have several students working on them. Please note that students work in groups. Some are on fellowships, or obtain funding from other sources too. Below, we indicate all students who undertake research associated with D-STOP, regardless of whether they obtain no funding support or only partial funding support from D-STOP. The students are:

Undergrad

Maitri Zalawadia, Lauryn Altena, Isha Deo (supervised by Chandra Bhat)
Rebecca Hutchinson, Rahul Patel, Tejas Chaudhary, Mark Stahl, Hagen Fritz (supervised by Stephen Boyles)
Bruno Chiquini, Abigail Smith (supervised by Jen Duthie)
Cooper Raterink (supervised by Robert Heath)

Grad

Supervised by Chandra Bhat: Sebastian Astroza (PhD), Alice Chu (MS), Amanda Deering (MS), Felipe Dias (PhD), Subodh Dubey (PhD), Vivek Kumar (MS), Patricia Lavieri (PhD).
Supervised by Stephen Boyles: John Helsel (MS), Ehsan Jafari (PhD), Rachel James (MS), Michael Levin (PhD), Venktesh Pandey (MS), Tarun Rambha (PhD).
Supervised by Jennifer Duthie: Jackson Archer (MS), Hao Pang (PhD).
Supervised by Constantine Caramanis: Xinyang Yi (PhD), Dohyung Park (PhD).
Supervised by Robert Heath: Anum Ali (PhD), Preeti Kumari (MS), Vutha Va (PhD), Yuyang Wang (MS), Enoch Yeh, (MS).
Supervised by Todd Humphreys: Lakshay Narula (MS), Jahshan Bhatti (PhD), Ken Pesyna (PhD).
Supervised by Sanjay Shakkottai: Tzu-Ling Kan (PhD).

Post Docs

Anastasios Kyrillidis (supervised by Constantine Caramanis)
Junil Choi (supervised by Robert Heath)

The D-STOP Center selected MS student Alice Chu (supervised by Dr. Chandra Bhat) as its 2015 Outstanding Student of the Year. MS student Michael Levin (supervised by Dr. Stephen Boyles) was awarded the Council of University Transportation Centers (CUTC) 2015 Milton Pikarsky Memorial Award for his MS thesis entitled “Integrating Autonomous Vehicle Behavior into Planning Models”. Alice and Michael were recognized at an annual awards banquet in January 2016 in Washington DC before the TRB Annual Meeting.

Education and Workforce Development Results Disseminated:

Activity-based Modeling: A Short Course

Chandra Bhat provided a one-day course on December 17, 2016 on activity-based travel modeling, including data and models for regional planning and policy analysis while at the 3rd Conference of the Transportation Research Group of India (3rd CTRG). The course was delivered to graduate students from around the world, and public agencies in Kolkata to move to the forefront of model development to address the increasingly complex land-use, built environment, transport, and environmental policies, the analyses of which far exceed the capabilities of the usual modeling/simulation techniques (approx. 250 attendees).

DTA Training 1.0 Workshop
The Network Modeling Center (NMC) at CTR has been working since 2011 on a new modeling tool for the Central Texas region, both researching and deploying advanced traffic models. The resulting dynamic traffic assignment (DTA) tool enables us to better understand traffic patterns related to congestion, particularly how congestion levels respond to changes to the infrastructure. In January, the NMC held two half-day workshops to share the technology and introduce local agency staff to DTA modeling and data and visualization tools. A small class size of 15 participants each day facilitated hands-on learning and discussion. Staff from the Capital Area Metropolitan Planning Organization, and its member cities and counties, were introduced to CTR's modeling and data visualization tools by the NMC's Jen Duthie, Mason Gemar, and Natalia Ruiz Juri. Modelers Ken Perrine and Itamar Gal were also on hand to provide one-on-one assistance.

Explore UT
Robert Heath and his students gave demonstrations of vehicular forward collision detection using a wi-fi based radar at Explore UT on March 5, 2016. Held annually at UT Austin, Explore UT aims to inform students, parents, teachers and community members from across the state about the importance of the public research institution and higher education in Texas. The day-long event invites Texans of all ages to experience robust research experiences, hands-on demonstrations and experiments, and participate in the richness of the university's scholarship and knowledge.

Prospective Grad Student Lunch: Dr. Chandra Bhat and Dr. Stephen Boyles met with visiting prospective graduate students and current graduate students during a lunch meeting organized by the transportation graduate program on March 4, 2016. This session was designed to provide information to prospective graduate students of research currently being undertaken at UT-Austin, including under the D-STOP Center. The presentation also discussed ways to make the transition to graduate school easy, and the expectations of graduate school.

Business Advisory Council Meeting
D-STOP held its first Business Advisory Council meeting on March 31, 2016. The overall purpose of the BAC is to help guide the direction of the D-STOP Center's overall research and education/work force development efforts. Together, the intent is that D-STOP serves not only as a mechanism to undertake cutting edge research of relevance, but also as a vehicle to reduce the incubation time from research to implementation and contribute to the next generation of thought leaders. The BAC meeting helped to (a) provide strategic planning advice to the Center, (b) provide input on Center activities and review project statements for research, (c) identify research projects for further collaborative funding and possible implementation beyond Center funding, and (d) facilitate the collaborative process of linking the Center with private, public, and policy entities, and with regional and national activities (approx. 30 attendees).

Dr. Bhat is a member of the Engineering Advisory Board of Westwood High School and continues to advise the school on engineering curriculum issues.

Plans for Next Reporting Period to Accomplish Education and Workforce Development Goal:
Continue discussions with the Business Advisory Council (BAC), following on a BAC meeting held March 31, 2016. The University Transportation Center-Undergraduate Internship (UTC-UI) program will be held for a third year in the summer of 2016, and organization is underway. Each intern will participate in a research project related to the D-STOP center, and a weekly seminar will be held. Recruit and introduce a fresh batch of graduate students to D-STOP.

Technology Transfer Accomplishments
Technology transfer activities will be pursued to deliver timely information on research activities and findings. These activities include: maintaining a D-STOP website, producing high quality peer-reviewed journal papers, and supporting researcher travel to participate in conferences that disseminate research results.

D-STOP website: The D-STOP website provides information about the Center and includes a listing of current research projects being conducted, as well as educational information, technology transfer, news and events, publications, and resources applicable to the to the overall D-STOP effort. The website address is dstop.utexas.edu

2015 Texas Wireless Summit

The Texas Wireless Summit (TWS), hosted by the Wireless Networking and Communications Group (WNCG), was held October 16, 2015 at UT Austin. TWS 2015 explored next-generation wireless networks in a day-long event focused on "The View to 5G: From Applications to the Air Interface." The 13th annual TWS provided a forum on emerging technology and business models for industry leaders and academics. Hosted by D-STOP affiliate center Wireless Networking and Communications Group (WNCG), TWS offered direct access to cutting-edge research and innovations from industry leaders, investors, academics, and startups. Through keynote and panel-driven discussions, leading business and technology executives and top academics shared entrepreneurially oriented research. D-STOP's Robert Heath and CTR affiliate researcher Jeff Andrews chaired this year's event, which supported D-STOP's technology transfer mission of disseminating information on research activities and findings, and actively promoting the utilization and implementation of research products/findings (in collaboration with industry and public agency partners). This year's keynote speakers included Gerhard Fettweis, the Vodafone Chair at the Technical University of Dresden, and Tom Marzetta, a Group Leader of Large-Scale Antenna Systems at Alcatel-Lucent Bell Labs.

Better Streets Week Lunch Event

The Center for Transportation Research organize a lunch event on October 26, 2015 as part of Better Streets Week. Better Streets Week is a series of community-facing events in the week leading up to the annual meeting of the National Association of City Transportation Officials (NACTO). The CTR lunch event, titled "Fast-Paced Stories: What Transportation Data Tells Us," highlighted key findings that point to solutions for our mobility future. Researchers from UT Austin, the Texas A&M Transportation Institute, and Texas State University used a brisk presentation format to translate research findings into layman's language; each seven-minute talk concluded with three minutes for Q&A and discussion. Dr. Jen Duthie, Director of CTR's Network Modeling Center, spearheaded the event organization for CTR, and Texas State Representative Celia Israel moderated the presentations.

Publications: Papers whose research is fully or partially supported by D-STOP:

Published:

Bhat, C.R., M. Castro, and A.R. Pinjari (2015), "Allowing for Complementarity and Rich Substitution Patterns in Multiple Discrete-Continuous Models." *Transportation Research Part B*, 81(1), 59-77.

Shin, J., C.R. Bhat, D. You, V.M. Garikapati, and R.M. Pendyala (2015), "Consumer Preferences and Willingness to Pay for Advanced Vehicle Technology Options and Fuel Types." *Transportation Research Part C*, 60, 511-524.

Bhat, C.R., S.K. Dubey, M. Jobair Bin Alam, and W.H. Khushefati (2015), "A New Spatial Multiple Discrete-Continuous Modeling Approach to Land Use Change Analysis." *Journal of Regional Science*, 55(5), 801-841.

Wafa, Z., C.R. Bhat, R.M. Pendyala, and V.M. Garikapati (2015), "A Latent-Segmentation Based Approach to Investigating the Spatial Transferability of Activity-Travel Models." *Transportation Research Record*, 2493, 136-144.

Khani, A., and S.D. Boyles (2015), "An Exact Algorithm for the Mean–Standard Deviation Shortest Path Problem." *Transportation Research Part B*, 81, 252-266.

Boyles, S.D., S. Tang, and A. Unnikrishnan (2015), "Parking Search Equilibrium on a Network." *Transportation Research Part B*, 81, 390-409.

Levin, M., and S.D. Boyles (2015), "Effects of Autonomous Vehicle Ownership on Trip, Mode, and Route Choice." *Transportation Research Record*, 2493, 29-38.

Levin, M., and S.D. Boyles (2015), "Intersection Auctions and Reservation-based Control in Dynamic Traffic Assignment." *Transportation Research Record*, 2497, 35-44.

Jafari, E. and S.D. Boyles (2016), "Improved Bush-Based Methods for Network Contraction." *Transportation Research Part B*, 83, 298-313.

Levin, M.W., and S.D. Boyles (2016), "A Multiclass Cell Transmission Model for Shared Human and Autonomous Vehicle Roads. *Transportation Research Part C*, 62, 103-116.

Perrine, Kenneth, Alireza Khani, and Natalia Ruiz-Juri (2015). "Map-Matching Algorithm for Applications in Multimodal Transportation Network Modeling." *Transportation Research Record: Journal of the Transportation Research Board* 2537, 62-70.

Krishnasamy, S., and S. Shakkottai, (2015) "Spectrum Sharing and Scheduling in D2D-Enabled Dense Cellular Networks." *Proceedings of 13th International Symposium on Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks (WiOpt*), Mumbai, India, May (invited paper).

Chen, Y., H. Xu, C. Caramanis and S. Sanghavi (2015), "Matrix Completion with Column Manipulation: Near Optimal Sample-Robustness-Rank Tradeoffs." *IEEE Transactions on Information Theory*, 62(1), 503-526.

Forthcoming:

Bhat, C.R., S. Astroza, and A.C. Bhat, "On Allowing a General Form for Unobserved Heterogeneity in the Multiple Discrete-Continuous Probit Model: Formulation and Application to Tourism Travel." *Transportation Research Part B*, forthcoming.

Bhat, C.R., S. Astroza, A.C. Bhat, and K. Nagel, "Incorporating a Multiple Discrete-Continuous Outcome in the Generalized Heterogeneous Data Model: Application to Residential Self-Selection Effects Analysis in an Activity Time-use Behavior Model." *Transportation Research Part B*, forthcoming.

Kumar, V., C.R. Bhat, R.M. Pendyala, D. You, E. Ben-Elia, and D. Ettema, "The Impacts of an Incentive-Based Intervention on Peak Period Traffic: Experience from the Netherlands." *Transportation Research Record*, forthcoming.

Lavieri, P., C.R. Bhat, R.M. Pendyala, and V.M. Garikapati, "Introducing Latent Psychological Constructs in Injury Severity Modeling: A Multi-Vehicle and Multi-Occupant Approach." *Transportation Research Record*, forthcoming.

Rambha, T., and S.D. Boyles (2016), "Dynamic Pricing in Discrete Time Stochastic Day-to-Day Route Choice Models." *Transportation Research Part B*, forthcoming.

Levin, M.W., and S.D. Boyles (2016), "A Cell Transmission Model for Dynamic Lane Reversal with Autonomous Vehicles. *Transportation Research Part C*, forthcoming.

Patel, R., Levin, M. W., and S.D. Boyles. Effects of autonomous vehicle behavior on arterial and freeway networks. *Transportation Research Record*, forthcoming.

Duell, M., M.W. Levin, S.D. Boyles, and S.T. Waller. The impact of autonomous vehicles on traffic management: the case of dynamic lane reversal. *Transportation Research Record*, forthcoming.

Levin, M.W., and S.D. Boyles. Improving bus routing for KIPP Charter Schools. *Interfaces*, forthcoming.

Boyles, S.D., and T. Rambha. A note on detecting unbounded instances of the online shortest path problem. *Networks*, forthcoming.

Va, V., T. Shimizu, G. Bansal, and R.W. Heath, Jr., "Beam Design for Beam Switching Based Millimeter Wave Vehicle-to-Infrastructure Communications," to appear in Proceedings of the IEEE International Conference on Communications, Kuala Lumpur, Malaysia, May 23-27, 2016.

Ali, A., N. González Prelcic, and R.W. Heath, Jr., "Estimating Millimeter Wave Channels using Out-of-Band Measurements, " (invited) to appear in Proceedings of the Information Theory and Applications, San Diego, California, January 31 - February 5, 2016.

González Prelcic, N., R. Méndez-Rial, and R.W. Heath, Jr., "Radar Aided Beam Alignment in MmWave V2I Communications Supporting Antenna Diversity, " (invited) to appear in Proceedings of the Information Theory and Applications, San Diego, California, January 31 - February 5, 2016.

Heath, Jr., R.W., N. González Prelcic, S. Rangan, W. Roh, and A. Sayeed, "An Overview of Signal Processing Techniques for Millimeter Wave MIMO Systems," to appear in *IEEE Journal on Sel. Topics in Sig. Proc.*, special issue on Massive MIMO.

Ghaderi, J., S. Shakkottai and R. Srikant (2016), "Scheduling Storms and Streams in the Cloud." *ACM Transactions on Modeling and Performance Evaluation of Computing Systems (ACM ToMPECS),* forthcoming.

Psiaki, M.L., and T.E. Humphreys (2016), "GNSS Spoofing and Detection." *Proceedings of the IEEE*, forthcoming.

Narula, L., and T. E. Humphreys (2016), "Requirements for secure wireless time transfer." *Proceedings of the IEEE/ION PLANS 2016 Meeting*, Savannah, GA, April, forthcoming.

Murrian, M., C. Gonzalez, T. E. Humphreys, and T. D. Novlan (2016), "A dense reference network for mass-market centimeter-accurate positioning." *Proceedings of the IEEE/ION PLANS 2016 Meeting*, Savannah, GA, April, forthcoming.

Humphreys, T.E., M. Murrian, K. M. Pesyna, Jr., F. van Diggelen, and S. Podshivalov (2016), "On the feasibility of centimeter-accurate positioning via a smartphones antenna and GNSS chip." *Proceedings of the IEEE/ION PLANS 2016 Meeting*, Savannah, GA, April, forthcoming.

Under review:

Chu, A., M. Motro, J. Choi, A.R. Pinjari, C.R. Bhat, J. Ghosh and R.W. Heath Jr., "Vehicular Ad-Hoc Network (VANET) Simulations of Overtaking Maneuvers on Two-Lane Rural Highways." Submitted to *Transportation Research Part C*.

Yeh, E.R., J. Choi, N.G. Prelcic, C.R. Bhat, and R.W. Heath Jr., "Security in Automotive Radar and Vehicular Networks." Submitted to *Microwave Journal*.

Choi, J., N. González Prelcic, R. Daniels, C. Bhat, and R.W. Heath Jr., "Millimeter Wave Vehicular Communication to Support Massive Sensing." Submitted to *IEEE Communications Magazine*, February 2016.

Va, V., J. Choi, and R. W. Heath Jr., “The Impact of Beamwidth on Temporal Channel Variation in Vehicular Channels and its Implications." *Submitted to IEEE Trans. on Veh. Tech.*, November 2015.

Presentations whose research is fully or partially supported by D-STOP:

Presented:

Bhat, C.R., S. Astroza, and A. Pinjari, "The Formulation and Estimation of a Spatial Skew-Normal Generalized Ordered-Response Model." *17th Advances in Econometrics Conference*, Louisiana State University, Baton Rouge, LA, October 2015.

Levin, M., and S.D. Boyles, "Optimizing Reservation-based Intersections for System Efficiency." *INFORMS Annual Meeting*, Philadelphia, PA, October 2015.

Khani, A., and S.D. Boyles "Auction-based Ridesharing with Pick-up and Drop-off Time Window." *INFORMS Annual Meeting*, Philadelphia, PA, October 2015.

Khani, A., and S.D. Boyles "Reliable Routing in Schedule-based Transit Networks with Stochastic Travel Times." *INFORMS Annual Meeting*, Philadelphia, PA, October 2015.

Rambha, T., and S.D. Boyles, "Mechanism Design for Route Assignment in Traffic Networks." *INFORMS Annual Meeting*, Philadelphia, PA, October 2015.

Jafari, E. and S.D. Boyles, "Decentralized Traffic Assignment for Multi-level Modeling." *INFORMS Annual Meeting*, Philadelphia, PA, October 2015.

Humphreys, T., "Low-Cost Precise Positioning and Perception Security." *Invited presentation, Google[X]*, Mountain View, CA, October 2015.

Humphreys, T., "Low-Cost Centimeter-Accurate Mobile Positioning." *Invited keynote presentation,* Texas GIS Forum, Austin, TX, October 2015.

Humphreys, T., "Low-Cost Centimeter-Accurate Mobile Positioning." University of Minnesota Roadway Safety Institute, Minneapolis, MN, October 2015.

Motro, M., A. Chu, R. Kalantari, J. Choi, J. Xu, A. Pinjari, J. Ghosh, R. W. Heath, C. R. Bhat, "Vehicular Ad-hoc Network (VANET) Simulations of Passing Maneuvers on Two-Lane Rural Highways." *9th University Transportation Centers Spotlight Conference on Connected and Automated Vehicles*, Washington, DC, November 2015.

Bhat, C.R., "Predictive Analytics for Transportation Planning and Operations in a World of Big Data." Keynote presentation, *3rd Conference of Transportation Research Group of India (CTRG)*, Kolkata, India, December 2015.

Bhat, C.R., R.M. Pendyala, and K.G. Goulias "Activity-Based Modeling of Transport Network Demand and Performance." Executive Short Course, *3rd Conference of Transportation Research Group of India (CTRG)*, Kolkata, India, December 2015.

Yi, X. and C. Caramanis, "Regularized EM Algorithms: A Unified Framework and Statistical Guarantees." Presented at the *29th Annual Conference on Neural Information Processing Systems (NIPS)*, Montreal, Canada, December 2015.

Yi, X., Z. Wang, C. Caramanis, and H. Liu, "Optimal Linear Estimation under Unknown Nonlinear Transform." Presented at the *29th Annual Conference on Neural Information Processing Systems (NIPS)*, Montreal, Canada, December 2015.

Bhat, C.R., "A Comprehensive Dwelling Unit Choice Model Accommodating Psychological Constructs Within A Search Strategy for Consideration Set Formation." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Bhat, C.R., S. Astroza, and A.C. Bhat, "On Allowing a General Form for Unobserved Heterogeneity in the Multiple Discrete-Continuous Probit Model: Formulation and Application to Tourism Travel." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Bhat, C.R., S. Astroza, A.C. Bhat, and K. Nagel, "Incorporating a Multiple Discrete-Continuous Outcome in the Generalized Heterogeneous Data Model: Application to Residential Self-Selection Effects Analysis in an Activity Time-use Behavior Model." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Kumar, V., C.R. Bhat, R.M. Pendyala, D. You, E. Ben-Elia, and D. Ettema, "The Impacts of an Incentive-Based Intervention on Peak Period Traffic: Experience from the Netherlands." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Bhat, C.R., A.R. Pinjari, and S.K. Dubey, "On Accommodating Spatial Interactions in a Generalized Heterogeneous Data Model (GHDM) of Mixed Types of Dependent Variables." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Wafa, Z., C.R. Bhat, R.M. Pendyala, and V.M. Garikapati, "A Latent-Segmentation Based Approach to Investigating the Spatial Transferability of Activity-Travel Models." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Ruiz Juri, N., R.M. James, N. Jiang, J. Duthie, A. Pinjari, and C.R. Bhat, "On the Computation of Skims for Large Scale Implementation of Integrated Activity-based and Dynamic Traffic Assignment Models." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Rambha, T., and S.D. Boyles. "Reinforcement learning approaches for dynamic congestion pricing in day-to-day network models." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Patel, R., M.W. Levin, and S.D. Boyles. "Effects of autonomous vehicle behavior on arterial and freeway networks." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Duell, M., M.W. Levin, S.D. Boyles, and S.T. Waller. "The impact of autonomous vehicles on traffic management: the case of dynamic lane reversal." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Levin, M.W., T. Li, S.D. Boyles, and K. Kockelman. "General framework for modeling shared autonomous vehicles." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Perrine, K., M.W. Levin, M. Duell, and S.D. Boyles. "Implications of traffic signal security on potential deliberate traffic disruptions." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Jafari, E., V. Pandey, and S.D. Boyles. "Static traffic assignment: a decentralized approach." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Duthie, J., N. Ruiz-Juri, and C.R. Bhat. "Role of Universities in Getting More out of Transportation Data." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Kumari, P., N. González Prelcic, J. Choi, and R.W. Heath Jr., "Combining mmWave Automotive Radar and Communication." Poster Presentation in *WNCG Open House*, Austin, TX, January 2016.

Heath Jr., R.W., "Cars Communicating: Automotive Applications of 5G and Millimeter Wave." *TFI Communications Technology & Asset Valuation Conference*, Austin, TX, January 2016.

Bhat, C.R., "Capturing Cause-Effect Relationships in Multidimensional Integrated Models: A New Econometric Approach with Application to Residential, Auto Ownership and Activity Choices." *Invited Seminar*, School of Civil and Environmental Engineering and The National Center for Transportation Systems Productivity and Management (NCTSPM), Georgia Tech, Atlanta, GA, February 2016.

Humphreys, T., "Precise Positioning for the Mass Market." *Invited keynote presentation, International GNSS Service Workshop*, Sydney, Australia, February 2016.

Bhat, C.R., "Graduate School: challenges and the excitement." *Transportation Prospective Graduate Student Visit*, UT Austin, Austin, TX, March 2016.

Bhat, C.R., "Connected and Automated Vehicles: Prospects and Challenges." *Invited guest speaker*, Rotary Club of Austin, Austin, TX, March 2016.

Forthcoming Presentations:

Heath Jr., R.W., "Implications of Millimeter Wave for 5G System Design*." 2nd Annual Stanford SystemX Alliance Headlights Workshop on Frontiers in Wireless Connectivity*, Stanford, CA, April 2016.

Kumari, P., N. González Prelcic, J. Choi, and R.W. Heath Jr., "IEEE 802.11ad V2X-Radar: A Joint Millimeter-Wave Vehicular Communication and Radar System." Poster Presentation in *2016 Center for Transportation Research Symposium*, Austin, TX, April 2016.

Humphreys, T.E., and M. Murrian, K. M. Pesyna, Jr., F. van Diggelen, and S. Podshivalov (2016), "On the feasibility of centimeter-accurate positioning via a smartphones antenna and GNSS chip." *IEEE/ION PLANS 2016 Meeting*, Savannah, GA, April 2016.

Narula, L., and T. E. Humphreys, "Requirements for secure wireless time transfer." *IEEE/ION PLANS 2016 Meeting*, Savannah, GA, April 2016.

Murrian, M., C. Gonzalez, T. E. Humphreys, and T. D. Novlan, "A dense reference network for mass-market centimeter-accurate positioning." *IEEE/ION PLANS 2016 Meeting*, Savannah, GA, April 2016.

Presentations Under Review:

Kim, M., and S. Vishwanath, "Index Coding for OFDM Downlink Systems." Submitted to IEEE GlobeCom 2016, Washington, DC, December.

Plans for Next Reporting Period to Accomplish Technology Transfer Goal: Continue to support researchers as they present their research results through peer-reviewed publications and professional presentations. Hold the 2nd D-STOP Symposium on April 1, 2016, which draws from different sectors, including academia, public agencies and industry; see attached agenda. Organize a Center for Transportation Research (CTR) Symposium to be held April 13, 2016. Hold a second training session on Dynamic Traffic Assignment offered by CTR/Network Modeling Center with Capital Area Metropolitan Planning Organization (CAMPO) staff members on April 19, 2016.

2. PRODUCTS

Publications, conference papers, and presentations:

Journal Publications - Published

Bhat, C.R., M. Castro, and A.R. Pinjari (2015), "Allowing for Complementarity and Rich Substitution Patterns in Multiple Discrete-Continuous Models." *Transportation Research Part B*, 81(1), 59-77.

Shin, J., C.R. Bhat, D. You, V.M. Garikapati, and R.M. Pendyala (2015), "Consumer Preferences and Willingness to Pay for Advanced Vehicle Technology Options and Fuel Types." *Transportation Research Part C*, 60, 511-524.

Bhat, C.R., S.K. Dubey, M. Jobair Bin Alam, and W.H. Khushefati (2015), "A New Spatial Multiple Discrete-Continuous Modeling Approach to Land Use Change Analysis." *Journal of Regional Science*, 55(5), 801-841.

Wafa, Z., C.R. Bhat, R.M. Pendyala, and V.M. Garikapati (2015), "A Latent-Segmentation Based Approach to Investigating the Spatial Transferability of Activity-Travel Models." *Transportation Research Record*, 2493, 136-144.

Khani, A., and S.D. Boyles (2015), "An Exact Algorithm for the Mean–Standard Deviation Shortest Path Problem." *Transportation Research Part B*, 81, 252-266.

Boyles, S.D., S. Tang, and A. Unnikrishnan (2015), "Parking Search Equilibrium on a Network." *Transportation Research Part B*, 81, 390-409.

Levin, M., and S.D. Boyles (2015), "Effects of Autonomous Vehicle Ownership on Trip, Mode, and Route Choice." *Transportation Research Record*, 2493, 29-38.

Levin, M., and S.D. Boyles (2015), "Intersection Auctions and Reservation-based Control in Dynamic Traffic Assignment." *Transportation Research Record*, 2497, 35-44.

Jafari, E. and S.D. Boyles (2016), "Improved Bush-Based Methods for Network Contraction." *Transportation Research Part B*, 83, 298-313.

Levin, M.W., and S.D. Boyles (2016), "A Multiclass Cell Transmission Model for Shared Human and Autonomous Vehicle Roads. *Transportation Research Part C*, 62, 103-116.

Perrine, Kenneth, Alireza Khani, and Natalia Ruiz-Juri (2015). "Map-Matching Algorithm for Applications in Multimodal Transportation Network Modeling." *Transportation Research Record: Journal of the Transportation Research Board* 2537, 62-70.

Krishnasamy, S., and S. Shakkottai, (2015) "Spectrum Sharing and Scheduling in D2D-Enabled Dense Cellular Networks." *Proceedings of 13th International Symposium on Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks (WiOpt*), Mumbai, India, May (invited paper).

Chen, Y., H. Xu, C. Caramanis and S. Sanghavi (2015), "Matrix Completion with Column Manipulation: Near Optimal Sample-Robustness-Rank Tradeoffs." *IEEE Transactions on Information Theory*, 62(1), 503-526.

Journal Publications - Accepted

Bhat, C.R., S. Astroza, and A.C. Bhat, "On Allowing a General Form for Unobserved Heterogeneity in the Multiple Discrete-Continuous Probit Model: Formulation and Application to Tourism Travel." *Transportation Research Part B*, forthcoming.

Bhat, C.R., S. Astroza, A.C. Bhat, and K. Nagel, "Incorporating a Multiple Discrete-Continuous Outcome in the Generalized Heterogeneous Data Model: Application to Residential Self-Selection Effects Analysis in an Activity Time-use Behavior Model." *Transportation Research Part B*, forthcoming.

Kumar, V., C.R. Bhat, R.M. Pendyala, D. You, E. Ben-Elia, and D. Ettema, "The Impacts of an Incentive-Based Intervention on Peak Period Traffic: Experience from the Netherlands." *Transportation Research Record*, forthcoming.

Lavieri, P., C.R. Bhat, R.M. Pendyala, and V.M. Garikapati, "Introducing Latent Psychological Constructs in Injury Severity Modeling: A Multi-Vehicle and Multi-Occupant Approach." *Transportation Research Record*, forthcoming.

Rambha, T., and S.D. Boyles (2016), "Dynamic Pricing in Discrete Time Stochastic Day-to-Day Route Choice Models." *Transportation Research Part B*, forthcoming.

Levin, M.W., and S.D. Boyles (2016), "A Cell Transmission Model for Dynamic Lane Reversal with Autonomous Vehicles. *Transportation Research Part C*, forthcoming.

Patel, R., Levin, M. W., and S.D. Boyles. Effects of autonomous vehicle behavior on arterial and freeway networks. *Transportation Research Record*, forthcoming.

Duell, M., M.W. Levin, S.D. Boyles, and S.T. Waller. The impact of autonomous vehicles on traffic management: the case of dynamic lane reversal. *Transportation Research Record*, forthcoming.

Levin, M.W., and S.D. Boyles. Improving bus routing for KIPP Charter Schools. *Interfaces*, forthcoming.

Boyles, S.D., and T. Rambha. A note on detecting unbounded instances of the online shortest path problem. *Networks*, forthcoming.

Va, V., T. Shimizu, G. Bansal, and R.W. Heath, Jr., "Beam Design for Beam Switching Based Millimeter Wave Vehicle-to-Infrastructure Communications," to appear in Proceedings of the IEEE International Conference on Communications, Kuala Lumpur, Malaysia, May 23-27, 2016.

Ali, A., N. González Prelcic, and R.W. Heath, Jr., "Estimating Millimeter Wave Channels using Out-of-Band Measurements, " (invited) to appear in Proceedings of the Information Theory and Applications, San Diego, California, January 31 - February 5, 2016.

González Prelcic, N., R. Méndez-Rial, and R.W. Heath, Jr., "Radar Aided Beam Alignment in MmWave V2I Communications Supporting Antenna Diversity, " (invited) to appear in Proceedings of the Information Theory and Applications, San Diego, California, January 31 - February 5, 2016.

Heath, Jr., R.W., N. González Prelcic, S. Rangan, W. Roh, and A. Sayeed, "An Overview of Signal Processing Techniques for Millimeter Wave MIMO Systems," to appear in *IEEE Journal on Sel. Topics in Sig. Proc.*, special issue on Massive MIMO.

Ghaderi, J., S. Shakkottai and R. Srikant (2016), "Scheduling Storms and Streams in the Cloud." *ACM Transactions on Modeling and Performance Evaluation of Computing Systems (ACM ToMPECS),* forthcoming.

Psiaki, M.L., and T.E. Humphreys (2016), "GNSS Spoofing and Detection." *Proceedings of the IEEE*, forthcoming.

Narula, L., and T. E. Humphreys (2016), "Requirements for secure wireless time transfer." *Proceedings of the IEEE/ION PLANS 2016 Meeting*, Savannah, GA, April, forthcoming.

Murrian, M., C. Gonzalez, T. E. Humphreys, and T. D. Novlan (2016), "A dense reference network for mass-market centimeter-accurate positioning." *Proceedings of the IEEE/ION PLANS 2016 Meeting*, Savannah, GA, April, forthcoming.

Humphreys, T.E., M. Murrian, K. M. Pesyna, Jr., F. van Diggelen, and S. Podshivalov (2016), "On the feasibility of centimeter-accurate positioning via a smartphones antenna and GNSS chip." *Proceedings of the IEEE/ION PLANS 2016 Meeting*, Savannah, GA, April, forthcoming.

Presentations

Bhat, C.R., S. Astroza, and A. Pinjari, "The Formulation and Estimation of a Spatial Skew-Normal Generalized Ordered-Response Model." *17th Advances in Econometrics Conference*, Louisiana State University, Baton Rouge, LA, October 2015.

Levin, M., and S.D. Boyles, "Optimizing Reservation-based Intersections for System Efficiency." *INFORMS Annual Meeting*, Philadelphia, PA, October 2015.

Khani, A., and S.D. Boyles "Auction-based Ridesharing with Pick-up and Drop-off Time Window." *INFORMS Annual Meeting*, Philadelphia, PA, October 2015.

Khani, A., and S.D. Boyles "Reliable Routing in Schedule-based Transit Networks with Stochastic Travel Times." *INFORMS Annual Meeting*, Philadelphia, PA, October 2015.

Rambha, T., and S.D. Boyles, "Mechanism Design for Route Assignment in Traffic Networks." *INFORMS Annual Meeting*, Philadelphia, PA, October 2015.

Jafari, E. and S.D. Boyles, "Decentralized Traffic Assignment for Multi-level Modeling." *INFORMS Annual Meeting*, Philadelphia, PA, October 2015.

Humphreys, T., "Low-Cost Precise Positioning and Perception Security." *Invited presentation, Google[X]*, Mountain View, CA, October 2015.

Humphreys, T., "Low-Cost Centimeter-Accurate Mobile Positioning." *Invited keynote presentation,* Texas GIS Forum, Austin, TX, October 2015.

Humphreys, T., "Low-Cost Centimeter-Accurate Mobile Positioning." University of Minnesota Roadway Safety Institute, Minneapolis, MN, October 2015.

Motro, M., A. Chu, R. Kalantari, J. Choi, J. Xu, A. Pinjari, J. Ghosh, R. W. Heath, C. R. Bhat, "Vehicular Ad-hoc Network (VANET) Simulations of Passing Maneuvers on Two-Lane Rural Highways." *9th University Transportation Centers Spotlight Conference on Connected and Automated Vehicles*, Washington, DC, November 2015.

Bhat, C.R., "Predictive Analytics for Transportation Planning and Operations in a World of Big Data." Keynote presentation, *3rd Conference of Transportation Research Group of India (CTRG)*, Kolkata, India, December 2015.

Bhat, C.R., R.M. Pendyala, and K.G. Goulias "Activity-Based Modeling of Transport Network Demand and Performance." Executive Short Course, *3rd Conference of Transportation Research Group of India (CTRG)*, Kolkata, India, December 2015.

Yi, X. and C. Caramanis, "Regularized EM Algorithms: A Unified Framework and Statistical Guarantees." Presented at the *29th Annual Conference on Neural Information Processing Systems (NIPS)*, Montreal, Canada, December 2015.

Yi, X., Z. Wang, C. Caramanis, and H. Liu, "Optimal Linear Estimation under Unknown Nonlinear Transform." Presented at the *29th Annual Conference on Neural Information Processing Systems (NIPS)*, Montreal, Canada, December 2015.

Bhat, C.R., "A Comprehensive Dwelling Unit Choice Model Accommodating Psychological Constructs Within A Search Strategy for Consideration Set Formation." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Bhat, C.R., S. Astroza, and A.C. Bhat, "On Allowing a General Form for Unobserved Heterogeneity in the Multiple Discrete-Continuous Probit Model: Formulation and Application to Tourism Travel." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Bhat, C.R., S. Astroza, A.C. Bhat, and K. Nagel, "Incorporating a Multiple Discrete-Continuous Outcome in the Generalized Heterogeneous Data Model: Application to Residential Self-Selection Effects Analysis in an Activity Time-use Behavior Model." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Kumar, V., C.R. Bhat, R.M. Pendyala, D. You, E. Ben-Elia, and D. Ettema, "The Impacts of an Incentive-Based Intervention on Peak Period Traffic: Experience from the Netherlands." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Bhat, C.R., A.R. Pinjari, and S.K. Dubey, "On Accommodating Spatial Interactions in a Generalized Heterogeneous Data Model (GHDM) of Mixed Types of Dependent Variables." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Wafa, Z., C.R. Bhat, R.M. Pendyala, and V.M. Garikapati, "A Latent-Segmentation Based Approach to Investigating the Spatial Transferability of Activity-Travel Models." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Ruiz Juri, N., R.M. James, N. Jiang, J. Duthie, A. Pinjari, and C.R. Bhat, "On the Computation of Skims for Large Scale Implementation of Integrated Activity-based and Dynamic Traffic Assignment Models." *Transportation Research Board (TRB) Annual Meeting*, Washington, DC, January 2016.

Rambha, T., and S.D. Boyles. "Reinforcement learning approaches for dynamic congestion pricing in day-to-day network models." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Patel, R., M.W. Levin, and S.D. Boyles. "Effects of autonomous vehicle behavior on arterial and freeway networks." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Duell, M., M.W. Levin, S.D. Boyles, and S.T. Waller. "The impact of autonomous vehicles on traffic management: the case of dynamic lane reversal." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Levin, M.W., T. Li, S.D. Boyles, and K. Kockelman. "General framework for modeling shared autonomous vehicles." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Perrine, K., M.W. Levin, M. Duell, and S.D. Boyles. "Implications of traffic signal security on potential deliberate traffic disruptions." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Jafari, E., V. Pandey, and S.D. Boyles. "Static traffic assignment: a decentralized approach." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Duthie, J., N. Ruiz-Juri, and C.R. Bhat. "Role of Universities in Getting More out of Transportation Data." *95th Annual Meeting of the Transportation Research Board*, Washington, DC, January 2016.

Kumari, P., N. González Prelcic, J. Choi, and R.W. Heath Jr., "Combining mmWave Automotive Radar and Communication." Poster Presentation in *WNCG Open House*, Austin, TX, January 2016.

Heath Jr., R.W., "Cars Communicating: Automotive Applications of 5G and Millimeter Wave." *TFI Communications Technology & Asset Valuation Conference*, Austin, TX, January 2016.

Bhat, C.R., "Capturing Cause-Effect Relationships in Multidimensional Integrated Models: A New Econometric Approach with Application to Residential, Auto Ownership and Activity Choices." *Invited Seminar*, School of Civil and Environmental Engineering and The National Center for Transportation Systems Productivity and Management (NCTSPM), Georgia Tech, Atlanta, GA, February 2016.

Humphreys, T., "Precise Positioning for the Mass Market." *Invited keynote presentation, International GNSS Service Workshop*, Sydney, Australia, February 2016.

Bhat, C.R., "Graduate School: challenges and the excitement." *Transportation Prospective Graduate Student Visit*, UT Austin, Austin, TX, March 2016.

Bhat, C.R., "Connected and Automated Vehicles: Prospects and Challenges." *Invited guest speaker*, Rotary Club of Austin, Austin, TX, March 2016.

Websites:
http://dstop.utexas.edu, D-STOP website
http://ctr.utexas.edu/, Center for Transportation Research (CTR)
http://ctr.utexas.edu/nmc/, Network Modeling Center at CTR
http://wncg.org/, Wireless Networking & Communications Group (WNCG)
http://www.caee.utexas.edu/prof/bhat/fULL_PAPERS.htm, Dr. Bhat's personal webpage
http://tinyurl.com/steveboyles/, Dr. Boyles' personal webpage

Technologies or techniques: Nothing to report for this period.

Inventions, patent applications, and licenses: Nothing to report for this period.

Other products: Nothing to report for this period.

3. PARTICIPANTS & COLLABORATING ORGANIZATIONS

What organizations have been involved as partners?
Samsung Research America, Dallas, TX: In-kind support
Texas Department of Transportation, Austin, TX: In-kind support, financial support
University of New South Wales, Sydney, Australia - Melissa Duell and S. Travis Waller were research collaborators.
Universidade de Vigo, Department of Signal Theory and Communications, Vigo, Spain - Nuria G. Prelcic was a Technical Consultant.

Have other collaborators or contacts been involved?
We have made DSTOP known to industrial affiliates of the Wireless Networking & Communications Group (WNCG): Crown Castle; Cisco; Huawei; Qualcomm; DOCOMO; Department of Defense; AT&T; CoomScope; National Instruments; Samsung; Yokagawa; Universidade de Vigo, Spain; Toyota; Iteris; Microsoft Research; 3M Traffic Safety Systems; RideScout.

We have also discussed DSTOP with several public agencies who have come on board as members of the D-STOP Business Advisory Council (BAC). These include North Central Texas Council of Governments (NCTCOG), Capital Metro, Austin Chamber of Commerce, the City of Austin, Texas, FHWA Texas Division, and the Texas Dept of Transportation. NCTCOG has begun a 4-year project to provide matching funds for D-STOP to examine connected and automated vehicle technology penetration in the DFW area, and transportation planning/operations implications.

4. IMPACT

Impact on the development of the principal disciplines of the program:
D-STOP projects are introducing psychometric measures of human behavior in characterizing transportation decisions of individuals, and using the resulting insights to drive transportation policy measures and system design.

Impact on other disciplines:
The D-STOP research projects involve collaborations with faculty in other disciplines, including electrical engineering and computer science. Several papers contribute in substantive ways to econometric techniques, high dimensional statistical analysis, optimization methods, and data fusion approaches.

Robert Heath's D-STOP research develops an IEEE 802.11ad V2X-Radar system with a signal processing perspective. This framework enables both radar and communication millimeter-wave (mmWave) technologies to exploit the same spectrum and hardware for automotive applications such as collision avoidance and cruise control. The V2X-Radar system is based on the mmWave consumer wireless local area network (WLAN) standard and motivates a common standard for automotive radar and vehicular communications at the mmWave band. It has significant advantages in terms of cost, size, performance and spectrum usage. The preamble structure of the IEEE 802.11ad single carrier physical layer frame is exploited and standard WLAN techniques are leveraged to develop multi-frame radar parameter estimation techniques with minimal receiver modifications. Our theoretical analyses and numerical simulations show promising results; cm-level range and cm/s-level velocity accuracy are achieved simultaneously with Gbps communication data rate.

Impact on the transportation workforce development:
Continuing to prepare the leaders of tomorrow through undergraduate and graduate student research and education. Providing opportunities for our student to be prepared to communicate orally as well as in writing through presentations at conference and publications.

Impact on physical, institutional, and information resources at the university or other partner institutions:
Implementing radar systems using low-frequency WiFi signals with NI equipment, and will implement mmWave joint radar and communication systems with NI equipment.

Impact on technology transfer:
The Business Advisory Council meeting provided a forum for the exchange of ideas and thoughts, and the identification of gaps in our current D-STOP activities. The feedback will help D-STOP further contribute to societal problems.

Collaborating with NI and Toyota to implement millimeter wave vehicular communications.

Impact on society beyond science and technology:
The models developed under DSTOP-supported research can lead to more efficient and safe use of transportation infrastructure, decreasing congestion, improving roadway safety, and supporting the economic competitiveness of the nation.

5. CHANGES/PROBLEMS

Nothing to report.

Data Supported Transportation Operations and Planning (D-STOP) Symposium

"Smart Cities"

Friday, April 1, 2016

AT&T Executive Education and Conference Center at The University of Texas at Austin;
1900 University Avenue, Austin TX 78705; http://www.meetattexas.com/

Symposium Agenda

7:30 AM - 8:00 AM: Breakfast at the Symposium Venue

8:00 AM - 8:05 AM: **Welcome** (Chandra Bhat)

8:05 AM - 9:00 AM: **"Smart Transportation Systems: The Need for a Collaborative Ecosystem"**
(Moderator: Chandra Bhat)

- Gaurav Bansal, Senior Researcher, Toyota InfoTechnology Center
- C. Michael Walton, Ernest H. Cockrell Centennial Chair in Engineering, Dept. of Civil, Architectural & Environmental Engineering, UT Austin
- Sherri Greenberg, Clinical Professor, Fellow of Max Sherman Chair in State and Local Government, LBJ School of Public Affairs, UT Austin
- Jim Dale, PE, Division Manager, Arterial Management Division, City of Austin
- J.D. Stanley, Global Director, Strategy and Integrated Solutions, Cisco

9:00 AM - 10:30 AM: **"Infrastructure-based Technology"**
(Moderator: Robert Heath)

- **The Value of Communication and Infrastructure for Automated Cars**
  Robert Heath, Cullen Trust Endowed Professor, UT Austin
- **Infrastructure for Instantaneous Precise Positioning**
  Todd Humphreys, Associate Professor, Dept. of Aerospace Engineering and Engineering Mechanics, UT Austin
- **Internet of Moving Things using Full Duplex Mesh Networks**
  Sriram Vishwanath, Professor, Electrical and Computer Engineering Dept., UT Austin
- **The Connected Car: Impact on Wireless Communication**
  Murali Narasimha, Wireless Communications Researcher, FutureWei Technologies (Huawei)

10:30 AM - 10:45 AM: Break

10:45 AM - 12:15 PM: **"Regional Planning and Analytics"**
(Moderator: Jennifer Duthie)

- **Data Rodeo: A Data Analytics Environment for the Central Texas Region**
  Jennifer Duthie, Director, Network Modeling Center, UT Austin
- **Predictive Analytics for Transportation in a High Dimensional Heterogeneous Data World**
  Chandra Bhat, Director of D-STOP and CTR, and the Adnan Abou-Ayyash Centennial Professor in Transportation Engineering, UT Austin
- **Planning for the Future in a Changing Environment**
  Arash Mirzaei, Senior Program Manager for Model Development and Data Management, North Central Texas Council of Governments

- **Using Publicly Available Datasets to Evaluate the Intersection between Bicycling and Commercial Vehicles**
  Alison Conway, Assistant Professor at City College of New York

12:15 pm - 1:30 pm: Networking Lunch

1:30 pm - 3:00 pm: **"Connected Vehicles"**
(Moderator: Stephen Boyles)

- **Connected Automation: Two Technologies That Need Each Other**
  Paul Avery, Principal Engineer, Cooperative Systems Section, Southwest Research Institute
- **Looking to the Future: Predictions of Automated Vehicle Impacts**
  Stephen Boyles, Assistant Professor, Dept. of Civil, Architectural & Environmental Engineering, UT Austin
- **Connecting Capital Metro**
  Joe Iannello, Vice President, Chief Information Officer, Capital Metro
- **Networks of Wearables and Augmented Reality for Vulnerable User Protection**
  Christian Claudel, Assistant Professor, Dept. of Civil, Architectural & Environmental Engineering, UT Austin

3:00 pm - 3:30 pm: **General discussions and wrap-up presentation**
(WNCG Director Sanjay Shakkottai)

3:30 pm - 4:30 pm: **Poster session** in the courtyard. Soft drinks and cookies provided.