Program Progress Performance Report

Submitted to:	U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology
Federal Grant No.:	DTRT13-G-UTC58
Project Title:	Data-Supported Transportation Operations and Planning (D-STOP) Center
Program Director:	Chandra Bhat, Director, bhat@mail.utexas.edu, 512-471-4535
Submitting Official:	Lisa Macias, Executive Assistant, lisaweyant@mail.utexas.edu, 512-232-6272
Submission Date:	October 30, 2017
DUNS Number:	170230239
EIN Number:	746000203
Recipient Organization:	The University of Texas at Austin Office of Sponsored Projects, Suite 5.300 101 E. 27th Street, Stop A9000 Austin, TX 78712
Recipient Identifying No:	OSP 201300867-001
Grant Period:	September 30, 2013 – September 30, 2018
Reporting Period End Date:	September 30, 2017
Report Term:	April 1, 2017 – September 30, 2017
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 28 projects were pursued with partial or full funding support from D-STOP. Of these, 7 projects were completed during this reporting period. Currently, 21 projects are underway.

Completed Projects

1. **Semi-Autonomous Parking for Enhanced Safety and Efficiency**
   (PI: Sriram Vishwanath); End date: June 30, 2017

2. **Analyzing Millimeter Wave Vehicular Communication Systems in Urban Areas**
   (PI: Robert Heath); End date: May 31, 2017

3. **Exploiting DSRC Information to Reduce Millimeter Wave Beam Alignment Overhead in Vehicular Environments**
   (PI: Robert Heath); End date: May 31, 2017

4. **Large-Scale Linear Programs in Planning and Prediction**
   (PI: Constantine Caramanis); End date: June 30, 2017

5. **Imputing Missing Data via Sparse Reconstruction Techniques**
   (PI: Constantine Caramanis); End date: June 30, 2017

6. **Performance Trade-Off for a Joint Automotive Radar and Communication System**
   (Old title: Blockage Avoidance for Millimeter Wave Vehicular Communications Using Radar)
   (PI: Robert Heath); End date: May 31, 2017

7. **Cooperative Mapping for Automated Vehicles**
   (PI: Todd Humphreys, with Robert Heath); End date: September 30, 2017

Ongoing Projects

1. **Transportation Data Discovery Environment**
   (PI: Natalia Ruiz Juri); Anticipated end date: August 31, 2018

2. **Real-Time Signal Control and Traffic Stability**
   (PI: Stephen Boyles); Anticipated end date: August 31, 2018

3. **Using Collected Data to Improve Dynamic Traffic Assignment Modeling**
   (PI: Natalia Ruiz Juri); Anticipated end date: August 31, 2018

4. **Accommodating a Flexible Response Heterogeneity Distribution in Choice Models of Human Behavior for Transportation Planning**
   (PI: Chandra Bhat); Anticipated end date: December 31, 2017

5. **Internet of Moving Things using Full Duplex Mesh Networks**
   (PI: Sriram Vishwanath); Anticipated end date: December 31, 2018

6. **Cybersecurity Challenges and Pathways in the Context of Connected Vehicle Systems**
   (PI: Chandra Bhat); Anticipated end date: December 31, 2017

7. **Evaluation of Routing Protocols for Vehicular Ad hoc Networks (VANETs) in Connected Transportation Systems**
   (PI: Chandra Bhat); Anticipated end date: December 31, 2017

8. **Spatial Correlation Estimation of Millimeter Vehicular Communication Channels Using Out-of-Band Information**
   (PI: Robert Heath); Anticipated end date: May 31, 2018

9. **Joint Millimeter-Wave Communication and Radar for Automotive Applications**
   (PI: Robert Heath); Anticipated end date: May 31, 2018

10. **ADAS Enhanced by 5G Connectivity**
    (PI: Todd Humphreys, with Robert Heath); Anticipated end date: September 30, 2018

11. **Improved Models for Managed Lane Operations**
    (PI: Stephen Boyles); Anticipated end date: August 31, 2018

12. **Capturing the Impacts of Ride-sourcing and HOVs**
    (PI: Chandra Bhat, with Natalia Ruiz Juri and James Kuhr); Anticipated end date: September 30, 2018

13. **New Microeconomic Theory-Based Model for Ranking Data**
    (PI: Chandra Bhat); Anticipated end date: September 30, 2018

14. **Megaregional Trends of Passenger and Freight Movement: Evidence from National Transportation Data Sources**
    (PI: Ming Zhang); Anticipated end date: September 30, 2018

15. **V2I Managed Lanes Test Bed**
    (PI: James Kuhr); Anticipated end date: September 30, 2018

16. **Transit Policy in the Context of New Transportation Paradigms**
    (PI: James Kuhr, with Chandra Bhat and Natalia Ruiz Juri); Anticipated end date: September 30, 2018

17. **Transition Period from Today to Fully Autonomous**
    (PI: Natalia Ruiz, with Chandra Bhat and James Kuhr); Anticipated end date: September 30, 2018

18. **Statistical Inference Using Stochastic Gradient Descent**
    (PI: Constantine Caramanis); Anticipated end date: August 31, 2018

19. **Clustering and Classification**
    (PI: Constantine Caramanis); Anticipated end date: August 31, 2018

20. **Bandit Algorithms for Online Learning and Resource Allocation**
    (PI: Sanjay Shakkottai, with Stephen Boyles); Anticipated end date: August 31, 2018

21. **V2X Spectrum Resource Allocation for Sensing and Communications**
    (PI: Sanjay Shakkottai); Anticipated end date: August 31, 2018

Research Results Disseminated: 14 papers were published and 9 papers are forthcoming in refereed journals based on the research projects associated with D-STOP. Several other papers are in the review process. 17 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 TxDOT, North Central Texas Council of Governments (NCTCOG), and UT SAVES (Situation-Aware Vehicular Engineering Systems). We are excited about data-related, fusion-related, and communication-related research we are undertaking within the transportation domain.

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:

<u>Undergrad</u>

Lauryn Altena, Jamie Hufnagel, Maitri Zalawadia, Christina Edgar (supervised by Chandra Bhat)
Maximilian Grether (supervised by Natalia Ruiz Juri)
Rahul Patel, Tejas Choudhary, Anthony Battista, Mathias Hanssen (supervised by Stephen Boyles)
Blair DeShong (supervised by Randy Machemehl)
Reid Wyde, Haoran Niu (supervised by Robert Heath)

<u>Grad</u>

Supervised by Chandra Bhat: Sebastian Astroza (PhD), Qichun Dai (MS), Amanda Deering (MS), Felipe Dias (PhD), Joseph Hutchinson (MS), Patricia Lavieri (PhD), Kamryn Long (MS), Gopindra Nair (PhD), Priyadarshan Patil (MS), Abhilash Singh (MS), Pragun Vinayak (MS).
Supervised by Stephen Boyles: William Alexander (MS), Dongxu (Henry) He (MS), John Helsel (MS), Ehsan Jafari (PhD), Rachel James (PhD), Michael Levin (PhD), Venktesh Pandey (PhD), Cesar Yahia (MS), Tengkuo Zhu (PhD).
Supervised by Jennifer Duthie: Jackson Archer (MS).
Supervised by Ming Zhang: Caleb Roberts (MS).
Supervised by Constantine Caramanis: Eirini Asteri (PhD), Craig Corcoran (PhD), Jessica Hoffman (PhD).
Supervised by Robert Heath: Anum Ali (PhD), Meixu Chen (MS), Preeti Kumari (PhD), Khurram Mazher (PhD), Megha Parhi (MS), Vutha Va (PhD), Yuyang Wang (MS), Ratbek Zhapparov (MS).
Supervised by Todd Humphreys: Lakshay Narula (MS/PhD).
Supervised by Sanjay Shakkottai: Soumya Basu (PhD).

Supervised by Sriram Vishwanath: Andrew Brigg (PhD), Yitao Chen (PhD), Hardik Jain (PhD), Muryong Kim (PhD), Murat Kocaoglu (PhD), Subhashini Krishnasamy (PhD), Kenneth Lee (PhD), Christopher Snyder (PhD).
Supervised by Jeff Andrews: Chang-sik Choi (PhD).
Supervised by Joydeep Ghosh: Ashish Bora (PhD), Rahi Kalantari (PhD), Taewan Kim (PhD), Michael Motro (PhD).

2017 Summer Internship: Five undergrad interns were supported by D-STOP in the fourth University Transportation Center-Undergraduate Internship (UTC-UI) program hosted at The University of Texas at Austin. The interns were Anthony Battista (from U. Mass Amherst), Blair DeShong (from U. Alabama), Christina Edgar, Mathias Hanssen, and Reid Wyde (from UT Austin). Each intern participated in a research project related to the D-STOP center, and were assigned to faculty and researchers associated with the Center for Transportation Research. A weekly seminar was held, consisting of lectures by experts in both wireless networking and transportation research, and served as the basis for conversations on research lying at the intersection of these fields (see attached weekly lecure schedule). The interns were also involved in professional development and social activities organized by the student chapters of the Institute of Transportation Engineers and ITS America.

New Student Orientation: The transportation and wireless networking programs welcomed many new graduate students to D-STOP, including a new student orientation, discussion of ongoing D-STOP projects, and faculty/student discussions of how data is fundamentally changing how we think and plan transportation systems.

Education and Workforce Development Results Disseminated:

Workshop on Writing Technical Papers
Hosted by the UT student chapter of the Institute of Transportation Engineers, this workshop in June 2017 featured an engaging presentation by Dr. Stephen Boyles. The three-hour workshop was geared for UT transportation graduate students, as well as the UTC-UI interns and interested postdocs/recent graduates. More than 40 students attended the event, which included these components:

- Presentations on technical writing, writing journal articles, and on time management and tactical writing strategies to overcome procrastination.
- A panel discussion with senior Ph.D. students and recent graduates on their experiences with publication.
- Short “breakout groups” for discussion and practicing concepts discussed in the presentations.
- Assignment into peer review groups to work with for the rest of the summer (reviewing each other’s drafts before submission).
- A packet of “writing advice” from different researchers Dr. Boyles has collected over the years.

High School STEM Outreach
In May 2017, Dr. Chandra Bhat presented at a STEM outreach program at Westwood High School, an annual event he helped design. Speaking broadly about science, engineering, and beyond—the possibilities and the challenges, and the increasingly interdisciplinary nature of fields as they merge to address societal needs—Dr. Bhat and his colleague Dr. Patricia Clayton, a structures expert, sought to create passion for STEM fields. Keeping the day informal, they discussed how students can prepare to transition to college in any field of their choosing. Dr. Bhat also arranged for a small group of senior UT-Austin undergraduate students (who are Westwood alums) to make a few remarks about their experiences, describing their experiences from their time at Westwood through their current year at UT.

Austin Hack for Change
The Center for Transportation Research, along with its partner Austin Transportation Department (ATD), was a “project champion” in the 2017 ATX Hack for Change, sponsored by St. Edwards University in June 2017. Through our participation, we were able to execute the second in our three-part series of proof-of-concept projects around City of Austin transportation data, and introduce the Data Rodeo initiative to the more than 300 civic hackers in attendance at the event.

Plans for Next Reporting Period to Accomplish Education and Workforce Development Goal:
Organize the second board meeting of UT SAVES. In partnership with CTR, WNCG has created this Center to address the challenges of wireless, networking, and sensing in vehicular systems. Continue discussions with the Business Advisory Council (BAC), and organize a third BAC meeting along with the 4th D-STOP Symposium in Spring 2018. Begin organization of the fifth University Transportation Center-Undergraduate Internship (UTC-UI) program to be held the summer of 2018.

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

Center for Transportation Research (CTR) Annual Symposium
The annual CTR Symposium was held on April 13, 2017, and was attended by TxDOT staff, as well as representatives from transportation public agencies in the Austin area. CTR staff, faculty, and students were present to discuss ongoing research pursuits. This included D-STOP-related poster presentations made by D-STOP funded students. This year's event demonstrated our tremendous range of transportation expertise, encompassing next-generation connected/autonomous vehicle technologies, freight trends, a tool to assist in the legislative planning process, and methods to maximize the lifespan of structures. Research being undertaken as part of D-STOP and supporting NCTCOG funding was presented at the Symposium by researchers James Kuhr and Chandra Bhat. This research included an overview of recent technological and communication advances relevant to transportation automation as well as penetration.

Workshop at 11th International Conference on Transport Survey Methods (ISCTSC 2017)
Dr. Chandra Bhat was the organizer and co-chair of a workshop on "Data Analytics and Fusion in a World of Multiple Sensing and Information Capture Mechanisms" at the 11th International Conference on Transport Survey Methods, held September 27-28, 2017 in Esterel, Quebec, Canada. This workshop examined data capture mechanisms and methods to fuse data as we enter into an era of active as well as passive survey data collection mechanisms. The emphasis was on how different data sources can be merged to fill "holes" in individual data sources as well as address concerns of representativeness in individual data sources. Examples of multiple-source data collections in the actual field were reviewed. The workshop harnessed the collective experience of leading survey analysts to forge a pathway forward in this fast-developing and exciting area of multiple, mixed, and heterogeneous data sources.

My35 Metrics Workshop
This event in September 2017, sponsored by TxDOT Austin District, brought together several agencies and transportation consultants to discuss meaningful corridor performance metrics in the context of new data sources. CTR presented some of its ongoing data analysis work and discussed the Data Rodeo concept.

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

Published:

Sen, R., K. Shanmugam, A. Dimakis and S. Shakkottai, "Contextual Bandits with Latent Confounders: An NMF Approach". *Proceedings of the 20th International Conference on Artificial Intelligence and Statistics (AISTATS 2017)*, Ft. Lauderdale, FL, April 2017.

Krishnasamy, S., P. T. Akhil, A. Arapostathis, S. Shakkottai and R. Sundaresan, “Augmenting Max-Weight with Explicit Learning for Wireless Scheduling with Switching Costs”. *Proceedings of IEEE International Conference on Computer Communications*, Atlanta, GA, May 2017.

Sen, R., K. Shanmugam, A. Dimakis and S. Shakkottai, “Identifying Best Interventions through Online Importance Sampling”. *Proceedings of the 34th International Conference on Machine Learning (ICML 2017)*, Sydney, Australia, August 2017.

Jafari, E. and S. D. Boyles. Multicriteria stochastic shortest path problem for electric vehicles. *Networks and Spatial Economics* 17, 1043-1070, 2017.

Levin, M. W., K. M. Kockelman, S. D. Boyles, and T. Li. A general framework for modeling shared autonomous vehicles, with dynamic ride-sharing and dynamic traffic assignment application. *Computers, Environment and Urban Systems*, 64, 373-383, 2017.

Yeh, E.R., J. Choi, N.G. Prelcic, C.R. Bhat, and R.W. Heath Jr., "Security in Automotive Radar and Vehicular Networks," *Microwave Journal*, 60(5), 148-165, May 2017.

Patil, P.N., S.K. Dubey, A.R. Pinjari, E. Cherchi, R. Daziano, and C.R. Bhat, "Simulation Evaluation of Emerging Estimation Techniques for Multinomial Probit Models," *Journal of Choice Modelling*, 23, 9-20, 2017.

Lavieri, P.S., V.M. Garikapati, C.R. Bhat, R.M. Pendyala, S. Astroza, and F.F. Dias, "Modeling Individual Preferences for Ownership and Sharing of Autonomous Vehicle Technologies," *Transportation Research Record: Journal of the Transportation Research Board*, 2665, 1-10, 2017.

Astroza, S., V.M. Garikapati, C.R. Bhat, R.M. Pendyala, P.S. Lavieri, and F.F. Dias, "Analysis of the Impact of Technology Use on Multimodality and Activity Travel Characteristics," *Transportation Research Record: Journal of the Transportation Research Board*, 2666, 19-28, 2017.

Pesyna, Jr., T. E. Humphreys; R. W. Heath; T. D. Novlan; J. C. Zhang, "Exploiting Antenna Motion for Faster Initialization of Centimeter-Accurate GNSS Positioning with Low-Cost Antennas," *IEEE Transactions on Aerospace and Electronic Systems*, 53(4), 2017.

Wang, Y., K. Venugopal, A.F. Molisch and R.W. Heath Jr., "Blockage and coverage analysis with mmWave cross street BSs near urban intersections." *IEEE International Conference on Communications* (ICC'17), May, 2017, Paris, France.

Ali, A. and R.W. Heath Jr., "Compressed Beam-selection in Millimeter Wave Systems with Out-of-Band Partial Support Information." *Proceedings of International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, New Orleans, March 2017, pp. 3499-3503.

Va, V., J. Choi, and R. W. Heath Jr., "The Impact of Beamwidth on Temporal Channel Variation in Vehicular Channels and its Implications." *IEEE Transactions on Vehicular Technology*, 66(6), pp. 5014-5029, 2017.

Eltayeb, M.E., J. Choi, T.Y. Al-Naffouri, and R. W. Heath Jr., "Enhancing Secrecy with Multi-Antenna Transmission in Millimeter Wave Vehicular Communication Systems." *IEEE Transactions on Vehicular Technology*, 66(9), pp. 8139-8151, 2017.

Forthcoming:

Jafari, E., and S. D. Boyles. On-line charging and routing of electric vehicles in stochastic time-varying networks. *Transportation Research Record*, forthcoming.

Jafari, E., V. Pandey, and S. D. Boyles. A decomposition approach to the static traffic assignment problem. *Transportation Research Part B,* forthcoming.

Levin, M. W., E. Jafari, R. Shah, and S. D. Boyles. Network-based model for predicting the effect of fuel price on transit ridership and greenhouse gas emissions. *International Journal of Transportation Science and Technology*, forthcoming.

Shah, R., P. Bansal, and S. D. Boyles. Robust network pricing and system optimization under combined long-term stochasticity and elasticity of travel demand. *Transportation*, forthcoming.

Sharon, G., M. W. Levin, J. P. Hanna, T. Rambha, S. D. Boyles, and P. Stone. Network-wide adaptive tolling for connected and automated vehicles. *Transportation Research Part C*, forthcoming.

Astroza, S., A.R. Pinjari, C.R. Bhat, and S.R. Jara-Diaz, "A Microeconomic Theory-based Latent Class Multiple Discrete-Continuous Choice Model of Time Use and Goods Consumption," *Transportation Research Record: Journal of the Transportation Research Board,* forthcoming.

Dias, F.F., P.S. Lavieri, V.M. Garikapati, S. Astroza, R.M. Pendyala, and C.R. Bhat, "A Behavioral Choice Model of the Use of Car-Sharing and Ride-Sourcing Services," *Transportation*, *TRB 2017 Special Issue,* forthcoming.

Lavieri, P., V.M. Garikapati, C.R. Bhat, R.M. Pendyala, S. Astroza, and F. Dias, "Modeling Individual Preferences for Ownership and Sharing of Autonomous Vehicle Technologies," *Transportation Research Record: Journal of the Transportation Research Board*, forthcoming.

Huang, L., Xu, W., Liu, S., Pandey, V., Ruiz Juri, N. “Enabling Versatile Analysis of Large Scale Traffic Video Data with Deep Learning and HiveQL”. Accepted for publication in IEEE Big Data 2017 Proceedings.

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

Bhat, C.R., and P.S. Lavieri, "A New Mixed MNP Model Accommodating a Variety of Dependent Non-Normal Coefficient Distributions," *5th International Choice Modelling Conference (ICMC 2017)*, Cape Town, South Africa, April 2017.

Bhat, C.R., "Predictive Analytics in a New Choice Data Landscape," *5th International Choice Modelling Conference (ICMC 2017)*, Cape Town, South Africa, April 2017.

Bhat, C.R., and J. Kuhr, "Connected and Autonomous Vehicles: Where Are We Going and What Happens When We Get There?," *Center for Transportation Research Annual Symposium*, Austin, TX, April 2017.

Krishnasamy, S., A.P. Thalasseryveettil, A. Arapostathis, S. Shakkottai, R. Sundaresan, “Augmenting MaxWeight with Explicit Learning for Wireless Scheduling with Switching Costs” *IEEE Infocom 2017*, Atlanta, GA, May 2017.

Lavieri, P.S., S. Astroza, F. Dias, C.R. Bhat, V.M. Garikapati, and R.M. Pendyala, "Autonomous Vehicle Ownership and Sharing: A Demand Forecasting Approach for the Puget Sound Region and Beyond," *16th TRB National Transportation Planning Applications Conference*, Raleigh, NC, May 2017.

Heath, R.W., “Verticals driving 5G development,” *5G North America*, May 16, 2017.

Heath, R.W., “Vehicle-to-X communication for 5G - a killer application of millimeter wave,” *IEEE 5G Summit, International Microwave Symposium*, Honolulu, June 6 2017.

Bhat, C.R., and J. Kuhr, "Connected and Autonomous Vehicles: Where Are We Going and What Happens When We Get There?," *Invited Seminar*, Department of Urban Studies and Planning, Massachusetts Institute of Technology, June 2017.

Motro, M., J. Ghosh and C. Bhat, "Optimal Alarms for Vehicular Collision Detection," *2017 IEEE Intelligent Vehicles Symposium (IV)*, Los Angeles, CA, June 2017.

Ruiz Juri, N. "A framework to support data-centric transportation research: the Data Rodeo concept," *CUTC 2017 Annual Summer Meeting*, Buffalo, NY, June 2017.

Bhat, C.R., "A New Mixed Multinomial Probit Model Accommodating a Variety of Dependent Non-Normal Coefficient Distributions," *Invited Seminar*, Institute for Transport Planning and Systems (IVT), Swiss Federal Institute of Technology (ETH Zurich), Zurich, Switzerland, June 2017.

Bhat, C.R., "A New Analytic Landscape for the Estimation of Discrete Choice Models," *17th COTA International Conference of Transportation Professionals (CICTP2017)*, Shanghai, China, July 2017.

Vinayak, P., M. Motro, P. Lavieri, J. Kuhr, R. Heath, J. Ghosh, and C. Bhat, "Using Infrastructure to Creating Necessary Redundancy in Connected Vehicle Systems and the Advantages to Enabling Cooperative Driving," *2017 Automated Vehicles Symposium*, San Francisco, CA, July 2017.

Lavieri, P., P. Vinayak, J. Kuhr, R. Heath, J. Ghosh, and C. Bhat, "A Systematic Approach to Evaluating Vehicular Communication and Sensor Technology in a Real-World Setting," *2017 Automated Vehicles Symposium*, San Francisco, CA, July 2017.

Bhat, C.R., "State DOT-UTC Partnerships and Networking," *CUTC/RAC Collaboration Task Force Breakfast Meeting*, 2017 National RAC and TRB State Representatives Meeting, Louisville, KY, July 2017.

Bhat, C.R., "A New Spatial Multivariate Model for the Analysis of Pedestrian Injury Counts by Severity Level," *Invited Seminar*, Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University (PolyU), jointly organized with the Hong Kong Society for Transportation Studies (HKSTS) and the Hong Kong Institution of Engineers Logistics & Transportation Division (HKIE-LTD), Hong Kong, August 2017.

Bhat, C.R., "On the Design and Implementation of an Agent-Based Activity-Travel Demand Microsimulation Modeling System," *Research Institute for Sustainable Urban Development (RISUD) Annual International Symposium 2017 (RAIS 2017)*, Hong Kong, August 2017.

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. Organize the 2017 Texas Wireless Summit to be held November 6-7, 2017 at UT Austin (The faculty organizers for TWS 2017 are WNCG Professors Jeffrey Andrews and Sanjay Shakkottai). The Texas Wireless Summit (TWS) is hosted by the Wireless Networking and Communications Group (WNCG), Dept of Electrical and Computer Engineering. Organize the 4th Data Supported Transportation Operations and Planning (D-STOP) Symposium to be held in Spring 2018. Organize a Center for Transportation Research (CTR) Symposium to be held in Spring 2018.

2. PRODUCTS

Publications, conference papers, and presentations:

Journal Publications - Published

Sen, R., K. Shanmugam, A. Dimakis and S. Shakkottai, “Contextual Bandits with Latent Confounders: An NMF Approach”. *Proceedings of the 20th International Conference on Artificial Intelligence and Statistics (AISTATS 2017)*, Ft. Lauderdale, FL, April 2017.

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Lavieri, P.S., V.M. Garikapati, C.R. Bhat, R.M. Pendyala, S. Astroza, and F.F. Dias, "Modeling Individual Preferences for Ownership and Sharing of Autonomous Vehicle Technologies," *Transportation Research Record: Journal of the Transportation Research Board*, 2665, 1-10, 2017.

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Pesyna, Jr., T. E. Humphreys; R. W. Heath; T. D. Novlan; J. C. Zhang, "Exploiting Antenna Motion for Faster Initialization of Centimeter-Accurate GNSS Positioning with Low-Cost Antennas," *IEEE Transactions on Aerospace and Electronic Systems*, 53(4), 2017.

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Presentations

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Bhat, C.R., "Predictive Analytics in a New Choice Data Landscape," *5th International Choice Modelling Conference (ICMC 2017)*, Cape Town, South Africa, April 2017.

Bhat, C.R., and J. Kuhr, "Connected and Autonomous Vehicles: Where Are We Going and What Happens When We Get There?," *Center for Transportation Research Annual Symposium*, Austin, TX, April 2017.

Krishnasamy, S., A.P. Thalasseryveettil, A. Arapostathis, S. Shakkottai, R. Sundaresan, “Augmenting MaxWeight with Explicit Learning for Wireless Scheduling with Switching Costs” *IEEE Infocom 2017*, Atlanta, GA, May 2017.

Lavieri, P.S., S. Astroza, F. Dias, C.R. Bhat, V.M. Garikapati, and R.M. Pendyala, "Autonomous Vehicle Ownership and Sharing: A Demand Forecasting Approach for the Puget Sound Region and Beyond," *16th TRB National Transportation Planning Applications Conference*, Raleigh, NC, May 2017.

Heath, R.W., “Verticals driving 5G development,” *5G North America*, May 16, 2017.

Heath, R.W., “Vehicle-to-X communication for 5G - a killer application of millimeter wave,” *IEEE 5G Summit, International Microwave Symposium*, Honolulu, June 6 2017.

Bhat, C.R., and J. Kuhr, "Connected and Autonomous Vehicles: Where Are We Going and What Happens When We Get There?," *Invited Seminar*, Department of Urban Studies and Planning, Massachusetts Institute of Technology, June 2017.

Motro, M., J. Ghosh and C. Bhat, "Optimal Alarms for Vehicular Collision Detection," *2017 IEEE Intelligent Vehicles Symposium (IV)*, Los Angeles, CA, June 2017.

Ruiz Juri, N. "A framework to support data-centric transportation research: the Data Rodeo concept,” *CUTC 2017 Annual Summer Meeting*, Buffalo, NY, June 2017.

Bhat, C.R., "A New Mixed Multinomial Probit Model Accommodating a Variety of Dependent Non-Normal Coefficient Distributions," *Invited Seminar*, Institute for Transport Planning and Systems (IVT), Swiss Federal Institute of Technology (ETH Zurich), Zurich, Switzerland, June 2017.

Bhat, C.R., "A New Analytic Landscape for the Estimation of Discrete Choice Models," *17th COTA International Conference of Transportation Professionals (CICTP2017)*, Shanghai, China, July 2017.

Vinayak, P., M. Motro, P. Lavieri, J. Kuhr, R. Heath, J. Ghosh, and C. Bhat, "Using Infrastructure to Creating Necessary Redundancy in Connected Vehicle Systems and the Advantages to Enabling Cooperative Driving," *2017 Automated Vehicles Symposium*, San Francisco, CA, July 2017.

Lavieri, P., P. Vinayak, J. Kuhr, R. Heath, J. Ghosh, and C. Bhat, "A Systematic Approach to Evaluating Vehicular Communication and Sensor Technology in a Real-World Setting," *2017 Automated Vehicles Symposium*, San Francisco, CA, July 2017.

Bhat, C.R., "State DOT-UTC Partnerships and Networking," *CUTC/RAC Collaboration Task Force Breakfast Meeting*, 2017 National RAC and TRB State Representatives Meeting, Louisville, KY, July 2017.

Bhat, C.R., "A New Spatial Multivariate Model for the Analysis of Pedestrian Injury Counts by Severity Level," *Invited Seminar*, Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University (PolyU), jointly organized with the Hong Kong Society for Transportation Studies (HKSTS) and the Hong Kong Institution of Engineers Logistics & Transportation Division (HKIE-LTD), Hong Kong, August 2017.

Bhat, C.R., "On the Design and Implementation of an Agent-Based Activity-Travel Demand Microsimulation Modeling System," *Research Institute for Sustainable Urban Development (RISUD) Annual International Symposium 2017 (RAIS 2017)*, Hong Kong, August 2017.

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://www.datarodeo.org/, Data Rodeo, A Data Analytics Environment for the Central Texas Region
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
http://www.profheath.org/, Dr. Heath's 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?
City of Austin, Austin, TX: In-kind support, financial support
Texas Department of Transportation, Austin, TX: In-kind support, financial support
Capital Area Metropolitan Planning Organization (CAMPO): In-kind support
Samsung Research America, Dallas, TX: In-kind support
Huawei Technologies, USA, In-kind support, financial support
TOYOTA InfoTechnology Center, U.S.A., Inc. - Takayuki Shimizu and Gaurav Bansal: Financial support and technical consultancy
Pohang University of Science and Technology, Korea - Junil Choi: Technical consultancy
Universidade de Vigo, Department of Signal Theory and Communications, Vigo, Spain - Nuria G. Prelcic: Technical consultancy.
Haris Vikalo, University of Texas at Austin: Technical consultancy
University of Southern California, Department of Electrical Engineering - Andreas F. Molisch: Technical consultancy

Have other collaborators or contacts been involved?
D-STOP has allowed us to build new relationships, including a new contract with TxDOT San Antonio District to assist with DTA modeling, and also a new task with TxDOT Austin District to help with planning to use advanced modeling.

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 Department of Transportation. We have also initiated collaboration discussions with Cintra.

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. D-STOP projects are also contributing to research on the potential of millimeter wave (mmWave) communication to enhance transportation safety.

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.

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 implementing mmWave joint radar and communication systems with NI equipment.

Impact on technology transfer:
The CTR Annual Symposium provided a forum for the exchange of ideas and thoughts, and the identification of gaps in our current research activities. D-STOP has also allowed us to reach out to high school students in the Austin region and inform them of educational and career opportunities in STEM fields.

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

Jennifer Duthis, a Co-PI of the D-STOP Center grant, has left UT Austin, and we have brought in Natalia Ruiz Juri to take up Jennifer's place as Co-PI.

UTC-UI 2017 SUMMER SYMPOSIUM SERIES

Date/Time	Lecturer	Room
Tuesday, May 30	**UTC-UI 2017 Orientation and Welcome Reception**	
11:00-12:00 pm	Orientation Session	ECJ 6th Floor, Rm 6.706
12:00-1:00 pm	Welcome Reception	ECJ 4.304
Thursday, June 1 3:00-4:00pm	**Prof. Steve Boyles**, Transportation Engineering "Transportation, Networks, and Paradoxes"	ECJ 6.706
Thursday, June 8 3:00-4:00pm	**Mr. Kirk Fauver**, Federal Highway Administration, Texas Division "Every Day Counts and Research Implementation Efforts in the State of Texas"	UTA 4.518
Thursday, June 15 3:00-4:00pm	**Prof. Christian Claudel**, Transportation Engineering "Inertial Measurement Units for Traffic Flow Monitoring"	ECJ 6.706
Thursday, June 22 3:00-4:00pm	**Prof. Randy Machemehl**, Transportation Engineering "Research in System Operations"	ECJ 6.706
Thursday, June 29 3:00-4:00pm	**Prof. Todd Humphreys**, Aerospace Engineering "Collaborative Map-Making for Connected and Automated Vehicles"	UTA 4.518
Thursday, July 6 10:00am-12:00pm	**UTC-UI Presentations 1** UTC-UI Interns	ECJ 6.706
Thursday, July 13 3:00-4:00pm	**Dr. Guni Sharon**, Post-Doc Researcher, Computer Science "Autonomous Intersection Management"	ECJ 6.706
Thursday**,** July 20 3:00-4:00pm	**Prof. Jorge Prozzi**, Transportation Engineering "Research Issues in Pavement Engineering"	ECJ 6.706
Thursday, July 27 3:00-4:00pm	**Prof. Kara Kockelman**, Transportation Engineering "Anticipating a World of Shared Autonomous Vehicles: Cost, Energy, and Urban Implications"	ECJ 6.706
Thursday, August 3 3:00-4:00pm	**Dr. Abhay Samant**, VP of Engineering, Hiller Measurements "Can You See Me Now? Introduction to the Role of Sensing and Analytics in Self Driving Cars"	UTA 4.518
Thursday, August 10	**UTC-UI 2017 Final Presentations & Farewell Reception**	ECJ 10th Floor
1:00-3:00 pm	Final Intern Presentations	Large Conference Rm
3:00-4:00 pm	Farewell Reception	