Program Progress Performance Report

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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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Reporting Period End Date: March 31, 2016

Report Term: October 1, 2015 – March 31, 2016

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 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:


**Forthcoming:**


*Under review:*


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

**Presented:**


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


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


Forthcoming Presentations:


Presentations Under Review:


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


**Journal Publications - Accepted**


Presentations


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.


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


**Websites:**

- [http://dstop.utexas.edu](http://dstop.utexas.edu), D-STOP website
- [http://ctr.utexas.edu/](http://ctr.utexas.edu/), Center for Transportation Research (CTR)
- [http://ctr.utexas.edu/nmc/](http://ctr.utexas.edu/nmc/), Network Modeling Center at CTR
- [http://www.caee.utexas.edu/prof/bhat/FULL_PAPERS.htm](http://www.caee.utexas.edu/prof/bhat/FULL_PAPERS.htm), Dr. Bhat’s personal webpage
- [http://tinyurl.com/steveboyles/](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.
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.