Program Progress Performance Report

Submitted to
United States Department of Transportation (USDOT), Research and Innovative Technology Administration (RITA)

Federal Grant number: DTRT13-G-UTC48

Project Title: Transportation Informatics University Transportation Center (TransInfo UTC): Harnessing the Power of Big Data in Support of USDOT Strategic Goals

Adel W. Sadek, Ph.D.
Professor and Director of TransInfo UTC
Department of Civil, Structural and Environmental Engineering
University at Buffalo, the State University of New York
Buffalo, NY 14260
E-mail: asadek@buffalo.edu
Phone: (716) 645-4367

October 31, 2014

DUNS#: 038633251
EIN#: 14-1368361

Recipient Organization: The Research Foundation for SUNY, 402 Crofts Hall, University at Buffalo, Buffalo, NY 14260

Recipient No.: 66473

Project/Grant Period: October 2013 – September 2017

Reporting Period: April 1, 2014 – September 30, 2014

Report Frequency: Semiannual

Signature:

1. Accomplishments

1.1 Major Goals of the Program

The volume, variety, quality and resolution of transportation-related "Big Data" currently present the transportation community with an unprecedented opportunity for improving system performance. Specifically, the wealth of data can be *studied, analyzed, and mined for insights and applications that can improve the efficiency, safety, sustainability, resiliency and reliability of the transportation system, and can inform and guide transportation policy.* It is to this goal that TransInfo's activities are dedicated. TransInfo's mission will be to undertake research, education, training, and technology transfer activities aimed at realizing the full potential of "*Big Data" and Transportation Informatics* in: (1) improving transportation system performance; and (2) guiding investments and policies. We anticipate that the activities performed under the umbrella of the TransInfo Center will advance the state of knowledge in the emerging field of transportation informatics, and will better prepare and educate both the existing transportation workforce, as well as the next generation of transportation professionals in how to harness the power of "Big Data" to address transportation challenges.

Because improved utilization of transportation data will help improve system performance, and because transportation serves as the very foundation of our nation's economy, the Center's activities are envisioned to directly address the US Department of Transportation (US DOT) Strategic Goal of "Economic competitiveness". However, "Economic competitiveness" is not the only goal that TransInfo UTC will address. The common thread behind all of TransInfo's research and educational activities is to compile, fuse, and mine various data streams to support a wide range of transportation applications in traffic operations, safety, emergency operations, travel behavior modeling, and performance measurement. As such, TransInfo also touches upon the goals of "Safety", "Environmental Sustainability", "Livable Communities", and the "State of Good Repair".

1.2 Progress and Accomplishments

Work during the reporting period covered by this report has focused on: (1) research activities; (2) graduate student involvement in TransInfo's research activities; (3) the transportation seminar series at the University at Buffalo (UB); (4) outreach activities to governmental agencies, members from the transportation industry, the International community as well as prospective transportation students; and (5) leveraging TransINFO funds for follow-on funding. Each of these accomplishments is described below.

1.2.1 *Research Activities*

1.2.1.1 Research at the University at Buffalo

a) Border Crossing Delay Prediction

Summary:

Project Status:

This research developed an Android smartphone application called the Toronto Buffalo Border Waiting (TBBW), designed to collect, share and predict waiting time at the three Niagara Frontier border crossings (i.e., the Lewiston-Queenston Bridge, the Rainbow Bridge, and the

Peace Bridge). The innovative app offers the user three types of waiting time estimates: (1) current waiting times; (2) historical waiting times; and (3) future waiting time predicted by an underlying traffic delay prediction model which provides predictions for the next 15 minutes (and updates them every 5 minutes). For the current waiting time, the app can provide estimates based on data collected by border crossing authorities as well as user-reported or "crowd-sourcing" data shared by the community of the app's users; reporting of the data could be done either manually or automatically through a GPS tracking function. For the historical waiting time, the app provides statistical charts and tables to help users choose the crossing with the likely shortest wait time. The ability to integrate officially reported delay estimates with crowd-sourcing data, and the ability to provide future border wait times clearly distinguish our app from others on the market.

Milestone Accomplishments and Dates:
April 2014: The University at Buffalo team submits a prototype android app for predicting border crossing delay at the Peace Bridge, along with a paper describing the concept and the tool, to the U.S. Department of Transportation's Data Innovation Challenge.

June 2014:
Lei Lin, a University at Buffalo doctoral candidate, working on this project won the ITS-NY Student Paper Competition for a paper entitled "Android Smartphone Application for Collecting, Sharing and Predicting the Niagara Frontier Border Crossings Waiting Time."

August 2014
The University at Buffalo submits a paper to the Annual TRB Meeting documenting the development of the android app. This paper has been accepted for presentation.

Planned Activities:

Several future directions are suggested by the current work. First, at the moment, the TBBW app is only predicting the delay for the next 15 minutes, it would be better to make the prediction horizon a user-specified value (e.g., some users may be interested in the future delay for the next 30 minutes or one hour, if their trip origin is farther away from the border). Second, although the app is currently designed for the Niagara International Frontier Borders, it can also be easily extended and applied to other US-Canadian borders as well as to the borders between the US and Mexico, provided that similar data are available. The app can even be extended to predict airport delay, as well as delay at many other similar queueing systems, in the future.

b) Novel Machine Learning Methods for Accident Data Analysis

Summary: With the recent advances in data collection, storage and archival methods, the size of accident datasets has grown significantly. This in turn has motivated research on applying data mining and complex network analysis algorithms, which are specifically designed to handle datasets with large dimensions, to traffic accident analysis. This project is exploring the potential for using a number of machine learning and data mining methods to accident data analysis, including methods such as the modularity-optimizing community detection algorithms, association rules learning algorithms, Bayesian Networks, and frequent pattern trees.

Project Status:
The community detection algorithm has been used as a method for clustering traffic accident data and was shown to yield very good results. The Associative rule learning algorithm was then used to gain insight into the characteristics of hot spots, using a test data set compiled from the Buffalo-Niagara area. In addition, Bayesian Networks and Frequent pattern trees were used to develop models for the prediction of accident risk from real-time traffic information, and to develop models for predicting anticipated accident duration. The project has resulted so far in a Transportation Research Board (TRB) paper which was recently accepted for publication, and two other papers in refereed conference proceedings.

Milestone Accomplishments and Dates:
May 2014: Two papers are accepted for presentation at the International Conference on Engineering and Applied Sciences Optimization (OPTI 2014).

August 2014: A paper describing the use of Bayesian networks for the real-time prediction of accident risk from real-time traffic data, is submitted for review by the *Transportation Research – Part C* journal.

Planned Activities:
Work is currently underway to submit a paper on the prediction of accident duration using a combined machine learning/hazard duration method, to the *Accident Analysis and Prevention* journal.

c) Mining Transportation Information from Social Media for Planned and Unplanned Events

Summary: The focus of this project is on mining social media data to deduce useful information about present or future travelers' behavior, with a special emphasis under events, including both planned events (sporting games, concert, parade, holidays and etc.), and unplanned events (such as inclement weather, earthquakes, hurricanes, floods and etc.). Specifically, the project proposes to develop effective and efficient techniques to collect, extract and mine social media data to support advanced traveler information systems and traffic operators. By mining social media based semantics, especially text semantics, this project aims to achieve the following goals: 1) Assess the impact of unplanned events. 2) Extract useful travel information to indicate congestion for planned events. 3) Identify causality between abnormal traffic pattern and social media data. A graduate student is currently being supported on this grant.

Project Status: (i) Substantial progress was made in data collection efforts. (ii) Papers were prepared and submitted to TRB focused on social media mining and transportation informatics.

Milestone Accomplishments and Dates: (i) A tweet streaming API was launched to collect tweets in four metropolitan areas, including Buffalo/Niagara area, Bay Area, NYC area and DC area. The tweet data has been collected continuously since then – January 2014. (ii) A Db2 database server was built in the PI's lab to store all the tweets data and facilitate further analysis – September 2014. (iii) During the summer of 2014, the team worked on two TRB papers in social media data mining and transportation informatics. One paper focuses on predicting traffic

volume during planned special events in Bay Area. The other paper focused on extracting inclement weather events from social media in Buffalo/Niagara area.

Planned Activities: (next quarter): In NYC metropolitan area, we will examine social media data to extract public complaints about city infrastructure (bridges, tunnels, etc.), services (subway, buses, etc.) and events (sporting games, shows, etc.). We will further develop a tweet-based performance measure to identify the high impact traffic spatial-temporal hotspots. In DC metropolitan area, due to multiple available datasets, we will combine three pieces of datasets, including social media data, traffic loop detector data and event data, and further examine their relationship. The goal is to find indicators in social media data to infer the spatial-temporal change in traffic data, potential caused by a variety of events.

1.2.1.2 Research at RPI

Developing Big Data Analytics Methods for Urban Transportation Modeling

Summary: As technologies advance, emerging urban data are increasingly available for wide urban areas. Such data are inherently heterogeneous, including both fixed location data (e.g.., those from loops) and mobile data (e.g., those from GPS), which we refer to herein as Urban Hybrid Traffic Data (U-HTD). U-HTD provides great opportunities for urban transportation/traffic system performance evaluation, modeling, and management, while posing great challenges in data collection, processing, storage, and use.This research aims to tackle some of these challenges by developing methods on how to best mine the different data elements in U-HTD, how to protect privacy when processing and using U-HTD, and how to develop novel methods that can best utilize U-HTD for critical urban transportation applications.

Project Status: (i) The team made significant progress in developing models/tools to assess urban system performance measurement using multiple data sources; (ii) Team members also made presentations at various conferences about urban system modeling using multiple data sources as well as Big Data in Transportation

Milestone Accomplishments and Dates: (i) developed a data fusion framework to combine mobile and fixed-location sensor data for urban arterials, with a draft paper completed in July, 2014; (ii) developed a spatial data modeling process that integrates satellite image data and socioeconomic data, the draft paper completed in July, 2014; (iii) started the development of analytical formulations of freight-demand-synthesis that are able to use GPS data.

Planned Activities: (next quarter): (i) complete the data fusion paper and submit it to TRB and relevant journals; (ii) complete the spatial data paper and submit it to TRB, RSAI and relevant journals; (iii) continue the development of the freight demand synthesis models; (iv) real time data feed/control between vehicles and traffic system for fuel consumption / emissions especially hybrid vehicles; (v) mobile apps to collect mobile data at specific times/locations to balance with privacy protection objectives

1.2.1.3 Research at George Mason University

Improving Incident Response System for Northern Virginia using Historical Incident and Traffic Data

Summary: This project aims at improving incident response strategies by exploring historical incident and traffic data. Traffic incidents have become a major cause of congestion and significant threat to urban mobility. Many road networks in major cities are currently operating near, if not beyond, capacity during peak hours. Capacity reduction and road closure due to incidents can cause significant delays over an extended period. An effective incident management system not only helps to mitigate congestion through swift incident detection, response, and site clearance, but also generates significant environmental benefits by reducing fuel consumption, emissions, and potential secondary incidents. By exploring both historical incident and traffic data, the system can be improved by proactively deploying response units. The system should adapt itself to evolving incident patterns over different time of day and under different traffic/weather conditions, and change the strategy accordingly. Moreover, an effective system must also consider the network effect and travel behavior in response to changed traffic conditions in the aftermath of major incidents. These factors are extremely important in an urban setting where traveler information system is usually readily available and multiple alternative routes co-exist. This study would address these challenges.

Project Status: Significant progress was made as indicated in milestones and accomplishments and the project is estimated to be 20% complete.

Milestone Accomplishments and Dates: (i) The research team reviewed literature and worked with Virginia Department of Transportation to identify the data needed to capture prevailing traffic/incident patterns during different time of day, and potentially, under different weather conditions in the Northern Virginia area June, 2014 (ii) A mesoscopic/microscopic traffic simulation model has been developed for the I-66/US29/US50 corridor in the Northern Virginia area as the test-bed to support the evaluation of different incident management strategies based on historical data – September, 2014.

Planned Activities: (next quarter): (i) The research team will continue to exploring historical traffic and incident data in Northern Virginia area and identify the prevailing traffic/incident patterns during different time of day, and potentially, under different weather conditions. (ii) The research team will continue with the development of a model to estimate/predict incident patterns (or lack of patterns) during different time of day and under different traffic conditions. (iii) The research team will continuously calibrate the mesoscopic/microscopic traffic simulation model using updated traffic data.

1.2.1.4 Research at the University of Puerto Rico at Mayaguez

a) Development of New Performance Metrics and Operational Strategies Based on Bus Location and Passenger Count Data

Summary: The transit industry in several cities, including the San Juan Metropolitan Area (SJMA), has relied on limited, general, and aggregate measures for reporting performance to

external funding and regulatory agencies. This implies the use of relatively small samples, with findings that had to be extrapolated to the whole system. However, with the implementation of new technologies in the transit industry, it is now possible to measure the performance of a transit system not with sample data but with a more complete set of data for the entire system. Several new real-time performance metrics need to be developed using big databases instead of a small sample of data. These metrics will assist AMA to improve their levels of service. Furthermore, there is an opportunity to develop preventive maintenance to improve the mechanical condition of the vehicles and avoid costly repairs. Passenger counts and load diagrams will also be used, not only to develop performance metrics, but to establish new strategies such as new express routes or the addition of new units in heavily used corridors. Thus, the main objectives of this research study are: (1) Develop the computational tools needed to process the immense amount of data produce by the GPS and passenger counter system; (2) Proposed better methods of saving these data to simplify their analysis; (3) Develop new performance metrics based on the data collected; and (4) Propose methods to enhance the performance of the system.

Project Status: The research project is currently on its development phase as follows: (i) Two graduate students have been hired to work to work on the project; (ii) A literature review was performed on the Model Minimum Uniform Crash Criteria (MMUCC), a guideline that includes all the information that must be collected in the report that police officers file when there is a vehicle crash. (iii) Accident reports from several states of the US have been collected, including one that is 100% MMUCC compliant, for the purpose of designing an application that complies with all the requirements.

The graduate student from INCI has studied the MMUCC and has identified all missing elements in the police report from Puerto Rico that should be included according to the guidelines. He was able to obtain the crash reports from Florida and Alaska, the latter which is 100% MMUCC compliant. A presentation of this research project was given to the Traffic Records Committee of Puerto Rico and the student has also met with the police from the town of San German.

The graduate student from ICOM has familiarized himself with the technical applications that are useful for programming with IPads and, after exploring various alternatives for programming the server, identified Java Play Frameworks as the appropriate one for this research. In addition, he has created an application that relates the knowledge pertinent to the client-server communication. Both graduate students are working together and meet regularly in order to develop the mobile application.

Milestone Accomplishments and Dates: (i) March, 2014 – a presentation was given to the Traffic Records Committee; the committee members expressed their support in the development of the mobile application. (ii) June, 2014 – the team met with Alex Silva, Police Commander of San German municipality; two police officers were identified as the ones that will give their feedback regarding the mobile application. The two police officers will meet with the team 1-to-2 times per month. (iii) September, 2014 – a presentation was given to members of the Budget and Management Office of the Commonwealth of Puerto Rico (OGP, due to its name in Spanish) and the Department of Transportation and Public Works and (DTOP, due to its name in Spanish).

DTOP has expressed interest in collaborating with the UPRM in the development of the application.

Planned Activities: A graduate student will learn how Apple's framework is able to sustain application with several languages (since the application will be available on both English and Spanish), and create, along an Entity Relationship Diagram (ERD) for the various fields of the crash report. The graduate student from INCI is expected to identify the order of the fields and elements that should be viewed in the application; he is also expected to schedule regularly meetings with police officers to gain insight regarding any suggestions and recommendations.

In addition, the team is arranging a meeting with the mayor of the town of Hormigueros who has shown interest in collaborating with this research.

The research will be promoted at the annual meeting of the Institute of Transportation Engineers Puerto Rico Section (ITE-PR) which will take place in October 24th, 2014, at the Double Tree Hotel in San Juan, PR.

b) Development of a Mobile Computer Application for the Process of Data Collection and Data Sharing for Vehicle Accidents

Summary: The main goal of the research study is to develop a mobile computer application for documenting and sharing data regarding vehicular accidents. The developed application will benefit the police workforce, the Puerto Rico DTOP, and higher education institutions by providing the means to collect accident data accurately and making it available for further research . The detailed objectives are: (1) Determine relevant data needed from accident reports and the key features of this data. This first step will help in the creation of reports, the development of the database and the proper transfer of the data to other interested agencies; (2) conduct an extensive literature survey on off-the-shelf equipment, and available software platforms for the development and deployment of the mobile application; (3) Select the proper architecture for the mobile application software and reporting system. The initial system will be deployed at a small-scale; however the design must be scalable; (4) Develop a mobile application that will substitute the police report that is filed in the field when a vehicle accident is reported; (5) Develop an accident data sharing system among the interested parties (i.e. local police station, central police station, Puerto Rico DTOP, and higher-education institutions). The collected data and reports could be available to the general public; and (6) Use data mining algorithms on the collected accident report data to develop transportation informatics.

Project Status: The mentioned research project is currently focused on two tasks: literature review and development of a pre-processing tool for data analysis. The literature review is considered an ongoing project and it is expected to continue throughout the rest of the research. The second task is the development of a computing tool to process the information of two databases. The Metropolitan Bus Authority (AMA, for its acronym in Spanish) has been collaborating with the University of Puerto Rico at Mayaguez (UPRM) and has shared two databases for the purpose of this project: the database regarding the bus stops of the AMA and the GPS database for all the buses.

Milestone Accomplishments and Dates: (i)The Matlab program for 4 of the 10 routes has been finished; this task began with the route with the highest ridership (route 7); the rest of the routes are expected to be finished by December, 2014. It is considered that, regarding this task, 75% of the work has been completed.

Planned Activities: (next quarter): (i) Continue with the literature review task and identify potential performance measures from currently available data and other sources of data related to the spatial and economic activities around the bus stops along the AMA routes. (ii) Finish all Matlab programs for the remaining bus routes. (iii) Collect information from the automatic passenger counters installed in a sample of the AMA buses.

1.2.1.5 Research at Calspan / University at Buffalo Research Center (CUBRC)

Developing Highway Safety Performance Metrics in an Advanced Connected Vehicle Environment Utilizing Near-Crash Events from the SHRP 2 Naturalistic Driving Study

Summary: MAP-21 requires that greater emphasis be placed on developing performance measures to justify roadway safety improvements. This project proposes to develop an alternative highway safety performance measure through the monitoring and classification of near crash events.

Near crash events are normally defined as the exceedance of accepted thresholds for various vehicle kinematics such as lateral/longitudinal acceleration/deceleration, forward or rear 'time to collision' (as measured by radar), and yaw rates. Many of today's vehicles contain the sensors required to measure these kinematics, and can be reported via the Data Acquisition System (DAS).

NHTSA, by 2015, will require that all new vehicles contain event data recorders (EDR) that will store vehicle kinematic data, and Connected Vehicle (CV) technologies in the future will allow for the communication of these events to state and federal transportation agencies. In the near term however, data from the second Strategic Highway Research Program (SHRP 2) Naturalistic Driving Study (NDS) can be utilized to identify new metrics and demonstrate their proof of concept. CUBRC is currently overseeing the collection of SHRP2 data in both Buffalo, NY and Tampa Bay, FL, and intends to utilize these data in this proposed research.

Project Status : Work is in progress. Project began 6/1/14 with expected completion of 5/31/15

Milestone Accomplishments and Dates: (i) Initiated literature review to identify SHRP 2 data analyses that address potential 'connected vehicle' technologies that could mitigate or reduce specific crash risks - June, 2014. (ii) All project personnel were approved as 'Qualified Researchers' for SHRP 2 NDS data - June, 2014. (iii) Review of available SHRP 2 NDS data has been initiated. Specific attention is being paid to InSight data on crashes and near crashes, recently added data, and plans to provide additional NDS data. In regard to the latter, VTTI has begun to reduce the radar data and will be adding selected radar information to the InSight database in the fall 2014 – July, 2014. (iv) Started analyses to compare crash rates experienced by the Erie County NDS participant fleet with crash rates experienced by the general population

of Erie County drivers. (v) Attended the Fourth International Symposium on Naturalistic Driving Research at Virginia Tech Transportation Institute (VTTI) - August 25-28, 2014

Planned Activities: (i) Summarize literature review SHRP 2 data analysis activities. (ii) Continue the review of the available SHRP 2 NDS data on the InSight website and initiate the development of a SHRP 2 NDS crash and near crash data dictionary defining the types and characteristics of events identified in the database. (iii) Complete the analysis of NDS fleet crash rates. (iv) Develop a request to be submitted to VTTI to obtain SHRP 2 NDS data to support this project. Prepare application for IRB waiver. (v) Begin to develop analysis strategy to predict potential severity of near crash events should they have not been successfully avoided.

1.2.2 Graduate student involvement in TransInfo's research activities

The TransINFO consortium is actively engaging nearly 30 undergraduate or graduate students in its research activities with each project facilitating the involvement of at least one student. Highlights of TransINFO student involvement include:

- UB doctoral candidate Lei Lin recently won the ITS-NY Student Paper Competition for *Android Smartphone Application for Collecting, Sharing and Predicting the Niagara Frontier Border Crossings Waiting Time.* Lei Lin is also taking steps to commercialize the Android Smartphone Application developed through the Border Crossing Delay Prediction project

- RPI doctoral candidate Dapeng Zhang recently received two awards. He was the winner of the GIS-T student paper contest organized by AASHTO, for *Transit Ridership Estimation with Network Kriging: A Case Study of Second Avenue Subway, NYC*; and received first place in the RIBTC (Rural Public and Intercity Bus Transportation) graduate student research competition, for *A Schedule Optimization to Improve Transfer Efficiency between Intercity Buses and Local Buses.*

- RPI Ph.D. Student, Wei Zou, received the WTS Greater New York Scholarship on July 21st, 2014.

1.2.3 Transportation seminar series at the University at Buffalo (UB)

The Transportation Seminar Series within the Department of Civil, Structural and Environmental Engineering at the University at Buffalo hosts speakers from academia, industry and government - from around the world - through the academic year. Past speakers have included:

Dr. Ansar-Ul-Haque Yasar, Transportation Research Institute (IMOB) Hasselt, Belgium. *Empowering Citizens with Sustainable Transportation in the Cities of Today & Tomorrow*

Dr. Hanghang Tong: Assistant Professor, Computer Science Department, City College, City University of New York. *Optimal Dissemination on Graphs: Theories and Algorithms*

Dr. H. Oliver Gao: Associate Professor, School of Civil and Environmental Engineering, Cornell University. *From Transportation Planning/Management to Air Pollution and Public Health Are We Doing the Right Thing, and Doing it Right?*

Jack Ampuja: President, Supply Chain Optimizers & Executive in Residence, Niagara University. *Packaging Optimization: The Route to Reducing Costs & Carbon Footprint*

Dr. Srinivas Peeta: Professor of Civil Engineering, and Director of the NEXTRANS Center, Purdue University. *Graph-based Modeling of Information Flow Propagation under Vehicle-to-Vehicle Communications*

Dr. Venky Shankar, PE: Professor of Civil Engineering, Director, Transportation Econometrics Lab, Pennsylvania State University. *Statistical modeling of discrete transportation outcomes including Big Data*

Christopher LaTuso, PE, MBA: Vice President, NY/NJ Transportation Business Group Manager HDR Inc., New York, NY. *Case Studies and Challenges in Highway Engineering*

Sissy Nikolaou, PhD, PE: Senior Associate and Director Geoseismic Dept. Mueser Rutledge Consulting Engineers, New York, NY. *Challenges in Highway Design, Bridge Foundation and Seismic Engineering: A Practitioner's Perspective*

1.2.4 Outreach Activities

1.2.4.1 National Summer Transportation Institute at the University at Buffalo

TransINFO core faculty members Dr. Qing He, Dr. Adel Sadek and Dr. Qian Wang were awarded a grant by Federal Highway Administration to host the 2014 UB National Summer Transportation Institute (UB NSTI) from July 7-11, 2014. UB NSTI successfully attracted 30 local high school students to participate in an innovative one week summer educational program in transportation. The overall goal of the Institute is "to support the inclusion of high school students, from diverse backgrounds, within National Summer Transportation Institutes that result in an increase in the number of students pursuing transportation related careers".

The 2014 UB NSTI curriculum included a blend of academic and enhancement activities, designed to introduce students to careers within the diverse modes of water, air, and ground transportation, and involved four lectures, five projects, field trips at five different locations and three enhancement sessions. Topics covered included transportation career opportunities, highway transportation, construction and transportation infrastructure, aviation, water transportation, and transportation safety. UB NSTI's participants learned about career opportunities and domain knowledge from professionals, representing public and private sector transportation organizations as well as academia. Hands-on activities related to each topic helped to develop students' problem-solving skills and reinforce what they had learned. In addition to classroom activities, students will participate in a number of team building projects and competitions, designed to build teamwork and communication skills while fostering creative

problem solving. Points will be awarded to participants throughout the program for various achievements, and the highest scoring participants will be awarded at the closing ceremony.

Field trips supplemented the classroom and laboratory activities, providing students with an opportunity to meet and speak with practicing transportation professionals. Students participated in three field trips during the program:

- Niagara International Transportation Technology Coalition (NITTEC) and Niagara Frontier Transportation Authority (NTFA). NITTEC runs the Regional Transportation Operation Center for the Greater Buffalo-Niagara Fall area, and NFTA is the transportation authority responsible for all the public transportation systems.
- The Erie Canal, regarded as one of the most successful and influential human-built waterways and one of the most important works of civil engineering and construction in North America. The tour will help students learn the history and functionality of water transportation in New York State.
- Buffalo Niagara International Airport and the Air Control Tower. During the tour, participants had an opportunity to speak with aviation professionals and learn about airport security, airport operations and maintenance, and air traffic control.

1.2.4.2 Transportation Informatics Tier I University Transportation Center Newsletter

The Transportation Informatics Tier I University Transportation Center newsletter was launched in June, 2014 and is designed to provide not only continuing information on the Center, but relevant updates on transportation informatics more generally. A mailing list of nearly 250 qualified recipients will receive the newsletter quarterly and we are pleased to report that the inaugural newsletter had an open rate at almost 50%. Archived copies of the newsletters can be retrieved from the TransInfo website at: http://www.buffalo.edu/transinfo/News/Enewletter.html

1.2.4.3 Marketing Materials

A TransINFO flyer was developed to be used among collaborating partners to promote the Center and invite collaboration.

1.2.4.3 Transportation Research Institute (IMOB); Hasselt, Belgium

In September, 2014, The University at Buffalo embarked on a discussion with the renowned Transportation Research Institute (IMOB) in Hasselt, Belgium to explore a number of different opportunities to collaborate including research and an exchange program for students and, potentially, staff.

1.2.5 Leveraging TransINFO funds for follow-on funding

CUBRC and UB, in collaboration with the New York State Department of Transportation, were selected in Round 4 of SHRP2 Implementation Assistance Program by the Federal Highway Administration and the American Association of State Highway and Transportation Officials for implementation and technical assistance in Round 4 of the Strategic Highway Research Program (SHRP2) Implementation Assistance Program in the Safety Focus

Area: "Concept to Countermeasure – Research to Deployment Using the SHRP2 Safety Databases."

2. Products

2.1 Publications, conference papers, and presentations

Publications:

L. Lin, Q. Wang, and A.W. Sadek. (2014). Border Crossing Delay Prediction using Transient Multi-server Queneing Models with Erlang Service Times. *Transportation Research – Part A*, Vol. 64, pp. 65 – 91.

L. Lin, Q. Wang, and A.W. Sadek. (2014). On-line Prediction of Border Crossing Traffic using the Spinning Network Method. *Transportation Research – Part C*, Vol. 43, pp. 158 – 173.

L. Lin, Q. Wang, and A.W. Sadek. (2014). Data Mining and Complex Network Algorithms for Traffic Accident Analysis. *Journal of the Transportation Research Board Meeting (in press).*

Zhu, Shanjiang, Woon Kim, Gang-Len Chang, and Steve Rochon, Design and Evaluation of Operational Strategies for Deploying Emergency Response Teams, *ASCE Journal of Transportation*, vol. 140(6), 2014, 04014021

Conference Papers:

Ban, X., Fined-Grained Transportation Knowledge Extraction from Mobile Sensing, New York State Association of Transportation Engineers Conference, May 29, 2014.

The following fall outside of reporting period – but were not previously reported:

Sun, Z., Hao, P., Ban, X., 2014. Trajectory-based energy/emissions estimation for signalized arterials using mobile sensing data. Presented at the 93rd Annual Meeting of Transportation Research Board, January, 2014.

Yang, X., Sun, Z., Ban, X., Wojtowicz, J., Holguin-Veras, J., 2014. Urban freight performance evaluation using GPS data, Presented at the 93rd Annual Meeting of Transportation Research Board, January, 2014.

Yang, X., Sun, Z., Ban, X., Holguin-Veras, J., 2014. Urban freight delivery stop identification using GPS data, Presented at the 93rd Annual Meeting of Transportation Research Board, January, 2014.

Hao. P., Ban, X., 2013. Platoon-based arterial corridor route travel time estimation using sample travel times, Presented at the 93rd Annual Meeting of Transportation Research Board, January, 2014.

Yang, X., Ban, X., Holguin-Veras, J., Wojtowicz, J., 2013. Urban freight performance measurement using GPS data, Presented at the INFORM Annual Meeting, Minneapolis, MN, October, 2013.

Hao. P., Ban, X., 2013. Platoon-based arterial corridor route travel time estimation using sample travel times, Presented at the INFORM Annual Meeting, Minneapolis, MN, October, 2013.
Sun, Z., Hao, P., Ban, X., 2013. Trajectory-based energy/emissions estimation for signalized arterials using mobile sensing data. Presented at the INFORM Annual Meeting, Minneapolis, MN, October, 2013.

Presentations:

S. Zhu and L. Schintler (2014). Big Data in Transportation. *International Road Federation*, e-learning webinar.

S. Zhu and L. Schintler (2014). Big Data in Transportation. *USDOT DataPalooza 2014*, Fredericksburg, Virginia.

Ban, X., Urban traffic modeling with mobile sensing, Department of Civil and Environmental Engineering, *Rutgers University*, October 08, 2014.

Ban, X., Urban traffic modeling with mobile sensing, Department of Civil and Environmental Engineering, *Tsinghua University*, July 02, 2014.

Ban, X., Urban traffic modeling with mobile sensing, Department of Civil and Environmental Engineering, *University of Wisconsin-Madison*, August 29, 2014.

2.2 Website(s) or other Internet site(s)

A website has been established for TransInfo and can be viewed at:

http://www.buffalo.edu/transinfo.html

2.3 Technologies or techniques

An Android Smart Phone app has been developed for the collection, prediction and dissemination of border crossing delay information at the Niagara Frontier border crossings.

2.4 Inventions, patent applications, and/or licenses

Nothing to report yet.

2.5 Other products

- A tweet streaming API was launched to collect tweets in four metropolitan areas, including Buffalo/Niagara area, Bay Area, NYC area and DC area.
- A Db2 database server was built in the PI's lab to store all the tweets data and facilitate further analysis.

- Developed a data fusion framework to combine mobile and fixed-location sensor data for urban arterials.
- Developed a spatial data modeling process that integrates satellite image data and socioeconomic data.
- A mesoscopic/microscopic traffic simulation model has been developed for the I-66/US29/US50 corridor in the Northern Virginia area as the test-bed to support the evaluation of different incident management strategies based on historical data
- The Matlab program for four of the 10 routes has been completed.

3. Participants and Collaborating Organizations

3.1 Organizations which have been involved as partners with TransInfo

Organization Name: Niagara International Transportation Technology Coalition (NITTEC)
Location of the Organization: Buffalo, NY
Partner's Contribution to the Project: In-kind support and Personnel exchanges

Organization Name: Peace Bridge Authority, Niagara Falls Bridge Commission
Location of the Organization: Buffalo, NY
Partner's Contribution to the Project: In-kind support (data)

Organization Name: Niagara Falls Bridge Commission
Location of the Organization: Niagara Falls, NY
Partner's Contribution to the Project: In-kind support (data)

Organization Name: New York State Thruway Authority
Location of the Organization: Albany, NY
Partner's Contribution to the Project: In-kind support (data)

Organization Name: New York City DOT
Location of the Organization: New York, NY
Partner's Contribution to the Project: In-kind support (data)

Organization Name: Virginia Department of Transportation
Location of the Organization: Richmond, VA
Partner's Contribution to the Project: In-kind support

Organization Name: Puerto Rico Department of Transportation and Public Works (DTOP, by its acronym in Spanish)
Location of the Organization: Puerto Rico
Partner's Contribution to the Project: In-kind support (data)

Organization Name: Metropolitan Bus Authority (AMA, by its acronym in Spanish).
Location of the Organization: Puerto Rico
Partner's Contribution to the Project: In-kind support (data)

Organization Name: Police Workforce (San German Municipality)
Location of the Organization: Puerto Rico
Partner's Contribution to the Project: In-kind support (data)

3.2 Have other collaborators or contacts been involved?

Work on TransInfo project has involved close collaborations across traditional disciplinary lines. For several of our research projects and initiatives, transportation researchers (from the department of Civil Engineering) are working very closely with their counterparts in the department of Computer Science and Engineering.

4. Impact

4.1 What is the impact on the development of the principal discipline(s) of the program?

TransInfo activities are envisioned to help advance the state-of-the-art in the application of advanced data mining, Artificial Intelligence (AI), Social Network analysis and Advanced Statistical and Econometric models to transportation Big Data. Applying such methods is envisioned to result into invaluable insight into how to improve transportation system efficiency, safety, sustainability, resiliency and reliability. It is also envisioned to help support sound transportation decision making through the development and application of appropriate performance metrics.

4.2 What is the impact on other disciplines?

TransInfo activities are likely to have an impact on the field of Big Data Analytics, as it pertains specifically to transportation data. The transportation Big Data context has several unique features which distinguish it from other application domains of Big Data. TransInfo research and educational initiatives are thus likely to have an impact on the emerging field of Transportation Informatics and Analytics.

4.3 What is the impact on the development of human resources?

Several graduate students are (or will be) supported by TransInfo either through fellowships or graduate research assistantships. TransInfo also has a number of outreach initiatives aimed at encouraging high school students to consider careers in transportation, which we hope to report upon in future progress reports. We also hope to contribute toward improving the diversity of the workforce.

4.4 What is the impact on physical, institutional, and information resources at the university or other partner institutions?

TransInfo Center plans to build several important data repositories during the course of its work which can help support future research in the area of Big Data Analytics. These repositories would be made available to other researchers via our website to promote research and technology transfer in this field of inquiry.

4.5 What is the impact on technology transfer?

The vision is for many of the transportation research projects undertaken by TransInfo to result in either products which can be implemented to address transportation challenges or improve the traveler experience (e.g., the smart phone app which was already developed for predicting border crossing delay), or in strategies and/or policies to improve transportation system performance and to support sound decisions regarding transportation investments. We hope to work with our stakeholders and partners in the future to make sure that TransInfo research and educational initiatives are having a positive impact on technology transfer.

4.6 What is the impact on society beyond science and technology?

The benefits to individual drivers and society in general with respect to the Android smartphone application, the Toronto Buffalo Border Waiting (TBBW) can be tremendous. For individual drivers, the app can help them choose the right crossing and the arrival time which would minimize their wait time, thereby saving them time, gas, and money. For society, the app can help reduce the cost of border crossing delay on a region's economy as well as on the environment in the area, which is estimated to be in the order of billions of dollars annually in lost business productivity, wasted fuel, traffic-related pollutants and associated health hazards.

5. Changes/Problems

Due to the extended scope of the project *Developing Big Data Analytics Methods for Urban Transportation Modeling* (not only limited to modeling of urban arterials now), the team suggests the title of the project be changed to "Urban System Modeling and Performance Measurement Using Multiple Data Sources" to properly reflect the scope of the project.