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

April 30, 2015

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: October 1, 2014 – March 31, 2015

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) continued research activities; (2) education and training activities for TransInfo graduate students; (3) outreach activities including the 94th Annual Meeting of the Transportation Research Board, formal collaboration agreement with the Transportation Research Institute (IMOB) of Hasselt University in Belgium, the 3rd Symposium on Connected and Autonomous Vehicles, planning for the First Annual Symposium on Transportation Informatics, and the Transportation Systems Engineering Seminar Series; (4) leveraging TransINFO funds for follow-on funding; and (5) faculty accomplishments. Each of these accomplishments is described in detail 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:

November 2014:
A promotion video describing the app and its unique features was developed and posted to YouTube at: https://www.youtube.com/watch?v=t04n0bB73DM

January 2015
A paper entitled "An Android Smartphone Application for Collecting, Sharing and Predicting Border Crossing Wait Time" by L. Lin, Q. Wang and A.W. Sadek was presented at the Annual Transportation Research Board (TRB) Meeting in Washington, D.C. The paper summarized the development and functionality of the Android app.

Planned Activities:
We are currently exploring with some of our local partners (e.g., the Niagara International Transportation Technology Coalition (NITTEC) and the border crossing agencies) ways to promote the use of the app, as always as information that may be helpful in improving the accuracy of the predictions (e.g., knowing the number of customs and inspection stations open at a given time).

b) Novel Machine Learning Methods for Accident Data Analysis

Summary & Project Status: 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.

Milestone Accomplishments and Dates:
March 2015:
A paper describing a novel variable selection method based on the Frequent Pattern Tree method was accepted for publication in the *Transportation Research – Part* C journal. The method was then applied to developing Bayesian Networks for predicting traffic accident risk from real-time traffic measurements.

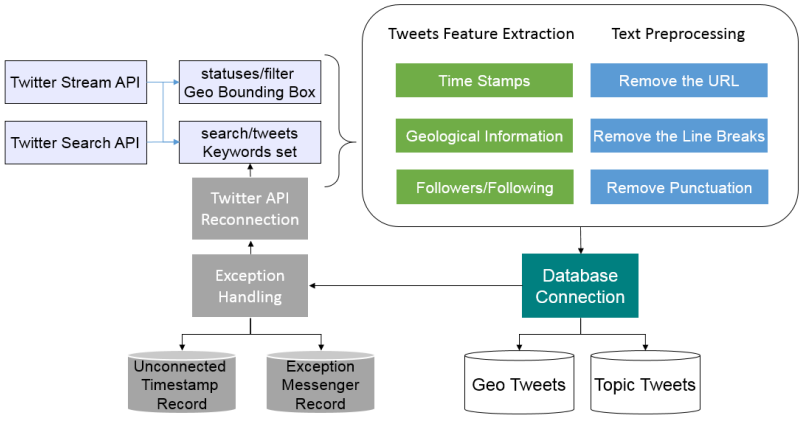
Planned Activities:
We are in the final stages of submitting a paper entitled "Duration Analysis and Prediction of Urban Freeway Traffic Accidents Based on the M5P Tree and Hazard-Based Duration Models" to the *Accident Analysis and Prevention* journal or the *Analytic Methods in Accident Research* journal.

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

Summary & Project Status: 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 on extreme 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.

Milestone Accomplishments and Dates: A paper related to traffic prediction under inclement weather with social data was accepted by Transportation Research Record (October, 2014). This work was also presented at the 94th TRB annual meeting in January 2015. The tweet streaming API was redesigned so that the real-time tweet data is retrieved and stored in DB2 database in real-time (January, 2015). In addition to the streaming API, a tweet Search API engine was built to collect tweets with keywords (February, 2015). Search API allows us to collect social media related to a hot topic or an event, which has no spatial constraints. The platform for social media data collection is complete, shown in figure below:



Since February 2015, an undergraduate student started to work with the PI for this project, in spatial-temporal analysis of social media data related to inclement weather and traffic.

Planned Activities: (i) Tweet classification and performance measurement with social media: plans to 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; (ii) Correlation between traffic/incident data and social media data. In the Northern Virginia metropolitan area, due to multiple available datasets, we will combine three pieces of datasets, including social media data, traffic loop detector data and incident 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

Urban System Modeling and Performance Measurement Using Multiple Data Sources
(formerly 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: The team made significant progress in developing models/tools to assess urban system performance measurement using multiple data sources. Team members also made presentations at various conferences about urban system modeling using multiple data sources as well as Big Data in Transportation, including the 94th TRB Annual Meeting, INFORMS Annual Meeting, and the Annual Meeting of the North American Regional Science Council.

Milestone Accomplishments and Dates: (i) Presented research results on vehicle classification and data fusion, using mobile data sources in urban areas; (ii) Developed a prototype mobile app for mobile data collection; (iii) Worked with NYSDOT, UTRC2, TransInfo Center, and other partners on a proposal to establish a Connected Vehicles test bed in Upstate New York; (iv) Submitted proposal to investigate strategies influencing adoption of Electric Vehicles. (v) The research results have been disseminated via meetings with transportation management agencies at the federal, state, and local levels, and industry partners. The team also submitted research results for publication by professional journals.

Planned Activities: (i) Continue research on data fusion; (ii) Testing and refining the development of mobile apps; (iii) Continue on the developing models, tools, and methodologies for urban system performance measurement using multisource traffic data, and to disseminate research results to a broader audience including public agencies, the industry, and the academia.

1.2.1.3 Research at George Mason University

a) 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 50% complete.

Milestone Accomplishments and Dates: (i) The research team reviewed literature and worked with the 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 (06/30/2014); (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 (09/30/2014); (iii) The research team collaborated with Virginia DOT to collect the traffic incident data in Northern Virginia. The data covers major freeway and arterial roads along I-66/I-495/US50/US29/Rt28 corridors from 2013 to 2014. Information collected includes starting time, duration, categories, reporting agencies, and coordinates of the incident sites. The research team analyzed the spatial-temporal patterns of the incident data, which will inform the modeling process. (03/30/2015); (iv) The research team obtained the INRIX data and traffic counts data along I-66/US50/US29 corridor and is calibrating the micro-mesoscopic traffic simulation model to support analysis of incident response strategies.

Planned Activities: 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. They will also continuously calibrate the mesoscopic/microscopic traffic simulation model using updated traffic data. In addition, the research team will evaluate different incident response strategies along I-66/US50/US29 based on historical incident and traffic data. Based on findings from the preliminary research, the research team will develop an integrated corridor management strategy to support active traffic management.

b) Developing a P3 Projects Database to Support Transportation Planning and Policy Analysis

Summary: The gap between increasing demand of infrastructure and shrinking funds poses great challenges to the governments of different levels. These governments are turning more to the private sector to help make projects both large and small to be built. It is suggested that private-public partnership (P3) projects can run more efficiently, be finished under budget and ahead of schedule and can have long term goals of maintaining and operating roads, tolls and bridges. However, many arguments in favor of P3 are anecdotal or based on limited number of case studies. Solid empirical studies and quantitative analysis is lacking in literature, most because of the lack of data. The analysis is further confounded by the diversity of projects in scale, time of completion, functional types, geographic distribution, financial sources, contract types, etc… Because of these challenges, there have been on consensus on the scale of benefits, if at all, related to P3 in literature. To address this challenge, this project proposes to develop a P3 project database to support transportation planning practice and policy analysis. This project will be review existing data in infrastructure finance and develop a data structure that provides a platform for projects of different size, financial sources, ownership, delivery methods, and age to be compared and analyzed. It will pool data collected from sources such as TIFIA, InfraAmerica, OECD, and others to build an initial database. The database will grow as more P3 project get funded and built. The strength of this database will be demonstrated through case studies and pilot transportation planning and policy analysis. Efforts will be dedicated to explore how qualitative features associated with a project could be quantified and analyzed using latest data mining techniques. Findings from this project will inform future decision makings on infrastructure finance.

Project Status: Progress was made as indicated in milestones and accomplishments and the project is estimated to be 25% complete.

Milestone Accomplishments and Dates: (i) The research team reviewed literature and had a teleconference with researchers from USDOT Bureau of Transportation Statistics and International Transport Forum, Organization for Economic Co-operation and Development (OECD) to discuss the data need to support decision making process of Public-Private Partnership in transportation infrastructure

development (03/30/2015); (ii) The research team is investigating the existing database on P3 transportation projects, including database compiled by TIFIA, InfraAmerica, OECD, and European banks to identify the gap in existing data sources (30% accomplished by 03/30/2015).

Planned Activities: The research team will continuously investigate the existing database on P3 transportation projects and identify the gap in existing data sources to support effective decision making in P3 projects. The research team will also start to develop a model using existing data and new data that may be collected to estimate the costs and benefits associated with P3 project delivery mechanism. The objective is to identify the comparative advantage and disadvantage of P3 projects delivery compared with conventional project delivery mechanism.

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 task of literature review has continued throughout the project since this is considered to be an ongoing process. Regarding the GPS data from the Metropolitan Bus Authority (AMA, due to its acronym in Spanish), Matlab Programs were developed for all 10 routes that were initially identified due to their high ridership. The Matlab programs are able to translate the data collected with the GPS equipment in each bus to tabulated data which can provide the investigators with information regarding the time of each bus at all bus stops. With this information, average running speed along segments, cycle lengths, frequency, and headways are calculated, plus space-time diagrams are created.

In addition, information from the Automatic Passenger Counters (APCs) was collected by a graduate student from Civil Engineering, who visited the offices of the AMA. The APC data was given in **.txt** file and it includes the passenger counts from August 3rd, 2013 to September 6th, 2013. Over 800 text files were collected during this visit.

Information from the APCs is not easily interpreted; the files do not include a first row that can help in identifying the information that is contained in each column. The research team contacted Urban Transportation Associates (UTA), which is the agency that sold the APCs to the AMA, in order to obtain a manual from the APCs that could help in interpreting the data. As of this time, we are still in communication with UTA personnel regarding the request. In addition, passenger count data was collected manually on Wednesday March 11th in one of the 10 routes initially identified in this project

(route #5). Besides performing passenger counts, the research team carried out a survey for the passengers in order to collect additional information that can help us in developing performance measures.

Milestone Accomplishments and Dates: (i) The Matlab programs for all 10 routes that were initially identified have been completed; (ii) The research project was promoted during Transportation Week, which took place at the University of Puerto Rico, Mayaguez campus during the week of March 16th-20th, 2015; (iii) A poster was also featured at the Annual Meeting of the Transportation Research Board in January 2015, in Washington DC; (iv) An interview with the Vice President of AMA was held during the last week of March to gain additional information regarding the status of the APCs installed in the buses.

Planned Activities: The following activities are expected to be performed in the next quarter: Continue with the literature review process, develop computational tools to analyze data from APC counters using Matlab, hire an electrical engineering student to work on this project and focus on the data from the APCs.

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 two graduate students hired to work on this project have continued to work together for the development of the mobile application that could substitute the written accident report filled by policemen. The first version of the mobile application, Car Accident Report System (CARS), has been completed and is ready to be field tested.

A graduate student from Civil Engineering (INCI, due to its acronym in Spanish), was able to design a crash report that includes all elements of the new version of the police report plus all elements required by the Model of Minimum Uniform Crash Criteria (MMUCC). The mobile application is 100% in compliance with the MMUCC, which was a goal of the research team, plus it was considered in its development the feedback from police officers who frequently met with the graduate student from INCI. All the information collected by the graduate student from INCI was then transferred to the graduate student from Computing Engineering (ICOM, due to its acronym in Spanish) who developed the mobile application in both English and Spanish languages. The developed application has 5 main tabs: Accident, Conditions, Data Entry, Vehicles, and Persons.

Milestone Accomplishments and Dates: (i) The first version of the mobile application was developed in the first year of the research project, as planned; (ii). A poster was presented during the Annual Meeting

of the Transportation Research Board in January, 2015, in Washington D.C; (iii) The project was also featured during Transportation Week at the University of Puerto Rico at Mayaguez that took place from March 16th to the 20th; a 15-minute presentation was given to the audience by the graduate student from INCI.

Planned Activities: The graduate student from INCI will be performing trial tests with both local and state police in order to measure the efficiency of the mobile application compared to the traditional written police report. Efficiency will be measured in terms of time and accuracy. The student will measure the time it takes police officers to include the data from the sample scenarios into both the mobile application and the written report, thus determining the average time it takes them to fill out both forms. After the reports are finished using both the mobile application and the written report, the student will identify if any of the reports have errors in them, such as input of incorrect data. Accuracy will then be determined based on number of correct items divided by the total number of input items.

The graduate student from ICOM will be working on the interaction between the client and the server in order to transfer all the data collected by mobile application police report to a server where data will be stored. The server will be programmed with Java Play Framework. The communication will be done using RESTful Web Services.

1.2.1.5 Research at Calspan / University at Buffalo Research Center

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 in progress. Project began 6/1/14 with expected completion of 9/30/15

Milestone Accomplishments and Dates: (i) Literature was reviewed and summarized to identify SHRP 2 NDS data analyses that could mitigate or reduce specific crash risks as well as documenting surrogates factors which explain crash and near-crash events (October 31, 2014); (ii) Review completed of available SHRP 2 NDS data that is available on finalized version InSight website. Data is available on crashes and near crashes as well as deduced surrogate measures (January 31, 2015); (iii) SHRP 2 Received Roadway Inventory (RID). This database contain detailed information on roadway characteristics and attributes as well as supplemental information on weather, traffic, roadwork, and traffic incidents. An analysis is

ongoing to identify useful characteristics of this dataset to perform our analysis (February 27, 2015); Received and completed an analysis of the New York State Department of Transportation (NYSDOT) Safety Management System (SMS) database. This database contains all reported motor vehicle crashes for Erie County, NY from 2011 through 2013. The analysis provided the number of property damage only (PDO), crashes, serious injury crashes, and fatal crashes to be used as a baseline comparison with the SHRP 2 NDS data (March 6, 2015). Also, during this reporting period CUBRC and UB staff had the opportunity for human subjects training and certification in order to access SHRP 2 NDS data. Dissemination of the results of this project have not been made available yet as work is ongoing.

Planned Activities: Complete the development of the SHRP 2 NDS crash and near crash data dictionary defining the types and characteristics of events identified in the database, finalize analysis strategy to predict potential severity of near crash events should they have not been successfully avoided, Complete analysis of crash versus near crash surrogate measures as measured in the SHRP 2 NDS fleet for Erie County, NY and the NYS DOT SMS database and produce a technical report that documents our findings. Attend TransInfo Conference in August 2015 and present summary of current and future work.

1.2.2 TransInfo graduate student 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:

- Nearly a dozen students associated with TransInfo showcased their work and/or attended the 94th Annual Meeting of the Transportation Research Board in January, 2015.

- Seminar presentations were made by a number of graduate students to showcase their research during the TransInfo sponsored Transportation Systems Engineering Seminar Series at the University at Buffalo. Examples of presentations made by TransInfo students as part of our seminar series include:

    - A Fixed Effects Bivariate Ordered Probit Analysis of Perceived and Observed Aggressive Driving Behavior: A Driving Simulation Study; Nima Golshani
    - A mixed logit analysis of motorcycle injury-severities of helmet and non-helmet users; Tawfiq Sarwar
    - An empirical exploratory analysis of factors affecting high-crash locations using random parameters ordered probit regression; Seyedata Nahidi
    - Destination Choice Model of Commercial Vehicle in Urban Area; Jinge Hu
    - Exploring Novel Applications Of Transportation Data; Lei Lin
    - Extremity and Influential Factors Analysis on Travel Time of Emergency Vehicles; Zhenhua Zhang
    - The Geography of Warehousing in Megaregions: Spatial Analysis and Findings of Transportation Warehouses and Distribution Centers in the New York Metropolitan Region ; Shuai Tang

- For both research projects being conducted at the University of Puerto Rico at Mayaguez, students have showcased their work with posters at the Institute of Transportation Engineers – Puerto Rico Section annual meeting. In addition, students have given presentations to industry and other students during Transportation Week, which took place at the University of Puerto Rico at Mayaguez in March.

- A graduate student from Civil Engineering (INCI, due to its acronym in Spanish) working on the project *Development of a Mobile Computer Application for the Process of Data Collection and Data Sharing for Vehicle Accidents*, was able to design a crash report that includes all elements of the new version of the police report plus all elements required by the Model of Minimum Uniform Crash Criteria (MMUCC). The mobile application is 100% in compliance with the MMUCC.

- An UPR-M graduate student from Computing Engineering working on the project *Development of a Mobile Computer Application for the Process of Data Collection and Data Sharing for Vehicle Accidents* developed a mobile application in both English and Spanish languages.

- Two RPI's Ph.D. students working on *Urban System Modeling and Performance Measurement Using Multiple Data Sources* were trained on basic and advanced skills of conducting research related to urban system performance measurement using multisource urban traffic data.

- An Electrical Engineering student at UPR-M was hired for *Development of New Performance Metrics and Operational Strategies Based on Bus Location and Passenger Count Data.*

- Recent University at Buffalo graduate, Dr. Lei Lin has started post-doc work at Xerox.

- University at Buffalo Ph.D. student Andrew Bartlett was selected as the 2014 Student of the Year for the Transportation Informatics Tier I University Transportation Center. He was honored by the U.S. Department of Transportation (USDOT) at a special ceremony held during the Transportation Research Board Annual Meeting.

- Shuai Tang, a third year Ph.D. student from the Transportation Systems Engineering program at the University at Buffalo was awarded several travel grants to present at industry conferences.

- Courtney Bentley, a graduate student in the University at Buffalo's Transportation Systems Engineering program was awarded a student scholarship from the Upstate New York Chapter of the Institute of Transportation Engineers.

1.2.3 Outreach Activities

1.2.3.1 The 94th Annual Meeting of for the Transportation Research Board

The 94th Annual Meeting of the Transportation Research Board took place in mid-January, 2015 with a strong presence from TransINFO. Highlights included a co-sponsored reception welcoming over 150 attendees; nearly 40 presentations, papers and posters showcased by TransINFO faculty and students (see http://www.buffalo.edu/transinfo/Research/TRB2015.html); and the selection of a University at Buffalo Ph.D. student as The Center's 2014 Student of the Year. During the meeting, TransInfo faculty, Dr. Shanjiang Zhu organized a forum in collaboration with Chinese Overseas Transportation Association to discuss research progresses and issues related to a transportation system empowered by big data. The workshop provided a forum for transportation professionals from different countries and regions to share their research findings in three areas: New Applications of Old Data in Transportation; Connected Vehicles Research and Applications; and Applications of Cellular Data in Transportation. Participants included federal and state DOT researchers, professionals from private sectors, faculty and students from different countries.

1.2.3.2 Formal collaboration with the Transportation Research Institute (IMOB); Hasselt, Belgium

The University at Buffalo, TransInfo's lead university, signed a Memorandum of Understanding with the Transportation Research Institute (IMOB) of Hasselt University (HU) in Belgium to promote collaboration between the two Universities in areas related to transportation research and education including:

1. Faculty exchange in master's & PhD program using a virtual environment through which teaching could be possible. The prospect of physical exchange could be further explored based on the availability of resources and time.
2. Student exchange in selected master's & PhD programs. Each university will evaluate the curriculum of the other and propose a smooth exchange mechanism to facilitate credit transfer.
3. Value Addition Short Courses; Two - three days short (virtual and/or physical) courses may also be arranged on variety of topics within Transportation field and faculty members of both institutes may organize/share/teach some sessions.
4. Cooperation between the respective Ph.D. programs of the partner universities through which joint research and possible joint supervision might be explored.
5. Joint Research in Specific areas of Transportation Sciences & Engineering

    - IMOB & UB have a Driving Simulator instrument, using these simulators to test some specific road accidents scenarios or enhancement of these simulators.
    - Research topics within public mass transportation will also be envisaged with the combined efforts.
    - Transport behavioral modeling; traffic congestion modeling, GIS based route planning and activity-based transport modeling.
    - Big Data Applications in Transportation

1.2.3.3 The 3rd Symposium on Connected and Autonomous Vehicles

TransInfo co-sponsored and was an integral planning member for the 3rd Symposium on Connected and Autonomous Vehicles at SUNY Polytechnic Institute in Albany, NY on November 5, 2014. The symposium offered the framework for the use of Connected and Autonomous Vehicles as a pathway to Smart Cities and the Internet of Things (IoT) by focusing on each phase of the Research, Development and Deployment Continuum. Highlights included dynamic keynotes by transportation and technology experts and panels that detail University-based Research Assets, Industry-driven Tech Roadmap, Government-directed Framework and Investment Strategies to Enable Success.

1.2.3.4 First Annual Symposium on Transportation Informatics

The First Annual Symposium on Transportation Informatics will take place on August 13th & 14th, 2015 in Buffalo, New York. Preliminary planning is underway for this event that will feature three major sessions: Big Data Analytics in Transportation Operations, Informatics Utilization in Public Transportation, and Application of Analytics to Transportation Safety; and two workshops: Big Data Analytics in Transportation Safety (SHRP2 Naturalistic Driving Data) and Big Data and Connected Vehicles.

1.2.3.5 Transportation Systems Engineering Seminar Series at the University at Buffalo (UB)

http://www.buffalo.edu/transinfo/Events/transportation-programs-seminar-series.html

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. Speakers during this reporting period have included:

> Venky Shankar, Ph.D.; Professor Pennsylvania State University *A behavioral framework for network wide estimation of non-motorized travel in urban grids*
>
> Henry Liu, Ph.D.; Professor, Department of Civil and Environmental Engineering & Research Professor, University of Michigan Transportation Research Institute (UMTRI) University of Michigan, Ann Arbor *Managing Oversaturated Arterials, From Measurement to Control*
>
> Linda Ng Boyle, Ph.D.; Professor and Chair, Industrial & Systems Engineering Professor, Civil & Environmental Engineering (joint appointment) University of Washington*; Advances in data collection and analysis to enhance road safety*
>
> Samer M. Madanat; Ph.D.; Distinguished Professor and Chair, Civil & Environmental Engineering University of California Berkeley *Incorporating Environmental Sustainability Objectives in the Planning, Operations and Maintenance of Transportation Systems*
>
> Martin Casstevens; Business Formation and Commercialization Manager at UB's Office of Science, Technology Transfer, and Economic Outreach; Commercializing University Innovation in Engineering

1.2.3.6 Miscellaneous Outreach Activities

TransInfo partner, the University of Puerto Rico, Mayaguez hosted Transportation Week, which took place on campus during the week of March 16th-20th, 2015.

TransInfo submitted a proposal to host the Council of University Transportation Centers (CUTC) Annual Meeting in summer 2016 in Buffalo Niagara.

The TransInfo website has experienced month over month increases for the reporting period with 527 users (30 % of which are new visitors) having 1,410 unique page views.

The Transportation Informatics Tier I University Transportation Center published and delivered two issues of its newsletter during the reporting period in an effort to continue to provide information on the Center and updates on transportation informatics more generally. The newsletter mailing list has increased by over 50% since the last reporting period, reaching nearly 400 transportation-related professionals and academics.

1.2.4 Leveraging TransINFO funds for follow-on funding

In collaboration with TransInfo partner CUBRC, the University at Buffalo and TransInfo faculty Anastasopoulos and Sadek received funding from FHWA's Exploratory Research Program for a project entitled Applications of Knowledge Discovery in Massive Transportation Data: The Development of a Transportation Research Informatics Platform (TRIP) - $989,000

TransInfo faculty also secured additional follow-on funding including (i) Dr. Wu, Dr. Qiao, Dr. Sadek and Dr. Hulme were awarded funding from NSF for Modeling Cyber Transportation and Human Interaction in Connected and Automated Vehicles - $499,952; (ii) Dr. Qing He received funding from UTRC2 to develop a mathematical framework to model heterogeneous objective traffic signal control for

different subnetworks; (iii) Dr. Jamie Kang received UTRC2 funding to study "Market Potential for Battery Electric Vehicles based on Multi-Day Activity- Travel Patterns.

TransInfo faculty are collaborating with New York State Department of Transportation, private industry and other academic partners on a Connected Vehicle Pilot Deployment Proposal.

1.2.5 Faculty accomplishments

Professor Panos Anastasopoulos and Professor Adel Sadek have established the Engineering Statistics and Econometrics Application (E-SEA) Research Lab at the University at Buffalo. Professor Anastasopoulos will serve as the Director of the lab, with Prof. Sadek serving as Associate Director.

Professor Panos Anastasopoulos, along with UB students T. Androutselis, U. Eker, N. Golshani, G. Jordan, S. Nahidi, and T. Sarwar present five papers at the 56th Annual Transportation Research Forum

TransInfo faculty, Professor Rajan Batta, received IIE's 2015 Holzman Distinguished Educators Award

TransINFO faculty and their collaborators have won the Best Digest Paper Award at the International Conference on Connected Vehicles and Expo (ICCVE) twice, once in 2014 and before that in 2012. The winning papers are listed below:

> S. Kundu, A. Singh, C. Qiao, S. Kundu, A. Sadek, Y. Hou, "Vehicle speed control algorithms for data delivery and eco-driving," ACM/IEEE/IFAC/TRB International Conference on Connected Vehicles & Expo (ICCVE), 2014.
>
> Y. Zhao, A. Wagh, K. Hulme, C. Qiao, A. Sadek, H. Xu and L. Huang, "Integrated Traffic-Driving-Networking Simulator: A Unique Research and Development Tool for Connected Vehicles," in ACM/IEEE/IFAC/TRB International Conference on Connected Vehicles & Expo (ICCVE), 2012.

Dr. Shanjiang Zhu received the International Transport Forum's 2014 Young Researcher of the Year. The award was presented during the ITF annual summit in Leipzig, Germany.

Dr. Ivette Cruzado, Assistant Professor of the Civil Engineering and Surveying Department at University of Puerto Rico at Mayagüez and a core TransINFO faculty member has received tenure at UPR-M.

NYSDOT, in collaboration with CUBRC and the University at Buffalo, were selected in Round 4 of SHRP2 Implementation Assistance Program.

TransINFO core faculty member, Dr. Qing He has been awarded the IBM Faculty Partnership Award in a worldwide competition.

Dr. Shanjiang Zhu won funds from the Department of Civil, Environmental and Infrastructure Engineering, George Mason University, to purchase Bluetooth detectors to enhance research and education activities.

1.3 How have the results been disseminated?

The research results have been disseminated via meetings with transportation management agencies at the federal, state, and local levels, and industry partners. The team also submitted research results for publication by professional journals, and presented their work at several conferences as mentioned above.

1.4 Plans for the next reporting period to accomplish goals

With respect to the TransInfo research projects, the research plan for the next reporting period was described under each individual project earlier in this report. In addition, TransInfo is planning to issue its first Request for Proposals (RFP) next month (May) in order to solicit new research ideas from TransInfo members. The submitted proposals will be peer-reviewed and the most promising proposals will be selected for funding by TransInfo. TransInfo also intends to continue its educational and outreach initiatives, previously described, during the next reporting period.

2. Products

2.1 Publications, conference papers, and presentations

Journal Publications:

Y. Hou, Y. Zhao, A. Wagh, L. Zhang, **C. Qiao**, K.F. Hulme, C. Wu, **A.W. Sadek**, and X. Liu. (2015). Simulation Based Testing and Evaluation Tools for Transportation Cyber-Physical System. *IEEE Transactions on Vehicular Technology (in press).*

L. Lin, **Q. Wang** and **A.W. Sadek**. (2015). A Novel Variable Selection Method based on Frequent Pattern Tree for Real-time Traffic Accident Risk Prediction. *Transportation Research – Part C (in press).*

L. Lin, M. Ni, **Q. He**, **J. Gao** and **A.W. Sadek**. (2015). Modeling the Impacts of Inclement Weather on Freeway Traffic Speed: An Exploratory Study Utilizing Social Media Data. *Journal of the Transportation Research Board* (in press).

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).*

Annual TRB Meeting Papers:

TransInfo researchers presented close to 40 papers at the 2015 TRB Meeting in Washington, D.C. this last January. Several of those papers are expected to be later published in the *Journal of the Transportation Research Board.* A listing of those papers presented can be found at the following link: http://www.buffalo.edu/transinfo/Research/TRB2015.html

Other Conference Papers:

Hao, P., Ban, X., 2014. Penetration requirement of mobile sensing data for arterial performance measurement. Presented at the INFORMS Annual Meeting Minneapolis, MN.

Sun, Z., Hao, P., ***Ban, X.***, 2014. Fine-Grained modeling of arterial traffic: A data fusion and information integration approach. Presented at the *INFORMS Annual Meeting Minneapolis, MN*.

Kundu, S., Singh, H., Qiao, C., Sadek, A., Hou, Y. 2014. Vehicle speed control algorithms for data delivery and eco-driving," Presented at ACM/IEEE/IFAC/TRB International Conference on Connected Vehicles & Expo (ICCVE).

Zhang, D. and **X. Wang**. "Investigating the Dynamic Spillover Effects of Low Cost Airlines Through Spatio-Temporal Regression Models" Presented at the 8th International Association for China Planning (IACP) Conference, Guangzhou, China (2014)

Zhang, D. and **X. Wang**. "Schedule Optimization to Improve the Trunk-Local Bus Transfer Efficiency in Small Conurbations: A Case Study of New York Capital Region" Presented at the 21st national conference on Rural Public and Intercity Bus Transportation (RIBTC) (2014) (the first place of RIBTC graduate student research competition)

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

http://www.buffalo.edu/transinfo

2.3 Technologies or techniques

A prototype mobile app to collect privacy-preserving mobile sensing data was *developed (Urban System Modeling and Performance Measurement Using Multiple Data Sources).*

The first version of a mobile application for accident reporting has been developed in both English and Spanish languages (*Development of a Mobile Computer Application for the Process of Data Collection and Data Sharing for Vehicle Accidents).*

2.4 Inventions, patent applications, and/or licenses

Nothing to report

2.5 Other products

Matlab programs for the ten routes of the Metropolitan Bus Authority with the highest ridership have been developed; these calculate several variables (i.e. cycle length, average speed) and produce graphs that provide a visual representation of the system (*Development of New Performance Metrics and Operational Strategies Based on Bus Location and Passenger Count Data).*

A traffic safety database has been compiled for Erie County NY in order to the support the analysis detailed in CUBRC's project plan. The database contains elements from SHRP 2 NDS data available through InSight, SHRP 2 NDS Roadway Inventory Data (RID), and NYSDOT Safety Management System (SMS) data *(Developing Highway Safety Performance Metrics in an Advanced Connected Vehicle Environment Utilizing Near-Crash Events from the SHRP 2 Naturalistic Driving Study).*

3. Participants and Collaborating Organizations

3.1 Organizations which have been involved as partners with TransInfo

Organization Name: INRIX
Location of the Organization:
Partner's Contribution to the Project: Data for research

Organization Name: University Transportation Research Center (UTRC)
Location of the Organization: New York New York

Partner's Contribution to the Project: Research Funding and Collaboration on organizing the third Symposium on Connected and Automated Vehicles and on submitting a proposal for Connected Vehicle Deployment in NY State.

Organization Name: SUNY-Albany
Location of the Organization: Albany, NY
Partner's Contribution to the Project: Collaboration on organizing the third Symposium on Connected and Automated Vehicles and on submitting a proposal for Connected Vehicle Deployment in NY State.

Organization Name: TrafficCast, Inc.
Location of the Organization: Madison, Wisconsin
Partner's Contribution to the Project: Proposal collaborations

Organization Name: New York State Department of Transportation (NYSDOT)
Location of the Organization: Albany, NY
Partner's Contribution to the Project: In kind labor hours to generate extract from Safety Management System Crash Database

Organization Name: New York State Department of Transportation – Region 5 (NYSDOT)
Location of the Organization: Buffalo, NY
Partner's Contribution to the Project: In kind labor hours to compile crash statistics for selected locations throughout Erie County, NY

Organization Name: Governors Traffic Safety Council (GTSC)
Location of the Organization: Albany, NY
Partner's Contribution to the Project: Provided project guidance in selecting research area

Organization Name: Greater Buffalo Niagara Regional Transportation Council (GBNRTC)
Location of the Organization: Buffalo, NY
Partner's Contribution to the Project: Provided database of traffic volumes and turning count movements for Erie County, NY

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: GPS and APC data sharing, 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

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

Organization Name: Urban Transportation Associates (UTA)
Location of the Organization: Cincinnati, OH
Partner's Contribution to the Project: APC Installation and file sharing

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 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 were reported on in the last PPPR. With the new IMOB collaboration reported on herein (section 1.2.4.2), we anticipate both faculty and graduate student opportunities for international exposure and experience. And, graduate students are primed to enter the work force through career preparation opportunities like the recent seminar "Beyond the Resume: Making a Positive First Impression with Professionally Composed Emails and Cover Letters", offered by Kirsten Meade, Human Resources Manager of Control Technologies, TT Enidine Inc. in October, 2014 at the University at Buffalo.

TransInfo's project focused on the development of a mobile computer application for vehicle accidents also presents an opportunity in training police officers in using the mobile application for accident 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.

It bears mentioning here, that a professor from the University of Puerto Rico, Medical Sciences Campus (UPR-MS), has approached the research team in order to determine if the mobile application can be linked to MapClick, a crash location identification tool that is currently under development by both UPR-MS and the University of Alabama. (Development of a Mobile Computer Application for the Process of Data Collection and Data Sharing for Vehicle Accidents)

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

Regarding the research project *Development of New Performance Metrics and Operational Strategies Based on Bus Location and Passenger Count Data,* the APCs installed in the buses have been turned off due to budgeting reasons; the research team is working with data stored previously. In addition, the data files from the APCs are not easily interpreted; therefore we contacted Urban Transportation Associates (UTA) in order to gain insight about the data files. The company has been helping us in understanding the data; this could represent a delay that the research team considers minimum.