University Transportation Research Center Presents

Transportation Technology Symposium

Tuesday
November 15, 2016
9:00 am to 5:00 pm

Innovative Mobility Solutions

NYIT Auditorium on Broadway,
1871 Broadway at 61st Street,
New York, NY 10023
Event DETAILS

2016 Transportation Technology Symposium: Innovative Mobility Solutions

Camille Kamga
Director, UTRC

Matthew W. Daus
Distinguished Lecturer, UTRC

Hongmian Gong
Professor, Hunter College

Marta Panero
Director, Strategic Partnerships, NYIT

Nadia Alsam
Assistant Director for Technology Transfer, UTRC

Penny Eickemeyer
Associate Director for Research, UTRC

This unique summit will bring together leading experts, academics, practitioners, industry stakeholders and advocates to discuss the rapidly changing and expanding world of transportation technology innovative solutions. The presenters will explore the cutting-edge intelligent transportation systems, big data aggregation, and innovative transportation technology solutions to promote efficiency, safety, security and sustainability goals, as well as the impact on broader inter-modal and multi-modal transportation considerations.

The event aims to encourage future and forward thinking innovative concepts and the pragmatic political reality of various movements (such as climate change/environmental policies and safety initiatives for reduced traffic fatalities).
Tuesday November 15, 2016
NYIT Auditorium on Broadway, 1871 Broadway at 61st Street, New York, NY 10023

**Program Overview**

**8:30am – 9:00am / Auditorium 1**
Registration and Breakfast

**9:00am – 9:45am / Auditorium 1**
Welcoming and Introductory Remarks

**9:45am – 11:00am / Auditorium 1**
Plenary Session 1
Future Modes & Emerging Transportation Technologies

**11:00am – 11:15am / Auditorium 1**
Coffee Break

**11:15am – 12:30pm / Break-out**
Auditorium 1
Breakout Session 2
Transportation Data Modeling, Analysis & Applications

Auditorium 2
Breakout Session 3
Transportation Technology for Traffic & Mobility Management

**12:30pm – 1:30pm / Auditorium 1**
Luncheon

**1:30pm – 2:45pm / Break-out**
Auditorium 1
Breakout Session 4
Transportation Technology & Data to Achieve Equity & Accessibility for All

Auditorium 2
Breakout Session 5
Transportation Technology for Safety & Security

**2:45pm – 3:00pm / Auditorium 1**
Break

**3:00pm – 3:30pm / Auditorium 1**
Keynote Speaker: Rohit T. “Rit” Aggarwala, Chief Policy Officer, Sidewalk Labs

**3:30pm – 4:45pm / Auditorium 1**
Plenary Session 6
Shared Mobility Technology

**4:45pm – 5:00pm / Auditorium 1**
Closing Remarks

**5:00pm – 5:45pm / Auditorium 1**
Networking Reception
### Program DETAILS

#### 8:30am – 9:00am

**Breakfast & Registration**

#### 9:00am – 9:45am

**Welcoming and Introductory Remarks**

- **Dr. Nada Marie Anid**, Dean of School of Engineering and Computing Sciences, NYIT
- **Dr. Camille Kamga**, Director, UTRC
- **Matthew W. Daus**, Distinguished Lecturer, UTRC

#### 9:45am – 11:00am

**Plenary Session 1**

**Future Modes & Emerging Transportation Technologies**

**Moderator:**

- **Dr. Robert E. Paaswell**, CCNY

**Presenters:**

- **Bill Long**, Mobility Mines
  - Mine your Business
- **Tracy Lamb**, SGS HART Aviation
  - Enabling Remotely Piloted Aircraft Systems (RPAS) Into your Commercial Environment
- **Catherine Lawson**, University at Albany, SUNY
  - Future of NYS Ferry System
- **Gennadiy Kosoy**, NYS Department of Transportation (NYSDOT)
  - Future of NYS Ferry System

#### 11:00am – 11:15am

**Break**

**Poster Exhibition**

- **Robert DeDomenico**, CargoFish
  - De Facto Teleportation Utility System
- **Solomon Caviness**, New Jersey Transportation Planning Authority
  - Technical Tools to Improve Transportation Planning
- **Zenobia Fields**, New Jersey Transportation Planning Authority
  - Technical Tools to Improve Transportation Planning
- **Jingqin Gao**, New York University
  - Modeling and Predicting the Frequency and Impact of Double Parking Activities in Urban Area Using Big Data
- **Ali Hamidi**, The City College of New York, CUNY
  - Quantifying the Impacts of Rainfall on Subway Ridership in Manhattan
- **Fan Zuo**, New York University
  - Crowdsourcing Incident Information for Disaster Response Using Twitter

**Posters will be displayed from 9:00 am to 4:00 pm in the Auditorium 1 Foyer**
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<td>11:15am – 12:30pm</td>
<td><strong>Transportation Data Modeling, Analysis &amp; Applications</strong></td>
<td><strong>Transportation Technology for Traffic &amp; Mobility Management</strong></td>
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<td><strong>Moderator:</strong> Dr. Hongmian Gong, Hunter College, CUNY</td>
<td><strong>Moderator:</strong> Dr. Camille Kamga, UTRC/CCNY</td>
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<td><strong>Presenters:</strong> Nikhil Puri, Cambridge Systematics, Inc.</td>
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<td>It’s Only a Matter of Time – Using GTFS in the NY Best Practice Model</td>
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<td>Energy Efficient Cooperative Adaptive Cruise Control of Platooning Vehicles</td>
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<td>Sandeep Mudigonda, CCNY/CUNY</td>
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<td>Extracting Useful Information from Twitter Posts for Traffic Incident Management</td>
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<td><strong>Moderator:</strong> Weinan Gao, New York University</td>
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<td>12:30pm – 1:30pm</td>
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Program DETAILS

Breakout

1:30pm – 2:45pm
Auditorium 1
Session 4

Transportation Technology & Data to Achieve Equity & Accessibility for All

**Moderator:**
Matthew W. Daus, CCNY/CUNY

**Presenters:**
Maureen Koetz, Koetz and Duncan LLC
The Expanding Transportation Network Company (TNC) “Equity Gap” —Adverse Impacts on Passengers with Disabilities, Underserved Communities, the Environment and the On-Demand Workforce

Rodney Stiles, NYC TLC
NYC TLC Data: Using Trip Data to Understand Transportation Equity and Advance Accessibility

Cecilia Feeley, Rutgers’ Center for Advanced Infrastructure and Transportation (CAIT)
Smart Arrival Notification System for ADA Passenger Paratransit Service Using Smartphone

Joyoung Lee, New Jersey Institute of Technology
Virtual Guide Dog: Next Generation Pedestrian Signal for the Visually Impaired

2:45pm – 3:00pm
Break

2:45pm – 3:00pm
Auditorium 1

3:00pm – 3:30pm
Auditorium 1

Keynote Speaker:
Rohit T. “Rit” Aggarwala Chief Policy Officer, Sidewalk Labs

Transportation Technology for Safety & Security

**Moderator:**
Dr. N. Sertac Artan, New York Institute of Technology

**Presenters:**
Branko Glad, Telegra, Inc.
Artificial Intelligence Saving Lives on Highways (with Existing Infrastructure)

Jerome M. Lutin, Independent Consultant

Jonathan Voris, New York Institute of Technology
Utilizing Behind-the-Wheel Behavior for Driver Authentication
**Plenary Session 6**

**Shared Mobility Technology**

**Moderator:**
Matthew W. Daus, CCNY/CUNY

**Presenters:**

Andrei Greenawalt, VIA
On-demand Mass Transit

S. Maurice Rached, Maser Consulting
Car Sharing in Planned Communities

Daniel Peterson, Dewberry
MaaS and AVs – Mobility as a Service and the effect of Autonomous Vehicles on Policy, Place and People

Tim Frisbie, The Shared-Use Mobility Center (SUMC)
Shared Mobility Trends in North America

**Closing Remarks**

**Networking Reception**
Rohit T. “Rit” Aggarwala
Chief Policy Officer for Sidewalk Labs

Rohit T. “Rit” Aggarwala is Chief Policy Officer for Sidewalk Labs. Previously, he headed the sustainability practice at Bloomberg Associates, a philanthropic consulting firm that serves city governments. He is also an Adjunct Professor of International and Public Affairs at Columbia University, and co-chairs the Regional Plan Association’s Fourth Regional Plan for the New York metropolitan area.

Rit served as Special Advisor to the Chair of the C40 Cities Climate Leadership Group from 2010-2013, guiding the organization’s strategic transformation into a global leader. During that period, he also developed the environment program at Bloomberg Philanthropies, which grew to a total of $145 million in grants under his management.

Rit served as Director of New York City’s Office of Long-Term Planning and Sustainability from 2006-2010, and led the creation and implementation of “PlaNYC: A Greener, Greater New York.” PlaNYC has been hailed as one of the world’s best urban sustainability plans, leading New York City to a 19% reduction in its carbon footprint since 2005. Prior to joining City Hall, he was a management consultant at McKinsey & Company.

Rit holds a BA, MBA, and PhD from Columbia University, and an MA from Queen’s University in Ontario. He was born in New York City, where he now lives with wife and three daughters.
Robert E. Paaswell
Distinguished Professor, The City College of NY, CUNY

Dr. Robert Paaswell is a Distinguished Professor of Civil Engineering at the City College of New York, the flagship institution of The City University of New York (CUNY). He served as its Interim President from 2009-2010. He is the emeritus Director of the College’s University Transportation Research Center, Region II and the founding Director (2001-present) of the CUNY Institute for Urban Systems (CIUS). He is also Site Director of the new NSF sponsored Industry/University Cooperative Research Center: Sustainably Integrated Buildings and Sites Center. A civil engineer and former CEO of the Chicago Transit Authority, Dr. Paaswell is an internationally recognized expert in public transportation issues and consulting. Dr. Paaswell is a Distinguished Member of the American Society of Civil Engineers.

Bill Long
Mobility Mine

Bill Long is an interesting character. He began his working life as a commercial fisherman, became a bar owner and started a tech company called Clever Devices in the basement of the bar. Clever Devices began as a digital audio company during the advent of that technology. Shortly thereafter his firm developed the very first automated announcement systems as an adaptive aid for the blind. The firm grew and developed many of the vehicle automation technologies now commonplace in the transit industry. Bill sold his interests in Clever Devices in 2010 but remained interested in the field. Recently he has come to see the future of transit technology in a cloud called Mobility Mine.

Bill is 62 and lives with his wife and two children in Sea Cliff New York.

Tracy Lamb
Global RPAS Safety Manager, SGS HART Aviation – CBE

Tracy Lamb has 20 years of experience in commercial aviation with over 7000 flight hours as a commercial pilot including operating as an International Airline pilot (Boeing 737), Senior Flight Instructor, Charter Pilot and international Corporate Jet Pilot. She is also a Qualified Remote Pilot, and works closely within the commercial RPAS inspection environment.

Tracy is a specialist in aviation Human Factors, Crew Resource Management, Risk and Safety Management Systems and has spent years focusing her research on these factors in the application of Remotely Piloted Aircraft Systems (RPAS or drones), including delivering world class safety training courses which have been recognized as best in class.

Tracy contributes to the International Civil Aviation Organization (ICAO) ‘RPAS Panel working group’ (WG7) and contributes as a board member on RPAS associations in Australia and Europe. As an ISO 9000:2008 lead auditor, she has conducted operational safety audits, inspections for manned, unmanned aircraft operators and maintenance organizations around the World.

Tracy holds awards for academic excellence from her research and qualifications in applied science (aviation), Masters Degree in business management, aviation human factors. In conjunction with RMIT University in Melbourne, Australia, Tracy remains active in research and development focusing on safety and risk management in all aspects of commercial aviation on a global scale.
Continues... **Session 1 SPEAKERS**

**Catherine Lawson**  
Associate Professor, University at Albany, Albany Visualization and Informatics Lab (AVAIL)

Dr. Lawson is an Associate Professor in the Geography and Planning Department at the University at Albany and the Director of AVAIL, a “new generation” research lab, specializing in advanced data-driven visualization and informatics. Her research interests include data science applications for transportation research and planning for freight, transit (including ferries) and passenger travel.

**Gene Kosoy, P.E.,**  
Civil Engineer II, NYS Department of Transportation, Public Transportation Bureau

Gene Kosoy works at the NYSDOT for about 25 years. He is statewide ferry mode program and project manager and oversees all ferry related developments across the state.

**Session 2 SPEAKERS**

**Dr. Hongmian Gong**  
Professor, Hunter College, CUNY

Hongmian Gong is a Professor of Geography at Hunter College and Professor of Earth and Environmental Sciences at the Graduate Center of the City University of New York. She has done substantial research on using GPS, mobile technologies, Web GIS, and cloud computing for urban transportation studies. Dr. Gong also serves as a member of the Board of Directors in UTRC. She established a research cluster team on GPS for Transportation at UTRC2 (http://www.geography.hunter.cuny.edu/~hgong/GPS/ClusterTeam.html) and organized a GPS for Transportation Symposium in New York City (program and presentation videos available at http://www.geo.hunter.cuny.edu/~h-gong/GPS/Symposium.htm).

**Moderator**

**Nikhil Puri**  
Senior Associate, Cambridge Systematics, Inc

Mr. Puri is Regional Manager of the Travel Demand Forecasting Practice in the NY-NJ Region, with 15 years of experience in transportation planning and travel demand forecasting. He has worked on regionally significant studies including environmental impact statements, alternatives analyses, economic impact and toll impact studies, long range planning efforts, and model development strategic plans, dealing with both transit and highway issues. He has successfully used large data sets derived from cell phone data, GPS and other probe data sources, in planning and modeling applications. Mr. Puri has expertise in analyzing, interpreting, and communicating complex model results to audiences that range from technical experts and decision-makers to the public.
Continues... **Session 2 SPEAKERS**

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**Michalis Xyntarakis**  
Senior Associate, Transportation Operations, Cambridge Systematics, Inc  
![Michalis Xyntarakis](image1)

Michalis Xyntarakis is currently the principal investigator for FHWA’s guidebook on Data Analytics. His principal fields of expertise are data analytics, modeling and simulation, and software development.

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**Josh DeLaRosa**  
Senior Analyst, Abt SRBI  
![Josh DeLaRosa](image2)

Josh DeLaRosa is a Senior Analyst with Abt SRBI. Josh designs and manages several travel data collection studies. Josh’s research interest includes the utilization of survey data, big data sources (e.g., sensors) and administrative data to inform policy. Prior to joining Abt SRBI, Josh was a Survey Statistician with the US Census Bureau. While at the US Census Bureau, Josh contributed to the statistical redesign of the National Health Interview Survey, the Current Population Survey and other national data collection programs. Josh earned his Masters degree in Applied Social Research from Queens College.

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**Nilofar Ghahramania**  
Ph.D. Candidate, Transportation Engineering, The City College of New York, CUNY  
![Nilofar Ghahramania](image3)

Nilofar Ghahramani is a Doctoral Candidate in Transportation Engineering at the City College of New York. She holds a Bachelor’s Degree in Civil Engineering from Iran University of Science and Technology and a Master’s Degree in Transportation Engineering from the City College of New York. Her research focuses on the role of smartphone information applications in public transit.
Camille Kamga
Assistant Professor, Department of Civil Engineering, The City College of New York, CUNY
Director, University Transportation Research Center

Camille Kamga is the Director of the University Transportation Research Center (UTRC) and an Assistant Professor of Civil Engineering at The City College of New York. As a consortium of 18 major U.S. academic institutions, UTRC asserts a significant role in the Federal Region 2 and nationally, conducting research and projects on surface transportation, carrying out training and educational programs and actively disseminating the results of its work. It is one of the few such Centers in the U.S. federally designated since 1987. Dr. Kamga is a member of the TRB’s Urban Transportation Data and Information Systems Committee (ABJ30). He serves in the Board of Director of the Intelligent Transportation Society of NY – a professional group providing education and outreach to foster the understanding of ITS applications and technologies.

He is also a member of Education and Research Committee of the International Association of Transportation Regulators. He holds a Ph.D. in Civil Engineering from the Graduate Center of the City University of New York, specializing in Intelligent Transportation Systems (ITS). He is the 2006 recipient of the National Pikarsky Award for Outstanding Dissertation in Science and Technology from the Council of UTC.

Dr. Nidhal Bouaynaya
Associate Professor & Graduate Coordinator, Department of Electrical and Computer Engineering, Rowan University

Dr. Nidhal Bouaynaya has an extensive experience in signal and image processing, including linear and nonlinear filtering, image classification and time-series analysis. She has authored over 70 peer reviewed scientific articles in the field of signal, image and video processing. Her work in image processing with mathematical morphology (“Theoretical Foundations of Spatially-Variant Mathematical Morphology – Part I: Binary Images” and “Theoretical Foundations of Spatially-Variant Mathematical Morphology - Part II: Gray-Level Images”, published in the prestigious IEEE Transactions on Pattern Analysis and Machine Intelligence, 2008) has been cited 183 times by pioneers and prominent researchers in the area of mathematical morphology. Her recent work focuses on big data analytics in the biomedical field and intelligent transportation systems. Specifically, she aims at deriving efficient algorithms for parameter estimation and prediction from high-dimensional, non-stationary and noisy measurements. In 2015, she received the Runner-Up Best Paper Award at the IEEE International Conference on Bioinformatics and Biomedicine (BIBM) for her paper “Level Set Segmentation using Non-Negative Matrix Factorization of Brain MRI Images.” In 2013, she received the Best Paper Award at the IEEE International Workshop on Genomic Signal Processing and Statistics for her work on the inference of gene regulatory networks from a highly under-sampled set of observations or experiments. Last August, she was awarded a National Science Foundation (NSF ACI 1429467) grant to acquire a High-Performance Computer (HPC) to conduct compute-intensive and memory-demanding projects in big data analytics. Dr. Bouaynaya is also PI on another NSF grant on optimal non-linear tracking and parameter estimation and Federal Aviation Administration (FAA) grant on algorithmic simulations of conflicting trajectories. She is also Co-PI on several federal grants, including USDA. Her research expenditures exceed $2M.
Jeevanjot Singh
Contract Manager for ITS – Resource Center
Working for Assistant Commissioner of Transportation Systems Management (TSM), Charles William Kingsland, at NJDOT

Ms. Jeevanjot Singh is the Contract Manager for ITS – Resource Center, working for Assistant Commissioner of Transportation Systems Management (TSM), Charles William Kingsland, at NJDOT. She has a Masters in Highway Engineering, a Project Management Professional license and certifications in Information Technology. Her career spans 20 years in private, public and academic sectors. She is an avid proponent of Arterial Management, serving for four years as the technical lead of the Advanced Arterial Management unit in TSM at the Department. Jeevan has been leading the Connected Vehicles efforts for the New Jersey DOT since 2008, representing the State at the Connected Vehicle – Pooled Fund Study, moderating ITE and ITS panels on Connected and Autonomous Vehicles. An avid proponent of collaboration, she has been the recipient of ITS-NJ Excellence Award for initiating the Complete Team, a best practice model for collaboration and coordination in NJ. While leading the Advanced Arterial Management unit with Mobility and Systems Engineering, she has been involved in initiative such as Integrated Corridor Management and Capability Maturity Model. She continued her involvement in the two initiatives, leading training initiatives for Systems Engineering, ITS Architecture, Network Training, serving as the FHWA liaison for Everyday Counts - 3 Smarter Work Zones and similar endeavors.

Parth Bhavsar, Ph.D.
Assistant Professor, Department of Civil and Environmental Engineering, Rowan University

Parth Bhavsar is an assistant professor in the Department of Civil and Environmental Engineering at Rowan University. His research interests include intelligent transportation system (ITS), connected vehicle technology (CVT), application of artificial intelligence (AI) algorithms in transportation engineering, and alternative fuel vehicles (AFVs). Bhavsar has published in peer reviewed journals such as the Transportation Research Part C: Emerging Technology, Transportation Research Part D: Transport and the Environment and Transportation Research Record Journal of the Transportation Research Board. Dr. Bhavsar was previously a postdoctoral fellow in a connected vehicle research program in the Glenn Department of Civil Engineering at Clemson University, where he worked on several connected vehicle technology research projects.

Bhavsar received his Ph.D. degree in 2013 and his M.S. degree in 2006 from Clemson University, South Carolina. He also has three years of experience in the private sector in developing transportation engineering and planning solutions, most specifically traffic micro-simulation projects. His current research sponsored by Region 2, University Transportation Regional Center (UTRC2), focuses on risk analysis of autonomous vehicles in mixed traffic stream. Dr. Bhavsar is also working on developing a prototype to equip an existing fleet of vehicle with connected vehicle technology for mobile data collection. This project is in collaboration with the New Jersey Institute of Technology and sponsored by New Jersey Department of Transportation (NJDOT).
Weinan Gao
Ph.D. Candidate, Control and Networks Lab, Department of Electrical and Computer Engineering, Tandon School of Engineering, New York University

Weinan Gao received the B.Sc. and M.Sc. degrees from the Northeastern University, Shenyang, China, in 2011 and 2013, respectively. He is currently working toward the Ph.D. degree with the Control and Networks Lab, Department of Electrical and Computer Engineering, Tandon School of Engineering, New York University, Brooklyn, NY, USA. His research interests include reinforcement learning, approximate/adaptive dynamic programming, cooperative adaptive cruise control, connected vehicles, sampled-data control systems, and output regulation theory.

Zhong-Ping Jiang received the B.Sc. degree in mathematics from the University of Wuhan, Wuhan, China, in 1988; the M.Sc. degree in statistics from the University of Paris XI, Paris, France, in 1989; and the Ph.D. degree in automatic control and mathematics from the École des Mines de Paris, Paris, in 1993. He is currently a Professor of electrical and computer engineering with the Department of Electrical and Computer Engineering, Tandon School of Engineering, New York University, Brooklyn, NY, USA. He is the author or coauthor of over 180 peer-reviewed journal papers with a Google Scholar h-index of 61 and also is coauthor of two books titled Stability and Stabilization of Nonlinear Systems (Springer, 2011) and Nonlinear Control of Dynamic Networks (Taylor & Francis, 2014). His main research interests include stability theory, robust/adaptive/distributed nonlinear control, adaptive dynamic programming, and their applications to information, mechanical, and biological systems. Prof. Jiang is a Fellow of the Institute of Electrical and Electronics Engineers and a Fellow of the International Federation of Automatic Control.

Sandeep Mudigonda
Post-doctoral Research Associate, University Transportation Research Center, Region 2
The City College of New York, CUNY

Dr. Sandeep Mudigonda is a Post-doctoral Research Associate at the University Transportation Research Center (UTRC), Region II at the City University of New York. His current research interests lie in connected vehicle applications and analysis via simulation, statistical analysis and visualization of transportation data, simulation and calibration of large traffic simulation models and their applications. Dr. Mudigonda has performed research sponsored by several state and national agencies. Prior to his appointment at UTRC, he worked as a post-doc at the Center for Urban Science and Progress (CUSP) at New York University (NYU). Dr. Mudigonda received Ph.D. and MS Degrees in Civil & Environmental Engineering from Rutgers University and BS from Indian Institute of Technology, Madras, Chennai, India.

Mengzhe Huang
Ph.D. Candidate, Control and Networks Lab, Department of Electrical and Computer Engineering, Tandon School of Engineering, New York University

Mengzhe Huang received the B.Sc. degree from East China University of Science and Technology, Shanghai, China, in 2013 and the M.Sc. degree in Electrical Engineering from Tandon School of Engineering, New York University, Brooklyn, NY, USA, in 2015. He is currently working toward the Ph.D. degree with the Control and Networks Lab in New York University. His research interests include vehicle control and approximate/adaptive dynamic programming.
Matthew W. Daus
Distinguished Lecturer, UTRC, CUNY

Matthew W. Daus, Esq. currently serves as a Distinguished Lecturer at the City University of New York’s (CUNY) Transportation Research Center of The City College of New York. Professor Daus conducts research and is extensively published as an expert on ground transportation regulation and technology. He teaches courses on transportation history, policy, sustainability, for-hire regulation and technology. Mr. Daus also continues to serve as President of the International Association of Transportation Regulators (IATR), a non-profit educational and advocacy peer group of government transportation regulators from around the world promoting best regulatory practices. Mr. Daus is the longest serving Chairman of the New York City Taxi and Limousine Commission (TLC), serving for 8 ½ years.

Prior to his tenure as Commissioner, Mr. Daus served in executive positions in NYC government for almost 16 years at several agencies including as General Counsel to the TLC and the NYC Community Development Agency, as Special Counsel to the TLC and NYC Trade Waste Commission, and as a NYC Human Rights Prosecutor. Mr. Daus is a partner and currently chairs the Transportation Practice Group at Windels Marx Lane & Mittendorf, LLP.

Maureen T. Koetz
Principal Partner, Koetz and Duncan LLC

Maureen T. Koetz is the Principal Partner in Koetz and Duncan LLC, a small, woman-owned consultancy to public and private enterprise on sustainability risk and value management. Applying operational analytics first developed for national security planning, Koetz and Duncan is an industry leader in quantification-based sustainability profiling using Natural Capital Asset Management™ to assess current and future enterprise capability. Clients and partners include Federal and municipal agencies, private equity, and international engineering firms.

Prior to forming Koetz and Duncan, Ms. Koetz served as a Presidential appointee and senior executive in the United States Air Force. In her capacity as Acting Assistant Secretary and Principal Deputy Assistant Secretary for Installations, Environment, and Logistics, she managed a 10-million acre/$250 billion asset portfolio in support of sustainable operations for the largest energy consumer in the federal government and one of the largest transport systems in the world. Serving in diverse capacities that included Natural Resource Trustee and Historic Preservation Officer, she oversaw ongoing base closures and disposition, streamlined department procedures, and reduced program spending while also developing the first Defense Department programs to sustain adequate natural capital capacity in response to increasing operational encroachment.

Ms. Koetz has also held positions as Counsel for the Senate Energy and Natural Resources Committee and Counsel to U.S. Senator Pete Domenici. As a Director for the Nuclear Energy Institute, she developed the first analytic models for “Emissions Avoidance,” the results of which have remained a key operational and policy element supporting continued global nuclear expansion. She has represented the nuclear industry at the Kyoto Climate Change Conference and the United Nations Conference on Sustainable Development.

Ms. Koetz has been an Adjunct Professor of Environmental Finance at NYU-Poly, is a veteran of active duty service with the U.S. Navy, and has written on several areas related to sustainability. She holds a Juris Doctor from the Washington College of Law at American University, a Bachelor of Arts degree from the American University, and is a member of the Bar of the State of New York.
Continues... **Session 4 SPEAKERS**

**Rodney Stiles**  
Assistant Commissioner, Data & Technology, NYC Taxi & Limousine Commission

Rodney Stiles is the Assistant Commissioner for Data & Technology at the Taxi & Limousine Commission, the City agency responsible for licensing and regulating taxis and other for-hire services in New York City. His team researches impacts of policies through big data analysis, liaises with technology companies who want to work in the for-hire space, and develops regulations and policies for the use of technology. Previously, he was a demographic analyst at the Department of City Planning, responsible for creating long-range population projections. His interests include walking, biking, open data, and data visualization. He is a 2009 graduate of the the Edward J. Bloustein School of Planning and Public Policy at Rutgers University.

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**Cecilia Feeley, Ph.D.**  
Transportation Autism Project Manager, Rutgers’ Center for Advanced Infrastructure and Transportation (CAIT)

Cecilia Feeley, Ph.D., is the Transportation Autism Project Manager at the Rutgers’ Center for Advanced Infrastructure and Transportation (CAIT) where she focuses on transportation needs of adults on the autism spectrum. She has a Ph.D. in Transportation Engineering at NJIT. Dr. Feeley has over 14 years of experience in the field of transportation research and since 2008 has been researching the transportation and mobility barriers issues for persons with autism and other developmental disabilities. She has served as the Principal Investigator/Co-investigator to research and development projects with funding from government agencies and industry; totaling over $1.4 Million. She is currently serving as the PI on the UTC project: Pilot Test Smart Phone/Tablet App for Paratransit Demand-Response Passenger Pick-up Alerts to Assist Passenger with Disabilities and Reduce No-Shows and Vehicle Dwell Times. In 2013, Dr. Feeley was appointed to the Committee on Paratransit of the National Academies Transportation Research Board. Her recent report Detour to the Right Place that studied the transportation and mobility barriers for on the autism spectrum is available as a PDF.

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**Joyoung Lee**  
Assistant Professor, New Jersey Institute of Technology

Dr. Joyoung Lee is an Assistant Professor with the John A. Reif, Jr. Department of Civil and Environmental Engineering, NJIT. He received the B.S. degree in transportation engineering from Hanyang University, Korea, in 2000 and the M.S. and Ph.D. degrees in civil engineering from the University of Virginia (UVA), Charlottesville, in 2007 and 2010, respectively. Prior to joining NJIT in 2013, he served as a laboratory manager of the Saxton Transportation Operations Laboratory (STOL) at Federal Highway Administration (FHWA) Turner-Fairbank Highway Research Center. Dr. Lee’s primary research interest lies in ITS and its applications for 1) Traffic Operations and Management, 2) Intelligent Transportation Systems (ITS), and 3) Connected Vehicle (CV). Dr. Lee has authored and co-authored more than 50 peer-reviewed journal and conference proceeding papers since 2008. Dr. Lee was awarded the best paper prizes of the 10th and 14th PTV VISSIM/VISSUM Users Group Meeting in 2008 and 2012. He is also the recipient of the Excellence in Research Award of the Department of Civil and Environmental Engineering.
Session 5 SPEAKERS

Dr. N. Sertac Artan
Assistant Professor, Electrical and Computer Engineering, New York Institute of Technology

Dr. N. Sertac Artan is an Assistant Professor of Electrical and Computer Engineering at the New York Institute of Technology (NYIT) School of Engineering and Computer Sciences. He got his Ph.D. degree in Electrical Engineering from New York University (formerly Polytechnic University). Before joining NYIT, Dr. Artan was on the faculty of the New York University School of Engineering. He also worked as an ASIC (Application Specific Integrated Circuit) Design Engineer and designed integrated circuits for commercial, academic and military applications.

Dr. Artan served in the organizing committees of the ACM/IEEE Symposium on Architectures for Networking and Communications Systems (ANCS), IEEE Sarnoff Symposium, and ACM Conference on Security and Privacy in Wireless and Mobile Networks (WiSeC). He is co-PI on the UTRC project Secure and Private Sensing for Driver Authentication and Transportation Safety, and also serves as Faculty Mentor for the NSF sponsored Research Experience for Undergraduates (REU) NYIT Site on Security of Mobile Devices and Wireless Networks.

Dr. Artan’s current research interests include low-power embedded systems and VLSI circuits for implantable medical devices, and efficient algorithms for biomedical signal processing and security for applications such as epileptic seizure detection, and network intrusion detection.

Branko Glad
CEO, Telegra, Inc.

Mr. Glad has over 15 years of experience in Computer Science, with over 10 years hands-on experience in Intelligent Transportation Systems.

Mr. Glad is currently managing highly sensitive processes of multi-million dollar ITS projects in the USA. He is actively and successfully contributing to educating clients in ITS, and bridging the knowledge gap between clients and industry standards, making him an unavoidable trusted advisor among many local, state, and federal agencies, as well as among leading A/E companies. Mr. Glad’s personal touch – hands-on approach to multi-million dollar projects, with in-person, daily contact with client – is something that is really appreciated in the community.

After earning a Master Degree in Computer Science from Syracuse University, Mr. Glad started his career in New York City, working for Goldman Sachs. Prior to becoming a CEO of Telegra, Inc., Mr. Glad’s experience at Telegra ranged from software development, to development and implementation of the highest standard ATMS quality assurance processes and procedures. He implemented the latest ITS testing and tracking procedures, and ensuring the delivered software complies with the latest industry standards, and clients’ rigorous requirements. Mr. Glad also dubbed as a Project Manager on some of the most demanding projects.
Continues... **Session 5 SPEAKERS**

**Jerome M. Lutin**  
Senior Director of Statewide and Regional Planning NJ TRANSIT (Retired)

Jerome M. Lutin is an independent consultant actively engaged in research and planning for automated vehicles. Jerry has written and lectured extensively on the implications of automated vehicles for the transit industry. He is currently serving as a Principal Investigator for the Washington State Transit Insurance Pool on a pilot project to test and evaluate automated collision avoidance systems for buses. He also is developing training material for the US Department of Transportation on automated and connected transit vehicles, and serves on several National Cooperative Highway Research Program (NCHRP) panels overseeing automated and connected vehicle policy and planning research.

Jerry’s career spans 50 years of professional experience in transportation planning and engineering. In 2010, he retired from his position as Distinguished Research Professor at New Jersey Institute of Technology where he led a $2.2 million research project on the interactions between transit and land development. He also taught courses on Transit Oriented Development and Transit Standards for the National Transit Institute.

Jerry retired in 2007 as Senior Director of Statewide and Regional Planning at New Jersey Transit where he served for 20 years in a variety of positions, planning new light rail lines and the Newark International Airport rail station, and overseeing pilot projects of new technologies.

A Fellow of the Institute of Transportation Engineers, Jerry earned a Master of Architecture and Urban Planning and a Ph.D. in Urban Planning from Princeton University where he served on the faculties of the School of Architecture and the Department of Civil Engineering. He is a licensed professional engineer, a certified planner, and a US Air Force veteran.

**Jonathan Voris**  
Assistant Professor, New York Institute of Technology

Jon is an assistant professor at New York Institute of Technology. He received his Ph.D. from the Department of Computer Science and Engineering at Polytechnic Institute of NYU in Brooklyn, New York. He graduated with a Bachelor’s Degree in Computer Science from Stevens Institute of Technology in 2006 and obtained a Computer Science Master’s Degree from Stevens in 2007. Prior to his academic career, Jon worked as a Software Engineer and Network Manager for companies in the New York metropolitan area. Prior to joining NYIT’s Computer Science Department, Jon had appointments as an adjunct assistant professor in the Columbia University Computer Science Department and as a postdoctoral research scientist in Columbia’s Intrusion Detection Systems Lab. Jon conducts research into the security, privacy, and usability of systems, particularly emerging mobile and embedded platforms. His work has been published at a variety of venues including TETC, FC, PerCom, WiSec, and SOUPS.
Andrei Greenawalt is the Vice President for Public Policy at Via, where he leads the company’s policy and government affairs efforts. He previously worked on regulatory and policy issues at the White House for several years (2009-14) in various key positions. As the Associate Administrator of the Office of Information and Regulatory Affairs (OIRA), he helped lead the development of regulatory policy and review of agency regulations. Prior to OIRA, he was Policy Advisor in the Office of the Chief of Staff, where he worked closely with White House offices and the leadership of federal agencies to advance the Administration’s domestic policy priorities. In addition, he served as Deputy Director in the Office of Cabinet Affairs, and as Counsel in the Office of Legislative Affairs.

In 2014, Andrei was awarded a Council on Foreign Relations International Affairs Fellowship in Japan (sponsored by Hitachi, Ltd.). He was a Visiting Scholar at the Research Institute of Economy, Trade and Industry (RIETI), in Tokyo, where he researched the Japanese regulatory system. He delivered numerous public presentations and taught an undergraduate course on The American Presidency.

In 2007/08, he worked on then-Senator Obama’s presidential campaign. He has also served as a law clerk to two Federal judges and worked for the U.S. House of Representatives Committee on Government Reform. Andrei graduated with honors from Princeton University with a degree in Politics. He earned a J.D. from Yale Law School, where he was a member of the Legal Services Organization Board of Directors and a Symposium Editor on the Yale Law Journal.
Continues... Session 6 SPEAKERS

S. Maurice Rached, PE, PTOE
Director of Transportation Services, Maser Consulting P.A.

Mr. Rached spent the first half of his career with the NJDOT focusing on traffic safety, traffic operations, and public outreach. In 2001, while he was a District Traffic Engineer for the State, he moved to the private sector, where he has been involved with sustainable transportation, land-use planning, large scale projects, and international consulting. He is currently retained by the Iraqi Ministry of Municipalities to prepare Master Plans for 3 cities. Previously, he was retained by the Ministry of Communications and Public Works to prepare the Nicosia Streetscape manual and to consult on various transportation planning initiatives. In 2010, he made a presentation at the United Nations in New York and participated in a round-table discussion with other experts on Sustainable Practices. In 2007, he was invited by the Chinese government to lecture on highway safety. Currently, he is working to advance and implement various ideas in support of sustainable development.

Daniel W. Peterson, PE, PTOE, PTP
NE Regional Mgr. Transportation Planning & Traffic Engineering, Dewberry

Daniel W. Peterson, PE, PTOE, is the northeast regional manager for transportation planning and traffic engineering based in Dewberry’s Bloomfield, New Jersey, office. With more than 25 years of experience, he is a specialist in transportation planning, traffic engineering, and project management. Peterson has undertaken doctoral studies in pedestrian simulation at the New Jersey Institute of Technology, earned a master’s degree in transportation planning and engineering from New York University, a bachelor’s degree in civil engineering from the City College of New York, and a bachelor’s degree in sculpture from the Pratt Institute. For more than 10 years, he has served as an adjunct associate professor for the School of Engineering and Applied Mechanics at Columbia University. He is a professional engineer in New York and New Jersey, a professional traffic operations engineer, a member of the Institute of Transportation Engineers, and chairs the South Orange Transportation Advisory Committee.

Tim Frisbie
Communications and Policy Director, The Shared-Use Mobility Center (SUMC)

Tim leads SUMC’s communications and policy efforts. He previously served as Senior Account Executive at KSA Public Relations/Public Affairs, where he worked on several transportation projects including helping to launch Getting America to Work, a national coalition advocating for increased federal transit funding. He also planned and executed strategic communications campaigns for clients such as Alexian Brothers Health System, Chicago Bar Foundation, HACIA (Hispanic American Construction Industry), Illinois Chamber of Commerce, Midwest Energy Efficiency Alliance and Mainstreet Organization of REALTORS.

Before KSA, Tim worked as Online Content Editor for Baird & Warner Real Estate in Chicago. He has also done communications work for Governor Quinn’s 2010 primary campaign, Friends of the Chicago River and boutique marketing firm Quast & Associates.

Tim has a BA in Political Science from the University of Iowa and serves on the executive board of the Publicity Club of Chicago, the nation’s largest independent public relations membership organization. A new Logan Square resident, Tim’s interests include Chicago history, public media and pancakes.
Solomon Caviness is Special Projects Manager for Planning for Operations initiatives at the NJTPA. He is currently the project manager for New Jersey’s ITS Architecture Advancement project. His focus is on regional Transportation Systems Management and Operations (TSM&O) strategies including in-vestment in Intelligent Transportation Systems (ITS) and technology innovation. He has his B.S. and M.S. in Civil Engineering and MBA from NYU Stern School of Business.

Zenobia L. Fields is Department Director of Planning with the North Jersey Transportation Planning Authority (NJTPA). She has over 15 years of diverse experience including capacity-building, asset planning, performance planning, urban design, transportation related design, data sharing, policy analysis and general community development. She has held positions with non-profits, government agencies, and private sector companies—including project work at the local, regional, state and federal level. At the NJTPA, she is specifically responsible for overseeing and integrating the technical analysis required to maintain an efficient planning process, or framework, for the organization’s plans and programs. Among these plans and programs, Ms. Fields is leading the NJTPA’s participation in the Regional Plan for Sustainable Development (RPSD) – funded by the five million dollar HUD Sustainable Communities Initiatives Grant. A component of the RPSD will include the development of a Regional Comprehensive Economic Development Strategy (CEDS). Ms. Fields is managing the development of a consultant-supported CEDS, designed to foster public-private partnerships to lay the groundwork for an economic roadmap to diversify and strengthen Regional economies. Ms. Fields has a Bachelor’s of Architecture from Rensselaer Polytechnic Institute and Master’s in Urban and Regional Planning with concentration in Community Development from Virginia Tech.
Speakers For Poster Presentations

Jingqin Gao
Ph.D. Candidate, Tandon School of Engineering, New York University

Jingqin Gao is a Ph.D candidate at New York University Tandon school of Engineering. She studied Science and Technology of Optical Information and received her B.S. from Tongji University at China and her M.S in Transportation Planning and Engineering from New York University. Her research interests lie at modeling and evaluation of parking activities, big data and machine learning approach for transportation, transportation economics, and development of real-time simulation models. She also worked for New York City Department of Transportation on modeling and data analysis to support the agency’s internal planning, technical review processes, and coordinated with external agencies on regional projects since 2012. Some of the key projects she involved includes Manhattan Traffic Model, Off-Hour Deliveries, NYBPM Network Review, LIE/I-495 Managed Use Lane, West Shore Expressway Ramp Plan, Taxi GPS analyses and Flushing Access and Circulation Enhancement Study.

Ali Hamidi
Ph.D. Student, Civil Engineering, The City College of New York, CUNY

Ali Hamidi is a Ph.D. student of Civil Engineering at the City College of New York. Ali’s major is water resources engineering and his research concentrates on spatial-temporal distribution of extreme precipitation and its effects on the city’s infrastructures. He used high resolution radar data in his research and his case study area is NYC.

Fan Zuo, M.Sc.
Ph.D. Candidate, Department of Civil & Environmental Engineering, New York University

Fan Zuo received his Bachelor Degree (2009) in Architecture Environment Engineering from Chongqing University (CQU) and Master Degree (2012) in Transportation Planning and Engineering from New York University. He is currently a Ph.D. candidate in the Department of Civil & Urban Engineering and a research assistant in the CitySmart Laboratory of UrbanITS Center at New York University (NYU). His research interests include shared mobility on demand (MOD) system analytics, autonomous vehicles behavior, GPS-based public transit service analytics, transportation economic modeling, and transportation data mining. He is passionate about using machine learning algorithms, big data technologies and statistical models to explore innovative solutions to transportation problems.
The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.” Mark Weber – Scientific American, 1991

Ours is a simple idea. We make data readily available and bring it into a form and a place that is most useful, a Cloud called Mobility Mine. This creates the interface between the Transit Authority and the Internet of Things. This is a game changer.

Mobility Mine is the place where the Transit Authority will place its data for use by third party providers of goods and services such as fare payment and passenger information. It does so by creating an e-marketplace within which the exchange of money and information takes place with products created by others. This methodology will greatly reduce costs and make the transportation system easier to use and more useful into the future.

The present methodology for implementing technology requires that the New York MTA define an end-to-end solution. Technologies like MetroCard are stand-alone and adding functionality to them has been complex, expensive and risky. Change has been achieved by having the agency define both the changes and the methodology. This has proven to be time consuming and risky. We propose a simple change in methodology that addresses these difficulties and promotes a competitive marketplace where vendors take that risk, provide new innovative products and compete for the riders business. This is accomplished by creating an e-marketplace within which vendors pay the agency or the source data under a license agreement.

It is a different world now where people connect with technology. New and innovative products and methodologies are made possible through the Internet. The MTA is presently planning a replacement for its MetroCard system and the risk is on them to define how to do so. We propose this tool from which others can provide the replacement(s) in a competitive environment based upon the availability of the Mobility Mine. Riders can choose how to obtain your services based on their own preferences. These competing entities then submit fares to the agency. This has already been accomplished with several pilot programs and now can be accomplished on a large scale with Mobility Mine.

Mobility Mine is an interim step in the integration process when compared with the existing methodology. It is the logical place to devise the relationship between your service and business at large. It limits the responsibility of the agency to providing the source data necessary to populate the cloud interface. It is no longer necessary to define how the end product works, just the integrity of the process and the end results. It will be the responsibility of the suppliers to provide both functionality and customer service. Perhaps most importantly it will be the responsibility of the suppliers to keep their products relevant with the demands of contemporary society.

Technology is accelerating. The world is changing and it is changing fast. It is fascinating to imagine what can happen. Other industries that have embraced this methodology have realized fantastic gains. Transportation itself has been greatly improved with technologies like MetroCard, Bus Time and others. How can an agency unleash the power of this technology? Creating the portal that facilitates this change can do it. This is the logical delineation between the MTA and Internet.

Once the cloud is offered, it will be the market forces that bring innovation and assume the risk. The Mobility Mine is the most efficient as well. The infrastructure can be readily deployed: the results will be a city that is vibrant, sustainable and smart. Perhaps the greatest tangential benefit will be to the unbanked. This format encourages independent entities to bank the poor and include fare payment. It encourages open markets providing alternatives to payday loans and check cashing. Mobility is fundamental to social justice and open markets beneficial to us all.

All existing technologies and systems stay in place until and if it is decided to remove or replace them.
Enabling Remotely Piloted Aircraft Systems (RPAS) Into your Commercial Environment

Author(s): Tracy Lamb, Global RPAS Safety Manager, SGS HART Aviation

As the commercial industries of the world move forward in enabling remotely piloted aircraft systems (RPAS or, drones), consideration must be given to some of the ageing risk management systems considered adequate and familiar. RPAS applications are being utilised at an exponential rate across industry from large scale pipeline survey operations in the Middle East, inspections of copper mines in Canada and Australia and tasks on offshore rigs in many of the oceans around the world. As we take advantage of this highly desirable technology, the eyes of the experts focus on integration of RPAS not only into our civil airspace, but also into our commercial space. Just as the challenges of airspace integration have the aviation experts occupied, the corporate world is now realising the challenges associated with due diligence, privacy and corporate responsibility when enabling RPAS. The industrial revolution invoked change in industry in the 1800s, and as a result of post war manufacturing in Japan in the 1950s, Quality Management processes were developed and refined the 1970s. The ‘drone age’ will drive a critical and multi-dimensional change in the approach to risk management.

A word of caution, the path to change can be turbulent, please, fasten your seatbelts.

Keywords: RPAS, due diligence, corporate responsibility, drones, risk management, ALARP, SFAIRP.

Future of NYS Ferry System

Author(s): Catherine Lawson, Associate Professor, University of Albany, SUNY
Gene Kosoy, P.E., Civil Engineer, NYS Department of Transportation, Public Transportation Bureau
Eric Krans, Program Manager, Albany Visualization and Informatics Lab (AVAIL)

At the beginning of the last century the NYS ferry system supported a robust statewide marine industry with numerous shipyards, dry-docking, and maintenance facilities all across the state. Today, NYS has almost entirely lost its market share in marine business. There is a bright future for a new marine industry, however, one that will include Artificial Intelligence in Applied Engineering related to the marine environment: automotive navigation systems, remote navigation control. Such companies will produce robotic navigational systems, electronic system monitoring data devices, and electronic energy efficiency solutions.

The market is very much in its infancy, but it’s starting to gain more attention. Driverless boats are a $6 billion industry. Rolls-Royce, for instance, recently unveiled plans to develop a land-based control center that would orchestrate the movements of an entire fleet of cargo ships as they carry goods around the world.

Currently New York State (NYS) has the largest US ferry system, servicing over 50 million riders annually (50% of nationwide ferry riders), with approximately two dozen ferry operators, 50 ferry routes, and 70 ferry terminals and landings. In support of future growth in maritime transit, consideration needs to be given to connecting the various information systems that operate across the different transit modes. Research is needed to harmonize ferries with the entire transit system to allow developers to create consumer applications for local ferry travel, and for transportation agencies to improve efficiencies in operations.

Data, clean energy, and the autonomous boat are the future of the maritime industry and NYS has an important advantage in this emerging market. Its rich maritime history, infrastructure, and current status as the nation’s largest ferry market coupled with its wealth of world class universities, puts NYS in a unique position.
The General Transit Feed Specification (GTFS) has been universally adopted by transit agencies as the de-facto standard to publish transit route and schedule information. It is commonly used by travelers through mobile apps or websites that provide transit routing information. As a public service, transit agencies devote significant resources to develop, publish and update GTFS data to provide the latest transit service information. The demand forecasting community, in contrast, has not taken full advantage of GTFS. Instead, many travel demand forecasting models rely on legacy transit information that has been assembled manually and in layers over many years.

This presentation will document how one of the largest MPOs in the country, NYMTC, is in the process of integrating GTFS into its travel demand model. In many cases transportation networks do not accurately follow the physical roadway network making conflation of GTFS routes challenging, and if successful, with approximations. The study team is using an iterative and semi-automated procedure to import more than 750 routes covering the New York Metropolitan region. This procedure conflates the longitude-latitude coordinates of the transit routes to an existing roadway network layer. In the process, errors in the roadway network were revealed and corrected. Conflation metrics were calculated to determine the extent of conflation between layers, to pin-point discrepancies and areas where manual intervention was required. Furthermore, we will document challenges faced during implementation of this procedure, treatment of multimodal connections, and the validation tests at the route or skim level that were developed.

Vehicle trajectory data are of increasing importance. At the macro level, they show the route a vehicle follows, vehicle speed in different route sections, and where congestion is. At the micro scale, vehicle trajectories reveal driving style, energy consumption, and how a driver interacts with surrounding vehicles. Understanding driver behavior at the micro level is fundamental for a number of applications including the analysis of mixed traffic flow that contains a percentage of autonomous vehicles. To measure driver behavior, on-board diagnostics and a GPS device are not fully sufficient. Radar or lidar devices need to be installed to scan the environment and obtain the positions of vehicles and nearby obstacles.

In this presentation, a data collection study designed by Cambridge Systematics, conducted by UC Berkeley, and sponsored by FHWA will be presented. The study team equipped a typical car with a high-precision GPS device and two of the latest-technology multimode radars that scan the surrounding environment every 50 milliseconds. Student drivers drove the instrumented vehicle in Oakland, California, for 20 days and 60 hours under varying conditions. A significant amount of data, approximately 2 gigabytes per hour, were collected by the on-board sensors that included the real-time kinematic GPS, inertial measurement unit, radar, and video. Vehicle trajectories were constructed from raw radar measurements and used to evaluate a number of performance measures that characterize traffic flow and individual driver behavior. The performance measures that will be presented include the microscopic fundamental diagram of traffic flow, acceleration noise, coherence, and distributions of speed and distances at different conditions. The study team will present analytics on the data and how driver characteristics can be obtained from such measurements.
**The Implications of Utilizing Consumer Grade GPS Receivers within a Transportation Research Application**

Author(s): **Josh DeLaRosa**, Senior Project Manager, Abt SRBI  
**Carlos Merchan**, Graduate Mechanical Engineering student and Research Assistant, University of Central Florida

When paired with travel diaries, Global Positioning System (GPS) devices can provide transportation planners and modelers with rich transportation data. The GPS devices offer high resolution spatial and temporal data, which supplement diaries with attitudinal data (e.g., trip purpose). The GPS devices can also minimize the underreporting of trips in a diary by collecting data passively and continually. Common practice in transportation research is to provide respondents with consumer grade GPS devices, equivalent to the chipsets found in smartphones. However, urban canyons, weather and tree canopies can obstruct satellite reception resulting in the deterioration of GPS accuracy (type I and/or type II error). This error could lead ultimately lead to the introduction of error into transportation models. To overcome the deterioration of GPS accuracy, researchers can process the data and filter out suspected erroneous GPS points.

To better understand possible measurement error associated with consumer grade GPS devices, this study will test and compare several GPS loggers. This study will also test different methods of processing GPS data. The results of these tests may help researchers better predicting conditions leading to GPS measurement error as well as quantifying the limitations and advantages of collecting GPS data within a transportation application.

**An Exploratory Analysis of Intercity Travel Patterns Using Backend Data from a Transit Smartphone Application**

Author(s): **Niloofar Ghahramani**, Doctoral Student, The City College of New York  
**Candace Brakewood, PhD**, Assistant Professor, The City College of New York  
**Jonathan Peters, PhD**, Professor, The College of Staten Island

Smartphone applications (“apps”) providing transit information are commonly used in urban areas. Many of these apps are available in multiple cities and automatically detect a user’s location via the location services in the smartphone app. The multi-city nature of these apps provides a unique opportunity to understand how transit riders seek information as they travel between cities. The objective of this paper is to identify intercity travelers to/from the New York metropolitan region using one month of backend data from an application called Transit App. Intercity travelers are identified based on the number of days each user has opened the app inside and outside of the New York region. Then, two classification methods are implemented: manual classification and a k-means clustering algorithm. Both methods are validated by comparing the results to self-reported home locations stored in the app by a small number of users. The results of both methods identified distinct subgroups of intercity travelers, including visitors and residents of New York. However, the validation only confirmed a small number of these users as having the correct home city. This may be because only one month of Transit App data was used or because only a small number of users stored their home location in the app. In conclusion, this exploratory analysis utilized a rich new data source and has identified many areas to refine the methodology in future analyses, such as considering consecutive days in the same city.
Framework for NJDOT Mobile Data Collection Management
Author(s): Parth Bhavsar, Ph.D., Assistant Professor, Rowan University
Nidhal Bouaynaya, Ph.D., Associate Professor, Rowan University
Jeevanjot Singh, PMP, Principal Engineer, Traffic, New Jersey Department of Transportation

For a State DOT, one of the ways to develop next generation transportation management system and train existing and future workforce is to utilize existing DOT vehicle fleet for mobile data collection and decision support. The primary objective of this project is to develop a working prototype of mobile data collection systems using the NJDOT vehicle fleet. The objective of the research is to provide a working data integration and visualization prototype, with evaluation of alternative communication systems that transmits the vehicle sensor data to TMC via an in-vehicle smart device (smartphone or tablet) and/or roadside unit. The data collected and transmitted will be:

1. Camera image of road conditions
2. Location, time and direction
3. Temperature, humidity dew point
4. ABS, traction control, wheel speed

The sensors used on-board the vehicle will be:

1. GPS
2. Depth sensor
3. Camera
4. Temperature sensor
5. DSRC radios with Bluetooth
6. Weather sensor

The presentation will include overall concept of the data collection platform, preliminary results of the prototype being evaluated and potential impacts of proposed data collection platform on NJDOT Transportation Systems Management and Operations.

Energy-efficient Cooperative Adaptive Cruise Control of Platooning Vehicles
Author(s): Weinan Gao, Ph.D. candidate, NYU Tandon
Zhong-Ping Jiang, Ph.D., Professor,
Kaan Ozbay, Ph.D. Professor, New York University

Enormous interdisciplinary efforts have been made by automobile companies and research institutions all over the world to develop, validate and deploy autonomous vehicles aiming at assisting, ameliorating and relieving the task of driving a car. Thanks to recent advances in connected vehicle technologies and the introduction of an international standard for dedicated short range communications, the cooperative adaptive cruise control (CACC) is now realizable in the near future via vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless communications. In comparison with traditional investigation on autonomous vehicles that operate in a myopic and highly localized way, CACC has the potential to further increase road safety and traffic throughput, reduce impact of transportation on the environment, and improve passengers’ comfort since it has better predictive, communication and collaborative abilities. Unfortunately, how to design safe, comfortable and optimal cooperative adaptive cruise controllers for platooning vehicles in the presence of uncertain driver behavior and complex vehicle dynamics is still a challenging issue. This research proposes a novel data-driven and model-free, optimal CACC approach based on adaptive dynamic programming approach applied to the longitudinal control of platooning vehicles with strong uncertain nonlinear vehicle dynamics and unpredictable driver behavior. The proposed approach has a strong learning capability such that the obtained approximated optimal cruise control policy can improve the safety, capacity of traffic while reducing overall fuel consumption. The proposed research is implemented in a Paramics based microscopic traffic simulation model and demonstrates its effectiveness under several mixed traffic scenarios with both human-driven vehicles and autonomous vehicles. Extensions to the fully nonlinear model will be discussed using recent developments in modern nonlinear control.
Extracting Useful Information from Twitter Posts for Traffic Incident Management

Author(s): Sandeep Mudigonda, Postdoctoral Research Associate, The City College of New York
Camille Kamga
Anil Yacizi, Stony Brook University
Wei Hao, The City College of New York
Nathalie Martinez, The City College of New York

Ubiquity of connected devices and microblogging platforms e.g., Twitter, are providing huge amount of user-generated information that has a great potential for applications in traffic operations. However, very limited studies have applied social media for traffic incident management (IM) from an application standpoint. In this study, the authors analyze various aspects of applying social media for IM. Information extraction involves, (1) collecting potential posts that are relevant and (2) classifying relevant posts with usable information. Though, the second step of text classification has been well studied, potentially, a variety of information can be extracted from the text, even though the length of the text (i.e., tweets) can be limited. Information such as geo-location, duration, etc. can be mined from tweets. Such information is especially useful for IM as the traditional sources of IM, such as loop detectors and sensors are expensive to invest for wide coverage. Hence, in this study, specific emphasis is placed on extracting useful information from tweets for traffic incidents.

In this study, the researchers use Twitter as the source of traffic incident information from social media in the New York City area. Publicly available tweets over fifteen months are used. The researchers perform text mining over the relevant tweet database obtained using term frequency-inverse document frequency and classification algorithms. As a rule of thumb, among all tweets, only about 5% of tweets use the geo-location from the GPS present in the device. This information, generally, can be provided only by the users’ permission. However, the text in the tweets itself can provide some location-based information. Hence, the relevant tweets are further parsed to mine information specific to incidents using various text mining methods. Using these methods, information such as the street on which the user is driving provides the relative location of the congestion resulting from the incident. Additionally, cross street and/or neighborhood information extracted could potentially be useful in providing warning to the traffic upstream or to the neighborhood traffic.

Vehicle Steering Control with Human in-the-Loop

Author(s): Mengzhe Huang, Ph.D. Student, NYU Tandon
Weinan Gao, Ph.D. Student, NYU Tandon
Zhong Ping Jiang, Professor, NYU Tandon

Recently, extensive research has been conducted on the topic of autonomous vehicle and advanced driver assistance system (ADAS) in order to relieve the workload of the driver, while the human factors seem to be neglected and are no longer in full command of the vehicle control. However, human’s over-reliance on the automation systems in the long run may cause fatal side effects, such as reduced awareness of situation and skill degradation. In our work, we propose new control methods to take into account the interaction between human driver and the vehicle. More specifically, we explicitly take human’s activity during driving into consideration and both the human driver and the ADAS make contributions to complete the lane keeping task and prevent unintended lane departure. In particular, a data driven optimal control problem is then formulated and solved to design the ADAS, which aims to assist the driver in achieving zero lane keeping error. A human in the loop optimal controller design approach is thus proposed. In contrast with previous studies, the human driver parameters and the vehicle parameters are not required to be perfectly known. A sampled data based adaptive dynamic programming (ADP) method is employed to develop an optimal ADAS. Furthermore, the efficacy of the ADAS is validated through two types of human driver model in the simulations. The first type of driver model is based on a two point visual model. It is assumed that the human driver manipulates his/her vehicle based on visual information from a far and a near points. The second type is the tracking error based model, which relates human’s activity mainly to the lane keeping error during driving, such as the lateral displacement and the heading angle error.
Virtual Guide Dog: Next Generation Pedestrian Signal for the Visually Impaired

Author(s): Joyoung Lee, Ph.D., Assistant Professor, NJIT
Zijia Zhong, Graduate Research Assistant, NJIT
Branislav Dimitrijevic, Senior Research Scientist, NJIT
Kitae Kim, Ph.D., Senior Transportation Engineer, NJIT

Accessible pedestrian signal (APS) was proposed as a mean to achieve the same level of service required by the American with Disability Act (ADA) for the visually impaired (VIs). One of the major issues of existing APSs is the failure to deliver adequate crossing information for the VIs. State-of-the-art passive devices to improve VIs situational awareness have been developed. However, the majority of such devices has not only limited by insufficient market penetration but also missed one of crucial aspects of a signalized intersection, which is the interaction between the users and signal controllers. This paper presents a mobile-based APS application, namely Virtual Guide Dog (VGD). Using consumer mobile device, VGD is designed to provide VIs with personalized intersection crossing instructions for safe and prompt crossing. Integrating intersection geo-information and smartphone onboard sensors (e.g., GPS, compass, accelerometer, and gyroscope sensor), the VGD application can notify VIs the close proximity of an intersection and the street information for crossing. By employing a screen tapping interface, VGD can remotely place a pedestrian crossing call to the controller wirelessly. In addition, VGD informs VIs the start of a crossing phase by using text-to-speech technology. The proof-of-concept test showed that VGD can keep user informed about the remaining distance as he or she approaches the intersection. It was also found that the GPS-only mode yielded greater distance deviation compared to the mode operating with both GPS and cellular positioning.
Smart Arrival Notification System for ADA Passenger Paratransit Service Using Smartphone

Author(s): Slobodan Gutesa, Graduate Research Assistant, NJIT
Branislav Dimitrijevic, Senior Research Scientist, NJIT
Joyoung Lee Ph.D., Assistant Professor, NJIT
Cecilia Feeley Ph.D., Transportation Autism Project Manager, Rutgers University
Lazar Spasovic Ph.D., Professor, NJIT

This research presents an arrival notification system for paratransit passengers with disabilities. Almost all existing curb-to-curb paratransit services have significantly large pick-up time window ranging from 20 to 40 minutes from the scheduled time producing large passenger waiting times. The arrival notification system presented in this study delivers an automated voice call to a registered user once the paratransit vehicle is in the near proximity to the pick-up location. The system utilizes Google Traffic API for the vehicle arrival estimation. Unlike other vehicle arrival notification systems in the state-of-the-practice, the proposed system is compact and does not require additional equipment such as radio transmitting and positioning devices. Using consumer mobile devices with Android or iOS platform, the proposed system is designed to exploit commercial cellular network service (i.e., 3G and 4G-LTE). In addition to the passenger notification, the proposed system provides paratransit drivers with real-time route guidance information developed through Google Maps API. Field evaluation conducted in Essex County, New Jersey, reveals significant reduction in passenger waiting time. The passenger waiting time was reduced by 15 to 20 minutes. In addition, accuracy of the notification system was tested: during the test, in almost all cases, vehicle arrived 1 minute earlier from the proposed arrival time.

Artificial Intelligence Saving Lives on Highways (with Existing Infrastructure)

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Although Video Incident Detection (VID) is nothing new in transportation, prompted by numerous criticism and papers on the lack of reliability in Video Incident Detection, a group of researcher decided to make changes and allow this extremely helpful idea take flight. Or drive.

The mission – set the new standards in the industry: high detection rate, low false alarm rate, work with the existing infrastructure, and operate unaffected by common causes of low reliability. From the mission came the following goals: completely redesign VID to be reliable, accurate, affordable, and easy to use.

To make the VID more like human vision, we had to throw away everything we know of video and computer vision, and get “the world turned upside down.” This presentation explores overcoming traditional VID obstacles and deficiencies, perfecting user experience, implementing the new VID on the existing infrastructure, and bringing additional benefits of modern VID and beyond.

The presentation also explores the solutions to most common causes of false alarms, and better recognition. Computer Vision, with Object Recognition & Tracking algorithms, supported by Artificial Intelligence/Machine Learning detection algorithms, virtually eliminating most common causes of unreliable operations: Camera Vibrations, Weather Conditions (rain, snow, sun reflection, backlight), Variations in Illumination (static or moving shadows, dynamic light pattern), Low Video Quality.

Furthermore, the presentation offers working solutions and results for the goals set forth.
Utilizing Behind-the-Wheel Behavior for Driver Authentication

Access to a vehicle has traditionally been restricted to the rightful parties by means of authentication tokens such as physical keys or RFID tags. However, such tokens are not capable of detecting all types of vehicle misuse. Issues such as theft, insurance fraud, and car sharing by unauthorized individuals persist despite the security afforded by access tokens. In this talk we propose a means by which to authenticate a driver to his or her vehicle using data collected by a vehicle’s sensors about its occupants and surroundings. Our proposed method can be applied to continually authenticate a driver’s identity throughout a session, which means it is capable of detecting even mid-session attacks such as carjacking, which prior solutions do not address. We developed a simulated driving environment in order to collect information on how different individuals operate a vehicle. We classified this data using a Support Vector Machine (SVM) learning algorithm. The results of our preliminary study illustrate that our approach to driver authentication is capable of detecting an unauthorized driver in under 2.5 minutes with 95% confidence while incurring only one false positive per driving day or less.
Transportation in American cities is rapidly changing as a result of technological innovation by private companies offering various forms of on-demand mobility. At the same time, cities, states, and the federal government are operating on tighter budgets and finding it increasingly difficult to muster the political will to invest in large mass transit infrastructure projects. While the advent of new technologies in some ways threatens traditional transportation options, we believe it also presents a significant opportunity for governments to improve transit for its citizens in a fiscally responsible way.

Via has successfully created and scaled an on-demand bus system in New York City. Through unique technology and a system-wide approach to urban transportation, we are providing 200,000 rides a week with significant aggregation of riders who pay low, flat fares. We believe our growth provides important lessons for policymakers and public transit agencies, especially as technology continues to develop and vehicles gradually become autonomous.

For the foreseeable future, there will of course continue to be a need for fixed routes on high-demand corridors. However, we believe on-demand bus technology provides transit agencies with the opportunity to more effectively democratize mobility while spending government funds more efficiently. Government managed on-demand bus service can provide first mile/last mile connectivity, optimize conventional service, and improve the productivity of underperforming fixed-routes without the massive capital expenditures traditionally associated with infrastructure development. It also can help connect disadvantaged communities to economic opportunities, healthcare, and other services in a cost-effective way. Finally, through the more efficient use of vehicles, it can help reduce the emission of harmful pollutants such as greenhouse gases.

Car Sharing in Planned Communities

Mr. Rached will present an innovative planning concept where car sharing is utilized as part of the approval process for land use applications to reduce dependency on the automobile, and to minimize the need for parking facilities. Developers will take credit for providing shared cars, which will reduce their parking requirements. Technologically, this concept will be coupled with a Virtual Concierge System (VCS) that manages the user’s time and activities as they relate to transportation needs. The VCS will become the user’s transportation “muse.”

As opportunities for new development in urban areas are increasingly limited, redevelopment is seen by planners and market watchers as the impending trend. This, however, carries many challenges including achieving the necessary density and meeting the requisite parking supply.

Commercial and residential developments are often constrained by local parking requirements, which precludes achieving the desired density in urban areas, transit oriented developments, and other locations where mass transit is available. Based on current economic and environmental trends, complying with local parking standards has proven, in most cases, to be cost prohibitive and environmentally objectionable. In this presentation, we will focus on car sharing, which is a program where subscribers have short term access to a car, as part of a lease of purchase agreement.

Parking standards in most areas do not promote lowering the dependency on the automobile. In urban areas that have access to mass transit, limiting parking supply should be used aggressively as a management tool, and part of larger transportation demand strategy, to reduce trips and improve mass transit ridership. This is where car sharing can be implemented to provide “part time” personal transportation, where one vehicle can address the mobility needs of several individuals.

CASE STUDY:
Car Sharing in a mixed use development. In this project, car sharing was incorporated into the lease/purchase agreements for this downtown, transit oriented development, which was designed to cater to young professionals, live in artists, and neighborhood/life style type retail. Vehicle ownership is limited, and car sharing is promoted and mandated via agreements with tenants.
The rise of Autonomous Vehicles would now seem inevitable and soon we will have vehicles that need no driver, indeed need no one in the vehicle. The concept of MaaS, Mobility as a Service, suggests ubiquitous availability of vehicles on demand through a number of national level providers.

Studies identify that significantly fewer vehicles are necessary (e.g., 20-25%). What disappears is the parked car. The de-automization of cities and suburbia will free up significant space for new purposes. An estimated 20% of the US population cannot drive, a significant number can’t afford a car and must rely upon rural public transit. AVs will provide mobility for all and vouchering in the poor provides access to jobs, daycare, schools and food, enabling people to succeed. Under MaaS, AVs can feed urban and line haul transit and provide 1st mile/last mile, front door to transit door service.

Trucks and smaller goods delivery will lead this transformation to AV. Buying cars by the millions, MaaS providers can demand lightweight vehicles with non-polluting, energy efficient engines. While the vast preponderance of vehicles will become AV, one can still drive one’s jalopy. Streets will become safer, speeds on highways faster, movement more efficient, costs lowered. Today’s DEIS process presupposes a future that is more of today. How will we assess these disruptions? Are we choosing the right projects to serve this new emerging reality?

Change is coming quickly, the AV revolution is just beginning. Much will be different in short order.
De Facto Teleportation Utility System

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Seldom is a problem solved, that is not first recognized. In goods distribution, last mile movements of small payloads are the most inefficient and expensive portion of the total journey. Specific energy intensity for shopping trips by car averages a million BTU's per ton-mile, at an average cost of $100 per ton-mile. Upstream of the retail store, trucking specific energy is only a few thousand BTU’s and less than $1 per ton-mile. This partially explains why bottled water costs $1 per gallon or more, yet tap water costs less than 1 cent per gallon. Last mile distribution of tap water is orders of magnitude more effective and efficient than bottled water. The current fast moving consumer goods distribution system is a problem, because a system similar to municipal water, except specialized for moving a stream of traffic instead of fluid, can deliver the goods far more cost effectively, energy efficiently, conveniently, and environmentally consciously. Examination of this problem and potential solution through extensive research (and development) reveals that solving it primarily upon overcoming prejudice against it. A proof of concept prototype has been completed, and the demonstratable findings include measured specific energy consumption of about 1 Watt-hour per mile, (EPA equivalent = 33,700 mpg), while carrying a 20 lb. payload at 30 mph, with total system material costs less than $10 per foot, all accoutrements included. Extensive analysis of a postulated limited area pilot implementation find total costs for hundreds of deliveries per serviced destinations per month will be less than $200. Policy implications of these findings include that any bias against even examining such a solution is severely flawed. Business implications include that revolutionary changes are coming to both brick and mortar and Internet retail, as well as mail delivery, courier services, and trash collection.

Technical Tools to Improve Transportation Planning

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The North Jersey Transportation Planning Authority (NJTPA) seeks to highlight shareable information products and services that support daily operations as well as on-going analytical work. As one of the NJTPA’s major business processes, sound information is used to inform the prioritization of capital projects. Thus, NJTPA’s goal is to increase access to information managed by partners, while streamlining the data exchange process by standardizing how data is identified, defined, created, and shared.

The NJTPA annually hosts an exposition to showcase a wide range of planning resources and tools available from the agency and its partners. The tools, which feature innovative uses of GIS, mobile technology, transportation models, data visualizations and more, are used to help streamline the planning process. The expo features innovative tools that have been deployed or are being developed in the NJTPA region. Examples include the NJTPA’s Planning Recommendation Integration Management Engine (PRIME) interactive database system; Freight Analytical and Forecasting Tools; Green House Gas Tools (inventory and tool kit of reduction strategies); NJ’s ITS Architecture; Modeling Tools (real-time data, transportation, land use and economic development) and ViZtools (for assessing current conditions, viewing forecasts and sketching future scenarios).

The NJTPA’s poster represents a sample of the “NJTPA Planning Tools Expo.” The poster responds to following topics: Data – Collection, Modelling & Analysis; GIS Technology Applications; Innovative Solutions for Traffic Management; and Transportation Modeling.
Modeling and Predicting the Frequency and Impact of Double Parking Activities in Urban Area Using Big Data

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Double parking is one of the key contributors to traffic congestion in dense urban areas. It routinely causes danger for cyclists, pedestrians and traffic disruptions. This study introduces a novel data-driven framework based on machine learning techniques including the LASSO, stability selection and random forest to identify influential factors and to predict the frequency of double parking events. Parking violation tickets, 311 service requests, social media information and street characteristics are utilized in the study. The random forest model achieves 85% prediction accuracy of double parking occurrences for 50 study locations in Midtown Manhattan, New York, where ground truth data is collected from recorded videos. The result also indicates that the number of hotel rooms, traffic volume, commercial usage, block length and curbside parking spaces are the top five factors contributing to double parking.

In addition, this study adopts a comprehensive modeling approach to estimate the impact of double parking with two types of models: 1) an M/M/∞ queueing model to estimate double parking’s effect on the average travel time; and 2) a micro-simulation model to study individual and combined effects on travel time with different levels of travel demand, double parking locations, frequency, and durations. Comparison results show that the M/M/∞ queueing model yields reasonably accurate predictions under uncongested traffic conditions, yet the micro-simulation model can capture the impact of additional road and traffic characteristics and provide more accurate results especially when the roadway is congested.

This study provides transportation agencies with a novel methodology to quantify the impact of double parking in a large-scale network and to predict potential double parking hotspots for better policy-making, enforcement, and management.

Quantifying the Impacts of Rainfall on Subway Ridership in Manhattan

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This paper is focused on assessing the fluctuation in subway ridership during rainfall events in the city of Manhattan. Combining subway ridership data with hydrology data for the year of 2010-2011, we conducted a comprehensive analysis to (a) investigate the range of changes in ridership level during rainfall events, using a Poisson regression model; and (b) incorporate characteristics of built environment as a parameter in a spatial-temporal Hierarchical Bayesian Poisson Regression Model framework. Parameter estimates, both for ridership and rainfall, are obtained through Markov Chain Monte Carlo sampling. Results indicate a significant decrease in ridership under rainfall conditions for north part of the city, which has a mixed land use pattern, and insignificant decrease in the southern part of the city, where the dominant land use is commercial.
Crowdsourcing Incident Information for Disaster Response Using Twitter

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Social media data, such as Twitter data has the potential to provide valuable information for real-time traffic operations as a supplement to existing data sources such as 511 and 311. This paper compares the incident datasets of the New York metropolitan area during Hurricane Sandy from two different sources: 1) a traditional data provider that collects incident reports from multiple agencies, and 2) text information from Twitter. A text classifier, built by utilizing keywords from actual incident reports, is trained using Naïve Bayes (NB) supervised classification method to extract incident related Twitter data. The keywords are identified by Term Frequency–Inverse Document Frequency (TF-IDF) and the NB method. The filtered Twitter data is cleaned, classified into various incident types and compared geographically with that collected by the traditional data provider. The results show that Twitter could provide geolocations of specific incidents along with their intensities, durations and impact on people. Furthermore, it could also identify incidents that are not captured by traditional incident detection systems, such as gas shortage. Twitter provides an inexpensive alternative way to collect incident data in real-time and with wide geographical coverage. It can be used as an excellent supplementary data source for disaster response, incident prediction and resiliency map generation. However, based on the findings of our study, it is not recommended to use Twitter as the only data source since it is incapable of reporting some incident types, such as traffic accidents, with a high level of reliability and accuracy.