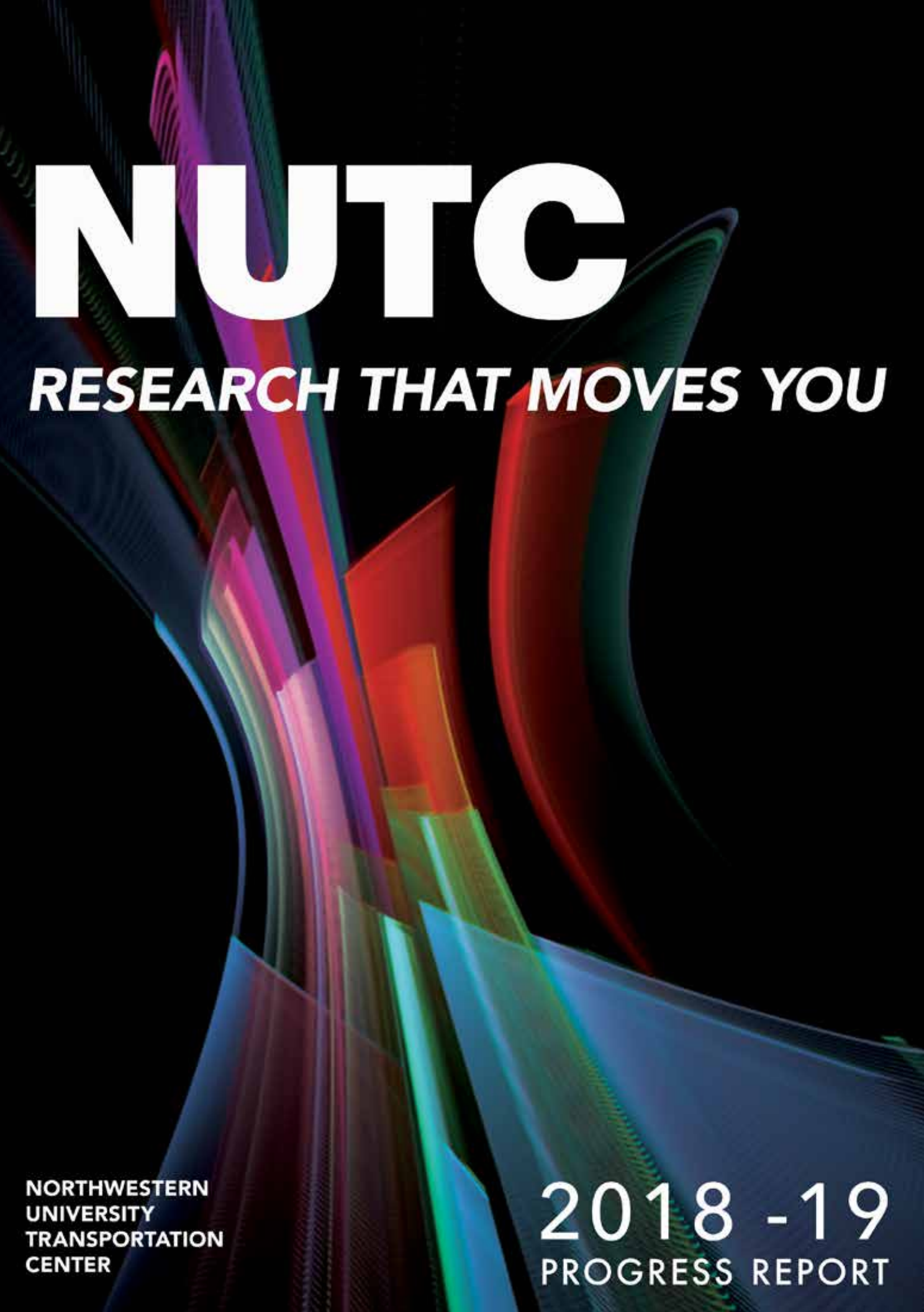




NUTC

RESEARCH THAT MOVES YOU

NORTHWESTERN
UNIVERSITY
TRANSPORTATION
CENTER

2018 -19
PROGRESS REPORT



Northwestern University Transportation Center
2018 - 2019 Progress Report

65 YEARS OF
TRANSPORTATION
RESEARCH

Mission and Vision

As Northwestern University Transportation Center (NUTC) looks to the future, we must retain the essential features of transportation research, outreach, and educational programming while recognizing the evolving industry focus in light of new technologies, markets and societal concerns.

This report reflects the reality of transformative change in the transportation industry, as well as within NUTC. Further, the collaborations and initiatives NUTC continues to pursue will benefit the greater goal of maintaining global recognition as a primary hub for the generation, dissemination, and implementation of new transportation-related knowledge.

Northwestern University Transportation Center (NUTC) has been recognized as a leading interdisciplinary education and research institution since 1954, dedicated to improving systems for the movement of materials, people, energy and information.

Northwestern | TRANSPORTATION CENTER



Report Contents

Welcome: Director's Letter2

Highlights: By the Numbers3

Collaboration and Connections4

Centers and Institutes.....8

Transportation Library9

Faculty and Research Affiliates12

Research

Emerging Challenges.....21

Core Research29

Industry Research46

Education

Academic and Executive Programs.....51

Students and Scholars54

Events and Community

Business Advisory Council60

Meetings, Lectures, Workshops, Seminars.....66

Sandhouse Rail Group / Icarus Aviation Society84



Director's Letter Hani Mahmassani

THE NEXT BIG THING IS NOW.

The digital transformation of mobility of people and goods is well underway. From established companies to startups, digital is happening. Companies without a digital strategy are destined for dinosaur-status in the proverbial backwater. Agencies that don't get digital are out of touch with their customers, especially millennials. But what exactly is this digital transformation about?

We still get around mostly in cars, buses, trains; goods move mostly in trucks, trains, ships and planes. More people in cities rely on bicycles—a return to an earlier pre-automobile era—and some walk more when destinations are accessible, though likely much less than in even earlier times.

While the safety of these vehicles has improved considerably, as have the amenities and comfort of their interior environment, fundamentally the mobility paradigm appears on the surface to have been little changed.

Pundits and soothsayers are always looking to the “Next Big Thing.” Gartner Inc. regularly updates its list of emerging technologies and their respective positions along the Hype Cycle—providing good fodder for a motivation slide in our future-looking

presentations on autonomous vehicles, connected transportation systems and smart cities.

But we see the change taking place across the mobility spectrum. From mobility apps that have become near-essential for many of us when we travel to foreign cities around the world, ensuring access to mobility at the press of a button, to the ability to have virtually anything ordered and delivered within hours, the provision of mobility services is transforming radically. And so are the supply chains and logistics processes enabling e-fulfillment.

Digital brings with it data—lots of it, often in real-time, geosynchronized, from multiple sources, at multiple levels of detail and spatiotemporal resolution. Data means opportunity—to track, learn, predict, and improve all aspects of the operation. As the data gets bigger, the challenges of taming it and leveraging it increase, but so do the rewards. Data is the elixir that fuels applications of machine learning and artificial intelligence, to estimate, predict, and optimize performance.

Digital enables unique insights into how transportation systems perform, and how users experience them. It enables us to go beyond individual transactions to capture the entire

“Digital is here and now, and its impact is increasingly felt in every corner of the mobility and logistics enterprise.”

customer journey, to develop strategies that create awesome experiences. Digital freight marketplaces enable greater efficiencies across the entire supply chain.

We've been promised a future of seamless connectivity and fully autonomous vehicles zipping around our smart cities, and autonomous trucks connecting automated warehouses operated by robotic creatures. Companies big and small have staked their future on the realization of that vision. We don't need to wait until these technologies are fully deployed and adopted to validate the digital transformation of mobility. Digital is here and now, and its impact is increasingly felt in every corner of the mobility and logistics enterprise.

In this changing world, NUTC is well positioned as a platform—for collaboration, knowledge creation, and transformation of that knowledge into practice. We bring together our various stakeholders inside and outside the university to share and create knowledge, and develop the next generation of leaders and tools that can leverage the opportunities unleashed by the digital transformation of mobility, freight and logistics. Well-rooted in the physical world of transportation, our platform provides a vibrant interaction space for innovation and exploration of what transportation futures will or ought to be like, and how to get there.

The pages of this NUTC Progress Report help convey the excitement and dynamism of our research, our faculty and students, as well as the critical role that our industry partners play in the life of our transportation community at Northwestern.

Hani S. Mahmassani

William A. Patterson Distinguished Chair in Transportation; Director, Transportation Center Northwestern University



Northwestern University Transportation Center 2018 - 2019 By the Numbers Highlights

- | | |
|----|--|
| 16 | NUTC Dissertation Year Fellows (DYF) and Greenbriar Undergraduate Fellows |
| 35 | PhD and MS Candidates enrolled in the Transportation Systems Planning & Analysis Degree Program |
| 30 | Academic and Special Interest Seminars |
| 63 | NUTC Faculty Affiliates |
| 20 | New Business Advisory Council (BAC) member companies and representatives |
| 65 | Years of commitment to furthering transportation and logistics research, as well as industry collaboration |

Collaboration and Connections

Regional and National

Conferences and Committees

- Dennis Muilenburg, Chairman, President and CEO of Boeing, delivered the 2018 Patterson Transportation Lecture, “The sky’s no limit: Boeing and the future of space exploration.”
- Brad Keywell, CEO and Founder of Uptake, was the featured distinguished speaker in November 2018 and delivered “The Future is Here: A Conversation with Brad Keywell” in conjunction with the BAC Fall Meeting.
- Lior Ron, Head of Uber Freight, delivered the 2019 Patterson Transportation Lecture: “Uberizing Logistics and the Future of Freight.”
- NUTC featured Nobel Laureate Daniel McFadden for the November 2019 Leon Moses Distinguished Lecture in Transportation Economics, “ATTEND! CONSIDER! DECIDE! What Planners and Machines Must Learn to Predict Travel Behavior.”
- Zdeněk P. Bažant delivered the Applied Mechanics Plenary Lecture at the ASME Annual Meeting.
- Zdeněk P. Bažant delivered the Highly Distinguished Lecture at Case Western Reserve University.
- Hani Mahmassani delivered invited keynote lectures at the:
 - 3 REVs Mobility Conference, University of California, Davis, October 2019.
 - National Science Foundation (NSF) Workshop on Control of Networked Transportation Systems, Philadelphia, July 2019.
 - National Science Foundation (NSF) Workshop on Real-time Learning and Decision Making in Dynamical Systems, Alexandria, VA. February 2018.
 - VISOR Multi-Modal Mobility Workshop: Addressing the Mobility and Congestion Challenges faced by Vanderbilt & Metro Nashville. January 2018.
- Hani Mahmassani, Karen Smilowitz and Marco Nie participated in the Transportation Symposium honoring University of California-Berkeley Institute for Transportation Studies’ Professor Carlos Daganzo.
- Kimberly Gray and the Center for Resilient Communities (CRC) in the McCormick School of Engineering organized the first Resilience Workshop with participation from NUTC faculty Amanda Stathopoulos, Joseph Schofer and Hani Mahmassani.

- Joseph Schofer chaired the organizing committee for TRB’s “Implementing a Freight Fluidity Performance Measurement System” conference. NUTC Business Advisory Council members Craig Philip and John Larkin also participated.
- Barry Nelson delivered the 2018 Alan B. Pritsker Scholars Distinguished Lecture at Purdue University.
- Breton Johnson organized and moderated a Plenary Keynote Super Panel on “Mission Critical and Operational Applications of CAV Technologies in Selected Industries” at IEEE’s 2018 Vehicular Technology Conference.
- NUTC held the Freight Transportation and Logistics: Accelerating First to Last Mile executive short course in Spring 2019.

Research Participation

- Fabian Bustamante received a Google scholar research project award for “A First Look at In-Flight Internet Connectivity.”
- David Corr received funding from the ACI (American Concrete Institute) Foundation to study structural nanomodified concrete.
- Gianluca Cusatis collaborated with Engineering and Software System Solutions, Inc. and the U.S. Army Corps of Engineers’ Construction Engineering Research Laboratory on a concrete 3D printing project.
- Barry Nelson launched a National Science Foundation GOALI project on Computer Simulation Analytics.
- Marco Nie and Amanda Stathopoulos continued to lead a NSF Partnerships for Innovation: Building Innovation Capacity research project on crowdsourced urban package delivery.
- Joseph Schofer and Lama Bou-Mjahed, Schneider Post-Doctoral Fellow, completed a study on Freight and Supply Chain Performance Measurement in State Freight Plans for the FAST Act legislation.
- Joseph Schofer led a National Cooperative Highway Research Program project on “Quantitative and Qualitative Methods for Capturing the Impacts and Value of NCHRP Research” with Texas A&M University.
- Karen Smilowitz led a NSF Partnerships for Innovation: Accelerating Innovation Research - Technology Translation Situational Awareness for Events project on data visualization systems.
- Karen Smilowitz partnered with the University of Notre Dame on an NSF EARly-concept Grant for Exploratory Research (EAGER) ISN project on “Unraveling Illicit Supply Chains with a Citizen Science Approach.”



Government Agencies

- Noshir Contractor and partners received several research awards from NASA for astronaut crew selection, performance measurement and crew collaboration studies.
- Noshir Contractor conducted a project with the Defense Advanced Research Projects Agency’s (DARPA) Ground Truth (GT) program.
- Hani Mahmassani and NUTC provided strategic and operations planning support to the Maricopa Area Government (MAG) in collaboration with Arizona State University.
- Hani Mahmassani partnered with Leidos Inc. on multiple projects for the US Department of Transportation’s Federal Highway Administration.
- Hani Mahmassani served on the Mobility Advisory Group for Mayor Rahm Emanuel’s New Transportation and Mobility Task Force.
- NUTC supported the Illinois DOT’s Planning Conference in Evanston, October 2019, where Hani Mahmassani delivered the keynote presentation.
- Adilson Motter studied network synchronization in partnership with the Army Research Office.
- NUTC collaborated with UIUC, UIC and Illinois Department of Transportation to launch the Smart Transportation Infrastructure Initiative (STII) for the Illinois Automated and Connected Track (I-ACT).
- NUTC collaborated with METRA regional rail agency in defining research programs addressing the long-term strategic role of commuter rail in the Chicago region.
- Joseph Schofer served on the Freight Committee and Bret Johnson served on the Economic Development Committee of the Chicagoland Metropolitan Agency for Planning (CMAP).

Industry Partnerships

- NUTC partnered with Greenbriar Equity Group to award eight Undergraduate Transportation Research Fellowships for summers 2018 and 2019.
- NUTC and CCITT hosted the Spring 2018 Industry Technical Workshop, “Freight by Air: Riding the Wings of Change.”
- NUTC and CCITT hosted the Fall 2018 Industry Technical Workshop, “Connect / Carry / Conquer: Innovative Practices for Freight Process Management.”
- NUTC and CCITT hosted the Spring 2019 Industry Technical Workshop, “Feeding First to Last Mile Demands for Fast(er) Food Delivery.”
- NUTC completed two studies on Less Than Truckload network operations with support from Daylight Transport.
- NUTC completed an urban air mobility study with Uber Elevate, a division of Uber Technologies.
- NUTC completed a study on event access logistics and onsite crowd mobility with the Experimental Aircraft Association (EAA), organizer of AirVenture in Oshkosh, Wisconsin.
- NUTC established ongoing collaborative research dialogues with Ford Motors, Uber Freight, Teradata, Oliver Wyman, Hub Group, United Cargo and Exelon Electric utility.
- NUTC served as a strategic advisory board member on City Tech Collaborative’s Advance Mobility Initiative.
- Diego Klabjan completed two data analytics projects with Allstate Insurance Company.
- Northwestern Transportation Club members toured the United Airlines Headquarters in partnership with alumnus and United Airlines pilot, Noam Alon, and United Airlines’ Business Advisory Council members.

International

Conferences and Committees

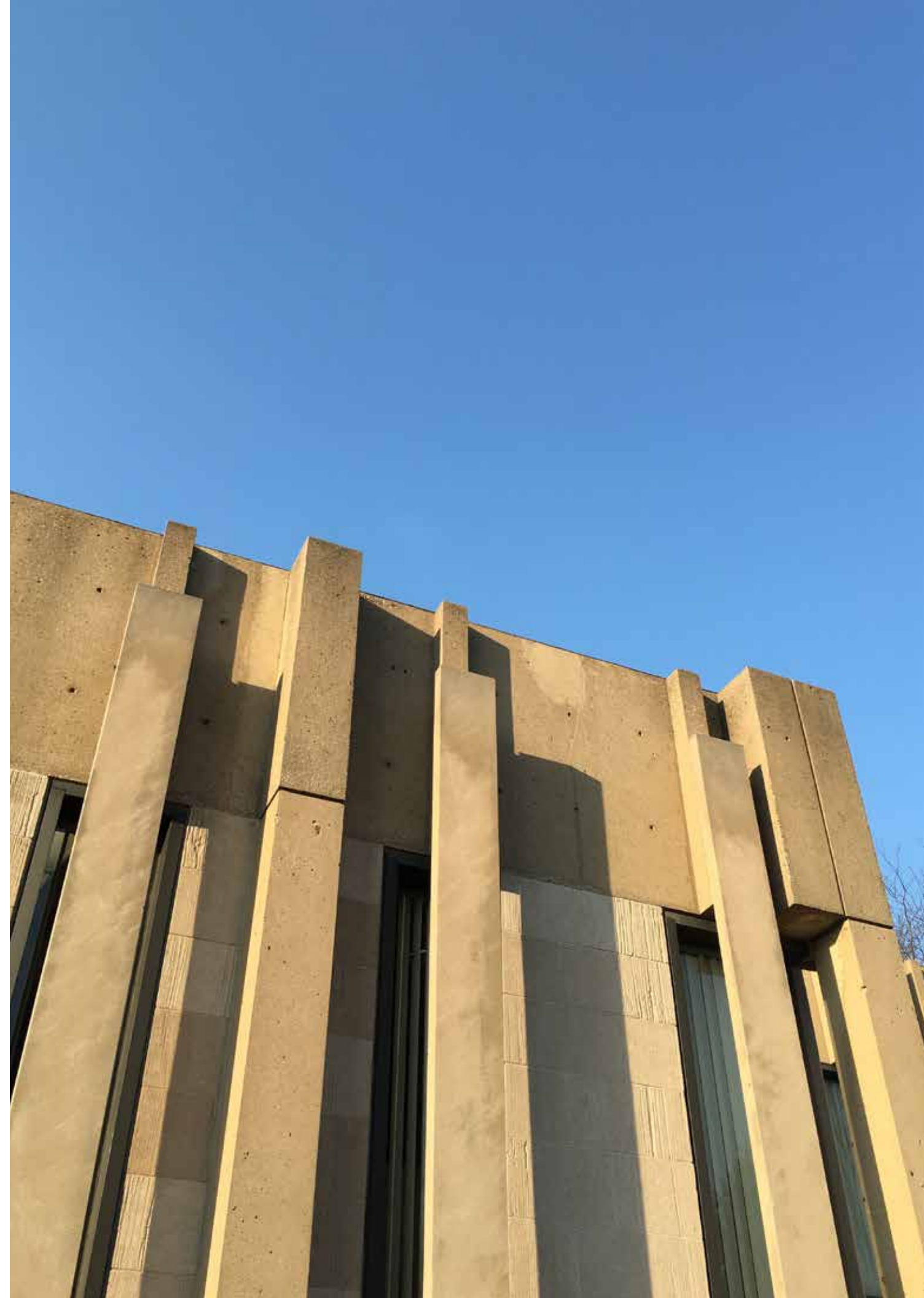
- Zdeněk P. Bažant delivered a plenary opening lecture at the ASCE International Conference at Tongji University.
- Hani Mahmassani elected Convener of International Symposium on Transportation and Traffic Theory IAC.
- Hani Mahmassani delivered Invited keynote lectures at the:
 - 5th NYUAD Transportation Symposium, Abu Dhabi, UAE November 2019.
 - ICTE 2019, Southwest Jiaotong Technical University, Chengdu, China, September 2019.
 - Optimization Days, Montreal, Quebec, Canada, 2019.
 - Dubai Future Mobility 2030-2071, Roads and Transport Authority Innovation Lab, Dubai, UAE, February 2019.
 - EWGT 2018 European Working Group in Transportation, Braunschweig, Germany, September 2018.
- Barry Nelson was a plenary speaker at the 13th International Conference in Monte Carlo & Quasi-Monte Carlo Methods in Scientific Computing in Rennes, France.
- In 2018 and 2019, NUTC faculty affiliates and students participated in workshops and conferences in:
 - Abu Dhabi, UAE;
 - Athens, Greece;
 - Beijing, China;
 - Beirut, Lebanon;
 - Braunschweig, Germany;
 - Brescia, Italy;
 - Chengdu, China;
 - Delft, NL;
 - Dubai, UAE;
 - Hamilton Island, Queensland, Australia;
 - Hong Kong, China;
 - Jeddah, Saudi Arabia;
 - Lausanne, Switzerland;
 - Lyon, France (Gustave Eiffel University);
 - Monte Carlo, Monaco;
 - Montreal, Canada;
 - Newcastle, UK;
 - Ontario, Canada;
 - Paris, France;
 - Rennes, France;
 - Rotterdam, NL.;
 - Shanghai, China;
 - *and more...*

Research Participation

- Noshir Contractor partnered with the Melinda and Bill Gates Foundation to evaluate demand-side community perceptions and barriers to family planning via social network analysis in Ethiopia.
- Marco Nie collaborated with Manbang Group Inc., an online freight exchange provider, to develop and test evaluate freight matching platforms in China.
- Marco Nie led establishment of a student and research scholar exchange program between Southwest Jiaotong Technical University, Chengdu, China and NUTC/NU CEE Department.
- Hani Mahmassani led new research collaboration in the area of autonomous vehicle systems operations and control with the Center of Excellence for NEOM Research at the King Abdulaziz University of Science and Technology (KAUST), Saudi Arabia.
- NUTC researchers have established active collaboration with researchers at TU-Munich, Germany in the area of Mobility as a Service autonomous fleet operations, subsequently extended to include urban air mobility.
- NUTC hosted visiting scholars from TU Braunschweig, Germany; TU-Munich, Germany; ENTPE, Lyon, France; University of Chile, Santiago, Chile; Technion, Haifa, Israel; Southwest Jiaotong Technical University, Chengdu, China; Tongji University, Shanghai, China; Leeds University, UK.

Governments and Industry Partnerships

- Hani Mahmassani was appointed to the Monaco Digital Advisory Council (MDAC), led by Prince Albert II of Monaco.
- Hani Mahmassani was appointed to the International Advisory Board for the Panama Canal Authority.
- Hani Mahmassani participated in future mobility visioning for the Roads and Transport Authority Innovation Lab, Dubai, UAE.
- NUTC established new collaboration with the National Road Safety Center in Riyadh, Saudi Arabia.
- NUTC has joined UITP (International Association of Public Transport), headquartered in Brussels, Belgium, as an Academic Partner, and our Director serves on UITP's Academic committee.



Centers and Institutes

NUTC's effective role in generating awareness and educating the Northwestern community on transportation-related topics with resulting reports, ongoing projects, and current research is evidenced by a growing list of synergistic centers and institutes.

These programs and centers provide enhanced opportunities for students and faculty to learn about and engage in a wide range of subjects affecting the complex and diverse transportation industry. The activities they spearhead are open to the campus community and generally to the transportation community beyond Northwestern, contributing to a rich intellectual and professional experience in virtually all aspects of transportation systems research and education.



CCITT - Center for the Commercialization of Innovative Transportation Technology

CCITT promotes technology innovation and entrepreneurship in transportation at Northwestern through events, speaker series, educational curriculum and industry research partnerships.



CEH - Center for Engineering & Health

Center for Engineering and Health's Humanitarian Logistics research takes modeling and solution approaches to coordinate people, organizations, and materials to deliver goods and services to people in need.



NUCPS - Northwestern University Center for Public Safety

Northwestern University Center for Public Safety (NUCPS) offers authoritative courses and programs for law enforcement and other public safety professionals from agencies at the local, state, and federal levels in the US and around the world.



ISEN - Institute for Sustainability & Energy

ISEN is an umbrella organization designed to create, advance, and communicate new science, technology, and policy for sustainable energy by focusing on supply, demand, and use.



NICO - Northwestern Institute on Complex Systems

NICO serves as a hub and facilitator for path-breaking and relevant research in complexity and data science transcending the boundaries of established disciplines.



Transportation Library

The Transportation Library is the largest collection of specialty transportation publications in the nation, staffed by expert reference librarians at Northwestern's campus in Evanston.



Transportation Library

The Transportation Library houses valuable research, provides public service programming, and hosts special events that support and celebrate Northwestern University's transportation research community, and beyond. Founded in 1958, the library supports the NUTC curricula and research programs. With a catalog containing over 926,000 books, journals, indexed articles, and more, the Transportation Library at Northwestern boasts one of the largest transportation-focused collections in the world.

Transportation Library materials and files are available on all transportation modalities including but not limited to, air, rail, highway, pipeline, water, urban transport, and logistics. More specifically, the Library hosts a sizable collection of law enforcement materials, transportation company annual reports dating back through the 19th century, and one of the nation's most comprehensive collection of printed US environmental impact statements (EIS).

The Library is open to the general public. For research assistance, please contact Library staff via email, telephone or stopping by during the scheduled hours of operation listed below.

The Library and Information Science for Transportation (LIST) committee serves as a forum for transportation librarians and the transportation research community on developments in information science and their applicability to transportation. The LIST committee is in the Research and Education (ABG00) Section of the Transportation Research Board (TRB).

Contact Information and Location

Northwestern University Transportation Library
1970 Campus Drive - Level 5 - Evanston, IL 60208

Hours: 8:30 am - 5:00 pm

transportationlibrary@northwestern.edu
libguides.northwestern.edu/transportation



Features and Farewells

Transportation Librarian Featured

Northwestern University Transportation Library's own Public Services Librarian Rachel Cole was featured in September 2018 as part of the Bright Young Librarians series from Fine Books & Collections. An excerpt from Cole's interview with Nate Pederson is below.

What is your role at your institution (and please introduce our readers to the Transportation Library at Northwestern)?

Rachel Cole: I'm the Public Services Librarian for Northwestern University's Transportation Library. We're the largest transportation information research center in the United States, and among the largest in the world. We work with transportation information on local, national, and international scales, with a community of users from across the nation and worldwide. Our primary constituents are the students and faculty of the university's Transportation Center, so the vast majority of our collections comprise technical resources related to current transportation research in support of their work. There's a lot of fascinating research happening here that is helping to shape the future of mobility and of cities—I regularly get to do instruction, research consultations, and reference support on topics like autonomous vehicles, shared mobility, active transportation, electric vehicles, and infrastructure. It's an area of personal interest to me, so I feel lucky to get

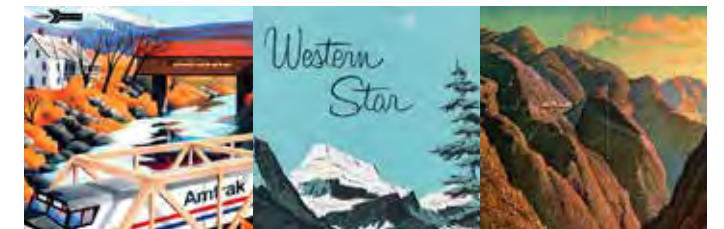


to do this work alongside working with our rare materials, which I get really excited about.

Special collections are a smaller and relatively recent area of collection development in the scope of the history of the transportation library, started under our current director Roberto Sarmiento. Many were acquired from donors who have contributed personal collections, though we do seek out materials for purchase with a very specific focus—a particular interest of mine for collection development is catalogs from bicycle manufacturers in Chicago during the manufacturing boom of the 1890s. Other collections focus on the passenger ephemera that's produced for travel—things like timetables for railroads, passenger steamships, transit operators, and airlines; mid-century menus from airlines, cruise ships, and railroads. We also have a small collection of rare books, and, even after being at Northwestern for two and a half years, I'm still surprised at what I find sometimes when I'm browsing our general collections.

Transportation Librarian Retires

NUTC toasted to Transportation Librarian, **Jordan ("Joe") Arthur Ellison's** 30 years of service at the university during the End-of-Year Event in June 2019. Farewell speeches were delivered by Professor Hani S. Mahmassani and Professor Joseph Schofer, at the event where faculty, students, staff and friends gathered to celebrate the beginning of summer and congratulate Ellison on his next big adventure. Ellison plans to spend his retirement reading and traveling. Cheers to Ellison and our many thanks for so many years of service and dedication.



Transportation Library
Award-Winning Instagram
[@transportationlibrary](https://www.instagram.com/transportationlibrary)
[instagram.com/transportationlibrary](https://www.instagram.com/transportationlibrary)



Faculty Affiliates and Researchers

Affiliations

FM	Feinberg School of Medicine	LB	Northwestern University Library
KM	Kellogg School of Management	CM	School of Communications
McC	McCormick School of Engineering and Applied Science	LW	Pritzker School of Law
MJ	Medill School of Journalism, Media, and Marketing Communications	WC	Weinberg College of Arts and Sciences
		LU	Loyola University Chicago
		UI	University of Iceland / Chalmers University

Jan D. Achenbach (McC)

Walter P. Murphy and Distinguished McCormick School Professor Emeritus, Civil & Environmental Engineering, Engineering Sciences & Applied Mathematics, and Mechanical Engineering
Airworthiness assurance of aircraft structures; ultrasonic methods in quantitative nondestructive evaluation; fracture mechanics

Zdeněk Bažant (McC)

McCormick Institute Professor; Walter P. Murphy Professor of Civil & Environmental Engineering, Mechanical Engineering & Material Science, and Engineering
Mechanics of materials and structures and structural safety; nanomechanics; hygrothermal effects; applications to concrete, fiber composites, tough ceramics, rocks, soils, bone, snow, and sea ice

Henry Binford (WC)

Associate Professor, History and Urban Affairs
Evolution of subcommunities within cities; redevelopment of cities; history of transportation relating to growth of cities

David E. Boyce (McC)

Adjunct Professor, Civil & Environmental Engineering
Urban travel and location forecasting models; transportation network analysis and modeling; history of urban travel forecasting methods

Ronald R. Braeutigam (McC)

Associate Provost, Undergraduate Education; Harvey Kapnick Professor of Business Institutions; Professor of Economics
Applied microeconomic theory and industrial organization; regulatory economics

Fabián E. Bustamante (McC)

Professor of Electrical Engineering and Computer Science
Design, deployment, and evaluation of large-scale distributed systems in both wide-area and mobile networks; experimental systems, particularly operating systems and distributed computing

Clarke L. Caywood (MJ)

Professor of Integrated Marketing Communications
Marketing and communications; crisis management and communications; humanitarian logistics; stakeholder relationship management; political and deceptive messages and advertising; China management education and training

Wei Chen (McC)

Wilson-Cook Professor of Engineering Design; Mechanical Engineering
Multidisciplinary design optimization; design under uncertainty; simulation-based design; design theory and methodology

Ying Chen (McC)

Research Assistant Professor
Machine learning, data mining, natural language processing, network analysis techniques on large-scale data problems in transportation

Sunil Chopra (KM)

IBM Distinguished Professor of Operations Management and Information Systems, Department of Managerial Economics & Decision Sciences
Supply chain management and operations; design of communication and distribution networks; supply chain risk

J. Edward Colgate (McC)

Allen K. and Johnnie Breed Senior Professor in Design; Professor, Mechanical Engineering; Director, Master of Science in Engineering Design & Innovation Program; Research Council Member, Segal Design Institute
Human/machine interface; haptics; mechatronic systems

James G. Conley (KM, McC)

Clinical Professor of Technology, Department of Managerial Economics & Decision Sciences, Clinical Professor of Mechanical Engineering (by courtesy)
Product design and development technologies; intellectual property strategies; intellectual capital; innovation management

Noshir Contractor (KM, McC, CM)

Jane S. & William J. White Professor of Behavioral Sciences; Professor of Industrial Engineering & Management Science; Professor of Communications Studies
Social and knowledge networks; statistical and computational methods; organizational theory

David Corr (McC)

Clinical Associate Professor of Civil & Environmental Engineering
Structural engineering and mechanics; structural sensing and diagnostics; failure analysis and forensic engineering; performance of civil engineering materials; stochastic methods and structural reliability

Anne Coughlan (KM)

John L. & Helen Kellogg Professor of Marketing
Distribution channel management and design; pricing strategy; reverse channels for product returns; competitive strategy

Gianluca Cusatis (McC)

Associate Professor of Civil & Environmental Engineering
Mechanics of infrastructure materials and constitutive modeling of concrete and cementitious composites

David A. Dana (LW)

Kirkland & Ellis Professor of Law, Associate Dean
Environmental and land use law, regulation, and policy, particularly methods of allocating carbon credits; regulation and technological change in the automobile industry; eminent domain reform and urban sprawl

Charles H. Dowding (McC)

Associate Chair and Professor of Civil & Environmental Engineering
Construction vibrations; structural health monitoring; subsurface exploration decisions

David Dunand (McC)

James N. and Margie M. Krebs Professor of Materials Science & Engineering
Lightweight metallic materials for energy-efficient transportation; high-temperature alloys for energy-efficient internal-combustion and jet engines

Pablo Durango-Cohen (McC)

Associate Professor, Civil & Environmental Engineering
Transportation infrastructure management; modeling and analysis of production control systems; capacity management; statistical performance modeling; contract analysis and design

Steven Franconeri (WC)

Professor, Cognitive Psychology
Visual cognition; guidance, capture, and tracking of visual attention and awareness; effective visual design

Robert J. Gordon (WC)

Stanley G. Harris Professor of Social Sciences
Macroeconomic theory; monetary theory; airline economics; airline management; airline history; airline customer experience

Kimberly A. Gray (McC)

Chair and Professor, Civil & Environmental Engineering; Professor, Chemical & Biological Engineering
Urban sustainability; brownfield and urban redevelopment; environmental impacts of transportation on ecological and human health; energy-efficient technology

Michael Hewitt (LU)

Assistant Professor, Information Systems & Operations Management, Quinlan School of Business
Quantitative models for decision making; solutions for transportation and supply chain management domains, particularly in freight transportation and home delivery

Paul M. Hirsch (KM)

James L. Allen Distinguished Professor of Strategy & Organizations; Chair, Management & Organizations Department *Organizational change; human resources and mass media*

Joel Horowitz (WC)

Charles and Emma Morrison Professor of Market Economics *Econometrics; travel demand modeling; urban transportation; air quality*

Agnes Horvat (CM, KM)

Assistant Professor, Communication Studies; Faculty Affiliate, NICO and Kellogg School of Management *Complex networks; collective intelligence; computational social science; data*

Thomas N. Hubbard (KM)

Elinor and H. Wendell Hobbs Professor of Management Professor of Strategy *Industrial organization; trucking industry; economics of strategy; applied econometrics; economics of technology*

John C. Hudson (WC)

Professor of Anthropology; Director, Geography Program; Associate Director, Environmental Sciences Program *Cultural and physical geography of North America; biogeography; economic geography; cartography and mapping; geographic information systems*

Albert Hunter (WC)

Professor of Sociology; Director of Urban/Communities Workshop, Faculty Chair Public Affairs Residential College *Transportation in urban areas; public policy; urban sociology; community; ethnicity, culture, and literature; methods*

Arthur P. Hurter (McC)

Professor Emeritus of Industrial Engineering & Management Sciences *Logistics; applied microeconomic analysis; routing and risk analysis; facility locations; plant and equipment investment and replacement*

Seyed M.R. Iravani (McC)

Professor of Industrial Engineering & Management Sciences *Stochastic modeling and analysis; production and logistics; optimization of queuing systems; manufacturing and supply chain management; white collar work and service operations systems; analysis of integrated production and maintenance policies*

Breton Johnson (McC)

Associate Director, NUTC *Technology transfer and commercialization; technology-based economic development; space and technology innovation policy; homeland security*

Richard Joseph (WC)

John Evans Professor of International History and Politics; Faculty Affiliate, Buffett Center of International & Comparative Studies *Growth, governance, and sustainable development; comparative democratization; African politics; HIV prevention strategies; energy, environment, and transportation*

William L. Kath (McC, KM)

Professor of Engineering Sciences & Applied Mathematics, Professor of Neurobiology & Physiology *Computational neuroscience; fiber optics; wave propagation; nonlinear dynamics; complex systems*

Leon M. Keer (McC)

Walter P. Murphy Emeritus Professor, Civil & Environmental Engineering, and Mechanical Engineering *Engineering mechanics; tribology*

Diego Klabjan (McC)

Professor of Industrial Engineering & Management Sciences; Director, Master of Science in Analytics Program *Business intelligence and analytics in air transportation; logistics; railway industry; retail; supply chain management*

Frank S. Koppelman (McC)

Professor Emeritus of Civil & Environmental Engineering *Travel demand modeling and prediction; yield management; urban, regional, and intercity transportation planning; development of advanced travel demand modeling concepts and methods*

Raymond J. Krizek (McC)

Stanley Pepper Professor of Civil & Environmental Engineering *Mechanical properties of grouted sands; disposal of waste slurries; engineering behavior of dredged materials*

Hani S. Mahmassani (McC, KM)

William A. Patterson Distinguished Chair in Transportation; Professor, Civil & Environmental Engineering; Director, NUTC; Professor, Managerial Economics & Decision Sciences *Dynamic traffic system management; network modeling and optimization; dynamics of user behavior and telematics; intermodal freight and logistics*

Therese McGuire (KM)

ConAgra Foods Research Professor of Strategic Management *State and local public finance; fiscal decentralization; property tax limitations; education finance; regional economic development*

David Morton (McC)

Chair and Professor of Industrial Engineering & Management Sciences *Stochastic optimization and its application to energy, security, and health problems*

Barry L. Nelson (McC)

Walter P. Murphy Professor of Industrial Engineering & Management Sciences; Co-Director of Master of Engineering Management Program *Computer simulation of dynamic stochastic systems; design and analysis of simulation experiments*

Yu (Marco) Nie (McC)

Professor of Civil & Environmental Engineering *Network optimization; traffic flow theory; traffic simulation*

Maciek Nowak (LU)

Department Chair, Information Systems & Supply Chain Management *Vehicle routing and tracking; supply-chain management; operations management and research; logistics and data analysis; quantitative methods; heuristic search*

Thomas O’Toole (KM)

Executive Director, Data Analytics Program *Connecting data science to business value creation, data-driven marketing, customer value management, digital business models, the emergent structure of marketing and loyalty programs*

John C. Panzar (WC)

Louis W. Menk Professor Emeritus of Economics *Theoretical and policy issues relating to network industries (telecommunication, electric transport, air transport and postal services); industrial organization; regulatory economics; applied microeconomic theory*

Mark A. Ratner (McC)

Lawrence B. Dumas Distinguished University Professor Emeritus of Chemistry, and Materials Science & Engineering *Organic electronics and photovoltaics; energy storage materials, particularly electrochemical; energy concentration routes, including exciton fission; agent-based modeling of complex systems*

Kathryn Reid (FM)

Research Associate Professor, Neurology *Impact of sleep loss and circadian disruption on human performance; health and safety with emphasis on the impact of shiftwork*

Roberto Sarmiento (LB)

Director, Transportation Library *Management issues for the digitization of transportation collections; analysis of Transportation Library’s collection at the national level; the role of journal article indexing in a full-text world*

Ian Savage (WC)

Associate Chair, Department of Economics; Professor of Instruction *Transportation safety; transportation economics; urban transit*

Mohanbir S. Sawhney (McC)

McCormick Foundation Chair of Technology; Clinical Professor of Marketing; Director of the Center for Research in Technology & Innovation *Business innovation, digital and social media marketing, network-centric innovation, growth and scaling strategies*

Joseph L. Schofer (McC)

Associate Dean, Faculty Affairs; Professor of Civil & Environmental Engineering *Transportation policy analysis and planning; uses of data and information in decision making; issues and factors in investment decisions; traveler behavior and market research*

Karen Smilowitz (McC)

James N. and Margie M. Krebs Professor, Industrial Engineering & Management Sciences; Co-Director, Center for Engineering & Health *Design and operations of logistics networks; vehicle routing and scheduling; supply chain management; applications in commercial and non-profit settings*

Richard Sobel (WC)

Visiting Scholar, Buffett Center for International and Comparative Studies *Political science, public opinion, and policy; intersection of security and domestic politics, civil liberties, right to travel and travel privacy; security and identification policies; housing and community development*

Amanda Stathopoulos (McC)

William A. Patterson Junior Assistant Professor of Civil & Environmental Engineering *Human aspects of sustainable mobility systems, transportation choice modeling and forecasting*

Gunnar Stefánsson (UI)

Professor, Logistics & Transport Management *Logistics and transportation management; collaboration management; information and communication systems; management of technology and economics*

Fred W. Turek (WC)

Charles E. and Emma H. Morrison Professor of Biology, Department of Neurobiology; Director, Center for Sleep and Circadian Biology *Sleep and circadian rhythms; metabolic, neurodegenerative and gastrointestinal disorders*

Brian Uzzi (McC)

Richard L. Thomas Professor of Leadership and Organizational Change and Industrial Engineering & Management Sciences; Co-Director of Northwestern Institute on Complex Systems; Director, Kellogg Architectures of Collaboration Initiative *Leadership, social networks, and big data*

Jan A. Van Mieghem (KM)

Harold L. Stuart Distinguished Professor of Managerial Economics; Professor, Operations Management, Department of Managerial Economics & Decision Science *Operations management and strategy; supply chain management and analysis; management and investment under uncertainty*

Michael Watson (McC)

Adjunct Professor, Department of Industrial Engineering & Management Sciences, Master of Engineering Management Program, and Master of Science in Analytics Program *Supply chain network design; facility location; analytics*

Kermit Wies (McC)

Senior Research Fellow and Adjunct Professor, Retired Deputy Executive Director for Research and Analysis – Chicago Metropolitan Agency for Planning (CMAP) *Transportation planning; professional practice; travel demand forecasting; freight modeling; geographic information systems (GIS)*

Hyejin Youn (KM)

Assistant Professor of Management and Operations *The interplay between technological innovation and socio-economic systems (urbanisation, economic diversity and specialisation, invention activity, future of work)*

New Faculty Affiliates

**Ágnes Horvát**

Assistant Professor, Communication Studies

Horvát is an Assistant Professor in the Department of Communication Studies, an affiliated faculty of the Northwestern Institute on Complex Systems (NICO), and the Department of Management and Organizations of the Kellogg School of Management (by courtesy). She seeks to measure, understand, and forecast the collective behavior of networked crowds in large-scale sociotechnical systems like peer-to-peer platforms. Her current research develops empirical and theoretical methods to support creativity and predict success in culture industries, identify expressions of collective intelligence and opportunities for innovation in crowdsourcing communities, as well as detect shared misconceptions and biases in online capital markets. Her work at the intersection of computational social science and social computing uses an interdisciplinary data-driven approach and builds on techniques from network science, machine learning, statistics, and exploratory visualization. Professor Horvát developed and teaches a 'Cultural Analytics' graduate course that is designed to train students for careers at the intersection of creative occupations and data science. She serves on the editorial board of PLOS One. Horvát has been the recipient of many fellowships and academic excellence awards, most recently a CISE CRII award from the National Science Foundation.

**Thomas F. O'Toole**

Executive Director, Program for Data Analytics at Kellogg
Clinical Professor of Marketing

O'Toole is Executive Director of the Program for Data Analytics at Kellogg, and Clinical Professor of Marketing, at the Kellogg School of Management of Northwestern University. His work, teaching and research at Kellogg focuses on subjects including: connecting data science to business value creation, data-driven marketing, customer value management, digital business models, the emergent structure of marketing and loyalty programs. He developed and teaches a new MBA course on Customer Loyalty strategy. Additionally, he teaches many C-level Executive Education programs, including: Leading with Big Data and Analytics, Advanced Marketing Management, The CMO Program and The Customer-Focused Organization. He is the author of "Branding Services in the Digital Era" in Kellogg on Branding in a Hyper-Connected World (Wiley, 2019).

**Hyejin Youn**

Assistant Professor, Management & Operations

Youn is an Assistant Professor of Management & Organization Department at the Kellogg School of Management, and a core faculty at NICO, the Northwestern Institute on Complex Systems. She is also Royal Society of Arts fellow, and an external fellow at London Mathematical Laboratory, London, UK. Prior to joining Kellogg, she worked at University of Oxford, Harvard University, and MIT Media Lab, and Santa Fe Institute, as a research fellow. Hyejin received her PhD in Physics in 2011 from Korea Advanced Institute of Science and Technology (KAIST). She was a Principal Investigator of the project a National Science Foundation grant (USA) to study Technological Change from the Map of Capabilities.

Faculty Recognition

Jan Achenbach

- 2018 Honorary Professorship, Xiamen University, China

Zdenek P. Bazant (pictured next page, bottom right)

- 2018 ASCE International Conference plenary opening lecture, Tongji University
- 2018 Alfred M. Freudenthal Medal, Engineering Mechanics Institute Conference
- 2018 Carleton Lecture at Columbia University
- 2018 Academy of Athens Inaugural Lecture
- 2018 Rector's Lecture, Czech Technical University, Prague
- 2018 Best Paper Award, journal Materials & Structure
- 2018 Plenary Speaker, ASME Annual Meeting honoring his 80th birthday, American Concrete Institute
- 2019 Highly Distinguished Lecture at Case Western Reserve University

David E. Boyce

- 2019 Northwestern University Archives initiates archive of work dating back to 1965



Wei Chen (pictured left)

- 2018 Northwestern Graduate School's Ver Steeg Award
- 2019 Election to the National Academy of Engineering (NAE)

Ying Chen (pictured next page, top left, far right)

- 2019 TRB Freight Planning & Logistics committee's Best Paper Award

Noshir Contractor

- 2018 Distinguished Alumnus Award, Indian Institute of Technology Madras

Gianluca Cusatis

- 2018 Awarded Fellowship, ASCE Engineering Mechanics Institute (EMI)



Kimberly Gray (pictured left)

- 2018 ChemSusChem Front Cover Feature
- 2018 AIChE Midwest Regional Meeting Plenary Lecture

Joel Horowitz

- 2018 Fellow, International Association for Applied Econometrics

Raymond J. Krizek

- 2019 ASCE Opal Leadership Award

Hani Mahmassani (pictured next page)

- 2018 Best Paper Award with UIC Prof Alireza Talebpour (former TC Dissertation Year Fellow), Transportation Research Part C: Emerging Technologies
- 2018 International Advisory Board, Panama Canal Board of Directors Appointment
- 2018 Keynote Speaker, National Science Foundation Decision-Making Workshop
- 2019 TRB Freight Planning & Logistics committee's Best Paper Award

- 2019 Inaugural Martin Beckmann Transformative Research in Transportation Award, TRB Transportation Network Modeling committee
- 2019 Best Reviewer Award, TRB Traffic Flow Theory committee
- 2018 Monaco Digital Advisory Council Appointment (Mahmassani is pictured far right with H.E. Prince Albert II of Monaco.)

David Morton

- 2018 INFORMS Best Publication Award in Energy
- 2018 Plenary Speaker, 17th Conference on Modeling & Optimization Theory & Applications, Lehigh University

Barry Nelson

- 2018 Plenary Speaker, 13th International Conference in Monte Carlo & Quasi-Monte Carlo Methods in Scientific Computing in Rennes, France
- 2018 Alan B. Pritsker Scholars Distinguished Lecture, Purdue University



Yu (Marco) Nie (pictured left)

- 2018 Stella Dafermos Best Paper Award by the TRB Transportation Network Modeling Committee
- 2019 TRB Standing Committee on Transportation Network Modeling Certificate of Appreciation

- 2019 Best Paper Award, Transportation Research Part C: Emerging Technologies

Ian Savage

- 2018 President of the Transportation Research Forum
- 2019 Appointment to National Research Council Transit Cooperative Research Program Review Committee Mitigation Strategies for Deterring Trespassing on Transit Rail Rights of Way (TCRP A-44)
- 2019 National Research Council Committee for Review of the Federal Railroad Administration Research & Development Program
- 2019 Member Transportation Research Board, Standing Committee on Highway/Rail Grade Crossings (AHB60) and subcommittee on trespass and suicide prevention



Joseph Schofer (pictured left)

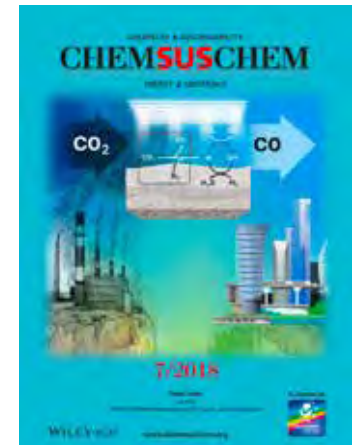
- 2018 Institute of Transportation Engineers Fellow
- 2019 Council of University Transportation Centers HNTB CUTC Lifetime Achievement Award

Karen Smilowitz (pictured next page)

- 2018 INFORMS Business Analytics Prize, Innovative Applications in Analytics
- 2018 Associate Editor Appointment, Journal of Operations Research

Amanda Stathopoulos

- 2018 Featured Speaker 15th International Association for Travel Behaviour Research (IATBR) conference
- 2018 Paper with Prof Alireza Ermagun (Mississippi St Univ.) recognized by TRB Urban Freight Transportation Committee
- 2019 Faculty Early Career Development Program Award, National Science Foundation



NUTC research is driven by the major challenges facing the transportation industry and society. Mobility, safety, environmental sustainability, energy, generational change, economic development, resilience, infrastructure renewal, and financial viability are at the forefront of transportation agencies' policy agendas. Competitiveness, globalization, changing customer expectations, uncertainty, volatility and technological change are major considerations in transportation enterprises' strategic and operational decision making.

NUTC Research

Emerging Challenges in Transportation

Strategic Research Themes

Research at the Transportation Center is motivated by the major challenges and opportunities facing the transportation industry and society. Mobility, safety, environmental sustainability, energy, generational change, social justice, health, well-being, economic development, resilience, infrastructure renewal, and financial viability are at the forefront of transportation agencies' policy agendas. Competitiveness, globalization, changing customer expectations, uncertainty, volatility, disruptions, worker skills and technology change are major considerations in transportation enterprises' strategic and operational decision-making.

The Center's portfolio of research projects and activities is continually evolving to anticipate, identify, characterize, and develop solutions for significant issues faced by the transportation industry, in both private and public sectors. Faculty and student researchers work together with industry and agency partners to gather information, track data and devise methodologies to analyze these problems, gain insight, formulate strategies, design solutions, and work towards implementation, testing and evaluation.

The Center engages its faculty and industry partners in identifying strategic research areas with significant societal and/or industry impact, and spanning the

interests of several faculty members. These areas share the following characteristics: (1) impact on society and/or industry; (2) significant opportunity driver, particularly technological developments; (3) fundamental and methodological challenges; and (4) need for cross-disciplinary perspectives. The list naturally evolves, along with strategic priorities, as emerging challenges become integrated, over time, in the core research areas for the Center's researchers.

Five Areas in Focus

Five of these areas are highlighted here, with several specific projects described in this report's Research section.

1. **Autonomous, Connected, Electric, Shared (ACES):** Towards smart urban mobility
2. **Digital Transformation** of Freight and Logistics
3. Dealing with the unexpected: **resilience**, disaster response and **humanitarian logistics**
4. The **customer journey**, one experience at a time
5. **Urban Logistics and Delivery**



Autonomous, Connected, Electric, Shared (ACES): Towards Smart Urban Mobility

The timeline for ubiquitous autonomous vehicles remains a moving target subject to speculation and vulnerable to setbacks along the bumpy road of technological innovation and adoption. However, many indications point to it being a question of when, in what form and at what rate, rather than if autonomous vehicles will become part of everyday mobility.

Automation is only one of the transformative dimensions shaping future urban mobility. Vehicles are increasingly connected—to each other, to the cloud, to the infrastructure, mostly through wide-area wireless networks. Special-purpose connectivity through ad hoc wireless networks or short-range communication with the infrastructure have been in planning documents for years, though rapid deployment of 5G wireless technology is changing the landscape considerably. Connected mobility is integral to the vision of smart sustainable cities, with different infrastructures and sectors integrated in a connected Internet of Things. In this context, the third transformative dimension comes into play, namely the electrification of transportation, as part of the continued greening of mobility. Electrification is synergistic with autonomous features, as vehicles are built from the ground up, and would thrive in a smart city environment, the ultimate smart grid for wirelessly-charging circulating vehicles.

The trend towards shared mobility is likely to continue as autonomous vehicles further change the economics of vehicle and fleet operations. Different business models with varying degrees of privacy, availability and pricing will emerge, conveying a wide array of mobility options. How to integrate these services with conventional high-capacity public transportation is a

topic of significant interest to NUTC researchers.

Many view these forces as no less than a revolution in mobility. Notwithstanding the hype cycle, our approach is to build the scientific and methodological foundation for understanding how these forces are shaping the future of mobility, and developing the mechanisms to influence these developments towards better outcomes from the standpoint of safety, efficiency and environmental sustainability. As these four considerations interact in shaping the future, critical challenges must be addressed—technological, methodological, operational, organizational, and institutional, among others.

Research at the Transportation Center already informs several facets of the problem, including the strategic and operational implications of connected and autonomous vehicles, simulation and optimization tools for real-time operation of transportation and logistics systems, strategic-level choices for public investment in urban infrastructure and services, machine learning and data science techniques in demand forecasting, understanding the growing role of connected personal devices in activity and travel engagement of individuals and groups, and the enabling role of these platforms in the sharing economy. However, considerable fundamental and applied research and development is required to enable the vision and its promise. Safety and cyber-security loom large as major considerations in any public deployments.

NUTC is actively engaged in expanding the multidisciplinary community working on the multiple facets of these problems at Northwestern, and in building partnerships with industry and public agencies to address the system-level aspects of these developments. A major collaboration has been initiated between NUTC and the University of Illinois at Urbana-Champaign and the University of Illinois at Chicago to establish a Smart Transportation Initiative for Illinois with major R&D facilities in conjunction with a test track and a testing village for cradle to deployment testing and development of various autonomous vehicle technologies and services.

Digital Transformation of Freight and Logistics

Freight and logistics are core research and education areas for the Transportation Center, and the focus of many of our interactions with our Business Advisory Council companies. Identifying and tracking developing trends that are impacting the industry is an essential part of our mission. Helping companies and agencies get ahead of the curve and leverage these developments is an important goal for our research. With continuing digital transformation of our economy and society, freight and logistics



may seem as the last frontier to be conquered by digitalization—as goods have to physically move at some point. However, digital is now touching virtually every aspect of freight movement and logistics operations.

In a recent white paper, Accenture Inc. identifies eight digital technologies as potentially disruptive in the freight and logistics realm: Blockchain, Augmented Reality, Robotics, Autonomous Logistics, Digital Platforms, Big Data Analytics, 3D Printing, and Software as a Service.

With much of manufacturing already highly automated, or having found its sweet spot between automation and human intervention, the search for efficiency and productivity continues towards greater automation in upstream and downstream processes—activities with traditionally high human engagement. In addition, the transformation of the retailing landscape, kicked off more than two decades ago with e-commerce, is gathering more momentum through greater omnichannel presence and innovation.

Disruptive technologies bring along new, digital entrants that seek to transform traditional business relationships. In freight and logistics, services built

on big data, cloud and connected platform technologies, are intended to give customers a seamless experience in terms of ease of access, price transparency, and near real time integrated service. How to integrate new technologies and practices into existing relationships and legacy processes is one of the challenges faced by established companies in this sector.

NUTC research is particularly focused on the opportunities created by the transactional data generated through greater automation, role of new technologies such as the blockchain, and the intersection between the logistics of e-fulfillment, urban deliveries and developments in last-mile technologies and service concepts. Areas addressed include:

- Role and optimization of unmanned aerial vehicles (drones) in last-mile delivery, and in shortening delivery times from fulfillment center to customer locations.
- Logistics network design for systems with varying degrees of process automation.
- Leveraging real-time transaction data for online fleet management and order fulfillment.
- Role and prospects for emerging on-demand delivery options through crowd-sourced and shared-economy concepts.

This effort ties together several research strands at the Center, and is part of a larger effort on freight mobility and intermodal hubs in the context of global supply chains, which also includes:

- Assuring safety, reliability, resilience and consumer responsiveness of freight and logistics networks;
- Alleviating congestion at critical urban hubs to eliminate bottlenecks through a combination of technological innovation, infrastructure investment, and policy initiatives;
- Defining models for public-private partnering in infrastructure development, financing, and operation to achieve national objectives regarding multimodal freight corridors; and
- Developing knowledge bases, data and tools to support freight planning, policy development and investment decisions at statewide and metropolitan levels within a national competitiveness framework.

These issues are of considerable strategic importance to industry as well as state and national-level agencies.



Dealing with the unexpected: resilience, disaster response and humanitarian logistics

Many companies have mastered the ability to optimize transportation and logistics operations under normal conditions. Some have developed robust approaches to deal with increasing volatility driven by political and trade tensions and other factors. Few are equipped to deal with major disruptions in the availability and flow of essential goods, products and services over extended periods of time. Weather events, earthquakes, floods, fires, pandemics, as well as wars, trade tensions, financial meltdowns, and other causes leave entire cities and countries lacking in essential goods and services.

The Humanitarian Logistics Initiative at Northwestern University was launched more than five years ago by a group of NUTC faculty, led by Karen Smilowitz, to address critical problems that arise in the chaotic arena of disaster relief distribution operations. The scope has considerably expanded, to include the logistics of mass events. Advances in aerial drone surveillance and delivery technologies, geographic information systems (GIS), mobile communications platforms with social media features, tracking technologies, optimization techniques networking power, and the decision sciences are being brought to bear on challenges such as relief supply vehicle routing in uncertain, rapidly changing settings; search and rescue that takes into account real-time information on access road networks and infrastructure conditions; and enhanced tools and

methods for locating and setting up mobile health clinics in relief zones.

The Initiative encompasses three interrelated fields: (1) humanitarian and nonprofit logistics involves the coordination of people, organizations, and materials to deliver goods and services to people in need; (2) evacuation logistics and management entails moving affected populations out of harm's way and providing for their needs during and after the process; and (3) logistics of organized mass events, such as marathons and other sports/cultural manifestations, celebratory events such as presidential inaugurations and visits by dignitaries, and religious manifestations such as pilgrimage in Makkah, entails complex scheduling and routing of people and resources to ensure safe and successful operations.

These approaches are not limited to the humanitarian realm, but more generally encompass the resilience of supply chains for medical goods and other essential products under disruptive events. How to keep food supply chains delivering to remote communities when access modes are not practicable, or how to deal with sourcing requirements for critical goods and components are important questions of interest.

In all categories the research aims to provide the information necessary for reliable decision-making by integrating relief routing and asset deployment models with new streams of imagery, mapping, and crowd-sourced real-time data into tools usable by aid practitioners in actual settings. In addition, the research seeks to understand and consider the psychological and sociological aspects of human response in these situations.

The Customer Journey, One Experience at a Time

At a time when some aspects of the travel experience appear to have reached abysmal lows (long airport security lines, damaged packages, missed delivery windows, and road-enraging near gridlock congestion), many segments of the travel and related industries have placed quality of the user experience at the core of their product and service design, and made it a central objective of their operation, with executive compensation tied to specific metrics of customer satisfaction. It is therefore not surprising that we have seen an explosion in methods and technologies to constantly measure and assess the subjective experience of travelers and transportation service users. From simple ratings of our meals, flights, and ride-hail drivers, and the now ubiquitous buttons with green, yellow and red smiley/frowning faces in washrooms and security screening facilities, to long surveys via email or telephone, measurement is key to quantifying customer satisfaction—an essential requirement for figuring out how to target and influence it.

An important development along this line is to go beyond the transactional aspects of individual experiences, to consider the entire customer journey through multiple stages and repeated interactions. A journey takes place over time, and overall satisfaction, and ultimately retention of that customer, is more than the sum of each transaction. A delayed flight and missed connection could undo the goodwill from several positive experiences— transportation companies rarely get credit for merely being on time, but certainly incur much ill will when they miss. And in many instances, customer delight requires something a little extra, beyond the mere fulfillment of a safe on-time transaction. The battle is no longer only about user satisfaction, but user

delight, and, in the broader policy realm, happiness. Addressing the customer journey as opposed to individual experiences in isolation raises both technological, institutional and organizational challenges. The latter may be the most difficult to overcome in that customers may have multiple touch points with a particular company or organization, and thus different groups within that organization.

NUTC research has long been at the forefront of understanding and quantifying preferences and attitudes underlying travel behavior, and approaches to predict demand as part of decision-support systems for planning, marketing and service design. This line of work continues, with renewed focus on the broader opportunities made possible by technology. For customer-savvy companies, personal connected devices open a direct two-way path to the consumer, enabling preference measurement and targeting through personalized, customized, and increasingly gamified incentives and opportunities. While applications in private sector travel, retailing and entertainment have advanced considerably in the past few years, urban mobility platforms such as Uber and Lyft are beginning to show public agencies the potential opportunities of direct customer interaction.

Recognizing the importance of this area, NUTC held an industry workshop specifically targeting tools for measuring and influencing user satisfaction and happiness. Doctoral work at NUTC has examined the interaction of technology engagement with activity and travel behavior patterns, developing tools for measuring and analyzing these complex phenomena. Efforts continue to adapt and evolve conventional choice modeling techniques to the new realms of real-time data, user dynamics and individualized incentives.



Urban Logistics and Delivery

It is one thing to move a large container from the port of Los Angeles to a warehouse in Memphis, and then on to Newark. It is another to deliver an item in that container to an apartment address in Manhattan. Growth of e-commerce, and rising expectations for timely delivery, have resulted in what is akin to a free-for-all in the proverbial last mile delivery to residences and businesses. A large number of agents are involved in the delivery process—from the warehouse to the customer's door.

Urban deliveries are where the freight world meets urban planning and design. When only a handful of large, organized entities (such as UPS, Fedex and the US postal service) handle deliveries, economies of consolidation result in efficient vehicle routes to cover the needed destination. However, today's competitive environment has brought out a plethora of services that rely on contract workers, all focused on getting packages to their respective destinations within increasingly tight timelines—ranging from a few hours to a few days from order placement.

While insisting on same day service for their packages, many residents also do not want to see freight delivery vehicles on their streets. Frequent

delivery trips to the same address or street multiple times during the week place a congestion and safety toll on residents, curbside parking in urban areas, and affect the character and walkability of the neighborhood. Sustainable practices encourage the use of electric vehicles for last mile delivery—requiring solution of new classes of routing problems that factor in emerging vehicle and recharging options. Most communities in the US have left freight movement largely unregulated, with provisions enacted to ensure security and safety of the public. Increasingly volumes and greater reliance on deliveries driven by ecommerce are motivating the need for a well-structured approach to urban deliveries from cradle to grave.

Smart city technology can play a role, and so could a dynamic, responsive approach to tactical and operational choices facing shippers and e-fulfillment intermediaries. NUTC has partnered with CityTech Collaborative in the Chicago area to create a program that addresses these challenges and demonstrates new approaches to urban deliveries and freight logistics that balance competing trade-offs between efficiency, safety, and sustainability while continuing to attain service standards commensurate with customer expectations.



NUTC's primary objective is to discover new insights, concepts, and tools that can be utilized by industry, business, and government to support decision-making. NUTC's ultimate goal with this intensive research agenda is to help all sectors move toward more efficient and responsive services and systems. The core research topics underline this goal.

transportation.northwestern.edu/research/core-topics

Core Research

CORE RESEARCH TOPICS

- Logistics and Supply Chain Management
- Network Modeling and Planning
- Transportation Demand, Economics and Forecasting
- Transportation Asset Management
- Transportation Policy
- Human Performance and Transportation Safety
- System Operations

CAREER: Transformative Mobility Analysis: Mixed Methods Framework

National Science Foundation

Amanda Irimi Blomberg Stathopoulos

The CAREER research project's goal is to define, measure and understand the dynamics of human behavior and social practices to support engineering solutions for transportation innovation adoption. The research focuses on the umbrella of transformative mobility services, fueled by crowd-sourcing (e.g. crowdshipping), sharing (bike-sharing), and new technology platforms (ride-hailing) in both personal and goods mobility.

Results from this project help to establish a comprehensive mixed-methods framework of mobility transformation analysis, providing a leap forward in studying how societies adopt innovation. The CAREER project's educational goal is to construct multi-tiered education and outreach curricula at the intersection of behavioral science and engineering. This objective enhances extant curricula, and provides a series of educational opportunities to help prepare future engineers and industry leaders to innovate and evaluate technical solutions that align with human behavior and societal goals.

Models And Policy Tools For Emerging Transportation Services: Promoting Socially Inclusive Outcomes

Federal Highway Administration

Amanda Irimi Blomberg Stathopoulos

Transportation Network Companies (TNCs) have changed the way the field views mobility by distinguishing itself

from traditional modes such as public transit or taxis. With this project, Professor Stathopoulos aimed to identify the ideal role of emerging transportation services in the overall urban network. The study concluded that because TNCs have now become an ingrained part of the system, research must be conducted to capture and understand its effects on transportation infrastructure, the environment, and social equity.

NeTS: SMALL: Broadband Service Reliability: Characterization and Improvement

National Science Foundation

Fabian Bustamante

While providing access and sufficient capacity remains a challenge in a great part of the world, in many developed countries, broadband services continue to improve rapidly, propelled by government and private interests. With widely available and faster broadband, consumers start to migrate key services such as television, telephony and home monitoring to over-the-top alternatives, and their expectations regarding broadband reliability are becoming paramount, ranking first in recent reports on consumer experience. Yet, despite the rich history of reliability engineering we have very limited understanding of reliability in the context of broadband, from the most appropriate metrics for characterizing it, to approaches for gathering measurements or assessing its impact on quality of experience. When reliability problems appear, troubleshooting them can be daunting, resulting in increased frustration for users, growing management costs for service providers, and

underperforming applications.

This project centered on the reliability of broadband services, with three parts to the research: (1) Characterizing broadband service reliability: Researchers developed techniques and explored metrics to study and characterize reliability problems in broadband services, and algorithms to diagnose and localize common problems. (2) Understanding the relation between reliability and QoE: They explored the impact of reliability problems on users' QoE with different services, investigating the value of proxy metrics for QoE (e.g., session time, traffic demand) and the application of natural experiments and related designs to understand their relationship at scale while controlling for most confounding factors. (3) Exploring edge-based solutions to improve reliability. With an understanding of reliability problems, researchers investigated possible solutions, leveraging platform deployments in access networks.



A First Look at In-Flight Internet Connectivity

Google LLC

Fabian Bustamante

In just a few years, ubiquitous connectivity has moved from a vision statement to an assumed reality in much of the developed world. Leveraging this expectation, several airlines offer in-flight connectivity (IFC) services among their extra amenities on commercial flights. In 2014, 19% of all commercial planes were equipped with IFC technology. By 2024, the fraction of IFC-equipped planes is expected to reach 55% potentially connecting nearly 2 billion passengers. Passengers are reported to increasingly consider IFC when making travel plans.

Continuous in flight connectivity opens an exciting new field of study in networked systems. Starting with the challenges of providing connectivity while traveling at 30,000 ft and speeds that exceed 500 mph, to understanding the design options at different layers, from network protocols to caching and networked system architecture, to investigating the potential for IP-based approaches to replace the aging traffic management system (supporting flight communication, tracking and navigation over either VHF audio or plane transponders). With this project, researchers analyzed the performance of deployed IFC systems. They profiled

these services over both available technologies for communication: direct air-to-ground communication (DA2GC) and mobile satellite service (MSS). Preliminary results showed that, while high access latencies are determined by the technical limitations of each approach (e.g., plane-to-satellite and satellite-to-ground distances), the actual performance is a function of physical features (e.g., distances to towers, alignment with satellites), protocols and systems designs.

Researchers explored the extent to which spatial/geographic features and the relative positions of the aircraft and ground equipment determine performance, and the potential benefits of hybrid systems. As part of this effort, the team developed a crowdsourced system for data collection and a portal for sharing and visualizing the flight and experience of contributor passengers.



An Extensible Middle-Box Service for Mobile Devices

ComCast Corporation

Fabian Bustamante

Modern mobile devices are indispensably handy and, simultaneously, fundamentally mysterious. While the closed nature of mobile devices has clear benefits—e.g., in terms of security and user-interface consistency—it also comes at a cost. The operation of the device and the apps is not easy to understand. There are not ready answers to the following: What is this app using my contact list for? Who, if anyone, is this app sharing my location with? Is this app tracking me by my phone's unique identifier? Why is this app consuming so much data? Further, as these devices naturally hop from one network to another, the performance user experience can vary greatly.

With this project, researchers argued for a middle ground between opening the entire system and opportunistically dropping middleboxes in the path. They advocated for employing virtual interfaces on a mobile device to create an on-board middlebox—termed, “middlebox zero” or MBZ—between the unmodified system and the broader network. Bustamante and his team realized the MBZ concept using virtual private networks (VPN) and building an extensible, safe architecture above it.

Master Multidimensional Network Analysis for Data Driven Vehicle Preference Modeling and Segmentation Prediction: An Extension to Spatiotemporal Modeling of Diffusion Pattern in China Auto Market

Ford Motor Company

Wei Chen

The objective of this project was to extend the previously developed multidimensional network analysis approach to developing a data-driven spatiotemporal modeling framework for analyzing and predicting complex diffusion and evolving patterns of customer preferences in the China auto market using the multi-year New Car Buyers Survey data.

Chen and her team developed a systematic, network-based spatiotemporal modeling framework for predicting customers' choices by integrating multidimensional network theory, time series analysis, and spatiotemporal econometrics. They analyzed and predicted customers' evolving preferences by considering social interactions, time-lagged effects, and regional differences to support Ford's market positioning and vehicle development.

As a result of the project, researchers developed an advanced analytics methodology and framework for application to attribute prioritization and revenue/volume forecast for future vehicle programs. The project helped to improve the forecast model accuracy, avoid annual revenue loss, reduce investment cost, and deliver volume with increased profit.

Team Task Switching in Astronaut Crews on the International Space Station: Integrating Multiteam Membership, Multiteam Systems, Multi-tasking, & Multidimensional Networks to Monitor & Enable Functional Work Shifts in Astronaut Crews

NASA Lyndon B. Johnson Space Center

Noshir Contractor

Interviews with current and former astronauts, as well as reports from astronauts on the International Space Station (ISS), revealed potential crew performance issues stemming from shifting back and forth between independent work and highly interdependent work. For example, ISS crews tend to work for extensive periods of time on independent tasks associated with research projects and other mission-related activities. However, these crewmembers are also expected to switch seamlessly and sometimes spontaneously to interdependent team-based tasks of high criticality and time.

Researchers defined this as a problem of team task switching, which impacts the cognitive, motivational, behavioral, and performance effects that result when individuals respond to changing work demands within teams. Further, the multiteam structure of NASA

requires individuals to regularly shift goal focus in response to dynamic situational requirements. Astronauts often work independently toward a goal, while at other times they work interdependently within a team, and yet at other times, they work as a part of a large system of teams. Hence, researchers concluded that team task switching encompasses both lateral shifts that entail a change in one or more dimensions of work (e.g., task versus tool shifts) as well as vertical shifts that entail a change in the degree of interdependence (e.g., shifting upward from independent to interdependent work versus shifting downward from interdependent to independent work).

US-Russian Collaborative Proposal for Data Collection in HERA: The Relationship between Composition, Interpersonal Relations, and Team Effectiveness in Space Crew

DePaul University

NASA Lyndon B. Johnson Space Center

Noshir Contractor

(Leslie DeChurch / Suzanne Bell - PI)

Long-duration space exploration missions (LDSEM) include a number of challenges, such as prolonged isolation and confinement, which are likely to impinge on team functioning and increase the importance of social integration, shared cognition, and effective team processes needed for mission success. For this project, Noshir Contractor, Leslie DeChurch, and their Northwestern teams worked closely with the PI Suzanne Bell to collaborate with Russian space researchers. The project integrated methods for team measurement currently in use by IBMP and NASA, to develop a model of interpersonal relations in isolated and confined environments (ICE).

A key intellectual advancement of the project was the use of multi-relational network analysis to track the development of interpersonal relations among astronaut crews. Contractor and his team were responsible for extending current relational event network modeling techniques to include multi-relational network events that co-evolve with individual and relational states in the network.



CREWS: Crew Recommender for Effective Work in Space

NASA Lyndon B. Johnson Space Center

Noshir Contractor

In this new era of human space exploration, humans are moving beyond low Earth orbit and the relative safety of the International Space Station. Meanwhile, near-Earth asteroids and Mars present previously unimaginable opportunities, as well as organizational challenges—including the complexity of the operating environment within which astronauts work. This complexity places enormous demands on astronauts. As a result of this multidisciplinary research project, astronauts were given what they needed to push beyond the bounds of human cognitive and social functioning, to multitask across tasks, teams, and tools in order to work toward personal, team and system-wide goals.

This three-year programmatic investigation into team task switching leveraged: (1) agent-based models to understand how task shifting behavior and performance-related switching costs occur based on dynamic interplay between independent and interdependent tasks, (2) laboratory experiments conducted in two multiteam systems laboratories (one at Georgia Tech, the other at Northwestern) to test the theoretical model derived from agent-based models, (3) unobtrusive data collection strategies to capture information on the tasks and complex social network structures of ISS crew members, (4) design of interventions to enable adaptive team task switches using virtual experiments, (5) validation of intervention strategies using one of NASA's space analogs, and (6) development of a dashboard decision aid to anticipate and pre-empt dysfunctional task switching.

Novel Approaches to Measuring Demand-Side Community Perceptions and Barriers to Family Planning via Social Network Analysis

George Washington University

Bill & Melinda Gates Foundation

Noshir Contractor

Contractor and his NU team were responsible for developing an egocentric and cognitive egocentric network survey to be administered in Ethiopia. The goal of the survey was to identify to what extent an individual's (ego's) use of contraceptives is influenced: (I) at the individual level by various demographics and personality characteristics; (II) at the meso-level by the ego's network contacts (or alters)—who influences them and how—as well as alters' characteristics and their contacts with one another, and (III) at the macro-level by community norms.

The NU team was primarily responsible for identifying key concepts for measurement, identifying and/or

developing scales for measuring said concepts, and implanting the survey using NetCanvas, a Microsoft Touch software tool available on GitHub to collect ego-centric network surveys.

Once the survey was finalized, Contractor traveled to Ethiopia to train and observe those conducting the survey, as well as train those surveying in the field.

CHS: Medium: Collaborative Research: Understanding Online Collaboration over Multidimensional Networks

National Science Foundation

Noshir Contractor

Thanks to the tremendous research interest in networks and the massive amounts of available digital trace data, conducting studies of population-level human interaction on a larger scale is now more possible than ever. Further, understanding the social structures and dynamic underpinning of socio-technical systems is crucial for system design, as well as for anticipating their impact on social, economic, and political lives.

Contractor looked at the crowdsourcing systems that are the socio-technical systems through which online communities comprised of diverse and distributed individuals coordinate work through dynamic interpersonal and socio-technical relationships. These systems were shown to not only generate creative content but to contain rich communities filled with collaboration and evaluation opportunities for creators and adopters of creative content to interact among themselves and with their artifacts (e.g., creative content) through overlapping relationships such as affiliation, communication, affinity, and purchasing. As a result these relationships constitute multidimensional networks and create structures at multiple levels.

Modeling Scientific Workforce Dynamics Using Social Network Analysis

Harvard University

National Institute of General Medical Sciences

Noshir Contractor

The scientific workforce requires teams to solve the most critical intellectual and social problems that confront us today. Scientists and inventors are embedded in self-organizing communities, where they share ideas and act both as critics and fans for each other. Recent research has shown that team collaborations, a growing trend across all disciplines, yield publications with higher intellectual impact than single researchers; and, the careers of young scientists are influenced by relationships with others in the community. Contractor and his team discovered differences in the networks of women and minorities

that explained some of the disparities existing in these subgroups. Thus, their project aimed to develop a systems-based approach to studying scientific workforce dynamics that models the mechanisms of how new collaborations form and how these influence both the effectiveness of teams and the career trajectories of individual scientists.

The three specific aims of the project were: (1) Develop empirically validated theoretical models that predict how teams form within the scientific workforce. Researchers used Exponential Random Graph Modeling (ERGM) to test Multi-Theoretical Multi-Level (MTML) models for the emergence of networks. (2) Determine how the assembly mechanisms of scientific teams influence their diversity and efficacy. Researchers modeled the composition of teams (e.g., gender, race, education, etc.) as well as a variety of productivity measures (e.g., citation counts and ability to obtain funding). (3) Determine the influence of a scientist's collaborators on his or her career trajectory. The team incorporated SNA centrality metrics into models that predicted advancement and retention in the scientific workforce, stratified by gender and race.



ACCESS Agent Based Causal Simulator with Cognitive Environmental and Social System Factors

Defense Advanced Research Projects Agency (DARPA)

Noshir Contractor

The Defense Advanced Research Projects Agency's (DARPA) Ground Truth (GT) program aims to improve knowledge of social science modeling capabilities and limitations. The purpose of the program is to use artificial, yet plausible, computer-based social-system simulations with built-in "ground truth" causal rules as testbeds to validate the accuracy of various social science modeling methods (i.e. the teams creating the simulations know the rules, but the teams creating the models don't). A further goal of the program is to use a series of GT challenges to explore new multi-disciplinary teaming approaches for enabling rapid "solution-oriented" social science modeling capabilities.

DARPA sought to leverage and advance complex social simulation capabilities in order to provide "minimally-viable" test beds for a wide range of social science modeling methods. Contractor and his team predicted that potential use of distributed and cloud computing

and GPUs would be required for simulating agents and groups capable of increased interaction over structured, yet dynamic, scales and networks. Researchers also looked into whether simulated agents and groups could exhibit purposive, adaptive, biased behaviors and social learning—which often lead to counter-intuitive behaviors at different levels in the simulation.

Project FUSION: Facilitating Unified Systems of Interdependent Organizational Networks

University of Georgia

National Aeronautics and Space Administration

Noshir Contractor

(Leslie Ann DeChurch)

Long-duration space exploration missions (LDSEM) in this project included a number of challenges. One of the most significant challenges encountered by Contractor and his team was the organizational challenge of designing a well-functioning social system with a semi-autonomous, multicultural and multidisciplinary flight crew working at an extreme distance from a large system of teams residing within one or more mission control centers on Earth.

Researchers working on Project FUSION developed a concrete understanding of the specific factors that affect integration among teams within multiteam systems, networks of teams, exploring deep space.

Structural Nanomodified Concrete: Investigation of Critical Properties

ACI (American Concrete Institute) Foundation

Dave Corr

With proper handling, small dosages of carbon nanofibers and nanotubes exhibit exceptional potential as additives for structural concrete, to improve critical properties such as modulus of elasticity, flexural strength, and cracking resistance. Prior research suggested that these improvements are achieved via fundamental changes to the nano- and micro-structure of calcium silicate hydrates (CSH), particularly in the interfacial transition zone.

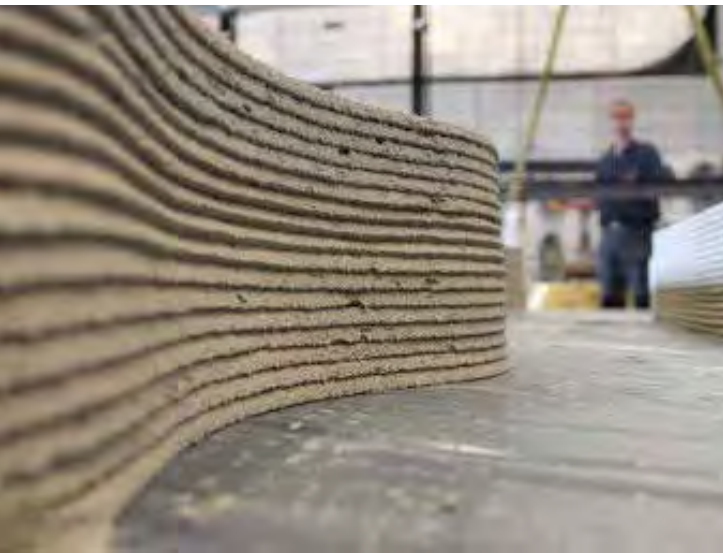
For this study, Corr addressed creep, shrinkage, and durability, as these properties are also (1) related to the observed structural CSH changes, and (2) critical to the use of concrete as a structural material. His research results filled a large gap in the state of knowledge of nanomodified concrete, and allowed the results of fundamental research to be adopted by concrete practitioners, to the broad benefit of the concrete industry, through the realization of previously unachievable properties and creation of new markets.

Collaborative Research: Innovation in Sustainable Mass Timber Building Systems

National Science Foundation

Gianluca Cusatis

The scientific objectives of this project were: (1) To formulate, calibrate, and validate a multi-physics and multiscale computational framework for the simulation of longterm (e.g. creep and shrinkage) and failure behavior (e.g. fracture, delamination, buckling) of CLT and NLT; (2) To obtain experimental data on large-size CLT/NLT structural members subject to varying environmental conditions (e.g., cycling temperature and relative humidity), sustained loads and ultimate load conditions.



3D Printing SBIR Ph II

Engineering and Software System Solutions, Inc.

Gianluca Cusatis

Cusatis and his NU team collaborated with the ES3 (Engineering and Software System Solutions) team and with the U.S. Army Corps of Engineers' Engineer Research & Development Center (ERDC) Construction Engineering Research Laboratory (CERL) personnel to define the details of the Concrete 3D Printing Virtual Simulator. The NU team contributed expertise for the aspects of the 3D-PVS (3D printed vibratory scaffold) relevant to the behavior of concrete at fresh state and its computational modeling.

The research team performed initial testing and performance evaluation for the extruding process. Different nozzle shapes and sizes were modeled along with a segment of extruding pipe. The DEM (Digital Elevation Matrix) system simulating fresh concrete was placed inside the pipe and extruded through the nozzles. Results were evaluated in terms of

computational performance, computational cost and qualitative agreement with experimental data.

The NU team also performed the parameter identification of a concrete model with CERL experimental data for a physics-based, age-dependent concrete model (based in the Bingham model) on the basis of experimental data available at ERDC CERL. This included simulation of slump tests, as well as International Center for Aggregate Research (ICAR) Rheometer tests.

Collaborative Research: Mechanisms of Visuospatial Thinking in STEM

National Science Foundation

Steven Franconeri

Using chemistry as a case study, Franconeri and his NU team discovered the relative contribution of three mechanisms for visuospatial representation and transformation in Science, Technology, Engineering and Mathematics (STEM): domain-specific chunking, domain-general compression skills, and raw visuospatial capacity. A deeper understanding of the mechanisms involved in spatial thinking was the goal, as it would lead directly to better pedagogy and curricular design for teaching spatial thinking in STEM classrooms.

The project focused on spatial thinking because it is a critical component of cognition in the STEM domains. This centrality of spatial thinking in STEM practice has made it an important focus of research on STEM learning in K-16 settings and spurred efforts to improve STEM success in students by training spatial abilities. Unfortunately, to date, none of these efforts have yielded lasting results. Franconeri suggested that such spatial training programs have been largely ineffective because they are based on an impoverished model of the cognitive capacities and processes underlying spatial thinking, both generally and in discipline-based education research. This project's focus on spatial training programs concentrated mainly on assessing and improving the types of spatial thinking processes measured by traditional measures of spatial ability, with little attention to how spatial information is actually processed by the STEM learner.

Spatial thinking in STEM requires students to encode and transform complex spatial information depicted in disciplinary representations despite known capacity limits of spatial working memory. The project showed how understanding these limits, as well as how spatial information is encoded and transformed differently by STEM novices and experts, creates new avenues for addressing challenges that students face in navigating STEM curricula.

The Industry Origins of Slow U.S. Productivity Growth

Smith Richardson Foundation

Robert Gordon

For the project, Gordon assessed four complementary explanations of the productivity growth slowdown – the diminished impact of innovations, reduced capital investment, mismeasurement, and an increased burden of regulations. The research focused on the 12 largest industries and investigated the sources of slow productivity growth via two approaches. The first approach was to assess the importance of past and current innovations by searching through industry trade publications and by interviewing industry experts. The second approach developed detailed studies of a subset of the industries, based on Census data and other sources, in order to determine the role of compositional shifts, measurement issues, and regulations.



CRII: CHS: Early Detection of Collective Misconceptions with Network-Aware Machine Learning Tools

National Science Foundation

Agnes Horvat

Concepts of collective intelligence or the so-called “wisdom of crowds” play increasingly fundamental roles in economic and political forecasting, as well as in addressing public policy disputes and panel decisions about creative merit. Diversity of information and expertise among crowd members has been identified as a key condition for the emergence of collective decisions that are superior to any individual's personal judgment. However, diversity is hard to attain: there are systemic difficulties in mobilizing minority groups on top of which additional factors related to social influence such as herding, groupthink, and conformity tend to further reduce the variety of point of views.

Horvat's project aimed to design network-aware machine learning tools that elicit useful diversity, counter herding and homophily effects in restraining the wisdom of crowds, and improve the accuracy of collective forecasting. The research trained graduate students and involved undergraduate students in state-of-the-art data

science as they developed and deployed novel research algorithms and software for effectively harnessing collective intelligence at the intersection of modern computational and sociological research. Ultimately, the team delivered new technical tools to optimize the wisdom of networked crowds, helping designers of online systems and policy makers leverage the benefits of collective intelligence.



Decision-Flow Queueing Networks for Analysis of Knowledge-Based Service Operations Systems

National Science Foundation

Seyed Mr Iravani

This project developed design and control principles for Decision-Flow Queueing (DFQ) Networks that are the underlying system of knowledge-based service organizations. In DFQ Networks, tasks flow within several nodes and, in addition to processing the task, each node also makes a decision of where the task should be routed next.

Unsupervised Data Extraction from Graphs and Data Plots

Semiconductor Research Corporation

Diego Klabjan

Quintessential technical information and IP (internet protocol) is often presented in the form of graphs and data plots (images). These images are usually embedded in one of many possible document types and formats, including presentation slides or whitepapers.

Especially in large corporations or research institutions, the number of documents containing this type of image data is vast. Extracting the underlying data correlations, parametric dependencies, and trends contained in these images in a fully automatic and large-scale fashion would open up new avenues to mine and understand crucial pre-existing domain knowledge. Further, many day-to-day engineering activities such as equipment troubleshooting, DOE (Design of Experiments) planning and excursion containment would benefit and be enhanced by enabling experts to discover multi-echelon causal relationships between control parameters, process variables and their effects.

Klabjan and his team developed deep learning models and algorithms to extract data in a structural form from graph and data plots, and incorporated said models into existing knowledge-management systems focused on text analysis only.

The project was motivated by social media's (e.g., Facebook, Twitter) effort to identify fake news before they spread out throughout the network. The applications of DFQ (Delayed Frame Queueing) networks, however, extended to other service organizations such as financial institutions, government and healthcare, among others.

RNN Based Retention Modeling and Attribution with Inverse Modeling

Allstate Insurance Company

Diego Klabjan

This project focused on the application of the relatively new memory-augment recurrent neural networks to model sequences of customer events, with the particular goal of predicting retention and using the differentiability of the resulting model to gain insight into an ordering of the importance of events and event components with respect to retention.

The core of the readily available data for the sequence of events exists at the level of an insured item in the context of a policy. An event constitutes a change related to coverage, claim, renewal, etc., in the policy when such a change becomes effective and the state of the policy remains constant until the next event for the respective insured item is recorded. The information included as "horizontalized" fielded previous events particularly relating to claims and violations from within (Allstate is carrier) or outside (other carrier) the scope of information in the given record's subject to some capping on years of history.

The combination of heterogeneous events mixing random and regular time intervals and the relative short length of many individual observations made traditional time series modeling unsuitable. Findings showed feature engineering of history sequences into aggregations per event record, for the purpose of traditional machine learning, suffer from consistency problems among fields representing different aspects of the same history.

Auto Claims Analysis from Video Games

Allstate Insurance Company

Diego Klabjan

Klabjan and his team did a qualitative and quantitative damage estimation in the context of car accidents based on video image data for this Allstate-sponsored

project. Allstate has millions of related images in auto claims processing. These images included photographs taken by claim adjusters for documentation purposes, as well as the consumer-facing quick photo claims (QFC) via Allstate's smartphone app.

All auto claims have structured "first notice of loss" (FNOL) fields for providing damage descriptions, but can be left incomplete/inaccurate. Researchers noted that while a large portion of the adjuster-sourced images depict details or conditions after a partial tear-down, the QFC-sourced images showing exterior views of vehicles are suitable for a deep learning-based, first-estimation of the damage.

The QFC smartphone app, in its current form, is only set up to collect images taken of the four corners of the vehicle (regardless of where the actual damage is located), the odometer and VIN (vehicle identification number) and a few other optional details.

To provide data for frame selection from video, the NU team crowd-sourced video from within the department (mostly undamaged, select frames for relevant views) and captured live feed video originating from interactive remote claim adjustments (mostly damaged – classify damage).



2017 Dwight David Eisenhower Transportation Fellowship Program (DDETFP)

Federal Highway Administration

Michael Highland (supervised by Hani S. Mahmassani)

This project involved modeling, optimizing, simulating, and analyzing the operations of shared-use mobility services, enabled by fully-autonomous vehicles (AV). The motivation for the research stemmed from two recent developments in the transportation industry.

The first was the emergence and growth of shared-use mobility services, such as those offered by ridesourcing companies Uber and Lyft, and carsharing companies Zipcar and Car2go. The second was the expected advent and adoption of AVs.



Together, shared-use mobility services, enabled by AV fleets, have the potential to fundamentally alter passenger transportation via shifting travelers away from personal vehicles. Personal vehicles have been the predominant mode of passenger transportation for decades; however, by eliminating the labor costs and performance limitations of human drivers, AVs should allow mobility service providers to compete with personal vehicles in terms of cost and quality of service for nearly all trip purposes.

Advisory Services for MAG ABM-DTA Model Integration – Phase II

Arizona State University

Maricopa Association of Governments

Hani S. Mahmassani

To support strategic and operational planning of transportation and mobility in fast-growing Maricopa Country, the Maricopa Area Government (MAG) invested in the development and application of a state-of-the-art integrated Activity-Based Model (ABM) and Dynamic Traffic Assignment (DTA) modeling system. Given the magnitude and complex nature of this undertaking, MAG sought guidance and quality control on the development process from the Northwestern University Transportation Center (NUTC), in cooperation with researchers at the Arizona State University. NUTC has considerable experience in the methodological and software implementation aspects of such tools, having been engaged in the development of an integrated ABM-DTA system for the multimodal network of the Greater Chicago area, in addition to numerous applications of advanced modeling tools to large-scale networks, including to the New York region's best practice model network.

This collaborative contract project resulted in an advisory role on the framework development for the integrated ABM-DTA modeling system, guidance on DTA software and ABM platform enhancement, design of the development and implementation plan, as well as quality control of the ABM-DTA integration project.

Autonomous Service Planning, Design and Real Time Operation

King Abdullah University of Science and Technology

Hani S. Mahmassani

In collaboration with colleagues at King Abdullah University of Science and Technology (KAUST), Northwestern University Transportation Center (NUTC) investigators developed algorithms for real-time shared autonomous fleet operations under different business models, intended to run at scale. These algorithms considered various possible scenarios for providing seamless Mobility as a Service (MaaS) with automated vehicles in a connected environment, allowing for high levels of service with minimum environmental impact, e.g. through electric powered vehicles.

The collaborating team (1) formulated the various scenarios of interest, with regard to the type of MaaS models, e.g. on-demand only vs. allowing reservations, use of heterogeneous vehicle fleets, degree and conditions for sharing rides, among others; (2) developed mechanisms to integrate personalized information from connected travelers to improve the quality of service delivered to customers; (3) investigated use of machine learning algorithms for predicting demand and performance of the system; (4) developed algorithms for solving the resulting formulations in light of the highly dynamic, stochastic and combinatorial character of the problem; (5) tested the approaches developed in a representative problem setting; and (6) provided recommendations on most promising MaaS service concepts along with directions for robust solution methods for at-scale deployment.

Analysis of Metra Rail Commuter Service Contraction Impact on Regional Mobility Using Integrated Multimodal Network Modeling Platform

METRA

Hani S. Mahmassani

Metropolitan areas the size of Greater Chicago could not function without effective multimodal transportation networks and services that provide businesses access to large pools of qualified employees, and residents the ability to access employment and other opportunities. Regional rail services offered by Metra (the Northeast Illinois Regional Commuter Railroad Corporation) are integral to the Chicago area's economic well-being and to the mobility of area workers and travelers.

By providing an efficient alternative to the region's chronically congested highway network, Metra services enable large numbers of area residents to commute to and from their place of employment, access the world-class amenities offered by a global metropolis, and remain connected to their geographically dispersed social ties.



NUTC has launched a collaborative research effort with Metra, which operates in the nation's most complex railroad environment with 1,300 to 1,400 trains moving through the Chicago region each weekday. The study seeks to quantify the regional rail services' contribution to overall mobility in the region, and its economic value to users and non-users. Using state-of-the-art methodologies, NUTC is analyzing various future scenarios regarding services offered by Metra and other mobility providers in the context of the Chicago metropolitan highway and rail transportation network. For this analysis, NUTC is building upon a multimodal network modeling methodology (NU-TRANS) originally developed in conjunction with the Chicago Metropolitan Agency for Planning (CMAP). The results of the study will provide important insight to guide future investment in the region's mobility.

Implementation of Analysis Modeling Simulation Tools for Road Weather Connected Vehicles

Federal Highway Administration, US Department of Transportation (with Leidos, Inc.)

Hani S. Mahmassani

The Federal Highway Administration (FHWA) Road Weather Management Program helps develop and deploy advisory, control and treatment strategies that help agencies respond to adverse weather conditions by providing traffic advisories and warnings to travelers, controlling the flow of traffic on the highways, and performing maintenance and operations actions to clear the roads of obstruction. This project was centered on a recent focus of the program using mobile observations and connected vehicle data to support weather-responsive traffic and maintenance management.

Adopting weather-responsive traffic and maintenance management strategies that use road weather data from Integrating Mobile Observations (IMO) and connected vehicle technologies, combined with informed decisions stemming from Pathfinder, will enable State and local

agencies to be proactive and manage the system before negative impacts occur. In addition, more accurate and location-specific road weather condition data will allow appropriate traffic management strategies to be deployed where they are needed and reduce the costs associated with winter maintenance.

For this project, the NUTC team evaluated existing analysis, modeling and simulation (AMS) tools available for road weather management applications, adapted and applied the AMS tools to an agency's (Chicago DOT) connected-vehicle enabled traffic management and winter maintenance strategies, synthesized the AMS application results as a basis for recommendations/guidance on the use of the AMS tools for evaluating CV-enabled road weather management strategies.

Integrated Modeling for Road Conditions Prediction Phase 3

Federal Highway Administration, US Department of Transportation (with Leidos, Inc.)

Hani S. Mahmassani

The Integrated Modeling for Road Condition Prediction (IMRCP) project created a tool that incorporates real-time and/or archived data and results from an ensemble of applicable deterministic and probabilistic forecast models (e.g. road weather, traffic, work zones, incidents, etc.) and fuses them in order to predict the current and future overall road/travel conditions for travelers, transportation operators, and maintenance providers.

In the initial phase of the project, the Concept of Operations and Detailed Requirements were created. In Phase 2, the System Architecture, System Design, Test Plans, Installation Guide, User Guide, and Marketing materials were created. Additionally, the IMRCP was deployed over highways and arterials in the southern part of the Kansas City Scout area. The study area was made up of 2006 links, 870 nodes, and 188 bridges. Data in the study area came from 205 traffic signals, 105 traffic detectors, 53 ramp detectors, 15 dynamic messaging signs (DMS), 20 StormWatch sites, 5 Advanced Hydrological Prediction System (AHPS) stations and an Automated Surface Observing System (ASOS) station.

Developing Analysis, Modeling and Simulation (AMS) Tools for Connected and Automated Vehicles (CAV) Applications

Federal Highway Administration, US Department of Transportation (with Leidos, Inc.)

Hani S. Mahmassani

Connected and Automated Vehicle (CAV) technologies offer potentially transformative societal

impacts, including significant mobility, safety, and environmental benefits. The United States Department of Transportation (USDOT) has led the development, research, and standards making of these technologies and is currently developing deployment approaches and guidance.

In order for CAV applications to be deployed, state and local transportation agencies must first be able to effectively and fully quantify the impacts of such deployments and identify which application best addresses their unique transportation problem. Traffic analysis, modeling, and simulation (AMS) tools provide an efficient means to evaluate transportation improvement projects prior to deployment. In fact, the FAST (Fixing America's Surface Transportation) Act dictates utilizing AMS tools "to the fullest and most economically feasible extent practicable" to analyze highway and public transportation projects¹. Current AMS tools are not well-suited for evaluating CAV applications due to their inability to incorporate vehicle connectivity/communication and automated features. Guidance on how these AMS tools can be extended to evaluate CAV applications is non-existent. Likewise, deployment concepts, strategies, and guidelines are needed to allow states to understand how and where CAV technologies may effectively be deployed.

Although several research projects, sponsored by the Federal Highway Administration (FHWA) and others, have modified available commercial models to include some connected automated features, there has not been a basis for validating their results, sharing the modified model with others, nor sharing "lessons learned" from detailed use cases—all of which, the research shows, are needed for deployment support.

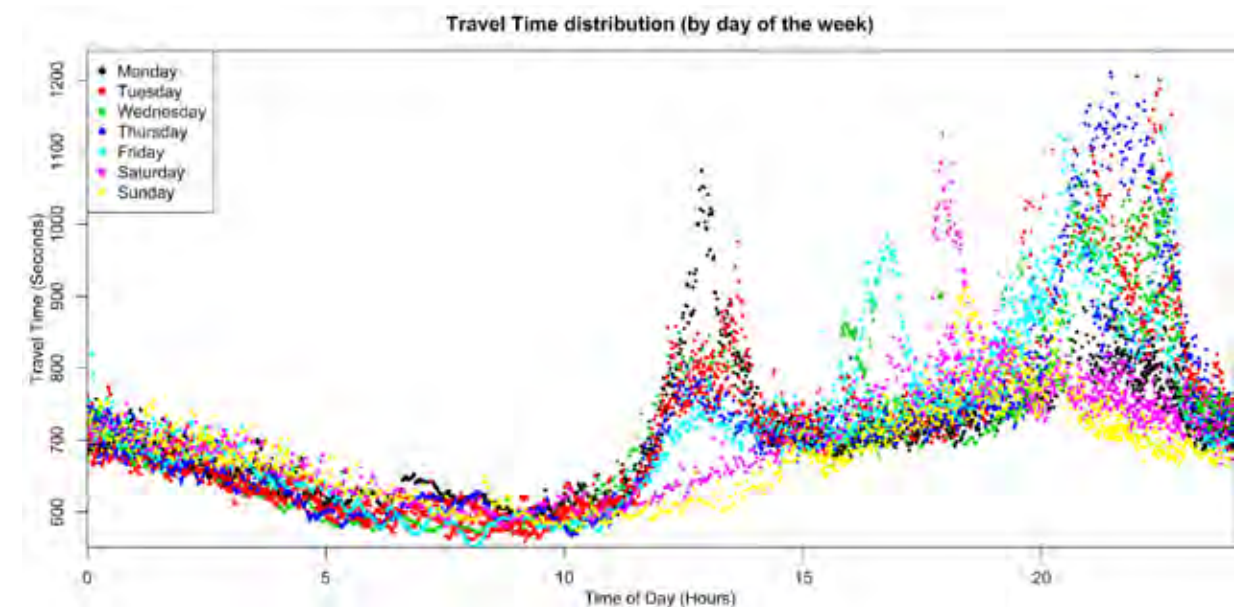
Estimation of Travel Time Distribution Along User-Defined Travel Paths

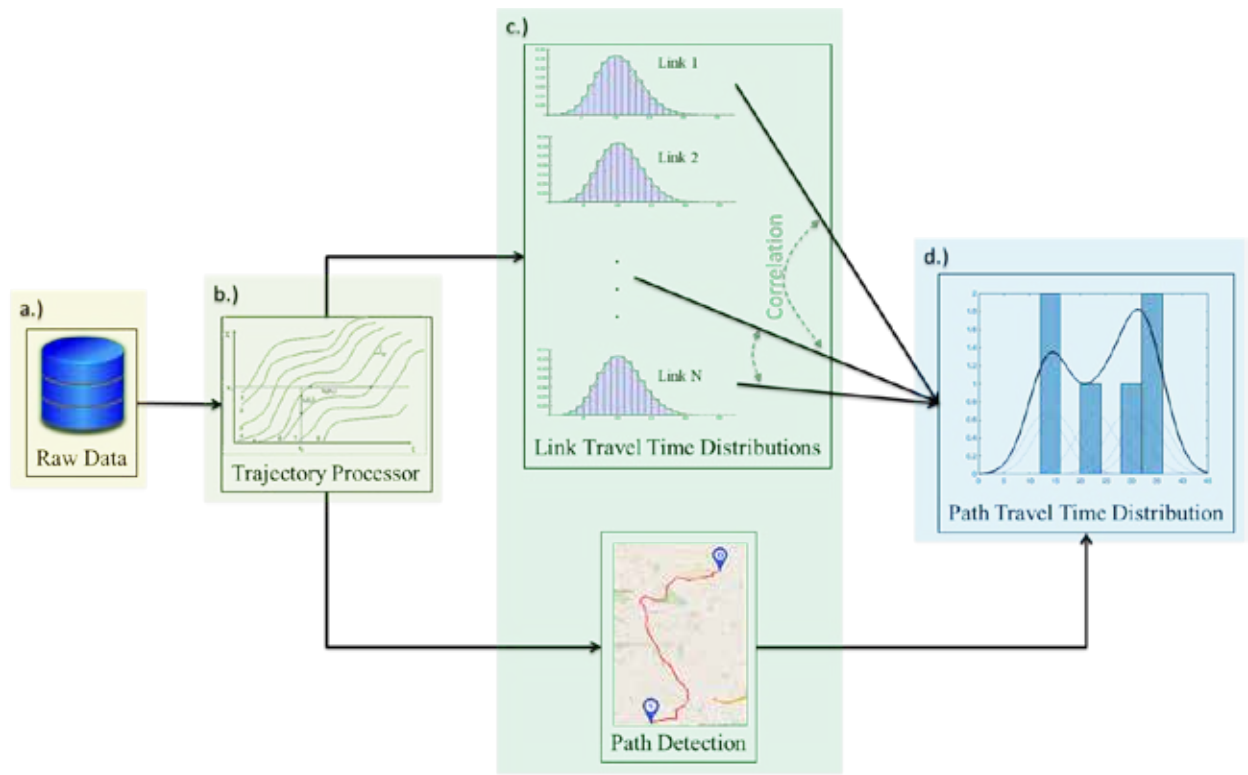
Federal Highway Administration, US Department of Transportation (with Leidos, Inc.)

Hani S. Mahmassani

Travel time reliability (TTR), a principal focus of the second strategic highway research program (SHRP2), is a critical dimension for understanding and evaluating travel network performance. TTR is applicable at a facility-level or as a person-based measure. Facility-based measures are well documented. Traveler-based measures have not been as thoroughly investigated. Traveler-based data has the distinct advantage over facility-based performance indicators of directly describing traveler performance at individual or group levels, as it captures the variability of travel times along any user-defined path, sets of paths, subareas, or origin-destination pairs. Measurements can be used directly to indicate facility and system performance. They are much better at capturing the full range of conditions travelers encounter as they go about their daily business, and explicitly account for a variety of endogenous and exogenous variables affecting travel.

Over the past decade, the collection and dissemination of travel time data and summary statistics has grown exponentially. Travel time information is available in numerous forms. In-pavement and roadside detectors, vehicle probe data, and GPS devices are but some of the sources of this information. Connected vehicle (CV) data are also expected to come on-line in the future. Each source of travel time data has distinct characteristics. Ultimately most point-detector data are translated, though a variety of estimation methods, to some form of path-based information. Such estimates are often limited to consecutive links equipped with data





collection instrumentation. They require continuous data streams without temporal or spatial breaks in coverage. At best, they are applicable to portions of a single facility over limited time frames under relatively homogenous flow conditions. They are mostly applicable to uninterrupted flow facilities. Path-based travel time estimates based on spot speeds cannot be accurately produced on interrupted flow facilities with traffic signals. Goods and people travel without regard to such restrictions. Furthermore, travel and simulation models should be able to replicate point-to-point travel times across a variety of facilities under a range of conditions and times regardless of facility instrumentation.

It is essential for analysts to be able to synthesize travel time distributions at the path level. Travel paths should not be limited by facility or area types; estimation along any travel path should be feasible. Person-based data is the best means to accomplish this need.

Role of Calibration in Quantitative Alternative Analysis
Federal Highway Administration, US Department of Transportation (with Leidos, Inc.)
Hani S. Mahmassani

Traffic analysis tools (TATs) are designed to assist transportation professionals in evaluating the transportation improvements that best address the transportation needs of their jurisdiction. TATs can help practitioners improve the decision-making process, evaluate and prioritize improvement alternatives, and

improve project design and operations. Over the past 15 years, the Federal Highway Administration (FHWA) TAT Program has developed the TAT Toolbox, a compendium of TAT guidance documents (see link below article). The Toolbox has helped establish consistency in good practice for traffic analysts across the nation.

Calibration is a key step in the application of TATs to a project or study. Calibration is the adjustment of model parameters to improve the model’s ability to reproduce local driver behavior and traffic performance characteristics. Current practice calls for analysts to calibrate their analytical tools to a base (or existing) condition and then use those tools to predict performance of a future condition. This practice is consistent with guidance currently in the TAT Toolbox. However, many times these future conditions incorporate improvements that are significantly different than the base condition modeled when the analysis tool was calibrated. This can result in performance outcomes that are either not trustworthy or erroneous.

The scope of this project was to provide guidance for transportation professionals on how to calibrate analytical tools to data that are reflective of the conditions for which the tool is being used to predict future performance. Users should be provided with an understanding of how to gather, understand, prepare, and analyze a wide range of future conditions that impact performance. The methodology/framework developed in this project allows agencies and transportation professionals to calibrate their analytical tools to enable validity, no matter how different the future condition modeled is from the base condition.

Fundamentals of Travel Time Reliability Guide
Federal Highway Administration, US Department of Transportation (with Leidos, Inc.)
Hani S. Mahmassani

Travel time reliability (TTR) is a principal focus of the second strategic highway research program (SHRP2). The reliability program took shape and matured under a central notion: successful transportation planning and operations considers the full range of conditions travelers encounter as they go about their daily business. This means abandoning well-worn habits of using average outcomes (e.g., average volumes or average travel times under “typical” conditions) and single measures as the basis of quantifying performance.

TTR has been received favorably, in large part because practitioners accept that congestion and long travel times are associated with a variety of factors such as weather, incidents, and demand surges, whose time and places of occurrence are unpredictable. Despite the maturation of reliability under the SHRP2 program over the past several years, Federal Highway Administration (FHWA) has found that practitioners, researchers, and advanced users of the reliability tools are not well-versed in the probabilistic thinking.

Development of a Real-Time Decision Support System for Proactive Response, including Recourse Planning, under Uncertain Active Cascading Emergencies
Arizona State University
Department of Homeland Security
David Morton

For this project, Morton and his team developed algorithms, procedures, and visualizations for a real-time decision system (RTDS) that emergency responders—federal, state and local—could use to coordinate and proactively respond to disasters and emergencies cascading in an uncertain manner.

Natural disasters, such as hurricanes, tornadoes, forest fires, tsunamis, floods, severe storms, etc., typically impact large areas and the impacts cascade in time and space. When predictions of impact can be made with little uncertainty, “what-if” scenario prediction (often through simulations) can be made and good response plans can be developed. However, when predictions of impending impacts are highly uncertain, a response strategy is needed. This project underlines the importance of studying responders and their recourse actions when mobilized to address disaster impacts. The continued observations will help responders better predict and guide resource improvements.

10.4: Properties Controlling Synchronization in Networks of Dynamical Systems
Army Research Office
Adilson Motter

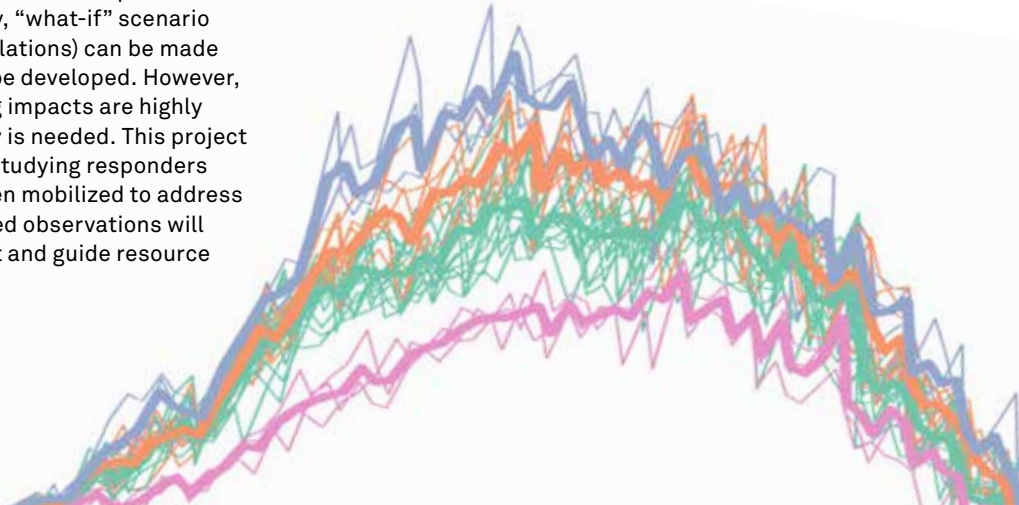
This project focused on network synchronization, which is a widespread and broadly significant form of collective dynamics in both natural and engineered systems. Specifically, the project investigated the problems of 1) incoherence-mediated synchronization, 2) competing network structural and dynamical properties governing synchronization, and 3) experimentally observing spontaneous symmetry breaking (chimera states) in the synchronization of homogeneous networks, as well as 4) applications to the stabilization and control of synchronization.

Motter centered the research on mathematical and computational development, but included concrete applications to power-grid networks and experiments using networks of mechanical metronomes. The project addressed network systems of interest to the Army, including robotic networks, power grids, biological networks (such as those underlying the circadian system), and social networks. The team’s proposed applications to the control and stabilization of synchronous states addressed a well-recognized Army need for perturbation-resilient infrastructure/physical networks, and contributed to the development of self-healing smart networks.

Green Simulation: A Methodology for Reusing the Output of Past Computer Simulation Experiments
National Science Foundation
Barry Nelson

This research project involved designing, analyzing, and testing algorithms for computer simulation experiment design and analysis. The objective was to improve the computational efficiency of simulation experiments in settings where there is a sequence of repeated experiments using the same simulation model with different inputs.

The project employed methods to reuse the results





of experiments, including simulation metamodeling and variance reduction techniques for stochastic simulation. In designing and analyzing the resulting algorithms, Nelson's team leveraged existing knowledge on simulation experiment design and analysis, including optimal design of experiments, metamodel validation, and adaptive design of sequential experiments.

Proposed algorithms were tested in computer experiments using examples, which are representative of realistic applications, of sequences of simulation experiments using the same simulation model but different inputs. In each example, the efficiency gain generated by the proposed algorithms, compared to standard practice, was measured in terms of reduced computational cost given a target accuracy, or in terms of increased accuracy given a fixed computational budget.

GOALI: Computer Simulation Analytics

National Science Foundation

Barry Nelson

The design and analysis of modern discrete-event, stochastic simulation has been greatly influenced by its heritage in queueing theory; and the strength of queueing theory is in deriving long-run performance measures for stationary service systems. Data analytics, on the other hand, stresses uncovering conditional relationships and making predictions. The success of data analytics in business and industry will lead simulation users to expect this sort of fine-grained, conditional analysis from their simulations, and if they cannot obtain it they may conclude that simulation is irrelevant.

The results of this project provide a foundation and proof-of-concept first step toward a data analytics treatment of dynamic, stochastic simulation. The research was not concerned with the use of "big

data" to drive or parameterize a simulation, and did not investigate the use of simulation to assist in the analysis of "big data." Instead, it addressed simulation in its traditional role for system design, and its less traditional role for system control.

The revolution was to treat stochastic simulation as data analytics for systems that do not yet exist, rather than as approximate queueing theory, and to extend the reach of simulation beyond parameter estimation and system optimization, and toward performance prediction and uncovering the key drivers of system behavior.

Collaboration with NU's GOALI partner, the SAS Institute, ensured the research would be relevant, and the result worthy of implementation.

PFI:BIC – Smart CROWdsourced Urban Delivery (CROUD) System

National Science Foundation

Yu Nie / Amanda Irini Blomberg Stathopoulos

The rise of e-commerce is rapidly changing the landscape of retail business. A 2014 U.S. Census Bureau report estimated that online sales would account for more than 10% of the \$4.5 trillion industry by 2017. To stay competitive, retailers are under enormous pressure to quickly deliver the goods to their consumers at low prices. Large asset-based carriers are not particularly cost-efficient for express local deliveries in urban areas, because their distribution networks are designed to transport through hubs rather than directly between customers and retailers. This inefficiency is worsened by mounting demand for same-day delivery—widely considered the Holy Grail for e-commerce at

present—that requires more frequent dispatch and in turn increases transportation cost.

Arrival of tech giants such as Amazon, Google and Uber in this battlefield attests to the tremendous opportunities and challenges in the urban delivery industry. Ironically, underutilized capacity exists in the millions of private passenger vehicles on the road with empty trunks that could be used for delivery. Addressing this lack of adequate coordination between demand and supply holds a potential key to solving the express urban delivery challenge. A promising solution, enabled by recent advances in wireless communication and mobile computing, is crowdsourcing technology that has been successfully applied in passenger transport (e.g. Uber and Lyft).

The goal of this project was to develop and evaluate a CROWd-sourced Urban Delivery (CROUD) system. With CROUD, consumers will enjoy faster, cheaper and more reliable delivery service; the retail industry will see a stronger consumer demand; and the delivery industry will improve its profitability and reduce its environmental impact, while employing a highly mobile and efficient workforce. The project also aimed to educate next generation entrepreneurs by providing training opportunities and materials for upgrading curricula in multiple disciplines.

The project resulted in four scientific contributions. First, the project investigated pricing mechanisms that focused on matching consumers with couriers under varying market conditions. Second, the project helped understand and predict behaviors and choices of humans in a CROUD system, a field completely new to behavioral econometricists. New econometric models, calibrated against behavioral data collected in this project, were built into management strategies to enhance the consumer-courier-technology interaction in the system. Third, the project investigated smartphone-based motion detection methods that are uniquely suited to track and interpret the activities of couriers. Finally, the project created computational



tools to facilitate collaborative delivery among couriers and to optimize routing plans based on real-time information.

This project involved two departments at Northwestern, the Center for Supply Chain and Logistics Management at the University of Illinois at Chicago (UIC), and primary industry partner, Roadie Inc.

NCHRP Project 20-44(09), Quantitative and Qualitative Methods for Capturing the Impacts and Value of NCHRP Research

Texas A&M University

National Cooperative Highway Research Program

Joseph Schofer

The goal of the National Cooperative Highway Research Program (NCHRP) was to produce applied research products that are practice-ready and implementable by state departments of transportation (SDOTs) and other transportation agencies for transportation planning, project delivery, operations, and maintenance activities. However, the mere creation of research products does not necessarily translate into application in transportation practice.

There is little systematic knowledge of what applications have occurred, the outcomes and impacts of those applications, and the value they produce. NCHRP needed to identify applications of research results, track the outcomes inside agencies, and follow those impacts as they reverberated through the transportation system and the broader environment. Evidence shows that NCHRP research is used to produce positive outcomes and impacts, increasing commitment to its application in the future and supporting continued investment in NCHRP.

PFI: AIR-TT SAFE (Situational Awareness for Events): A Data Visualization System

National Science Foundation

Karen Smilowitz

This Accelerating Innovation Technology Translation project seeks to expand the initial development and deployment of a data visualization system for mass participation endurance running events to the wider market of emergency management for mass gathering events. The system developed by Smilowitz and her team is the first comprehensive dashboard for endurance event management. The system provides a dynamic representation of the flow of people and resources. At the core is a simulation tool that predicts and displays runner density on the course.

Exploiting Network Structure in Routing Problems: Applications to School Bus Routing

National Science Foundation

Karen Smilowitz

Across the United States, public school districts are facing critical budget crises. Aiming to keep cuts “away from the classroom,” bus transportation is often a common area to look for cost reductions. This is the case at Evanston/Skokie District 65 (D65), a pre-K - 8 public school district north of Chicago with approximately 8,000 students at 18 schools (attendance area elementary schools, middle schools, magnet schools, an early childhood center, and a school for students with special needs).

When the school district projected a deficit of more than \$100 million over the next ten years in 2015, D65 and Northwestern University partnered to improve transportation operations, identify cost-saving opportunities and help maintain service. A number of challenges and opportunities in bus transportation were identified by the partners and motivated this project.

School bus routing has been studied by the operations research community for fifty years, identifying creative routing and scheduling approaches for school districts. In recent years, school districts have adopted routing and scheduling software to assist in bus transportation planning. However, such software can be limited in application. NU researchers took a different approach, by exploiting the grid-like network structure common in many urban and suburban school districts to obtain simple solution approaches providing robust options to budget-challenged school districts. The results of this project contributed to a growing literature on routing problems with special network structure, and addressed a critical problem faced by many public school districts.

EAGER ISN: Unraveling Illicit Supply Chains with a Citizen Science Approach

University of Notre Dame

National Science Foundation

Karen Smilowitz

Illicit supply networks by their nature do not advertise, register, or obey regulations. They avoid or circumvent enforcement activities by falsifying packaging and regulatory paperwork, changing payment and distribution pathways, shifting their location of operations, or by changing from one product to another. However, they can be traced through chemical signatures inside the products. Consider the process of making fake medicines: if the pills do not contain the



correct API, they still have to contain something—typically, a cheap, white powder that is easy to handle and form into pills.

Smilowitz and her team focused on the importance of tracking the active ingredients and fillers as a means to identify different batches of illicit products (including street drugs) as they enter the market. To maximize the utility of knowledge about entry of deceptive actors into markets, researchers tracked the chemical composition of falsified medicines and street drugs at the post-market level in close to real time. The team used a new lab-on-paper tool to enable wide participation from citizen scientists and revealed the entry of falsified pharmaceutical products into markets in resource-constrained settings.



NUTC collaborates with industry partners on novel, high-impact research initiatives that address operational, policy and technical challenges. NUTC engages individual companies through technical “knowledge exchanges.” Throughout 2018 and 2019, NUTC connected with several associations and companies in the freight, logistics and transportation industries, including ADM, AM General, Allstate Insurance, Arity, Commonwealth Edison, Cummins, Daylight Transport, DiDi, the Experimental Aircraft Association, Ford Motor Company, Honda Motor Company, HERE Technologies, the Illinois Autonomous Vehicle Association, Maven, Milla Group, Teradata, United Airlines, Uber Elevate, and Uber Freight. NUTC also partnered with City Tech Collaborative on its Advance Mobility Initiative involving many more mobility companies.

transportation.northwestern.edu/research/industry-research

Industry Research



LTL Trucking Service Network Design

Daylight Transport, an asset-light, expedited, long-haul LTL (Less Than Truckload) carrier based in Long Beach, California partnered with NUTC to evaluate new approaches for LTL service network design. Through the use of driver teams, Daylight provides coast to coast trucking service in minimum time. Daylight operates regular line haul services between its various terminals across the US, essentially forming a network structure with quasi-regular frequencies in its various lanes, with ongoing adjustments to reflect demand variation. These services are provided through a combination of dedicated teams, long term contracts and one-way trips based on both demand and supply conditions. Within this operational context, NUTC worked with Daylight to evaluate new approaches for operational network design with dual goals of cost efficiency and service quality.

NUTC conducted extensive exploration and mining of existing data, and extracted various operational metrics to characterize service patterns over time and space. NUTC formulated and implemented a rolling horizon optimization algorithm for evaluating Daylight's operational LTL network and providing re-structuring recommendations. A scheduling formulation was also prototyped to support the network planning algorithm. As noted by Daylight executive vice president Greg Steele at the end of the research engagement, “[Daylight] found NUTC's integrative and interdisciplinary perspective on transportation systems to be best suited to assist us with a real and viable solution.”



Online Freight Exchange

Online freight exchange (OFEX) platforms serve the purpose of matching demand and supply for freight in real-time. Between 2017 and 2019, Professor Nie's group worked with Manbang Group Inc., a leading OFEX startup in China, to investigate how to leverage the power of such a platform.

The group attempted to address a question central to OFEX's value-added services: is it possible to leverage the network-wide demand and supply information of an OFEX platform to guide an individual truck that does not have a contractual relationship with the OFEX platform? To test this theory, the team developed a novel routing algorithm that was field

tested by Manbang in the summer of 2018. Truckers who used the proposed algorithm could earn up to 20% more in revenue than truckers that did not.

Overall, the experimental results showed that the algorithm could potentially help Manbang improve operations, increase revenue and profit, and lessen environmental impacts by creating fewer empty miles traveled. Transportation Research Part C published a paper summarizing these results and the Journal of Transportation Science recently accepted another paper for publication entitled “Hyperpath Truck Routing in an Online Freight Exchange Platform” by John Miller, Marco Nie and X. Liu.



The Future of Urban Air Mobility

NUTC partnered in a research study with Uber Air, the division of Uber Technologies Inc. in charge of advancing development and deployment of an urban aerial ridesharing service in metropolitan regions using a new generation of small vertical take-off and landing aircraft. The scope of the project involved multiple aspects of modeling and predicting the demand for short-distance intra-metropolitan air travel, as well as evaluating the overall impact of such services on metropolitan mobility.

A primary focus of the collaboration involved developing mobility strategies using readily available data to assess potential latent demand for the aerial ridesharing service. The approach was applied to the Metropolitan Los Angeles area, where one of the first deployments is being planned.



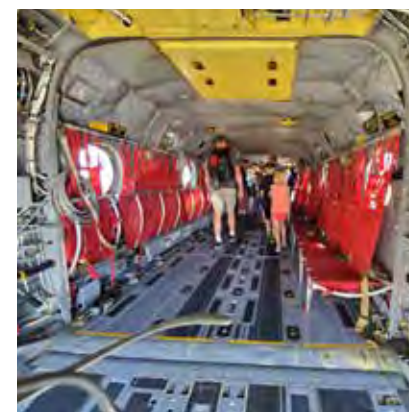
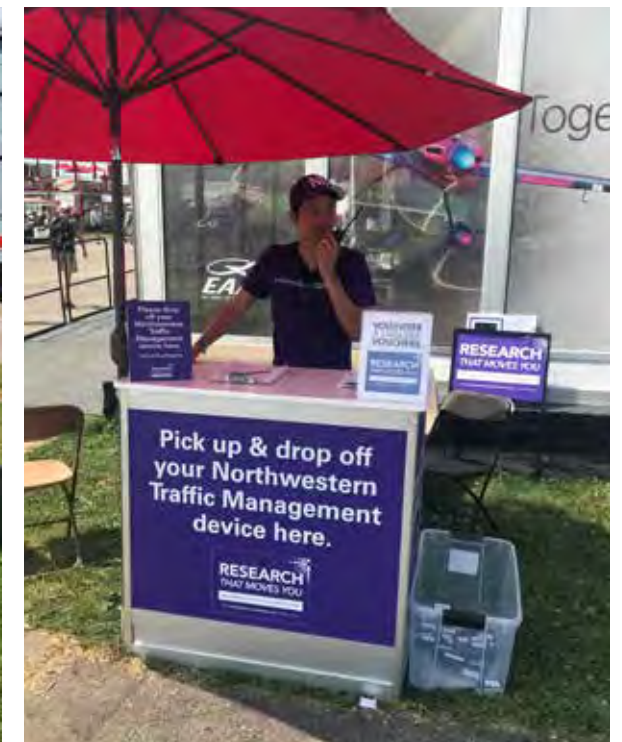
EAA AirVenture Access Logistics

Large-scale events are complex systems with many interacting parts that pose serious operational challenges. The annual, week-long AirVenture air show in Oshkosh, Wisconsin attracts over 600,000 attendees, along with thousands of aircraft, and a wide array of suppliers and delivery vehicles. In a study led by Hani Mahmassani and Karen Smilowitz, and coordinated by Breton Johnson, NUTC has been engaged in a collaborative effort with the Experimental Aircraft Association (EAA), which organizes the Air Show, to conduct research into the management of such large-scale events. The collaborative effort with EAA staff has focused on event access logistics and onsite crowd movement with the goal of helping to provide an enhanced user experience for attendees and exhibitors.

In July 2019, after several site visits, NUTC staff members and more than a dozen undergraduate and graduate students attended 50th anniversary of AirVenture in Oshkosh, Wisconsin. The students collected data on vehicle and attendee arrival and egress, parking and park entry fee payment processes, parking lot management, on site bus and shuttle system

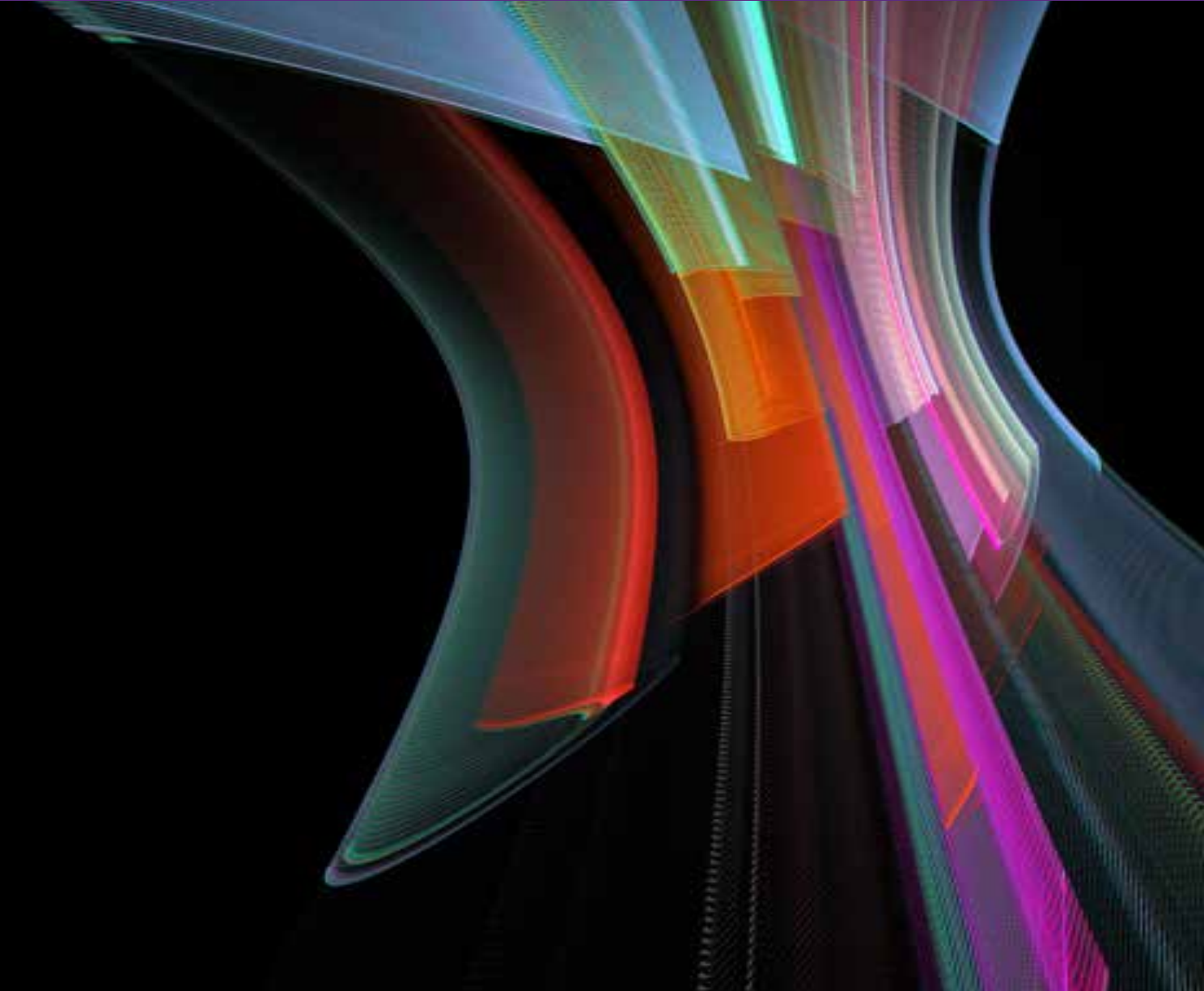
performance, and customer journeys throughout the grounds for all seven days of the airshow. NUTC personnel witnessed a complex event with myriad activities from morning until dusk and evening, and air shows every day and twice on Wednesday and Saturday that EAA's staff and volunteers managed quite well even after having dealt with severe weather two days prior to the start of AirVenture.

The data collected through a variety of techniques at multiple resolutions provide a comprehensive view on all aspects of the event, and a unique characterization of the anatomy of a large-scale event of this magnitude. With the data, as well as post event survey data and data provided by EAA such as aerial photography, NUTC is applying logistics methodologies and data science techniques to assess the performance of the AirVenture facility and EAA's operations strategies. Through regular collaboration with EAA staff, and based on extensive data analysis and simulation modeling techniques, NUTC provided recommendations for EAA's vehicle access strategies, vehicle parking strategies, and guest and exhibitor movement about the grounds. Without question our Northwestern students have been challenged but have demonstrated they have the "right stuff" on this project.





NUTC Education



Academic Degree Programs

Northwestern is recognized throughout the world as a premier institution for transportation and logistics education. NUTC's interdisciplinary programs prepare students for careers in such diverse fields as transportation operations, planning, engineering, and management. Our students graduate into professional roles within a wide array of sectors—public and private, including government, business, independent consulting and academia.

Graduate Programs

Northwestern offers a number of different avenues for students interested in transportation at the graduate level. NUTC currently offers eight academic graduate degree routes:

PhD in Civil Engineering

Sponsored by the Robert R. McCormick School of Engineering & Applied Science

The PhD in Civil Engineering with a specialty in transportation is a natural continuation for MSCE students who plan to work in academia or in advanced research and technical studies in industry and consulting.

PhD in Industrial Engineering

Sponsored by the Robert R. McCormick School of Engineering & Applied Science

The PhD program in Industrial Engineering and Management Sciences department is suited for students interested in the development of theoretical and practical tools for solving problems in industry and government. Students enrolled in this program develop research strategies and tools used in scheduling, planning, distribution, design, location, and control.

Master of Science in Civil Engineering (MSCE)

Sponsored by the Robert R. McCormick School of Engineering & Applied Science

The MSCE in transportation integrates theory and applied analytical methods of transportation systems, public transit planning, traffic engineering, and environmental, urban, and regional development. This is a research-oriented program, requiring three quarters of course work and a three- to six-month research period resulting in a thesis. After graduating, many students in the MSCE program enter research or consulting fields or pursue doctoral degrees.

Master of Business Administration (MBA)

Sponsored by the Kellogg School of Management

The MBA program's unique approach to management education balances the study of organizations with the study of the processes that drive consumer, business, and financial markets forward. Kellogg offers full-time, part-time, and executive MBA programs.

MMM Program (MBA + MS in Design Innovation)

Sponsored by the Kellogg School of Management and the Robert R. McCormick School of Engineering & Applied Science

The MMM Program works to develop whole-brained innovators by providing an analytical foundation coupled with a qualitative human centered approach to research, problem framing and concept development. Earning both an MBA and an M.S. in Design Innovation, MMM graduates leverage design and business skill sets to develop and drive end-to-end solutions grounded in desirability, feasibility and viability. This is a full-time, six-quarter program.

Master of Engineering Management (MEM)

Sponsored by the Robert R. McCormick School of Engineering & Applied Science

The MEM is an interdisciplinary program providing a foundation in industrial engineering and technology augmented with general business management concepts needed by managers in those fields. The MEM is an eight-quarter, evening program.

Master of Project Management (MPM)

Sponsored by the Robert R. McCormick School of Engineering and Applied Science

The MPD program is designed to prepare technically qualified individuals for responsible management roles in the construction and operation of major engineering projects. Four areas of specialization are available: Construction Management, Environmental Management, Infrastructure Management, and A/E/C Business Management.

Master of Science in Analytics (MSiA)

Sponsored by the Robert R. McCormick School of Engineering and Applied Science

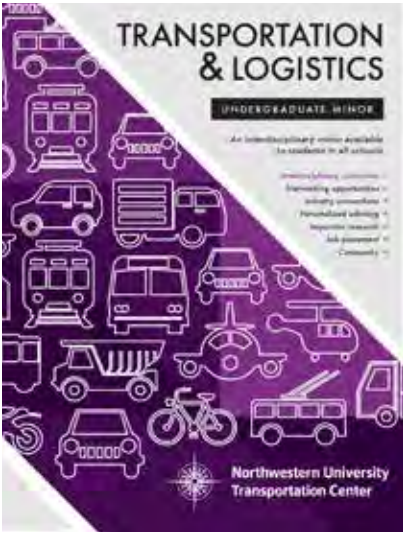
The MSiA program combines mathematical and statistical study with instruction in advanced computational and data analysis. Students learn to identify patterns and trends; interpret and gain insight from vast quantities of structured and unstructured data; and communicate their findings in practical, useful terms. The MSiA is a 15-month, full-time program.

Undergraduate Minor

Undergraduate Minor in Transportation & Logistics

The Minor in Transportation and Logistics offers undergraduate students the opportunity to explore the exciting world of transportation and logistics through an interdisciplinary set of courses intended to complement their major and immerse them in the NUTC network.

Celebrating 50 Classes of T&L Minor Graduates



Academic Advisor
Ian Savage - Professor of Economics
ipsavage@northwestern.edu

LEARN MORE: transportation.northwestern.edu/education/undergraduate-minor

- 2018 Class**
Benjamin Connelly
MEAS - Industrial Engineering
TandLA, Highland Park
- Daniel Diaz**
MEAS - Industrial Engineering
United Airlines, Chicago
- Bryce Halloran**
WCAS - Economics
Deloitte Consulting, Chicago
- Ben Kullavanijaya**
WCAS - Economics
Via, Chicago
- Ben Powell**
SESP - Social Policy
- Keaton Tatoes**
WCAS - Economics
Walmart, San Francisco

- 2019 Class**
(pictured below)
Rebecca Angoyar
WCAS - Neuroscience
KPMG, Atlanta
- Joshua Avery**
WCAS - Economics / BIP
United Airlines, Chicago
- Erik Birk**
MEAS - IEMS / Econ. Minor
United Airlines, Chicago
- Luke Gordon**
WCAS - Environmental Science
Transportation One, Chicago
- Guilherme Vendemiatti**
WCAS - Economics / Statistics
Kimley Horn, Reston VA



Transportation & Logistics Undergraduate Minor Presentations



NUvention: Transportation

“The Transportation Center has enjoyed partnering with Mark Werwath (Farley Center for Entrepreneurship & Innovation), the lead instructor for this course, to cultivate student passion for transportation innovation across the University.”

- Bret Johnson, NUTC Sr Associate Director

NUvention: Transportation is an interdisciplinary, experiential course created through collaboration between the Transportation Center and the Farley Center for Entrepreneurship and Innovation within the McCormick School of Engineering. It is designed to teach students about creating businesses in the transportation space.

NUvention: Transportation looks at the evolutionary and revolutionary changes that are recreating the face of transportation, and provides opportunities for student teams to build business models in this field under the guidance of industry veterans. This class is designed to expose students to all aspects of the business development process from the idea, to the creation, to the financing and the running of a start-up business. Finally, this is a project-based class in which students will receive mentorship and expert advice from the course advisory board members in order to ensure a proper product-market alignment.



NUvention: Transportation was launched with support from The Boeing Company.

Advisory Board

- Iqbal Arshad, Former Senior VP, Engineering, Global Product Development, Motorola
- Patricio Azcunaga, Director of Intermodal Operations, Mexico, [Union Pacific](#)
- Willem Bakker, Innovation Coach
- Joe Burns, CEO, Sensurion Aerospace
- Anne Johlie, Senior Program Director, Mobilitie
- Bret Johnson**, Senior Associate Director, NUTC
- John Kwant, VP, City Solutions, Ford Motor Company
- Chacko Poothicote, IT Leadership Program, Ford Smart Mobility, City Solutions
- Paul Pebbles, CTO, Urban Active, General Motors
- Bob Perrin, President & CEO, Magellan Associates LLC
- Chris Pickett, Chief Strategy Officer, [Coyote Logistics](#)
- David Rosen, Founder and CEO, TechX Foundry
- Brian Schettler, Managing Director, Boeing HorizonX Ventures
- Chad Strader, Co-Founder & Partner, Red Arts Capital

**Business Advisory Council members*

Student Awards and Recognition

Dissertation Year Fellows

NUTC awards Dissertation Year Fellowships (DYF) to PhD Candidates in their final year of study, conducting dissertation research on transportation or logistics-related topics.

2018



Alec Biehl
Civil & Environmental Engineering
Investigating Theories of Individuals and Communities for thresholds-of-change. Analysis in the context of active travel adoption
Advisor: Amanda Stathopoulos



Amr Elfar - *Schneider Fellow*
Civil & Environmental Engineering
Traffic Operations of Connected and Automated Vehicle Systems: Machine Learning Applications
Advisor: Hani S. Mahmassani



Archak Mittal
Civil & Environmental Engineering
Assessing the Impact of Connected Vehicles at Freeway, Arterial and Path Level: Modeling, Characterization and Active Management
Advisor: Hani S. Mahmassani



Aymeric Punel - *Ruan Fellow*
Civil & Environmental Engineering
Evaluating the Performance of Crowdsourced Delivery system. Sender Behavior agent interaction and Network Variables
Advisor: Amanda Stathopoulos



Hang Shu
Civil & Environmental Engineering
Pareto-optimal decision making and mechanism design for road franchising
Advisor: Pablo Durango-Cohen

2019



Lama Al Hajj Hassan - *Schneider Fellow*
Civil & Environmental Engineering
Less-than-Truckload freight planning problem: Designing the service network for fleet automation
Advisor: Hani S. Mahmassani



Haleh Ale-Ahmad
Civil & Environmental Engineering
On-Demand Air Mobility
Advisor: Hani S. Mahmassani



Sida Luo
Civil & Environmental Engineering
Integrated design and analysis of multimodal hybrid mobility systems
Advisor: Marco Nie



Liwei Zeng
Civil & Environmental Engineering
Leveraging Structure in Public School Transportation Problems
Advisor: Amanda Stathopoulos



Greenbriar Undergraduate Fellows

NUTC's BAC member Greenbriar Equity Group created the Undergraduate Transportation Research Fellowship to support summer research internships in transportation and logistics for NU undergraduate students.

2018



Dipayan Banerjee
Industrial Engineering & Management Science
Model Generalization for the School Bus Routing Problem
Advisor: Karen Smilowitz



Robert Belson
Computer Science
Malolo, an Inflight Wi-Fi Characterization Tool
Advisor: Fabian Bustamante



Othman Muhammad
Industrial Engineering & Management Science
Using Operations Research for School Bus Transportation
Advisor: Karen Smilowitz



Emmanuel Proussaloglou
Political Science
Lessons from Transit System Equity across the United States
Advisor: Amanda Stathopoulos

2019



Aidan David Sheehy
Industrial Engineering & Management Science
EAA Air Show Access Logistics
Advisor: Karen Smilowitz



Ayobami Sheriff Bolaji*
Computer Science
Developing Data Analytics for Improved Public School Transportation
Advisor(s): Karen Smilowitz & Jill Wilson



Huangda Shang - *Travel Award*
Industrial Engineering & Management Science / Economics
Operations Research to Fight Against Counterfeit Drug Supply Chains in Low- and Middle-Income Countries
Advisor: Karen Smilowitz

TC Students Take First in Data Competition

1st Annual Supply Chain Data Analytics Competition

Presented by:
Loyola University Chicago & Quinlan School of Business

Organized by:
Professor Michael Hewitt (Loyola; NUTC)

Spring 2019 - Loyola's Quinlan School of Business hosted its first ever Supply Chain Data Analytics Competition. Participating students had the opportunity to work with and analyze a large-scale data set from Reyes Holdings, a Chicago-based holding company for multiple large food and beverage distribution companies.

The data analyzed came from statistics regularly collected by Reyes via on-board devices in an ongoing effort to understand when and why road accidents occur.

By taking part in this event, students played a role in ensuring the health and safety of Reyes' fleet of drivers as they drive over 300 million miles a year. The competition was organized by Dr. Mike Hewitt, TC Affiliate Faculty and Associate Professor of Supply Chain Management at Quinlan, in collaboration with Annelies Van Thillo and Paul Rizzo of Reyes Holdings.

The competition was open to all schools in the Chicagoland area; eight teams submitted presentations and reports for consideration for the final round, where \$1,500 in prize money was awarded. There was one submission from Illinois Institute of Technology (IIT), one from Northwestern University (NU), four submissions from Quinlan School of Business, and two from the University of Illinois

NU Participants:

- **Haleh Ale Ahmad**
- **Lama Al Hajj Hassan**
- **Moein Hosseini**
- **Maher Said**



at Chicago (UIC). Those eight submissions were evaluated by both academic and industry experts, including Dr. Hewitt and Ms. Van Thillo. From the eight submissions, the finalists were:

- One team from Quinlan: Anjali Patel, Maxine Scotty, and Grace Sperr (Undergraduate students in Business),
- The team from IIT: Inigo Alonso, Aurora Lopez, and Sahil Ahmed (Masters students in Industrial Engineering), and
- **The team from NU:** Lama Al Hajj Hassan, Haleh Ale Ahmad, Moein Hosseini, and Maher Said (PhD students in Civil/Transportation Engineering).

Those three teams then presented to a panel of six supply chain professionals who determined the final ranking of teams. This ranking was based on the rigor of the analysis performed by the team and how well the team communicated the managerial relevance of that analysis to Reyes. The team from Quinlan tied for first place with the team from NU, with the team from IIT coming in a close second.



TC graduate student **Jason Soria** (pictured center, left) received the Dwight David Eisenhower Fellowship for his work in microtransit and, for the fellowship program, presented a poster titled, "Exploring how users differentiate microtransit from traditional modes" at TRB's 26th Annual Research Showcase as part of the 2019 TRB Annual Meeting in Washington, DC.

The **Dwight David Eisenhower Transportation Fellowship Program** (DDETFP) awards fellowships to students pursuing degrees in transportation-related disciplines. This program advances the transportation workforce by helping to attract the nation's brightest minds to the field of transportation, encouraging future transportation professionals to seek advanced degrees, and helping to retain top talent in the US transportation industry.



TC doctoral researcher **Lama Al Hajj Hassan**, TC director Hani Mahmassani, and research assistant professor Ying Chen received the TRB Freight Planning & Logistics committee's **Best Paper Award** for "A Reinforcement Learning Framework for Freight Demand Forecasting to Support Operational Planning Decisions."

The award was presented during the committee meeting at the 2019 TRB Annual Meeting in Washington DC by committee chair, Dr. Matt Roorda (pictured far left with award recipients).

Lama was also awarded the **Helene M. Overly Scholarship** for the 2018-2019 academic year. The scholarship is gifted on behalf of the Women in Transportation (WTS) Greater Chicago Area Chapter.

TC Student, IRF Road Scholar / Class President



PhD Candidate **Helen Pinto** attended the International Road Federation (IRF) Road Scholar Orientation at the TRB Annual Meeting in January 2018 and was elected president of the 2018 IRF Fellows Class for what she described as her, "ability to keep the class united."

The photo (left) was taken immediately after Helen and her IRF teammates were presented with their fellowship certificates.



"I am honored to receive this scholarship especially because it is aimed at empowering women to pursue a career in transportation," says Lama Al Hajj Hassan. "I find freight operations and logistics a fascinating field and a growing incubator for experimentation and daring innovative solutions. And I am thrilled that through the scholarship I will have the opportunity to meet the Chicago area transportation professionals and to learn from their experiences. I am also looking forward to learn how they are leveraging their leadership to support WTS's efforts so hopefully one day I'll be able to pay it forward!"



Northwestern Engineering's **Dipayan Banerjee**, a senior in the Department of Industrial Engineering and Management Sciences, was one of four winners of the 2018 **INFORMS Inaugural Undergraduate Student Scholarships**. The scholarship, which was awarded to faculty-nominated students who intend on pursuing a career in operations research, covered winners' travel expenses and registration for the 2018 INFORMS Annual Meeting in Phoenix, Arizona in November.

Dipayan is pictured second from left in the photo.

Executive Education Series

NUTC offers non-degree short courses through the Executive Education Series, which exposes industry professionals to a wide range of management techniques and expert guidance. Course content is carefully curated to ensure attendees leave equipped with the necessary tools for excelling in today's competitive global market.

Courses are aimed at decision makers and investors in transportation and logistics, including shippers responsible for purchasing freight transportation domestically or internationally and those in the logistics, traffic, sourcing and finance functions. Carrier staff and line executives who handle freight operations, marketing, and finances can benefit, as well. Program content is thoroughly integrated by experienced course faculty, ensuring participants emerge with a comprehensive understanding and dynamic perspective of both domestic and international transportation.



FREIGHT TRANSPORTATION & LOGISTICS Accelerating First to Last Mile

MAY 20 - 22, 2019

Rapid expansion of transportation and logistics e-fulfillment has been a constant stress on the industry. From the first mile to the last in transportation, carriers, customers, investors, networks, service levels, and economics are being tested. The transportation playbooks of the past, promising higher productivity, lower costs and cheaper shipping, no longer apply—making this the perfect time to change thinking and approach.

Keeping this in mind, NUTC invited transportation and logistics industry leaders to the lower level of Chambers Hall, NUTC headquarters, in May 2019 for the Executive Education Program, Accelerating First to Last Mile. Guest experts spoke about the evolution of the global transportation and logistics market and the challenges of shifting trade environments, rising fuel costs, growing impacts of e-commerce, capacity constraints, looming talent shortages, aging infrastructure, and more. Speakers also presented case studies and celebrated

the increase in opportunities—more efficient vehicles, improved transportation management systems, increased use of mobile technology, enhanced data analytics and tools, agile business models, and new sources of investment capital.

FEATURED SPEAKERS

Rick D. Blasgen

President & CEO, CSCMP

Mike Brennan

Executive Team, Farmer's Fridge

Ken Heller

Chief Transportation Officer, DSC Logistics

Tim Jones

Principal, Timothy Jones & Associates

Hani S. Mahmassani

Patterson Transportation Chair / Director, NUTC

Shawn McWhorter

President (Americas Region), Nippon Cargo Airlines

Chris Pickett

Chief Strategy Officer, Coyote Logistics

Woody Richardson

Senior VP, Global Commercial Services, Schneider

Steven Rothberg

Founding Partner, Mercator International LLC

Ian Savage

Professor & Associate Chair, Economics Dept, NU

Jan A. Van Mieghem

Professor of Managerial Economics, Kellogg, NU

Mike Watson

Adjunct Prof., NU / Co-Founder & Partner, Opex Analytics

Barbara W. Wilson

Fmr. Head, Surface Transportation Finance, Wells Fargo Rail

Mark Yeager

CEO, Redwood Logistics

Justin Zubrod

Managing Partner, Justin Zubrod & Co.



Northwestern | TRANSPORTATION CENTER

EXECUTIVE EDUCATION SERIES
Freight Transportation & Logistics

Accelerating First to Last Mile

MAY 20 - 22, 2019

Northwestern University Transportation Center 600 South Green, Evanston, IL 60208



Unequaled by any academic transportation advisory board in the country, the Business Advisory Council (BAC) has long been a major force behind NUTC's success. The BAC is comprised of senior-level executives representing all modes of transportation including shipper and carrier firms, freight forwarders and third party logistics providers, financial institutions, consulting firms, and trade associations.

The BAC is framed by four membership levels: Leadership, Sustaining, Individual, and Association. Each category offers specific member benefits, and calls for different degrees of commitment and financial support for NUTC research, education, and outreach initiatives.

Business Advisory Council



Membership Levels

Leadership Level Members are companies that demonstrate an exceptional degree of commitment to NUTC programming through support and participation.

Sustaining Level Members are companies that provide NUTC with the support needed to sustain programming.

Association Level Members are industry groups that actively participate in NUTC programs.

Individual Level Members are persons that support NUTC directly and participate in programs independent of their company or current employer.

Member Directory



Jared Azcuy
COO, AGI
- Alliance Ground
International



Farrukh A. Bezar
Senior Vice President
& Chief Strategy
Officer, CSX
Corporation



Jason Birnbaum
Vice President,
Operations &
Employee Technology,
United Airlines



Frank Bush
Vice President,
Operations
Technology, United
Airlines



Satish Chandra
Director, Corporate
Strategy, Growth
Office, Cummins Inc



Sameer Dohadwala
GM & Head of Central
Operations
Uber Freight



Bill Driegert
Head of Operations
Uber Freight



Toby Enqvist
Chief Customer
Officer
United Airlines



Ankit Gupta
VP, Domestic Network
Planning
United Airlines



Gary Hallgren
President, Arity
Allstate Insurance
Company



Bobby Harris
Founder & CEO
BlueGrace
Logistics



Warren Jones
VP, Business
Development
Alliance Ground
International



Robert M. Knight Jr.
Executive VP
& CFO,
Union Pacific



Jan Krems
President, United
Cargo,
United Airlines



Suresh Krishna
Senior VP & Chief
Operations, Supply
Chain & Lean Officer,
Sleep Number



Robert E. Martínez
VP, Business
Development &
Real Estate
Norfolk Southern



Roger Nober
EVP, Law & Corporate
Affairs; CLO,
BNSF Railway



Jon Panzer
Senior VP,
Technology &
Strategic Planning
Union Pacific Railroad



Paul Pebbles
Chief Technology
Officer
MAVEN, a GM
company



Chris Pickett
Chief Strategy Officer
Coyote, a UPS
company

Leadership Level



Jennifer Rumsey
VP & Chief Technical
Officer,
Cummins Inc



Eugene D. Seroka
Executive Director,
Port of Los Angeles



Dov Shenkman
Group VP, Supply
Chain Development,
Walgreens Co.



Jeff Silver
Co-Founder & CEO,
Mastery Logistics
Systems



Susan Sweat
VP, Global Operations
Control; Operations
Planning & Eng.,
FedEx Express



Doug Waggoner
Chairman & CEO,
Echo Global
Logistics



Nicholas Walker
AVP Operations,
US East, Canadian
Pacific Railway



Phillip Yeager
Chief Commercial
Officer
Hub Group

Sustaining Level



David Arganbright
VP, Government
Affairs, OmniTRAX,
Inc.



Ann M. Drake
Chairman & CEO,
DSC Logistics



Regg L. Jones
Founder & Managing
Partner, Greenbriar
Equity Group LP



Matt Mullarkey
Senior VP, Strategic
Projects & Planning,
CenterPoint
Properties



Ken Sain
VP, Digital Solutions
& Analytics, Boeing
Global Services



Charmin Tillman
Chief Marketing
Officer, GE
Transportation



Scott Bolick
COO, Uptake



John Engstrom
CSO, FreightWaves



Chris Kettering
Chief Engineer,
Aeromechanics
Technology,
Boeing



Pat Nolan
VP, North America,
CH Robinson



Konrad Salaber
Managing Director,
Wind Point Partners



Jeffrey Walker
CEO, North America,
CIMC Capital



Andrew Boyle
Co-President, Boyle
Transportation



Ed Feeley
Managing Director,
Littlejohn & Co., LLC



Brad Keywell
CEO & Founder,
Uptake



Aurelio Pérez Alonso
Director General &
CFO, Mobility ADO



Andrew J. Schmidt
Managing Director,
Seabury Capital



Thomas F. Wells
President & CEO,
TTX



Mike Burton
President & CEO,
C&K Holdings
Acquisition, LLC



Bill Flynn
President & CEO,
Atlas Air Worldwide
Holdings



Stephanie Kolaczynski
Chief Operating Officer,
FourKites



Jean Regan
President, CEO &
Chairman, TranzAct
Technologies



Paul J. Schneider
Managing Director,
Schneider



Seth E. Wilson
Founder & Managing
Partner, Headhaul
Capital Partners LLC



Perry A. Cantarutti
Senior VP, Alliances,
Delta Air Lines



Eli Gross
Managing Dir.; Head,
Global Transportation
& Infrastructure,
Morgan Stanley



H. Merritt Lane III
President & CEO,
Canal Barge



Mike Reymann
Senior VP &
Manager, National
Transportation
Banking, US Bank



Alex Setness
Managing Director,
Bank of America
Merrill Lynch



Mike Wychocki
Chairman & CEO,
EagleRail Container
Logistics



Grace Cerocke
VP, Finance, Matson
Logistics, Inc.



James L. Hamilton
Managing Director,
J.P. Morgan & Co.



Rob Levin
Founder & CEO,
Republic Partners



Steven Rothberg
Founding
Partner, Mercator
International LLC



Jeff Starecheski
Vice President,
Transportation,
CVS



James Zubik
VP, Finance &
Administration,
Anacostia Rail
Holdings



Robert Chapman
President & CEO,
CenterPoint
Properties



Marty Haycraft
President & CEO,
Progress Rail, a
Caterpillar company



Eric Marchetto
Senior VP, Trinity
Industries, Inc.;
Group President,
TrinityRail



Benjamin J. McLean
CEO, Ruan
Transportation
Management Systems



Andrew Bata
Regional Manager
(North America),
Union Internationale
des Transports Publics



Edward R. Hamberger
Former President
& CEO, Association of
American Railroads



Robert Puentes
President & CEO,
Eno Center for
Transportation



Keith W. Dierkx
Global Industry
Leader, Rail; Dir.,
IBM Global Rail
Innovation Center



David A. Horwitz
VP & Executive
Director, GATX
Corporation



Shawn McWhorter
President (Americas
Region), NCA - Nippon
Cargo Airlines



Rick Blasgen
President & CEO,
Council of Supply
Chain
Management
Professionals



Jennifer Hedrick
Executive Director,
National Industrial
Transportation
League



Chris Spear
President & CEO,
American Trucking
Association

Association Level

Individual Level



L. Price Blackford
Managing Director
Scott-Macon Ltd.



Mark G. Fornasiero
Managing Partner
Clarendon Group



Cliff J. Porzenheim
Chief Operating
Officer
FarmLogix LLC



John D. Bowe
Principal
American Maritime
Group LLC



Andrew Fox
President
Overland Limited
Associates



James P. Rankin
CEO
West Star Aviation



Mike Brennan
President
Farmer's Frigate



Robert Hart
Senior Consultant
AllTranstek LLC



Kathleen L. Ross
Independent Director
Celadon Group Inc.



Vicki Bretthauer
Independent
Consultant



Adam Inselbuch
Managing Director,
South Street
Ventures LLC



James A. Runde
Special Advisor,
Investment Banking
Division
Morgan Stanley



Edward A. Burkhardt
Chairman, President
& CEO
Rail World Inc.



Edward Jenkins
Principal, Strategy
& Logistics Consulting



Andy Sze
Managing Director &
Partner
Fastraxx Group LLC



James H. Burnley IV
Partner
Venable LLP



Peeter Kivestu
Principal
Oplytix LLC



Barbara W. Wilson
President & CFO,
RailUSA, LLC



Norman Carlson
Chairman
Metra



John G. Larkin
Operating Partner,
Clarendon Group



Justin F. Zubrod Sr.
Managing Partner
Justin Zubrod & Co.
LLC



Lee A. Clair
Managing Partner,
Transportation &
Logistics Advisors LLC



Charles B. Lounsbury
Former Senior VP
Ryder System Inc.



Richard J. Craig
VP, Business
Development
NACPC - North
American Chassis
Pool Cooperative



Craig E. Philip
Research Professor &
VECTOR Director
Vanderbilt University

Member Companies





BAC Meeting Fall 2018

THURSDAY, NOVEMBER 8, 2018 | NUTC - Chambers Hall, Evanston

Meeting Summary

Call to Order & Opening Comments (BAC Chair presiding)
Justin Zubrod – Managing Partner, Justin Zubrod & Co., LLC

Welcome to Northwestern University
Julio Ottino - Dean, McCormick School of Engineering, NU

Northwestern Research Enterprise
Jay Walsh - Vice President for Research, NU

Director's Report & Discussion
Hani S. Mahmassani – Director, NUTC / Patterson Transportation Chair

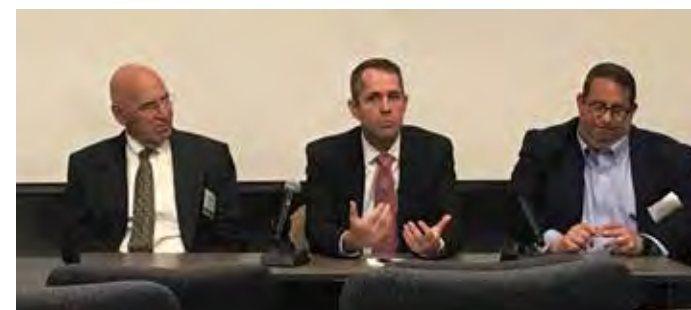
BAC Membership: New Member Introductions

Session 1: Intermodal Moves: Looking to 2019 and Beyond
Barbara Wilson (Moderator) – President, Wells Fargo Rail
Larry Gross (Featured Speaker) - President, Gross Transportation Consulting
Dan McLaughlin – Assistant Vice President - Premium Marketing, Union Pacific Railroad
Michael Zamost – Vice President of Intermodal, Vice President of Carrier Solutions, Echo Global Logistics

Session 2: Featured Northwestern Faculty Presentation
Kristian J. Hammond – Professor, Computer Science, CS Plus X, McCormick School of Engineering
Bringing AI into the Enterprise - Navigating the promise and dangers of the new technologies of intelligence
Simge Kucukyavuz – Associate Professor, Industrial Engineering & Management Sciences, McCormick School of Engineering
Optimization under Uncertainty for Humanitarian Relief Network Design

Session 3: When Things Go Wrong: Managing Disruptions
Ken Heller (Moderator) – Senior Vice President, Operations for DSC Logistics
Mike Macyauski – Vice President, Operations Planning & Engineering, FedEx Express
Jim McGowan – Director, Information Management & Situational Awareness at American Red Cross
Karen Smilowitz – Professor, Industrial Engineering & Management Sciences, McCormick School of Engineering

Closing Comments & Meeting Adjournment
Transportation Student Introductions
Lunch with Transportation Students





BAC Meeting Spring 2019

THURSDAY, MAY 16, 2019 | NUTC - Chambers Hall, Evanston

Meeting Summary

Call to Order & Opening Comments (BAC Chair presiding)
Jeff Silver - Co-Founder, Coyote, A UPS Company

Welcome to Northwestern University
Julio Ottino - Dean, McCormick School of Engineering, NU

Northwestern Research Enterprise
Jay Walsh - Vice President for Research, NU

Director's Report & Discussion
Hani S. Mahmassani - Director, NUTC / Patterson Transportation Chair

BAC Membership: New Member Introductions

Session 1: Growth, Efficiency and Rail Service in an Uncertain Trade Environment
Patrick Lortie (Moderator) - Partner, Global Transportation Practice, Oliver Wyman
Eugene D. Seroka (Featured Speaker) - Executive Director, Port of Los Angeles
Roger Nober - Executive VP, Law & Corporate Affairs / CLO, BNSF Railway
Krishna C. Jha - Executive Vice President, Optym

Networking Break

Session 2: Software, Automation & Trust
Kristian J. Hammond (Moderator) - Professor, Computer Science, NU
Nicholas Diakopoulos - Assistant Professor, Communication & Computer Science, NU
Daniel W. Linna Jr. - Visiting Professor of Law, NU
Todd D. Murphey - Professor, Mechanical Engineering, NU

Session 3: Beyond the Hype: Advancing Technology Adoption in Transportation / Logistics
Cliff J. Porzenheim (Moderator) - Chief Operating Officer, FarmLogix LLC
Kevin Glynn - Chief Information Officer, DSC Logistics
Zach Jecklin - Vice President of Strategy, Echo Global Logistics
Jim Monkmeyer - President of Transportation, North America, DHL Supply Chain

Closing Comments & Meeting Adjournment

Transportation Student Introductions

Lunch with Transportation Students



Patterson Transportation Lecture

The Annual William A. Patterson Distinguished Transportation Lecture is named for William A. “Pat” Patterson. In 1980, the NUTC established the Lecture as an integral part of the Patterson Endowment. It has since become an annual highlight at Northwestern University, drawing influential speakers from all facets of the transportation industry.

William A. “Pat” Patterson was a central figure in the United States air transport industry for more than four decades. He served as president and chairman of United Airlines from 1934 until his retirement in 1966. He was a life trustee of Northwestern University and was instrumental in the establishment and strategic leadership of the Transportation Center.

37TH ANNUAL PATTERSON LECTURE *The Sky's No Limit: Boeing and the Future of Space Exploration*

Dennis A. Muilenburg

Chairman, President & CEO, Boeing



MAY 2, 2018 Over the course of decades, Boeing has celebrated lunar footsteps, space shuttle launches and the assembly of the International Space Station, among other milestones. Now the aerospace leader is focused on what comes next.

At the 37th Annual Patterson Transportation Lecture, Boeing Chairman, President and CEO Dennis Muilenburg discussed the future of space exploration, from traversing deep space and taking our first steps on Mars to the evolving combination of commercial air and commercial space travel.

WATCH VIDEO - Visit the URL listed below to watch these Patterson Lecture recordings and more.

38TH ANNUAL PATTERSON LECTURE *Uberizing Logistics and the Future of Freight*

Lior Ron

Head of Uber Freight



MAY 15, 2019 Titled “Uberizing Logistics and the Future of Freight,” Ron devoted his Patterson Lecture to detailing the ongoing evolution of logistics before a crowd of some 150 faculty members, students and industry personnel a mere five days after Uber’s Initial Public Offering (IPO).

Ron addressed a range of audience questions around issues such as barriers to working with shippers, Uber Freight’s plans for international expansion and the feasibility of truck platooning. He also touched on innovations in warehousing and loading trucks and said technology continues “stepping up the requirements to run a business efficiently.”







FEATURED SPEAKER

The Future is Here: A Conversation with Brad Keywell

Brad Keywell - Founder & CEO, Uptake

NOV. 7, 2018 With smart technologies like artificial intelligence (AI) and the Internet of Things (IoT) transforming transportation by air, road, sea, and rail, veteran entrepreneur Brad Keywell reminds that the potential to run a data-driven business exists in the present as well as the future.

“There are conditions now in transportation ... that you can’t even envision what can be done,” Keywell said during a November 7th program hosted by the Northwestern University Transportation Center (NUTC) on the University’s Evanston campus. During the hour-long program moderated by Gregg Latterman, an adjunct lecturer of innovation and entrepreneurship at the Kellogg School of Management, Keywell discussed his entrepreneurial roots and interest in the transportation field, which he called one of the reasons “humanity exists.”

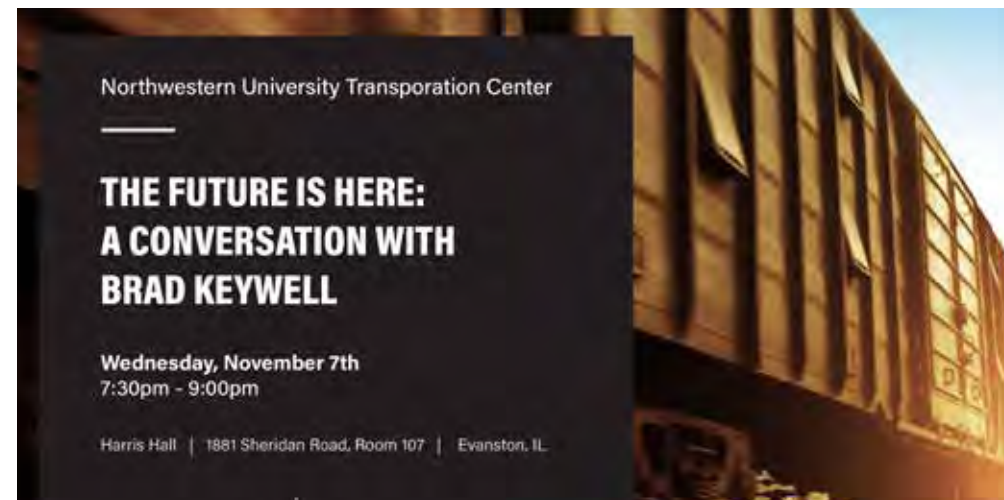
Keywell is the founder and CEO of Uptake Technologies, a founding investor in Tempus and co-founder of Groupon (NASDAQ:GRPN), Echo Global Logistics (NASDAQ:ECHO), MediaOcean, Drivin (acquired by NYSE:KAR), and the venture capital firm Lightbank.

Keywell's talk was the special feature connecting two days of NUTC events focused on increased knowledge sharing and collaboration within the dynamic transportation industry.

“There is never a dull moment in the transportation world, with each day bringing some announcement of a new technological milestone, major merger or acquisition, new service innovation, or potentially significant geopolitical event with implications for global trade.”

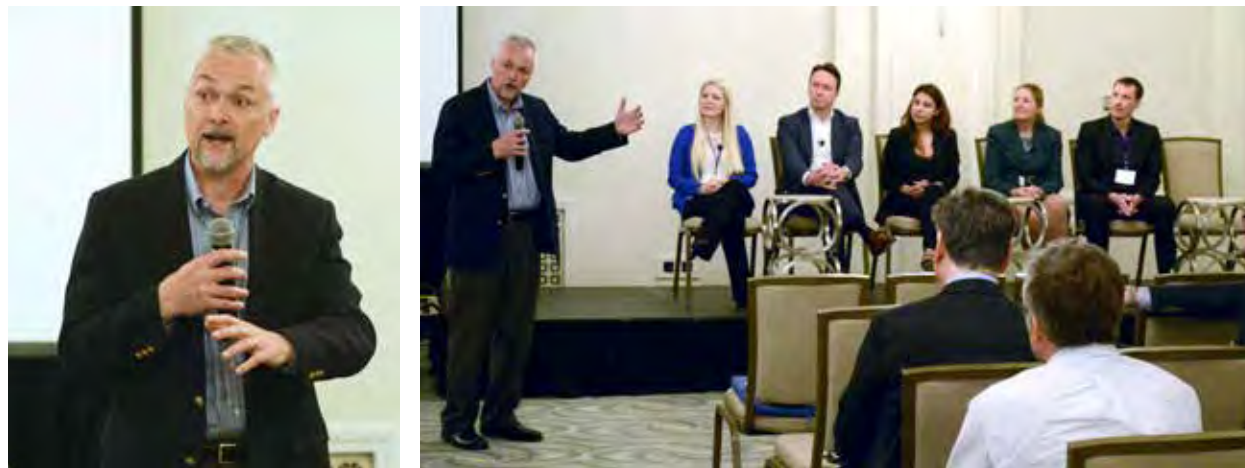
- NUTC director Hani S. Mahmassani

WATCH VIDEO - Visit tiny.cc/Keywell2018 to read more and watch a video recording of this special event.



Industry Technical Workshops

Every year, Northwestern University Transportation Center (NUTC) and the Center for the Commercialization of Innovative Transportation Technology (CCITT) co-host two Industry Technical Workshops in conjunction with both Fall and Spring Business Advisory Council (BAC) meetings. The Spring 2018, Fall 2018 and Spring 2019 Workshops are summarized in this report.



Spring 2018 Workshop

Freight by Air: Riding the Wings of Change

MAY 2, 2018 Workshop attendees gathered at the Hilton Orrington Hotel in Evanston for the Spring 2018 Industry Technical Workshop: “Freight by Air: Riding the Wings of Change.”

The workshop, moderated by Shawn McWhorter (President of BAC member company, Nippon Cargo Airlines) featured experts speaking on: Demand growing faster than Capacity; Drivers behind the changes and the impact on general air freight; Accessing and managing capacity; The future of aircraft autonomy; and Last-mile delivery by drone. Speakers cited multiple issues impacting cargo efficiency including: FAA regulations and anti-globalization movements inducing geopolitical stress; enormous real estate and infrastructure costs stifling investment in new facilities; status quo complacency and poor decision-making using bad industry data; poor air capacity optimization; and the lack of truck drivers and warehouse workers needed to support cargo hubs and operations.

The panelists recommended enhancing collaboration among competitors and partners to improve air cargo operation. They expressed an interest in seeing joint ventures among supply-side agents as well as between the air freight industry and its customers. Renewed collaboration among air and ground cargo operators was recommended to increase intermodal transport efficiency and capacity optimization. Looking to the future speakers suggested that companies should create advisory boards to facilitate smarter and more responsible investments in (autonomous) technology, since resistance to change is notorious in the air cargo industry, and adapt to “sharing economy” principles to foster future collaboration among industry participants.

Featured Speakers

Shawn McWhorter

President, Nippon Cargo Airlines

Michael Steen

Executive VP & CCO, Atlas Air Worldwide; President & CEO, Titan Aviation Holdings, Inc.

Helen Kristensen

Managing Director, United Cargo Sales, United Airlines

Wayne Tyndall

Director of Sales, US & Northern Europe, Freightos WebCargo (FWC)

Sedef Albrecht

Director, Strategy & Operations, Boeing HorizonX

Andi Kilgore

Chief of Staff, Office of the CEO, Flirtey





Fall 2018 Workshop

Connect. Carry. Conquer. Innovative Practices in Freight Process Management

NOV. 7, 2018 Chicago-area companies are leading the business and technology innovations that drive freight and supply chain management today. On November 7, established leaders and rising upstarts from six of these leading companies shared a stage at Norris University Center, Evanston for the Fall 2018 Industry Technical Workshop, “Connect. Carry. Conquer. Innovative Practices in Freight Process Management.” Experts discussed the current state of the freight industry and best practices for connecting customers to carriers going forward, as well as ways improve the end-to-end user experience—all for the purpose of conquering the supply chain.

Lee Clair, BAC member and managing partner of Transportation and Logistics Advisors, led a panel discussion of Chicago-area freight and logistics leaders whose companies are developing and deploying business and technology innovations that are driving change in freight and supply chain management around the country and world. The speakers discussed the current state of the freight industry, best practices for connecting customers to carriers, and new methods and processes to improve the end-to-end freight and logistics user experience. This group identified several opportunities to improve the customer experience and workflow including: enhancing visibility across the fragmented supply chain using new cloud-based software and opening up access to freight flow information; eliminating manual



processes, phone calls and spreadsheets; automating workflow with machine learning techniques; providing real time information and pricing through data analytics; and deploying information through apps directly to the end users (drivers). In sum, the panelists all promoted developing new software automation and collaboration tools to allow operators to operate with as little friction as possible.

Featured Speakers

Tommy Barnes - President, project44
Matt Bernstein - Founder & CEO, HubTran
Lee Clair - Managing Partner, TandLA
Harris Ligon - Head of Marketplace Solutions, Uber Freight
Dave Menzel - President & COO, Echo Global Logistics
Cameron Ramsdell - CTO, Coyote, a UPS company
Al Toliver - CLO, Redwood Logistics





Spring 2019 Workshop

Feeding First to Last Mile Demands for Fast(er) Food Delivery

MAY 15, 2019 Industry leaders, students and academic experts gathered at the Hilton Orrington, Evanston for the Spring 2019 Industry Technical Workshop, “Feeding First to Last Mile Demands for Fast(er) Food Delivery.” Experts discussed the current trends, expert tech, consumer cravings and the future of (even faster) food and grocery delivery.

Justin Zubrod, Managing Partner for Justin Zubrod & Co. LLC and BAC member, led a panel of food and last mile delivery experts to address the explosion of last mile food delivery, advances in food distribution and delivery logistics, business and service risks, new and emerging technologies, and other challenges brought on by e-commerce and high customer expectations. The speakers addressed a many factors impacting delivery including rising customer expectations for delivery speed and visibility of orders, trends in food delivery customer experiences, new delivery service providers and their innovative service offerings, unexpected corporate partnerships and business models, and new technology emerging to address last mile challenges. A consistent viewpoint among the panelists was the need to develop delivery partnerships and services that are sustainable to customers while also allowing generating profits for delivery services, and managing the expectations of grocery and restaurant partners that both operate on tight profit margins.

To better serve the grocery market, one panelist showed how decreasing the ambient transit from two days to one improves customer satisfaction, customer conversion, and customer retention, although it can



increase the complexity of delivery logistics and potentially impact the overall logistics cost. The goal is to balance both constraints. For the restaurant market, another panelist predicted that delivery will become the future “anchor tenant” in restaurant sales. Ultimately the evolution of best delivery practices and business strategies such as dynamic routing, order pooling and automation have the potential to unlock future service value.

Featured Speakers

Mike Brennan

Executive Team, Farmer's Fridge

James E. Carbine

CEO, Local Foods + Butcher & Larder

Anesti Dhima

Business Development Team Lead, Instacart

Mark McKenna

Supply Chain & Logistics Manager, Home Chef

Thomas Parkinson

Co-Founder & CTO, Peapod

Janine Renella

Vice President of Sales, Deliv

Justin Zubrod

Managing Partner, Justin Zubrod & Co., LLC



TC Seminar Series

NUTC's Seminar Series provides students, faculty and the community access to real-world experiences, as told by seasoned industry professionals and researchers in the field. Seminars are designed to enhance the classroom experience and each year NUTC features a wide variety of academic speakers, transportation professionals and researchers.

- 02/01/2018** *Research, Planning, & Lessons Learned in Evacuation & Transportation Resilience* - Brian Wolshon, Louisiana State University
- 02/08/2018** *The Role Of Space In Design, Scale Economies And Optimal Pricing In Public* - Sergio Jara-Diaz, University of Chile
- 02/22/2018** *Safety Implications of the Transition to CAVs: Getting at the S-Curve Parameters* - Reg Souleyrette, University of Kentucky
- 03/01/2018** *The 4th National Climate Assessment: Maintaining Hope While Assessing the Science* - Donald J. Wuebbles, University of Illinois
- 03/08/2018** *The History of Road Safety in Industrialized Countries (and the Future of Road Safety in Developing Countries)* - Kavi Bhalla, University of Chicago
- 04/26/2018** *Modeling & Optimizing Paratransit in the Age of TNCs* - Eric Gonzales, University of Massachusetts, Amherst
- 05/10/2018** *Travel Behavior Implication of Automated Vehicles* - Yoram Shiftan, Transportation Research Institute, Technion, Israel
- 05/17/2018** *Forgiving Roads* - Michael G. Dreznes, International Road Federation (IRF)
- 05/31/2018** *Statistical Inference of Probabilistic Origin-Destination Demand Using Day-to-Day Traffic Data* - Zhen (Sean) Qian, Carnegie Mellon University
- 08/24/2018** *Transit Network Design Under Demand Uncertainty* - Hong Lo, Hong Kong University
- 10/04/2018** *Ground Transportation Gaps: The Most Heavily Traveled Intercity Routes in the US without Rail or Express Coach Service* - Joseph Schwieterman, DePaul University & Chaddick Institute
- 11/15/2018** *Spillover Parking Congestion & Retail Business* - Robin Lindsey, University of British Columbia
- 11/29/2018** *Impact of Non-Hub Cities to United's Success* - Mandeep Grewal, United Airlines
- 02/07/2019** *Control of traffic composed of humans and automated vehicles* - Dan Work, Vanderbilt University
- 02/21/2019** *Understanding the 'Crowd' in Crowd-Shipping* - Aymeric Punel, Northwestern University
- 03/14/2019** *The Pilot of the Future* - Geoff Murray, Oliver Wyman
- 04/11/2019** *Understanding the adoption of connected and autonomous vehicles (CAV) and the role of peer influence* - Cara Wang, Rensselaer Polytechnic Institute (RPI)
- 05/23/2019** *Spatial distribution of logistics facilities and truck traffic* - Kazuya Kawamura, University of Illinois, Chicago
- 05/30/2019** *Navigating the Maelstrom; Perspectives on and Challenges Facing Transit in a Turbulent and Uncertain World* - Brendon Hemily, Hemily & Associates, Toronto, Ontario, Canada

Current Events (TC Seminars): transportation.northwestern.edu/news-events/seminar-series

Featured Seminars

The History of Road Safety in Industrialized Countries (and the Future of Road Safety in Developing Countries)

Kavi Bhalla

Assistant Professor, Department of Public Health Sciences, Biological Health Division
University of Chicago

MARCH 8, 2018 “Developing countries do not have to wait until they get rich to care about reducing traffic deaths,” said Kavi Bhalla, Assistant Professor of Public Health at the University of Chicago, in a guest lecture presented to Northwestern University students and faculty on March 8, 2018, held at NUTC. In an analysis of long-term trends in road traffic deaths in industrialized countries, Bhalla found a remarkably consistent pattern of rising traffic deaths until the 1960s, followed by a decline until present day. Previous studies attributed these trends to economic development, similar to a Kuznet's Curve, wherein environmental factors, including determinants of public health, worsen during growth and industrialization and then improve as countries become wealthy enough to impose policies to improve conditions.



“The History of Road Safety in Industrialized Countries (and the Future of Road Safety in Developing Countries)”

Kavi Bhalla, PhD

Assistant Professor, Department of Public Health Sciences, Biological Sciences Division;
Affiliated Faculty, Harris School of Public Policy
University of Chicago

According to Bhalla: “A look at the road fatality data from before 1960 until the now shows us that significant paradigm shifts in public policy, most of which originated in the in the US, sparked dramatic declines in traffic deaths. These changes had little to do with wealth.” Each marked decline in traffic deaths corresponded with key policy interventions, including seatbelt and other interior car design requirements, which the federal government instituted following Ralph Nader's pivotal book, *Unsafe at Any Speed*. The enactment of a 55-mile-per-hour national speed limit in 1973 (in response to the OPEC oil crisis) combined with fewer vehicle miles traveled due to the spike in gas prices, also caused a drop in fatalities. The prevailing view that the way to reduce traffic accidents is to change the behavior of every “nut behind the wheel,”

has now been debunked, as the safety benefits of improved roadway and vehicle design have been implemented.



Travel Behavior Implication of Automated Vehicles

Yoram Shiftan

Transportation Research Institute, Technion; Israel Institute Visiting Professor
Northwestern & University of Illinois, Chicago

MAY 10, 2018 Much of the recent research on automated vehicles has focused on full automation—the day when driverless cars, trucks and transit will be the norm. Experts predict we will reach that point somewhere between 2025 and 2070. That is a large window of time during which drivers and customers are predicted to gradually adapt to the new technology. As with all major technological leaps, there will be early adopters who will jump at the chance to own or use a driverless car and skeptics who will wait until all conventional options are extinguished.

Yoram Shiftan, of the Transportation Research Institute at Technion in Israel and the current Israel Institute Visiting Professor at Northwestern University and the University of Illinois at Chicago, has been studying people's perceptions and behaviors relating to autonomous vehicles. In a May 10th TC Seminar, Shiftan described the current state of research and his ongoing work studying travel behaviors surrounding the shift to driverless communities. He says safety, cost, and time savings are the major factors currently influencing consumer behavior and the potential options for autonomous vehicles going forward.

Sandhouse Rail Group

The Hagestad Sandhouse Rail Group began in 2002 as an effort to connect active and veteran rail practitioners with students and academics interested in rail-related issues. Named for Douglas Dean Hagestad, a primary group founder who passed away in 2007, the Sandhouse Group meetings typically feature presentations from field experts, followed by an open forum discussion. Sandhouse meetings take place on weekdays and begin around 3PM, lasting roughly 90 to 120 minutes.

- 01/16/2018** *Operating & Capital Needs of Metra* - Jim Derwinski, Metra Executive Director & CEO
- 03/20/2018** *South Shore Railroad: A public private partnership that really works* - Andrew Fox, Managing Director, & Eric T. Jakubowski, CCO, Anacostia Rail Holdings Company
- 04/12/2018** *Wally Abbey visits Cincinnati Union Terminal* - George Hamlin, President, Hamlin Transportation Consulting
- 06/07/2018** *Machine Learning, Industrial Analytics, and AI Outcomes in Rail and Beyond* - Joe Becker, Director, Center for Rail Excellence, Uptake Technologies
- 10/18/2018** *Vision Systems & Automation in Rail* - Roger Martinez, Senior Product Owner, Visual Analytics, Wi-Tronix, LLC
- 12/04/2018** *North American Freight Rail 2019: PSR-driven 'Renaissance 2' or Missed Opportunity?* - Anthony Hatch, ABH Consulting
- 05/09/2019** *Metra: On Track to Excellency & Regional Vitality* - Jim Derwinski, Executive Director & CEO; Chris Krakar, Chief Engineering Officer; Kevin McCann, Chief Mechanical Officer
- 09/12/2019** *Trains... A less locomotive-centric look at railroad photography* - George Hamlin, President, Hamlin Transportation Consulting

Current Events (Sandhouse): transportation.northwestern.edu/news-events/sandhouse-rail-group

Icarus Aviation Society

Icarus, a Greek mythological aviator, failed to heed his father Daedalus' sage advice about climbing too near the sun and died when his fledgling wings melted. Formed in 2006, NUTC's Icarus Society, or Icarus Aviation Forum, is a public forum created for the discussion and of all issues related to aviation and sharing knowledge with all interested parties, and for the dissemination of new ideas. The Icarus Society promotes in-depth dialogue about airlines, aircraft manufacturing, aviation services, technology, government oversight, and significant elements of business aviation.

- 11/29/2018** *Impact of Non-Hub Cities to United's Success* - Mandeep Grewal, United Airlines
- 03/14/2019** *The Pilot of the Future* - Geoff Murray, Oliver Wyman

Current Events (Icarus): transportation.northwestern.edu/news-events/icarus-aviation-society



JUNE 2018 CNBC named Chicago-based BAC member Uptake Technologies one of the Top 50 Disruptors in the tech startup space in both 2017 and 2018. This is remarkable considering the firm just launched in 2014 and many of its clients are in heavy industry and transportation sectors, including airlines, railroads, oil and gas production.

Joe Becker, Director of Uptake's Center for Rail Excellence, made a presentation to Northwestern University Transportation Center's (NUTC) Sandhouse Rail Group on June 7. Becker described how Uptake's machine learning, big data and analytics on a SaaS platform (together, an Internet of Things (IoT) approach), are helping the rail sector optimize performance, reduce failures and enhance safety for its most valuable assets, locomotive engines.

Uptake Technologies combines its IoT expertise with its clients' inherently deep knowledge and experience with heavy industry and equipment. In rail, Uptake has developed machine diagnostics and predictive analytics for locomotives that can sound the alarm about likely failures far in advance of their actual occurrence. It does this by placing sensors on every piece of equipment on a locomotive. Those sensors transmit data on failure prediction, anomaly detection, and fuel management to data scientists at Uptake who track the condition of assets on an around-the-clock basis. Becker told his June 7 audience, "This has fundamentally changed the way in which repairs are scheduled, by routing the locomotives to a repair shop well before it fails. It doesn't have to be in the shop and out of commission for six days for routine maintenance and expected repairs anymore. In just three years, we've been able to show our Class 1 railroad clients how our data analytics can very quickly increase reliability and productivity."

Uptake has also added a weather forecasting tool to its toolbox, which enhances its analysis by predicting when heavy snow and rain may hamper freight train performance or when wind speeds drop, severely limiting energy-producing windmill productivity. "The freight rail industry has been a great partner," said Becker. "Many long-time employees have a lot of

Featured Sandhouse Presentation

Industrial Analytics, Machine Learning, and AI Outcomes in Rail and Beyond

Joe Becker

Director, Center for Rail Excellence
Uptake Technologies



equipment know-how in their heads." Uptake talks with those experts at length to extract information about how their machines work, what can go wrong, and how long it takes to fix it. "One of first things we do with our rail clients is to clean up and standardize the data that has been gathered by each repair shop over time."

Uptake moved to further strengthen data reliability in early 2018 when it acquired Albuquerque-based Asset Performance Technologies (APT), a preventive maintenance consulting company that developed the world's biggest database of industrial equipment maintenance needs and causes of equipment failures. The database includes information on nearly 800 pieces of equipment across numerous industries, including power generation, mining and steel-making and has catalogued some 55,000 conditions that can identify when industrial equipment is about to fail.

Becker expects that IoT technologies and analyses, that Uptake and others can provide, will soon be the new normal for rail and other industrial clients. "Rail and heavy industry have done things the same way for a very long time, but changes are now occurring very rapidly," Becker reported. This is great news, he says, noting that a study of the manufacturing sector by the American Society for Quality found that the "digital transformation" currently underway will add \$500 billion in productivity to the global economy in the next five years.



Beyond its world-class research and education, the Transportation Center is first and foremost about community—a community of students and faculty, of researchers and dedicated staff, loyal alums, industry partners and transportation professionals. Each year, NUTC fosters this community by means of networking events, speaker forums, clubs, and social gatherings.

NUTC Community



Welcome Reception

At the beginning of each school year, NUTC faculty, students, staff and friends gather for a Welcome [Back] Reception where attendees toast to the upcoming year and network with old and new members of the NUTC community.



New Student Lunch

Each year, NUTC welcomes new students with a lunch, tour of the Center and special presentations from NUTC staff and the Transportation Library.



End-of-Year Event

At the end of each school year, NUTC faculty, students, staff and friends gather for an End-of-Year Event where attendees toast to academic successes and say farewell to the newly graduated.



Northwestern Transportation Clubs

The NTC (Northwestern Transportation Club) and Kellogg Transportation Clubs engage students in the airline, aerospace, railroad, ocean shipping, logistics (supply chain) and mobility industries. Both clubs were created to raise student awareness and provide resources related to management opportunities with companies in these industries.

Club members are students focused in Transportation Systems Analysis & Planning, the Transportation & Logistics Undergraduate Minor, Civil & Environmental Engineering, as well as Industrial Engineering & Management Sciences. Members of both clubs seek to inform their fellow students about employment and recruiting opportunities, and collaborate throughout the year in an effort to plan social gatherings and informative events where all transportation enthusiasts are welcome.



Kellogg School of Management

Kellogg's **Transportation Club** engages students in the airline, aerospace, railroad, ocean shipping and logistics (supply chain) industries with goals to raise student awareness and provide resources related to management opportunities with companies in these industries.

MORE INFO: kellogg.campusgroups.com/transportation



AUTOMOBILITY CLUB

Kellogg's **Automobility Club** generates excitement about the "new mobility" future—autonomous, connected, electric, and shared—and provides its members the resources and connections to become leaders and founders of mobility companies.

MORE INFO: kellogg.campusgroups.com/auto

Panel Discussion Urban Mobility Policy with BCG, Lyft and the City of Chicago

MAY 2019 NUTC Senior Associate Director, Bret Johnson, helped lead a panel for the Automobility Club at Kellogg's Global Hub on May 9th titled, "Urban Mobility Policy with BCG, Lyft, and the City of Chicago." The panel discussion focused on the current state

of urban mobility policy in the United States and panelists shared their experiences working with the public and private sectors to influence mobility policy, including their contributions to Mayor Emanuel's report for the *New Transportation and Mobility Task Force*.

The panel moderated by Bret included BCG's Global Head of Automotive and Mobility (and member of the Mayor's New Transportation and Mobility Task Force), Lyft's Director of Public Policy and the Deputy Chief of Staff for Economic Development for the City of Chicago.

Special Events and Engagements

TC Supports: IDOT “Autonomous Illinois” Special Press Event

OCT. 2018 NUTC director Hani Mahmassani was invited to an exclusive press event on October 25th hosted by the State of Illinois to launch “Autonomous Illinois,” a new initiative to foster a safe, innovative environment for the seamless deployment of connected and automated vehicles (CAVs) and other transportation technologies.

Joined by Illinois Department of Transportation (IDOT) Secretary Randy Blakenhorn, community and business leaders, Professor Mahmassani celebrated the signing of an Executive Order that established an Autonomous Illinois public roads CAV testing program, and participated in calling on state agencies to collaborate on CAV opportunities, such as establishing Illinois as a hub for freight-related CAV testing and research. The press conference was followed by demonstrations of emerging technologies from Illinois-based companies such as Innova and Autobon.



TC Hosts: DiDi Leadership Visits NU for Special Presentation



NOV. 2019 NUTC welcomed Tiger Qie, Vice President of DiDi Chuxing and his team from China for an event-filled day at Northwestern that closed with Mr. Qie’s TC Seminar entitled, “Redefining Transportation with AI,” on the afternoon of November 7th.

Prior to this special DiDi seminar NUTC director Professor Hani Mahmassani and senior associate director Bret Johnson hosted a lunch for Mr. Qie and ten other colleagues, including Hua Chai and Mandy Ma. The formal lunch was followed by a presentation on NUTC research delivered by Professor Mahmassani. The DiDi team had traveled to Chicago for SIGSPATIAL 2019 for which they organized a workshop on ride-hailing algorithms, applications and systems.

TC Connects: BAC Member Ruan Hosts NU Alumni Event



MAY 2019 Business Advisory Council member Ruan Corporation hosted the 3rd Annual Alumni Speaker Event on May 29th at World Food Prize Hall in Des Moines, Iowa.

NUTC director Hani Mahmassani was invited by NU Alum, BAC member and Ruan’s Chief Executive Officer, Ben McLean to deliver the keynote address.

TC Participates: I-ACT Project Info Day

JUNE 2019 The Illinois Department of Transportation (IDOT) with UIUC, UIC and Northwestern University—its academic partners in the Smart Transportation Infrastructure Initiative (STII)—hosted an industry forum on June 4th at the Illini Center to present the Illinois Automated and Connected Track (I-ACT) project, a closed-environment test track facility planned for Rantoul, Illinois.

After brief presentations by Erin Aleman, IDOT’s Director of Planning and Programming, Imad al-Qadi, Director of UIUC’s Illinois Transportation Center, Peter Nelson, Dean of UIC’s Engineering School, and NUTC’s Associate Director, Bret Johnson, al-Qadi and Aleman fielded questions from forum attendees.

As a partner in STII, IDOT had issued a Request for Information (RFI) to gauge interest and gain understanding into how private and public entities, academia, and other potential stakeholders might partner and participate in the use of the I-ACT. A smart-freight loop, connected village, and off-road testing facility were among the primary features proposed by presenters.



TC Advises: Monaco Digitalization Council



NOV. 2018 TC Director Hani Mahmassani attended the first official meeting of the Monaco Digital Advisory Council (MDAC) on November 28th and 29th in Monaco, which was presided over by Prince Albert II.

MDAC is comprised of renowned experts from both the private and public sectors. Most council members have backgrounds in digital technologies. MDAC was formed to guide Monaco in its strategic vision for its path toward digitalization.



TRB Reception and Alumni Reunion

The Transportation Research Board (TRB) Annual Meeting in Washington, DC begins with an NUTC-hosted reception that provides NU alumni the opportunity to reconnect with fellow alumni from across the country, as well as meet current NU faculty, students and staff.

JAN. 2018 On Wednesday, **Lama Bou Mjahed**—who successfully defended her PhD dissertation in late 2017—presented the paper she'd co-authored with NUTC director **Hani Mahmassani**. The poster, “Wired at Birth: Childhood, Technology Engagement, and Travel Behavior” was presented during a session on “Information and Communications Technology and Travel Behavior: A spectrum of findings.”

Earlier that day, Lama presented another paper co-authored with Professor Mahmassani, “Young adults’ activity-travel behavior: why are we still operating within the same framework? A conceptual exploration” in a session on “Travel Behavior of Special Population Groups.” Lama reported that her posters were “...well-attended—a reflection of the great interest in this particular topic and in our work.” Lama is pictured on the following page in the second row, middle photo with her colleagues and fellow Northwestern students, **Marija Ostojic** and **Amr Elfar**.

On Tuesday, Jan. 9th Northwestern PhD Candidate **Amr Elfar** presented, “Machine Learning Approach to Short-term Traffic Congestion Prediction in a Connected Environment,” which he co-authored with Alireza Talebpour of Texas A&M University and NUTC director **Hani Mahmassani**. Amr presented as part of a session entitled, “Estimation, Detection, and Prediction of Traffic Conditions with Machine Learning Tools.”

Amr also presented during Wednesday’s poster session, “Traffic Flow Theory and Characteristics,” a poster focused on “Traffic Shockwave Detection in a Connected Environment using the Speed Distribution of Individual Vehicles,”—a paper he’d co-authored with Professor Mahmassani, as well as Connie Xavier and Alireza Talebpour of Texas A&M University.



Northwestern Professor **Marco Nie**, who presented four papers during the week-long event, was awarded the 2018 Stella Dafermos Best Paper Award by the TRB Transportation Network Modeling Committee for “A



Greedy Path-based Algorithm for Traffic Assignment,” co-authored with Jun Xie and Xiaobo Liu of Southwest Jiaotong University.

The Stella Dafermos Best Paper Award is offered annually for the best paper submitted for presentation and publication to the Transportation Network Modelling Committee (ADB30) of TRB. Stella Dafermos (1940-1990), one of the most influential early researchers in transportation network modelling, developed new mathematical methods of analyzing congested transportation networks and proposed innovative techniques to find solutions to complex network equilibrium problems. Her research has had a profound and lasting effect on the field of network equilibria and transportation system modelling.

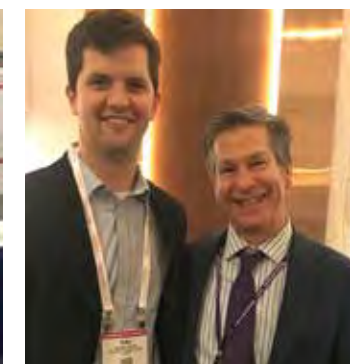
PhD Candidate **Helen Pinto** presented her poster Tuesday for “Integrated Mode Choice and Dynamic Traveler Assignment Simulation Framework to Assess the Impact of Suburban First Mile Shared Autonomous Vehicle Fleet Service on Transit Demand,” co-authored with fellow PhD Candidate **Michael Hyland**, Omer Verbas of Argonne National Laboratory, and NUTC director **Hani Mahmassani**.

Then, on Wednesday, Helen attended the International Road Federation (IRF) Road Scholar Orientation and was elected president of the IRF Fellows Class of 2018 for what she described as her “ability to keep the class united.”

When asked about her IRF fellowship and favorite moments at TRB, Helen said, “I had the amazing opportunity to meet leaders in the transportation industry and visit recognized institutions such as the World Bank, AASHTO, Turner-Fairbank Highway Research Center, and the National Transportation Safety Board. I also learned valuable lessons on leadership, networking and professionalism. I especially want to thank the company Louis Berger for sponsoring my participation.”

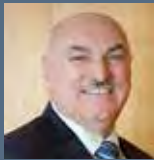


JAN. 2019 The Transportation Research Board (TRB) 98th Annual Meeting was held Jan. 13 - 17, 2019, at the Walter E. Washington Convention Center, in Washington, DC. The information-packed program attracted more than 15,000 transportation professionals from around the world—including dozens of talented academics from Northwestern. To kick off the week, NUTC invited Northwestern alumni to join TRB attendees for a Welcome Reception & Alumni Reunion at the Marriott Marquis on Jan. 13th.





Northwestern University Transportation Center
Director & Staff



Hani S. Mahmassani
Director
masmah@northwestern.edu
847.491.2282



Breton Johnson
Senior Associate Director
bretj@northwestern.edu
847.491.2194



Goldie McCarty
Assistant Director,
Research & Operations
goldie.mccarty@northwestern.edu
847.491.2276



Joan Pinnell
Assistant Director,
Communications & Outreach
joan.pinnell@northwestern.edu
847.491.2787



Andrea Cehaic
Program Assistant
andrea.cehaic@northwestern.edu
847.491.2280

Northwestern University Administrative Officers
University Administrators

Morton O. Schapiro
President

Kathleen Hagerty
Provost

Milan Mrksich
Interim Vice President of Research

Julio Ottino
*Dean, McCormick School of
Engineering & Applied Science*

Report Production

Editors

Andrea Cehaic
Bret Johnson
Joan Pinnell

Managing Editor

Hani S. Mahmassani

Photography

Genie Lemieux
Alan P. Santos

Writers

Rachel Cole
Bret Johnson
Hani S. Mahmassani
Amanda Morris
Joan Pinnell
Daniel P. Smith

Organizational Structure



Contact

Northwestern University Transportation Center

600 Foster Street | Evanston, Illinois 60208
847.491.7287 | tcinfo@northwestern.edu
transportation.northwestern.edu