

Northwestern University

Northwestern University Transportation Center

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Northwestern University

TRANSPORTATION CENTER



Northwestern University Transportation Center 2016-2017 Progress Report

MANAGING:
DATA
DECISIONS
INNOVATION
MOVEMENT
CHANGE
POSSIBILITIES

Progress Report

2016-2017



NUTC MISSION 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.

63
YEARS OF
TRANSPORTATION
RESEARCH



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Director's Letter

Hani S. Mahmassani

There is never a dull moment at the Northwestern University Transportation Center (NUTC), reflecting the considerable activity and dynamism characterizing our field and the transportation sector in general. A growing economy means more demand for transport, and for mobility. Lack of past investment during leaner times means stress throughout the transportation system, reflected in greater endemic congestion, and less resilience in the face of more frequent disruptions. Natural disasters exacerbate these symptoms, paralyzing entire cities and regions of the country, and indeed the world.

Transportation companies in the business of moving freight and meeting the logistics challenges of continuing customer expectations for near-immediate gratification, continue to innovate in systems and processes to accompany retailers and shippers' changing supply chain and logistics practices. Technological advances loom large, as both a source of opportunity for those who embrace and master them, and a threat for those who are left behind. After a session on automation at the Fall 2017 meeting of our Business Advisory Council (BAC), John Larkin, managing director of Stifel Transportation & Logistics Research Group, a Leadership Level Member of the BAC, concluded in a note to clients: "Avoid technology at your own peril."

NUTC's research programs continue to reflect the strategic challenges and opportunities for the transportation industry, for both freight and passenger mobility. Automation and connectivity remain major game changers not only for transportation systems, but for cities and regions as well. Technologically, platforms enabling greater automation also facilitate faster adoption of electric and hybrid electric vehicles, with important implications for more sustainable urban patterns and industry practices. NUTC is at



the leading edge of developing tools for agencies to evaluate and plan for the advent of these technologies, and guide their deployment. NUTC also provides a forum for discussion and exchange at all levels of stakeholders and industry players to help understand and frame the intellectual questions and practical implications of these technologies for business practice as well as public policy.

This Progress Report is a double-header, covering two years in the life of our Center. We hope that through these pages, we are able to convey the sense of excitement and dynamism that characterize our programs, the diversity and richness of our intellectual community, and the range of activities and events to engage our industry and agency partners. Through all these we strive to remain the premier academic and research institution for transportation research, enticing the best and the brightest to study transportation and dedicate their technical and leadership skills to the advancement of our transportation, logistics and mobility systems.

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



Highlights

By the Numbers

2016 - 2017

9 NUTC Dissertation Year Fellows (DYF)

35 PhD & MS Candidates enrolled in the Transportation Systems Planning & Analysis Degree Program

33 NUTC Seminars

60 NUTC Faculty Affiliates

20 New Business Advisory Council (BAC) members and representatives

40 Years of dedicated service to NUTC celebrated (Assistant Director Diana Marek retired January 2018)



After 40 years of service and dedication to NUTC, Assistant Director Diana Marek, shown here at a 2016 BAC Reception, retired in January 2018. See page 10 for a tribute to Diana.

Collaboration and Connections

Regional & National

Symposia, Conferences, & Committees

A Memorial Tribute for Aaron Gellman was held in April 2016 at the Vail Chapel of Northwestern's Alice Millar Chapel and attended by over eighty friends, colleagues and family. (story p. 61)

Jeff Silver, Founder and CEO of Coyote Logistics, delivered the 2016 Patterson Lecture in Transportation: No Excuses: Technology and Culture Meet a New Era of Expectation. (story p. 60)

Lance Fritz, Chairman, President and CEO of Union Pacific, delivered the 2017 Patterson Lecture in Transportation: Connecting People, Creating a Better Future—Why International Trade Benefits America. (story p. 60)

Gene Seroka, Executive Director, Port of Los Angeles, presented NUTC's Fall 2016 Distinguished Lecture: Supply Chain Dynamics Impacting North America's Containerized Trade.

Martin Eichenbaum, Charles Moskos Professor of Economics, Northwestern University, delivered the 2017 Moses Transportation Lecture: Outlook for the US Economy: Is This as Good as It Gets? (story p. 61)

Research Participation

Hani Mahmassani Named the Recipient of the 2016 Thomas B. Deen Distinguished Lectureship Award and to the 2016 Class of National Associates by National Research Council.

Karen Smilowitz named the 2016 recipient of the Award for the Advancement of Women in Operations Research and the Management Sciences by INFORMS.

Joseph Schofer received the S.S. Steinberg Award from the American Road and Transportation Builders Association.

Ian Savage won the Transportation Research Forum's prize for Best Paper with Northwestern undergraduate Caroline Miller (WCAS, 2015) for "Does the income level of a neighborhood affect transit demand responsiveness?"

Joseph Schofer gave the 10th Annual Martin Wachs Distinguished Lecture in Transportation: When Forecasting Fails: Making Infrastructure Decisions in an Uncertain World at the UCLA Institute of Transportation Studies.

Karen Smilowitz, President, INFORMS Transportation Science & Logistics (TSL) Society, with Michael Hewitt and Maciek Nowark, organized and hosted INFORMS TSL First Triennial Conference in July 2017.

NUTC faculty and students gave presentations at the 95th and 96th Annual Transportation Research Board Meetings in Washington, DC. (story p. 76)

Transportation Library Director, Roberto Sarmiento, named 2018 Special Libraries Association (SLA) President.

Marco Nie and Amanda Stathopoulos are leading a NSF Partnerships for Innovation: Building Innovation Capacity research project on crowdsourced urban package delivery in collaboration with the Kellogg School of Management and the University of Illinois Chicago.

Governments & Agencies

NUTC hosted and Hani Mahmassani moderated a pre-ISTTT22 workshop with USDOT: *Getting There From Here: Traffic Modeling, Data Streams, & Prediction For Connected / Automated Vehicle Systems Planning & Operations* (story p. 65)

NUTC completed a technical assistance project for the Chicago Department of Transportation for Red Light Camera Enforcement: Best Practices and Program Road Map.

Victor Mendez, former deputy secretary of the US Department of Transportation, gave the keynote speech at "Mobility 2050: A Vision for Transportation Infrastructure and How We Can Get There," a symposium co-hosted by NUTC, the McCormick School of Engineering and Applied Science, and the Association of Equipment Manufacturers (AEM). (story p. 63)

NUTC and the Chicago Metropolitan Agency for Planning hosted a panel discussion: Have we reached peak driving? Planning for future travel in the Chicago region.

Business Advisory Council member and Sandhouse Group leader Norman Carlson unanimously elected as chairman of Metra (commuter rail) board.

Hani Mahmassani has partnered with Leidos on the Federal Highway Administration project: Analysis Modeling Simulation (AMS) Framework for Connected and Automated Vehicle (CAV) Applications. (story p. 25)

Hani Mahmassani participated in a special roundtable discussion, "The Road Ahead: Developing Technology and Policy to Accelerate the Safe Deployment of Connected and Driverless Cars," led by US Representative Dan Lipinski, Member of Transportation & Infrastructure Committee and Science, Space, & Technology Committee. (story p. 62)

Joseph Schofer serves on the Freight Committee and Bret Johnson serves on the Economic Development Committee of the Chicagoland Metropolitan Agency for Planning (CMAP).

Industry Collaboration

Kimberly Gray, Hani Mahmassani and Joseph Schofer presented results of the study, "Mobility 2050 A Vision for Transportation Infrastructure," at the Mobility: 2050 Symposium co-hosted by NUTC and AEM. (story p. 63)

NUTC hosted four Technical Industry Workshops: Machine Learning in Transportation; BioLogistics in a Changing Healthcare World; Innovation in Large-Scale Infrastructure Development; and Making the Customer Happy: Innovation & Best Practices. (stories pp. 67–71)

NUTC completed a study on intermodal container logistics with support from Hub Group.

NUTC conducted an extensive study on "Grain Industry Dynamics & Rail Service" with support from BNSF Railway, producing three reports: Analytical Models of Rail Service Operations; Trends in Grain and Soybean Economics; and Econometric Analysis of Rail Transport Rates.



International

International Symposia

NUTC hosted the 22nd International Symposium on Transportation and Traffic Theory (ISTTT22) at Northwestern University, July 24–26, 2017.

Learn more: sites.northwestern.edu/isttt22

Noshir Contractor delivered keynote addresses at:

- IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining
- NetSci Computational Social Science Conference

Hani Mahmassani delivered keynote addresses at:

- 3rd International Conference on Evacuation Modeling and Management, Tainan, Taiwan.
- 18th EURO Working Group on Transportation (EWGT 2015), Delft, The Netherlands.
- 2nd Interdisciplinary Conference on Production, Logistics and Traffic, Dortmund, Germany.
- 11th International Conference of the International Institute for Infrastructure Resilience and Reconstruction, Seoul, South Korea.
- 2nd NYUAD Transportation Symposium, Abu Dhabi, November 20–21, 2016.
- 6th International Symposium on Dynamic Traffic Assignment (DTA 2016) in Sydney, NSW, Australia.

In 2016 and 2017, NUTC faculty affiliates and students presented papers, conducted workshops and executive courses, gave talks, and participated in conferences in:

- Beijing, Harbin and Xi'an, China
- Clayton, Australia
- Delft, Groningen and Tilberg, The Netherlands
- Dortmund, Germany
- Florianópolis, Brazil
- Hong Kong, China
- Jeddah, Kingdom of Saudi Arabia
- Kobe and Kyoto, Japan
- La Rochelle, Lyon and Paris, France
- Pretoria, South Africa
- Seoul and Incheon, South Korea
- Tainan and Taipei, Taiwan
- Toronto, Ontario, Canada
- Singapore
- Southampton and Windsor, United Kingdom
- Vienna, Austria
- Zaragoza, Spain

International Research Collaboration

NUTC continued its partnership with the University of Chile through the International Time Use Observatory.

Marco Nie is an adjunct professor in the School of Transportation and Logistics at Southwest Jiaotong University (Sichuan, China).

International Governments & Industry

NUTC continued its advisory role in the development of a national Roads and Transportation Research Center for the Kingdom of Saudi Arabia's Ministry of Transportation, in collaboration with SETS, Inc.

Synergistic Institutes and Centers

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 generate 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.

Center for the Commercialization of Innovative Transportation Technology (CCITT)

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



(left to right) CCITT Director Bret Johnson, Joe Burns, Michael Drobac, Sean McCann, Hani Mahmassani.

Institute for Sustainability and Energy (ISEN)

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.



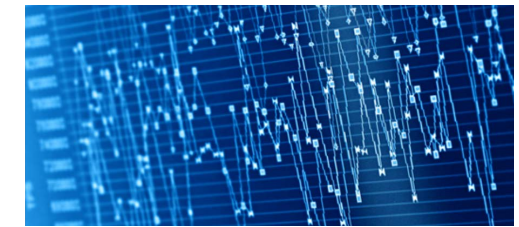
Transportation Library

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.



Northwestern Institute on Complex Systems (NICO)

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



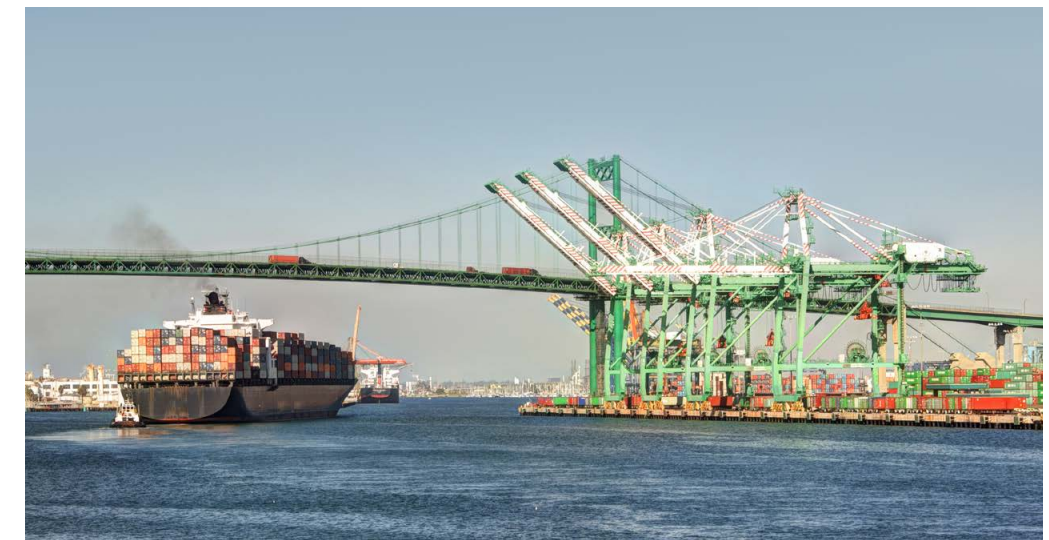
sustainNU

sustainNU is a university-wide program that aims to engage students, faculty, and staff in reducing—and eventually eliminating—Northwestern's contribution to climate change.



Center for Operations & Supply Chain Management (COSCM)

COSCM studies operational research questions in supply chain and other business contexts.



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.

Location

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

Hours: 8:30 am - 5:00 pm

Contact

transportationlibrary@northwestern.edu
847.491.5273

2017 Highlights

The Transportation Library completed projects to provide access to materials, adding over 23,434 e-books, e-journals, and e-reports to its catalog view. Digitization projects expanded access to Library collections including the Ira Silverman Railroad Menu Collection and the photo album Lou and Kate: Souvenir of Auto Trip to San Francisco, 1915.

The Library's outreach efforts included an open house in January to present its resources to Transportation Center faculty, staff, and students. Students and faculty alike received instruction on library databases, collections, and services throughout the year with instruction sessions and individual research consultations. The Library completed an extensive review and update of its subject- and course-specific research guides. Additionally, the Library reached an audience from around the world with several pop-up exhibits, including for groups of librarians visiting from China, Mexico, and France.

Two online exhibits debuted in 2017: in January, the library launched *Lovers of the Open Road and The Flying Wheel*, an immersive exhibit based on a photo album in the Library's collection chronicling a 1915 Iowa-to-San Francisco journey in a Model T.

On Board with Design: Passenger Transportation and Graphic Design in the Mid-20th Century launched in July, highlighting 20th century graphic design with items from the Library's archival, special, and circulating collections.

Librarians presented their work to several local and national audiences including at workshops and meetings for the Chicago Collections Consortium, the National Transportation Library, and the Special Libraries Association.

2016 Highlights

In 2016, the Transportation Library continued its support of transportation research by offering instruction sessions, individual research consultations, and reference assistance to Northwestern students, faculty, and staff. The Library continued to add both digital and print materials to its research collections, as well as special collections of rare books and ephemera, in addition to digitizing portions of those collections for access by researchers around the world.

In January, the Library opened an exhibition titled *Making Connections: Unique Gifts to the Transportation Library*, which showcased some of the Library's 14,000 items donated by scholars and transportation enthusiasts. In June, the Library debuted an online exhibition, *Bicycles on Paper*, which highlighted rare books and ephemera on bicycling at the turn of the twentieth century.

The Library's environmental impact statement (EIS) collection, one of the largest in the world, became accessible in full text through the Library's catalog, HathiTrust, and Google.

Transportation Library Director Roberto Sarmiento presented a workshop on the process titled "Developing an Online Database of Environmental Impact Statements" to Columbia University Law School's Sabin Center for Climate Change Law.



(left to right)
Transportation
Library Director
Roberto Sarmiento,
Public Services
Librarian
Rachel Cole, and
Library Assistant
Joe Ellison



Fine Books and Collections magazine featured the Library's Instagram account, transportationlibrary, in an article on the best rare books Instagram accounts around the world: [Instagram.com/transportationlibrary](https://www.instagram.com/transportationlibrary).

Director Roberto Sarmiento was elected President of the Special Libraries Association (SLA), an international organization with members in 75 countries around the world. He will serve as president-elect for 2017 and as the organization's President in 2018. Public Services Librarian Rachel Cole was elected secretary of the Midwest Transportation Knowledge Network. Library Assistant Joe Ellison began his term as treasurer-elect of the Transportation Division of the Special Libraries Association.

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 Transportation 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 at right.

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).

40+
YEARS OF NUTC
DEDICATION &
TRANSPORTATION
APPRECIATION

Celebrating Diana Marek

Thank You for Keeping NUTC in Motion!

After more than 40 years of service and dedication to NUTC Diana Marek retired from Northwestern University in January 2018. Diana began her NUTC career on February 14, 1977. The farewell honors and festivities were bittersweet, as Diana became NUTC’s cornerstone over the years. Her warmth, wisdom and ever-welcoming presence are truly irreplaceable and we will miss her dearly.



2017 EVENTS TO HONOR & THANK DIANA

JUNE 6 Diana is one of 163 honorees recognized at Northwestern's 40th Annual Staff Service Recognition Luncheon.

NOVEMBER 14 Diana is honored by Dean Julio Ottino & McCormick School of Engineering in Cohen Commons for the Staff Appreciation Awards. The staff appreciation event recognized 24 Northwestern Engineering staff members who have reached significant service milestones.

DECEMBER 7 NUTC director Hani Mahmassani hosts a retirement party for more than 150 of Diana’s friends, colleagues and fellow staff members at the Guild Lounge in Scott Hall to share cherished memories and celebrate pending retirement.



DIANA MAREK STUDENT EXPERIENCE FUND

Diana Marek’s dedication, service and role as Northwestern University Transportation Center’s (NUTC) cornerstone over the last 40+ years continues through support from generous donors like you.

The Diana Marek Student Experience Fund will support undergraduate and graduate students in their transportation career-enhancing education and research pursuits.

DONATE ONLINE <http://tiny.cc/NUTCgive>

Instructions: Select “Transportation Center” (Gift Designation) & enter “Diana Marek Fund” in space provided for “Other.”

MAIL DONATION 600 Foster Street, Evanston, IL 60208

Instructions: Make checks payable to “Northwestern University Transportation Center” w/ “Diana Marek Fund” in memo space.



Faculty Affiliates and Researchers

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AFFILIATED
FACULTY AND
RESEARCHERS

Jan D. Achenbach (McC)

Walter P. Murphy and Distinguished McCormick School Professor Emeritus of Civil and Environmental Engineering, Engineering Sciences and 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 and Environmental Engineering, Mechanical Engineering and 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 and 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*

Ying Chen (McC)

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

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*

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 and 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 and Management Science; Professor of Communications Studies *Social and knowledge networks; statistical and computational methods; organizational theory*

David Corr (McC)

Clinical Associate Professor of Civil and 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*

FM Feinberg School of Medicine

KM Kellogg School of Management

McC McCormick School of Engineering and Applied Science

MJ Medill School of Journalism, Media, and Marketing Communications

LB Northwestern University Library

AFFILIATIONS

CM School of Communications

LW Pritzker School of Law

WC Weinberg College of Arts and Sciences

LU Loyola University Chicago

UI University of Iceland / Chalmers University

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 and 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 and Environmental Engineering *Construction vibrations; structural health monitoring; subsurface exploration decisions*

David Dunand (McC)

James N. and Margie M. Krebs Professor of Materials Science and 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 and Environmental Engineering *Transportation infrastructure management; modeling and analysis of production control systems; capacity management; statistical performance modeling; contract analysis and design*

Alireza Ermagun (McC)

Postdoctoral Fellow *Smart cities/communities, travel behavior modeling, urban freight and logistics, social/economic impacts of transportation*

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 the Social Sciences *Macroeconomic theory; monetary theory; airline economics; airline management; airline history; airline customer experience*

Kimberly A. Gray (McC)

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

Michael Hewitt (LU)

Assistant Professor of Information Systems and 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 and 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*

Thomas N. Hubbard (KM)

Elinor and H. Wendell Hobbs Professor of Management Professor of Startegy *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 and Management Sciences *Logistics; applied microeconomic analysis; routing and risk analysis; facility locations; plant and equipment investment and replacement*

Seyed M.R. Irvani (McC)

Professor of Industrial Engineering and 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 and 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 and Physiology *Computational neuroscience; fiber optics; wave propagation; nonlinear dynamics; complex systems*

Leon M. Keer (McC)

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

Diego Klabjan (McC)

Professor of Industrial Engineering and Management Sciences; Director, Master of Science in Analytics Program *Machine learning and artificial intelligence—text analytics, deep learning, optimization; transportation, finance, healthcare*

Frank S. Koppelman (McC)

Professor Emeritus of Civil and 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 and 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 of Civil and Environmental Engineering; Director, NUTC; Professor, Managerial Economics and 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 and Management Sciences *Stochastic optimization and its application to energy, security, and health problems*

Barry L. Nelson (McC)

Walter P. Murphy Professor of Industrial Engineering and 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 and Environmental Engineering *Network optimization; traffic flow theory; traffic simulation*

Maciek Nowak (LU)

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

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*

Kalyan Raman (MJ, FM, KM)

Professor of Integrated Marketing Communications; Professor of Psychiatry and Behavioral Sciences; Affiliated Professor of Marketing *Integrated marketing communications; marketing mix optimization issues; sales force compensation; brand name recall and implications for advertising and market structure; pricing; diffusion models; supply chain management*

Mark A. Ratner (McC)

Lawrence B. Dumas Distinguished University Professor Emeritus of Chemistry and Materials Science and 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 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 and 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)

Charles Deering McCormick Professor of Teaching Excellence, Industrial Engineering and Management Sciences; Co-director, Center for Engineering and 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 and 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 *Investigation of circadian rhythms and their importance to human health, safety, performance, and productivity; relationship between abnormal sleep-wake cycles on fatigue and alertness in the workplace and transportation industry*

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 of the Kellogg Architectures of Collaboration Initiative (KACI) *Leadership, social networks, and big data*

Jan A. Van Mieghem (KM)

Harold L. Stuart Distinguished Professor of Managerial Economics; Professor of 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 and 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) *Advanced travel modeling research, oversight for USDOT and TRB research*

NEW Faculty Affiliates and Researchers

JOINED NUTC AS VISITING FACULTY IN 2017



Yoram Shiftan (McC)
Senior Research Fellow and Adjunct Professor

Professor of Civil and Environmental Engineering at Technion, the Israel Institute of Technology and Head of the Transportation Research Institute. Yoram Shiftan teaches and conducts research in travel behavior with a focus on activity-based modeling and response to policies, the complex relationships between transport, the environment and land use, transport economics and project evaluation. He is an active member of various Transportation Research Board (TRB) Committees and was the previous chair of the International Association of Travel Behavior Research (IATBR).



Nikolas Geroliminis (KM)
Research Fellow and Adjunct Professor

Associate Professor and Head of the Urban Transport Systems Laboratory, École Polytechnique Fédérale De Lausanne (EPFL). He is a member of the Transportation Research Board's Traffic Flow Theory Committee. His research interests focus primarily on urban transportation systems, traffic flow theory and control, public transportation and logistics, and optimization and large scale networks.

Richard Joseph Lifetime Social Justice Award from Dartmouth College in 2016



Hani Mahmassani Named to 2016 Class of National Associates by National Research Council of the National Academies.



Named the Recipient of the 2016 Thomas B. Deen Distinguished Lectureship Award

Yu (Marco) Nie Promoted to Professor of Civil & Environmental Engineering



Julio M. Ottino Received 2017 Gordon Prize: Innovative Engineering & Technology Education



Roberto Sarmiento Elected in 2017 as 2018 president of the Special Libraries Association (SLA)



Ian Savage Awarded Best Paper at 2017 Transportation Research Forum with undergraduate student, Caroline Miller (WCAS, 2015)



Received the Best Paper Award at the 57th Annual meeting of the Transportation Research Forum (TRF) in Toronto in May 2016 for his paper "Does the demand response to transit fare increases vary by income?" with Caroline Miller (BA, 2016)

Named President-elect of the TRF in 2016 and served as president in 2017

Appointed as a member of the National Research Council's Special Committee for the Study of Domestic Transportation of Petroleum, Natural Gas, and Ethanol in 2016

Mohanbir Sawhney Received the NASSCOM Thought Leadership Award at the National Leadership Forum, in Mumbai in February 2016 (NASSCOM is India's consortium for the IT and BPO industry.)



Joseph Schofer 2017 recipient of the S.S. Steinberg Award from the American Road and Transportation Builders Association



Karen Smilowitz (October 2017) Collaborated with a student team and Feinberg's George Chiampas to assist the Chicago Marathon by using data analytics to optimize the placement of medical tents and staff for the 26.2-mile course.

2016 recipient of the Award for the Advancement of Women in Operations Research and the Management Sciences by INFORMS

CIC Academic Leadership Program Fellow, 2015-2016



Faculty Affiliates and Researchers

Awards and Recognition

Zdeněk P. Bažant Elected to receive the Austrian Cross of Honor for Science and Art by President Heinz Fischer of Austria and was honored at a May 11, 2016, ceremony at the Hofburg Palace in Vienna



Elected to the Royal Society of London by the Royal Academy in 2016

Elected to the Academy of Athens in 2016

American Society of Mechanical Engineers (ASME) Medal in 2016

J. Edward Colgate Named Fellow of the National Academy of Inventors in 2016



Noshir Contractor Named Fellow of the International Communications Association (ICA) in 2016



Charles Dowding Named Distinguished Member of the American Society of Civil Engineers in 2016



Steven Franconeri Named to the 2016-17 Northwestern Associated Student Government Faculty Honor Roll



Richard Sobel Received 2017 NCTE George Orwell Award for Distinguished Contribution to Honesty and Clarity in Public Language



Amanda Stathopoulous



Appointed the William A. Patterson Junior Professor for 3-year term (2015–2018).

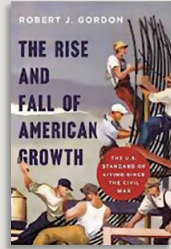
Named a recipient of the Alumnae of Northwestern University Award for Curriculum Development for 2017

Publications and Presentations

Robert S. Gordon

Boom vs. Doom: A Debate on the Future of the Economy

Gordon joined colleague Joel Mokyr in presenting opposing views on America's future at a special event hosted by the Chicago Council of Global Affairs in October 2016: "Boom vs. Doom: A Debate on the Future of the Economy."



Gordon delivered presentations at several 2016 economic conferences based on the observations outlined in his recent book, *The Rise and Fall of American Growth*. They included presentations at the International Monetary Fund Open Forum in Washington, the London School of Economics, the New York City Marco Advisers Outlook Conference and the CUNY Conversation with Paul Krugman.

Richard Joseph

State, Governance, and Democratic Development: The Nigerian Challenge

NUTC Faculty affiliate, Professor Richard Joseph traveled to Nigeria in June 2017 to present on the infrastructural challenges confronting the "pivotal nation." At seminars in four separate cities, he emphasized a need for greater discussion of "developmental governance and the building of coherent and effective democratic states."

Visit Professor Joseph's AFRICAPLUS blog: africaplus.wordpress.com



(left to right) Ayo Olukotun, Funso Adesola, Richard Joseph, and Mashood Omotoso following a roundtable at Obafemi Awolowo University, Ife-Ife.

Hani Mahmassani

Micro Models and Mega Data: Taming Complexity for Deep Insight and Robust Decisions

Mahmassani delivered the Thomas B. Deen Distinguished Lecture at the Transportation Research Board's January 2016 Annual Meeting in Washington, DC: *Micro Models and Mega Data: Taming Complexity for Deep Insight and Robust Decisions*.

He was also a keynote speaker at the May 2016 Swiss Transport Research Conference (STRC) in Monte Verità,

Ascona, Switzerland: *Autonomous Vehicles, Market Adoption and Flow Implications*.

Mahmassani also delivered the Keynote address at the June DTA2016, University of Sydney in Australia, an international scientific symposium at which academics, researchers, and model developers present novel methodologies and discuss new ideas on dynamic traffic assignment.

Mohanbir Sawhney

The Sentient Enterprise: A Revolutionary Approach to Agile Decision Making

In 2017, Teradata (a leadership level company member of NUTC's Business Advisory Council) hosted an executive invite-only Think Tank focused on "Analytics Innovation into the Future." It featured Teradata's EVP and Chief Product Officer, Oliver Ratzesberger, with Kellogg Professor and NUTC Faculty Affiliate, Mohanbir Sawhney, and their hot-off-the-press co-authored book, *The Sentient Enterprise: A Revolutionary Approach to Agile Decision Making*. Hani Mahmassani and Teradata Director Mary Gros attended the event.



(left to right) Ratzesberger and Sawhney sign a copy of their book for Mahmassani.

Joseph Schofer

When Forecasting Fails: Making Infrastructure Decisions in an Uncertain World

Schofer delivered the 10th Annual Martin Wachs Distinguished Lecture in Transportation, *When Forecasting Fails: Making Infrastructure Decisions in an Uncertain World*, at the UCLA Institute of Transportation Studies.

Jan Van Mieghem

Humans vs. Machines

Van Mieghem delivered the 12th Annual Meir Rosenblatt Memorial Lecture at Washington University in St. Louis on May 23, 2016: *Humans vs. Machines*. He also presented *Collaboration and Multitasking in Processing Networks: Humans versus Machines* at the CORE 50th Anniversary Conference in Louvain-la-Neuve, Belgium in May 2016. (CORE: Center for Operations Research and Econometrics).

Emerging Challenges in Transportation

Northwestern University Transportation Center (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.

Strategic Research Themes

NUTC'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 and devise methodologies to analyze these problems, formulate strategies, design solutions, and work toward implementation, testing and evaluation.

NUTC engages its faculty and industry partners in identifying strategic research areas with significant societal and industry impact, and spanning the interests of several faculty members. These areas share the following characteristics: Impact on society and industry; Significant opportunity drivers,

particularly technological developments; Fundamental and methodological challenges; Need for cross-disciplinary perspectives; and Strategic dimension. The list naturally evolves, along with strategic priorities, as emerging challenges become integrated, over time, in the core research areas for NUTC's researchers.

4
RESEARCH
THEMES
IDENTIFIED

- 1 **Smart Sustainable Cities—including connected systems, sustainability, and mobility in real time.**
- 2 **Humanitarian Logistics and Disaster Response—including large-scale event management.**
- 3 **Automation in Supply Chains and Logistics—including e-fulfillment, automated trucking, and unmanned aerial vehicles.**
- 4 **The User Experience: Revisited, Personalized and Gamified.**

1. Smart Sustainable Cities

Imagine the city as one big connected computing cluster, where myriad transactions (corresponding to financial, information, energy, material, people, and vehicle flows) are sensed in real time, where virtually all machines and people are interconnected, can provide status information passively, and can receive personalized information and instructions through various media. The city's vital infrastructure systems would be always-on, always-aware of the demands on their different components, and would accordingly adjust allocation of resources to meet and anticipate spatial and temporal patterns of demand. Entities would transact



seamlessly in that environment, matching customers to retail, recreational and other opportunities. In this environment, the user's urban experience would be paramount, while enabling sustainably optimized operation of vital infrastructures. Coupled with

innovations in physical and process design intended to achieve zero-net carbon impact in virtuous cycles of material and fluid flows, cities can learn and adapt toward achieving the dual goals of environmental and economic sustainability.

The vision of smart cities as the logical outgrowth of connectivity in an Internet of Things is not only the target of marketing efforts by virtually all major information technology providers, but increasingly an opportunity that is capturing the attention of public and private stakeholders in metropolitan areas. Additional opportunities arise from two key developments in automotive technology: electrification and autonomous vehicles. Both could thrive in a smart city environment, the ultimate smart grid for wirelessly-charging circulating vehicles, while autonomous vehicles of all types could fundamentally alter the economics of many forms of person and freight mobility.



Evolving the vision, and bringing even some of its elements to reality, raise critical challenges—technological, methodological, operational, organizational, and institutional, among others. NUTC research already informs several facets of the problem, such as use of real-time sensor and probe data for predictive system management and control, simulation and optimization tools for real-time operation of transportation and logistics systems, strategic and operational implications of connected and autonomous vehicles, 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 devices in the sharing economy. However, considerable fundamental and applied research and development is required to enable the vision and its promise. Safety and cybersecurity loom large as major considerations in any public deployments.

Through a series of industry workshops, NUTC has brought together leading industry participants, along with NUTC faculty, in delineating some of the challenges and opportunities in the evolving vision of the smart city. NUTC is actively engaged in expanding the multi-disciplinary community working on the multiple facets of these problems at Northwestern University, and in building partnerships with industry and public agencies to address the system-level aspects of these developments.



2. Humanitarian Logistics and Disaster Response

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) technologies, mobile communications platforms with social media features, optimization techniques, networking power, and the decision sciences are now 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 four interrelated fields: (1) humanitarian 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 event;



(3) logistics of organized mass events, such as marathons and other sports and cultural manifestations, celebratory events such as presidential inaugurations and visits by dignitaries, and religious manifestations such as the pilgrimage in Makkah, entails complex scheduling and routing of people and resources to ensure safe and successful operations; and (4) nonprofit logistics focuses on the operations of nonprofit organizations at local, regional and national levels.

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.

3. Automation in Supply Chains and Logistics

Freight and logistics are core topic areas for NUTC. 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 omni-channel presence and innovation.

NUTC research is particularly focused on the opportunities created by the transactional data generated through greater automation, the role of new technologies such as the blockchain, and the intersection between the logistics of e-fulfillment and 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 centers 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.

4. The User Experience: Revisited, Personalized and Gamified

Since the dawn of commerce, sellers have tried to understand what makes buyers click—beyond the obvious role of price. In an open market, users will typically have many options to meet their various needs for products and services, including transportation and travel. At a time when certain aspects of the travel experience appear to have reached abysmal lows (think long airport security lines, damaged packages, missed time 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. Reinventing the user experience is first about understanding its determinants, being able to measure it and quantify it, and figuring out how to target and influence it. The battle is no longer only about user satisfaction, but user delight, and, in the broader policy realm, happiness.

Generational change is a major factor in this focus—millennials (the generation born between 1984 and 2002) are believed to be more inclined towards purchasing experiences than mere products; they are also more intimately engaged with technology and their



personal connected devices, providing a ready platform for delivery of personalized interfaces, custom information and opportunities, as well as incentives. However, NUTC and other research shows that trends that may have originated with one or the other generational group rapidly spread to other groups, especially with regard to technology engagement.

NUTC research has long played a leading role in understanding and measuring travel behavior, and developing approaches to predict demand, and integrate these capabilities with decision-support systems for marketing and service design. This line of work continues, with renewed focus on the broader opportunities made possible by technology. For savvy companies, personal connected devices open a direct two-way route to the consumer, enabling preference measurement and targeting through personalized, customized, and increasingly gamified incentives and opportunities. While applications in private sector travel and retailing have grown considerably in the past few years, more timid experiments are beginning to appear in the public transport and mobility realm as well.

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 and individualized incentives.

Core Research

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. The ultimate end of NUTC's intensive research agenda is to help all these sectors move toward more efficient and responsive services and systems. NUTC's core research areas reflect this goal.

- 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

7 CORE RESEARCH AREAS

Analyze This! How to Plan for Connected and Autonomous Vehicle Technologies?

The past two decades have seen substantial integration of advances in wireless communication, digital processing, and sensing technologies into traffic management systems, with the goal of enhancing efficiency, productivity, sustainability, safety, and reliability of these systems. The next major wave of technological innovation seeks to impact the system through vehicle-based innovation. Autonomous vehicles have been prototyped with substantial advances in sensing technologies and associated pattern recognition and control intelligence, while pervasive wireless communication technologies provide the opportunity to create an internet of vehicles where individual vehicles can communicate with other vehicles (through Vehicle-to-Vehicle (V2V) communications) and the infrastructure (through Vehicle-to-Infrastructure (V2I) communications). Consequently, virtually all aspects of driver decision making, from strategic to operational decisions, would be impacted and generally enhanced through connectivity. Eliminating drivers altogether through automated logic further enables robotic-like control of vehicular flow.

The implications for traffic and urban systems can be profound, and far reaching. Most large cities in the US are afflicted with severe congestion and air quality problems, and both budget limitations and social resistance preclude major infrastructure investment. There is therefore considerable interest in the potential for traffic system efficiency gains through con-

nectivity, coupled with autonomous fleets that offer opportunities for reduced environmental footprint through greater reliance on clean energy sources.

Technological change of this nature, scope and potential raises many questions for planners, policymakers, and transportation researchers. Starting from shifts in economic, business and social activity patterns, and the attendant changes in the demand for mobility, and on to changes in mobility service supply patterns, to implications for investment in infrastructure and how to finance them, to urban livability and sustainability, planners and policymakers face greater strategic uncertainty than at any time in recent memory. To help navigate this uncertainty, and help reduce congestion and make cities more sustainable, planners and engineers need tools and techniques to analyze the impact of these technologies, and evaluate the desirability of different measures and investment in deployment options.

Are agencies charged with planning and operating traffic systems sufficiently ready to address and meet the challenges brought on by still-unfolding technological realities? Two projects, funded by the US Department of Transportation, are helping address this gap.

PROJECT 1 TITLE: *Developing Analysis, Modeling, and Simulation (AMS) Framework for V2I and CV Environment*

NUTC PI: Hani Mahmassani

Current traffic analysis tools are not well suited for evaluating connected and automated vehicle tech-

nology applications due to their inability to incorporate vehicle connectivity as well as autonomy. Furthermore, guidance on how these traffic analysis tools can be extended to evaluate connected and automated vehicle applications is nonexistent.

At the planning level, transportation agencies use sketch planning tools and travel demand models to evaluate transportation improvement projects. Current sketch planning tools are unable to estimate the impacts of connected and automated vehicle technology applications, which would need to be informed by literature and past studies. Similarly, existing travel demand models are unable to account for mode shifts associated with connected and automated vehicle technology, or for the changes in household activity and travel patterns enabled by autonomous vehicle capabilities. The lack of analysis tools for connected and automated vehicle technology applications prevents effective planning, and consequently the ability of agencies to deploy these technologies.

Traffic simulation tools, which are often used to evaluate a wide range of operational strategies or roadway modifications across an entire network, lack the appropriate micro behavior mechanisms required to model and estimate the impacts of connected and automated vehicle technology applications. Off-the-shelf traffic simulation tools are unable to emulate the communications and sensing capabilities present in connected and automated vehicles.

In order to quantify/evaluate the full impacts of connected and automated vehicle technologies on the transportation system, transportation agencies must be equipped with the necessary traffic analysis, modeling and simulation tools needed to predict potential impacts and support decision making, both at the planning and operational levels. This is particularly important for achieving V2I connectivity, as public agencies must have the information and tools to justify, plan, and operate the infrastructure investments that enable V2I applications.

This research lays a foundational framework for the development of AMS tool capability that includes connected and automated vehicles, and engages in small-scale V2I AMS development using this framework that encourages future development activities, toward a vision where practitioners have CAV-aware tools available.

PROJECT 2 TITLE: *Developing Analysis, Modeling, and Simulation (AMS) Tools for Connected and Automated Vehicle (CAV) Applications*

NUTC PI: Hani Mahmassani (in collaboration with UC-Berkeley, Texas A&M and Leidos, Inc.)

Although several research projects, sponsored by 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 are needed for deployment support.

This research will: (1) develop AMS tools for the most prominent CAV applications; (2) incorporate these tools into existing AMS products, improving the state-of-the-practice; and (3) conduct real-world case studies (practical implementation scenarios and real-world transportation networks) for the most prominent CAV applications to better understand their impacts and deployment strategies/methods.

Traffic Analytics: Recalibrating Industry Practices

PROJECT TITLE: *Role of Calibration in Quantitative Alternatives Analysis*

NUTC PI: Hani 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.

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. The importance of calibration cannot be over-emphasized because no single model can be expected to be equally applicable for all possible traffic conditions.

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. 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 just plain wrong.

Different calibration methods need to be developed so that the tools are calibrated to data that are reflective of what the future condition will be. The scope of this project is to provide guidance for transportation professionals on how to calibrate analytical tools to data that are reflective of the conditions that the tool is being used to predict future performance. The methodology that is developed in this project will

allow 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.

How Reliable is this Route?

PROJECT 1 TITLE: *Estimation of Travel Time Distributions along User Defined Travel Paths*

NUTC PI: Hani Mahmassani

Travel time reliability (TTR) has been established as a robust method for understanding and evaluating travel and transportation system performance. TTR is applicable at a facility-level or as a user-centric measure. Facility-based measures developed through the SHRP2 research program are well documented. They are typically measured at a spot or link level. Spot level measures are often expanded to indicate performance along a series of road segments. Traveler-based, or user-centric measures have not been as thoroughly investigated. Traveler-based data have the distinct advantage over facility-based performance indicators of directly describing traveler performance at individual or group levels, as they capture the variability of travel times along any user-defined path, sets of paths, subareas, or origin-destination pairs. 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 factors 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, and different methods measure different properties of travel.

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

This research develops the methods to successfully synthesize and replicate traveler-based distributions of travel time along continuous paths regardless of facility type. The methods use numerical integration based on Monte Carlo sampling of empirical vehicle-based or person-based data. Methods are validated based on observed data from travel trajectories.

The research will result in practical techniques to use empirical data as the basis for summarizing a full range of traveler performance along a path, along multiple paths between origin and destination, or at a link, facility, or system level under a variety of conditions. The methods will be used to support performance evaluation; enhance model calibration and validation; and provide a sound basis for making routing decisions taking known risks into account.

PROJECT 2 TITLE: *Fundamentals of Travel Time Reliability Guide*

NUTC PI: Hani Mahmassani

Travel time reliability (TTR) is a principal focus of the second strategic highway research program (SHRP2). The reliability program took shape 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 moving away from using average outcomes (e.g., average travel times under “typical” conditions) and single measures as the basis of quantifying performance. Travel time reliability 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, FHWA has found that practitioners, researchers, and advanced users of the reliability tools find it challenging to develop data associations in multiple dimensions, understand probabilistic outputs, and acknowledge the inherent variabilities and uncertainties associated with reliability analyses. They also find it challenging to convey results infused with uncertainties to other analysts, managers, decision makers, and the public.

There is room for improvement. While the uncertainties associated with reliability are difficult and challenging, the central concept of reliability itself is readily understood by most people. This research acknowledges the challenges of working within univariate and multidimensional reliability spaces and guides practitioners toward working comfortably with probability distributions and underlying data full of noise and contradictions.

More Options for Smart Urban Mobility

PROJECT TITLE: *Multimodal Network Modeling for Integrated Planning of Shared Autonomous Fleet Mobility and Transit Services*

NUTC PI: Hani Mahmassani

Rail and bus transit provide large volumes of travelers high-quality affordable transportation service. However, in most urban areas many origin-destination (OD) pairs are poorly served or completely inaccessible via fixed-route transit, especially during the off-peak period. Ridesourcing can fill in fixed-route transit gaps in a cost-effective manner. Furthermore, the advent of autonomous vehicles has the potential to change the economics ownership and use of private automobiles, likely accelerating trends towards greater use of app-based ride hailing and/or sharing by private TNCs (Transportation Network Companies), through shared autonomous vehicle (SAV) fleets. When intelligently integrated with conventional transit, the resulting multimodal network could provide higher service levels to more people at a fraction of the cost of conventional transit.

There is a need for research that provides transportation planners (at transit agencies, regional planning organizations, and mobility service companies) modeling tools to plan and design multimodal transportation systems and evaluate the economic and societal benefits of different alternatives. Hence, we propose an agent-based, integrated mode choice and dynamic traveler assignment-simulation model that explicitly incorporates multimodal (car, bus, rail, biking, walking, SAV) travel alternatives and models transit systems and SAV services. Several potential business models with varying degrees of ride sharing and public vs. private involvement in the delivery of mobility as a service (MaaS) are considered in this study. Algorithms for SAV fleet management are developed, then integrated in an intermodal network modeling framework, applied to the Chicago region to evaluate the impact of new services on mobility and sustainability.

By reinventing themselves as mobility agencies, public transit companies can leverage these developments to focus resources on providing high-quality services along high-density lines, resulting in significant improvement in overall urban and regional mobility.

Cloudy with a Chance of Internet

PROJECT TITLE: *Mile High WiFi: A First Look at In-Flight Internet Connectivity*

NUTC PI: Fabian E. Bustamante

In-Flight Communication (IFC), which can be purchased on a growing number of commercial flights, is often received by consumers with both awe for its mere availability and harsh criticism for its poor performance. Indeed, IFC provides Internet connectivity in some of the most challenging conditions with aircraft traveling at speeds in excess of 500 mph at 30,000 feet above the ground. Yet, while existing services do provide basic Internet *accessibility*, anecdotal reports rank their quality of service as, at best, poor.

This work presents the first characterization of deployed IFC systems. Using over 45 flight-hours of measurements, the study profiles the performance of IFC across the two dominant access technologies — direct air-to-ground communication (DA2GC) and mobile satellite service (MSS). It is shown that IFC QoS (Quality of Service) is in large part determined by the high latencies inherent to DA2GC and MSS, with RTTs averaging 200ms and 750ms, respectively, and that these high latencies directly impact the performance of common applications such as web browsing. While each IFC technology is based on well-studied wireless communication technologies, the study findings reveal that IFC links experience further degraded link performance than their technological antecedents. In particular, median loss rates of 7%, and nearly 40% loss at the 90th percentile for MSS, are an order of magnitude larger than recent characterizations of residential satellite networks.

The study is further extended to explore the potential of the newly released HTTP/2 and QUIC protocols in an emulated IFC environment, finding that QUIC is able to improve page load times by as much as 7.9 times. In addition, HTTP/2's use of multiplexing multiple requests onto a single TCP connection performs up to 4.8x worse than HTTP/1.1 when faced with large numbers of objects. Using network emulation to explore proposed technological improvements to existing IFC systems, it is shown that high link losses account for the largest factor of performance degradation, and that improving link bandwidth does little to improve the quality of experience for applications such as web browsing.

With All Due Consideration

PROJECT TITLE: *Forecasting Technological Impacts on Customers' Consideration Behaviors: A Data-Driven Network Analysis Approach*

NUTC PI: Wei Chen

Forecasting customers' responses and market competitions is essential before launching major technological changes in product design. In this research, we present a data-driven network analysis approach to understand the interactions among technologies, products, and customers. Such an approach provides a quantitative assessment of the impact of technological changes on customers' co-consideration behaviors. The multiple regression quadratic assignment procedure (MRQAP) is employed to quantitatively predict product co-consideration relations as a function of various effect networks created by associations of product attributes and customer demographics. The uniqueness of the proposed approach is its capability of predicting complex relationships of product co-consideration as a network. Using vehicles as a case study, we forecast the impacts

of two technological changes — adopting the fuel economy-boosting technology and the turbo engine technology by individual auto companies. The case study provides vehicle designers with insights into the change of market competitions brought by new technological developments. The proposed approach links the market complexity to technology features and subsequently product design attributes to guide engineering design decisions in the complex customer-product systems.

What Drives Auto Buyers in China?

PROJECT TITLE: *Analyzing and Predicting Heterogeneous Customer Preferences in China's Auto Market Using Choice Modeling and Network Analysis*

NUTC PI: Wei Chen

As the world's largest auto producer and consumer, China is both the most promising and complex market given the country's rapid economic growth, huge population, and many regional and segment preference differences. This research is aimed at developing data-driven demand models for customer preference analysis and prediction under a competitive market environment. Regional analysis is first used to understand the impact of geographical factors on customer preference. After a comprehensive data exploration, a customer-level mixed logit model is built to shed light on fast-growing vehicle segments in the Chinese auto market. By combining the data of vehicle purchase, consideration, and past choice, cross-shopping behaviors and brand influence are explicitly modeled in addition to the impact of customer demographics, usage behaviors, and attributes of vehicles. Scenario analyses are performed for segment demand forecasting by examining influencing factors such as economic change, fuel economy improvement and infrastructure development. Finally, a new network analysis approach is proposed to model customer cross-shopping behaviors that can inform the firm about the implied market structure and product competitive positioning. Our proposed approach is demonstrated by using a rich set of market data collected in China.

Charging Ahead: EV Swap Meet

PROJECT TITLE: *Optimization of Battery Charging and Purchasing at Electric Vehicle Battery Swap Stations*

NUTC PI: Diego Klabjan

An operator of a network of battery swap stations for electric vehicles must make a long-term investment decision on the number of batteries and charging bays in the system and periodic short-term decisions on when and how many batteries to recharge. Both decisions must be made concurrently, because there

exists a trade-off between the long-term investment in batteries and charging bays, and short-term expenses for operating the system. Costs for electric energy as well as demand rates for batteries are stochastic. In this study, the researchers consider an infinite time horizon for operation of the system. An optimization problem is derived, which cannot be solved optimally in a reasonable time for real world instances. By optimally solving various small problem instances, the mechanics of the model and the influence of its parameters on the optimal cost are demonstrated. A near-optimal solution heuristic based on Monte Carlo sampling is developed, following the ideas of approximate dynamic programming for the infinite horizon dynamic program. The numerical experiments demonstrate that operating battery swap stations in a network where lateral transshipments are allowed can substantially decrease expected operating costs.

Out of This World Performance

PROJECT TITLE: *CREWS: Crew Recommender for Effective Work in Space*

NUTC PI: Noshir Contractor

Team composition, the configuration of member attributes and their relationships, is a critical feature to enable effective teamwork and will play an important role in the success of future long-distance space exploration (LDSE). Research on team composition in LDSE is limited, and it is unclear how to optimize team composition to improve team performance in these environments. Our research aims to: (1) identify the effects of team composition on team functioning in LDSE and the critical factors of team composition driving this effect, (2) identify particular patterns of this effect with different team compositions, (3) identify methods, best practices, and technologies that improve team functioning and performance through team composition, (4) develop a predictive team composition model for use in composing teams and identify potential issues with already composed teams, and (5) provide recommendations for composing teams for LDSE. Team composition is expected to affect mission success through four paths that highlight the role of social integration, team processes, and emergent states, both between and within teams. Understanding these paths helps to identify the personal, relational, and network factors, as well as key moderators that influence the relationship between team composition and performance in LDSE. To address the above aims, we are in the first year of a 3-year, multi-method research effort, to identify psychological and psycho-social factors that can be used to compose highly effective crews (Team Gap 8). Specifically, we will (1) develop an agent-based model of team composition for LDSE based on empirical data linking key model inputs to team functioning

(e.g., social integration, team processes, team cohesion, team conflict) in LDSE-relevant contexts, (2) conduct virtual experiments using characteristics and relationships identified in Phase I to identify the team functioning patterns that arise under different member compositions, and create a predictive model of team composition; and (3) conduct an initial validation of the model developed in Phase 2 in LDSE-analog environments, using specific manipulations of key factors (e.g., compositions; situational characteristics). These research products will allow us to develop a predictive model of team composition in LDSE, and a mockup of a proposed interface to assist in the staffing and management of LDSE crew and mission teams.

Multitasking in Hyperspace

PROJECT TITLE: *Team Task Switching in Astronaut Crews on the International Space Station: Integrating Multiteam Membership, Multiteam Systems, Multitasking, & Multidimensional Networks to Monitor & Enable Functional Work Shifts in Astronaut Crews (NNX15AK73G)*

NUTC PI: Noshir Contractor

Moving beyond low Earth orbit and the relative safety of the International Space Station (ISS) toward near-Earth asteroids and Mars present previously unimaginable opportunities as well as organizational challenges. One significant challenge is the complexity of the operating environment within which astronauts will work. This complexity will place enormous demands on astronauts, and research is needed that develops concrete countermeasures to mitigate the risks stemming from performance decrements due to inadequate cooperation, coordination, communication, and psychosocial adaptation within a team.

Interviews with current and former astronauts as well as reports from astronauts on the International Space Station (ISS) reveal the potential for decrements in crew performance stemming from difficulties in 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 urgency (e.g., Extravehicular Activity - EVAs, spacecraft maintenance).

Investigators define this as a problem of team task switching. Team task switching impacts the cognitive, motivational, behavioral, and performance effects that result when individuals respond to changing work demands within teams. Changes requiring members to switch tasks, switch teammates, and/or switch

tools and technologies deplete attentional resources and make additional cognitive processing demands, which in turn affect the potential for adaptive and seamless task switching. 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 at yet other times, they work as a part of a large system of teams. Hence, 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).

Back to School

PROJECT TITLE: *Using Operations Research to Integrate Support Services into Public Service System Planning*

NUTC PI: Karen Smilowitz

The objective of this award is to show how operations research can facilitate the integration of support services, such as transportation and logistics, into broader system decision making to improve the overall system. This project focuses on bus transportation within a public school system to demonstrate these ideas. The work expands a partnership between Evanston/Skokie District 65 (D65), a pre-K-8 public school district north of Chicago, and Northwestern University, focused on bus transportation, looking for opportunities to save costs while maintaining service. This work addresses a critical problem faced by many public school districts; it is anticipated that these results can be applied to other school districts and public service systems. Working closely with school district administration and teachers, the research team aims to provide comprehensive, high quality solutions that are easy to implement. Undergraduate research is an instrumental component of this project. Participating students will learn valuable lessons about the implementation of model solutions in real-world contexts, and the challenges that result as assumptions and input data change. Further, this work will impact curriculum at multiple levels at Northwestern University and D65 schools. The educational component involves D65 teachers in efforts to develop teaching modules for younger students. Such modules can help younger students understand the complexities of a practical problem (transportation planning), while helping them to ground fundamental mathematical concepts in real-world contexts.

The results of this research will lead to advances in route optimization modeling and solution approaches,

contributing to a growing literature on routing problems with special network structure. In the school bus routing literature, bus stop selection and bus route generation are approached either independently or jointly, typically with integer linear programming formulations. Depending on the complexity of the underlying problem setting, solutions are derived from exact methods or heuristics. This work introduces an innovative approach to the joint problem of bus stop selection and bus route generation, leveraging the underlying grid-like structure of the road network to obtain robust, easy-to-implement solutions. The research begins with analysis of the single vehicle covering tour problem on a complete grid to establish fundamental principles; then the problem setting is generalized to ultimately address the complexities of public service systems. In later years, the research focus expands more broadly to decision making for support systems within public service systems. Ultimately, this work will demonstrate the ability of operations research techniques to improve support services for public service systems, providing much-needed cost savings in budget-constrained environments.

Following the Crowd

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

NUTC PI: Karen Smilowitz

This National Science Foundation (NSF) Partnerships for Innovation (PFI) program: AIR Technology Translation (AIR-TT) project focuses on translating operations research models and data analytics to improve situational awareness and decision making for mass gathering events. This research significantly expands the development of a Data Visualization System focused on medical preparedness for mass gathering events, originally conceived for marathons. This system has been created for event organizers and relevant stakeholders to effectively manage and oversee all participants, monitor the dynamic location of participants, and manage health and safety resources throughout the event, both under normal operating conditions and in the event that emergency issues arise. The system provides a dynamic representation of the flow of people and resources: at the core is a novel simulation tool that predicts and displays runner density on the course over time. While this system was initially developed for marathons, its applicability can go beyond endurance events. Such mass gathering events are growing in popularity, and thus require significant resources to ensure safety and success. Event management tools have not grown to meet this need. This project is designed to address gaps in event management tools. The data visualization system is the first comprehensive dashboard for endurance event management. The project will result in a significant ramp-up of the current prototype of the

data visualization system to expand functionality and make the system more turn-key. The project will also result in the development of a business plan for commercialization, working with Northwestern University's Innovations and New Ventures Office (INVO).

Reuse and Recycle

PROJECT TITLE: *Green Simulation: A Methodology for Reusing the Output of Past Computer Simulation Experiments*

NUTC PI: Barry L. Nelson

The proposed research will involve designing, analyzing, and testing algorithms for computer simulation experiment design and analysis. The objective is to improve the computational efficiency of stochastic simulation experiments in settings where there is a sequence of repeated experiments using the same simulation model with different inputs. The proposed algorithms will improve efficiency of later experiments by storing and reusing the output of earlier experiments. In contrast, standard practice is to perform and analyze every experiment in the sequence separately, throwing the output of an experiment away as soon as it delivers an answer. The methods to be employed to reuse the output of experiments include the likelihood ratio method, metamodeling, and variance reduction techniques for stochastic simulation. In designing and analyzing the resulting algorithms, we will leverage existing knowledge on simulation experiment design and analysis, including optimal design of experiments, metamodel validation, and adaptive sequential experiment design. The proposed algorithms will be tested in computer experiments using examples, representative of realistic applications, of sequences of repeated 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, will be measured in terms of reduced computational cost given a target accuracy, or in terms of increased accuracy given a fixed computational budget.



4

INDUSTRY
RESEARCH
AREAS

- Freight, Logistics & Economic Competitiveness
- Data-Driven Operations & Analytics
- Sustainable Practices
- Safety
- Urban Logistics & Smart Cities

Industry Research

NUTC strives to be an industry-responsive academic partner for novel, high-impact collaborative research. Throughout 2016-17, NUTC conducted technical “knowledge exchanges” with several companies in the freight, logistics and transportation management industries, including AT&T, Boeing, BMW Technology Group, Echo Global Logistics, HERE, Hub Group, IBM, Jacobus Energy, Karma Automotive, SEKO Logistics, and Uptake Technologies.

Blazing New Trails for Delivery Services—One Gig at a Time

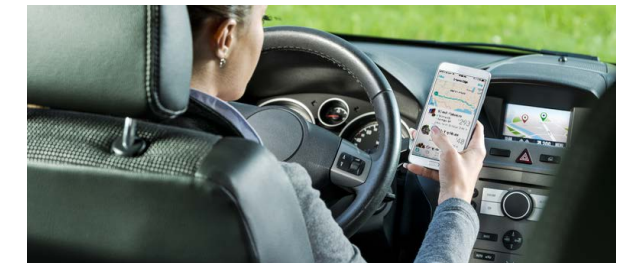


Professor Marco Nie and Professor Amanda Stathopoulos led a National Science Foundation Partnership for Innovation: Building Innovation Capacity research project in partnership with the University of Illinois at Chicago (UIC) to study the behavioral, market, optimization and computation challenges of a proposed crowd-sourced goods delivery system. The project leveraged the resources of the Center for Commercialization of Innovative Transportation Technology (CCITT) at Northwestern and the Center for Supply Chain Management and Logistics at UIC together with the business operations of primary industrial partner, Roadie, an “on-the-way delivery network” company that provides “gigs” to drivers who move goods for Roadie’s customers. The ultimate goal was to develop and evaluate a smarter, faster, and greener urban delivery service system by developing, enhancing and expanding the capabilities of a CROWD-sourced Urban Delivery (CROUD) technology.

The research team’s expertise spanned four relevant yet distinctive disciplines and three NSF divisions, namely transportation systems engineering and design (NSF-CMMI), economic theory and market science (NSF-SBE), computer and information science (NSF-CISE), and behavioral science (NSF-SBE). To encourage cross-discipline collaborations between Northwestern and UIC, Professor Nie managed and coordinated the project among three primary research teams: James Schummer, Associate Professor of Managerial Economics & Decision Sciences (Northwestern), led a business analytics group focused on developing a pricing and load matching system; Ouri Wolfson, Professor of Computer Science (UIC), led a behavior and data group focused on developing a consumer and

courier management and data dashboard system; and Nie led an operational tactics group focused on developing a collaborative delivery and routing system.

The rapid rise of e-commerce and demands for same day or next day delivery as an integral part of the shopping experience inspired the research team to investigate crowd-sourced delivery as part of the solution to the urban delivery challenge. The scope of



this challenge required scientific contributions from the team across several disciplines and has resulted in multiple outcomes, including:

- Pricing mechanisms that focus on matching consumers with couriers under varying market conditions. The use of matching models is novel in pricing analysis for two-sided markets found in CROUD systems, and it promises insights in other markets.
- Understanding and predicting behaviors and choices of humans in a CROUD system, a field new to behavioral econometrists. New econometric models, calibrated against behavioral data collected in this project, will be built into management strategies to enhance the consumer-courier-technology interaction in the system.
- Smartphone-based motion detection methods that are uniquely suited to track and interpret the activities of couriers.
- Computational tools to facilitate collaborative delivery among couriers and to optimize routing plans based on real-time information.

Partnering with Roadie has generated several benefits for the academic partners. Roadie was generous

in providing detailed data, continuously updating it with an online database that was essential to the research progress. Through regular project discussions, Roadie shared valuable insight about ongoing initiatives, business decisions, and research needs related to its delivery operations. And most importantly, the connection with Roadie allowed the research team to validate, explain and further improve the interpretation of several of the empirical models developed by various team members, such as duration models, logistic regression on bids, and discrete choice models.

The project has and continues to contribute to the education and training of multiple graduate and undergraduate students, as well as new materials for

upgrading curricula in multiple scientific disciplines. The project involved two PhD students from Civil and Environmental Engineering Department at Northwestern, one PhD student from Kellogg School of Management at Northwestern, two PhD students from UIC, and one PhD student from Georgia Institute of Technology working at Roadie as a summer intern.

Research team members have generated multiple research papers, presentations and proceedings from the CROUD research, notably a special virtual issue on “Emerging Urban Mobility Services: Characterization, Modeling and Application,” organized by Drs. Nie, Jane Lin (UIC), and Amanda Stathopolous for the *Journal Transportation Research Part C: Emerging Technologies*.



and provides opportunities for student teams to build business cases under the guidance of industry experts. 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. Bret Johnson works closely with Werwath to assemble a diverse advisory board for the class, which serves as a mentor group for the students to ground them in a realistic product to market alignment. Advisory board members have included former NUTC BAC member Tony Belkin, and Chris Pickett from NUTC BAC Leadership member company Coyote Logistics.

In 2016, NUTC issued its third report, “Econometric Analysis of Rail Transport Rates,” related to the dynamics of the grain production industry and the rail service in the US that support grain shipments domestically and internationally. The previous two reports issued in 2015 were *Analytical Models of Rail Service Operations* and *Trends in Grain and Soybean Economics*.

The Staggers Act of 1980 gave railroads considerable flexibility in terms of price discrimination. Despite expectations of the contrary, rail transport rates decreased for most shippers after the Staggers Act. The Surface Transportation Board (STB) handles rate disputes between shippers and railroads due to the fact that in certain regions of the country railroads face little to no competition. The STB collects a one percent stratified sample of all waybills in the US. In addition to the use of the waybill data by the STB, a version of the data is available to the public to analyze rail transport rates. This report uses the STB carload waybill sample (CWS) to analyze grain rail transport rates and rail transport rates in the Upper Midwest. The goal of the analysis is to determine if (1) grain shippers in the Upper Midwest paid higher or lower rates than grain shippers in other regions of the country and (2) grain shippers in the Upper Midwest paid higher or lower rates than other commodity shippers in the Upper Midwest. The analysis also determines the types of shipments (e.g., long-distance shipments, high number of railcar shipments, etc.) that received (paid) rail transport rate discounts (premiums).

The CWS is a very large data set; it was necessary to conduct an in-depth exploratory analysis of the data. First, the exploratory analysis revealed errors in the dataset; therefore, the data was cleaned and also filtered to remove extreme outliers. The data exploration procedures uncovered correlation between variables

in the dataset and also determined important temporal trends of specific variables. The data exploration results informed the econometric models, which were developed to further analyze the CWS and rail transport rates. Multivariate regression models were developed to analyze rail transport rates and answer the research questions posed in the background section. In order to answer the aforementioned research questions, the CWS dataset was segmented by commodity-type and region of origin.

The econometric model results indicate that rail transport prices increased significantly, in real terms, between 2001 and 2013 with most of the increase occurring between 2004 and 2012. Further analysis showed that although rail transport prices increased in the Upper Midwest and for grain shipments, the increase was consistent with a general increase in rail rates during the period from 2001 to 2013. The regression model results show that grain shippers received lower rates than many other commodity types, and shippers in the Upper Midwest received lower rates than many other regions of the country. Moreover, grain shippers in the Upper Midwest received lower rates than (1) grain shippers in other parts of the country and (2) other commodity shippers in the Upper Midwest. These results were obtained while simultaneously taking into account and measuring the impact of shipment characteristics.

Boeing Supports Launch of NUvention: Transportation



Through the generous gift from the Boeing Company, the Farley Center for Entrepreneurship and Innovation at the McCormick School of Engineering, in collaboration with NUTC, launched the inaugural NUvention: Transportation course in the fall 2016 academic quarter. NUvention: Transportation is an interdisciplinary, experiential course designed to teach students about creating businesses in the transportation industry. The inspiration for the course grew from the strong research relationship between NUTC and Boeing, as well as the leadership from Northwestern’s Corporate Engagement office, which secured financial support from Boeing to support innovation and design engineering undergraduate and graduate educational programs.

Farley Center co-director Mark Werwath led both offerings of the course in fall 2016 and fall 2017. The course addresses the evolutionary and revolutionary changes that are impacting the world of transportation,

BNSF Project on Track and Impacting Supply Chain Workers across the Country



Mobility 2050: A Vision for Transportation Infrastructure



The Association of Equipment Manufacturers (AEM) sponsored an in-depth study, “Mobility 2050: A Vision for Transportation Infrastructure,” performed by NUTC, which examined the future trends and opportunities influencing how US transportation infrastructure will move people and goods in the year 2050. The report was developed as part of AEM’s Infrastructure Vision 2050 Task Force, a thought leadership initiative focused on crafting a vision for a long-term, national plan for U.S. infrastructure and how people, freight, and energy will move in the future.

NUTC director Hani Mahmassani led the study in collaboration with Joseph Schofer, associate dean at the McCormick School of Engineering. Mahmassani and Schofer hand-selected and led a multi-disciplinary team of Northwestern and Loyola University of Chicago experts in civil and environmental engineering, economics, logistics, supply chain management, and sustainability in the exploration of the factors,

technologies and trends facing US transportation infrastructure in the next 35 years.

The 168-page report, developed through multiple workshops with the experts and AEM staff, includes forward-looking assessments on ten topics impacting future infrastructure decisions and outcomes. The report features chapters on: “Where We Stand: Transportation Infrastructure Today” by Lama Bou Mjahed and Joseph L. Schofer; “Transportation Infrastructure and Economics” by Ian Savage (NUTC); “Technological Innovation and the Future of Urban Personal Travel” by Hani S. Mahmassani; “Information and Communication Technologies and Transportation” by Fabian Bustamante (NUTC); “Supply Chain Management, Logistics and Transportation Infrastructure” by Mike Hewitt (Loyola); “The Evolution of Retail Through Omni-Channel Retailing” by Sunil Chopra (Northwestern); “Addressing the Challenges of Transportation Infrastructure Condition” by Gianluca Cusatis; “Transportation Infrastructure and the Future of Cities” by Kimberly A. Gray; and “Paying the Way for Future Transportation Infrastructure” by Joseph L. Schofer.

AEM and NUTC unveiled the study during a symposium hosted by AEM and NUTC at the McCormick School of Engineering during Infrastructure Week 2016.

Education Academic Programs

8

GRADUATE-LEVEL
DEGREES
RELATED TO
TRANSPORTATION

Northwestern University 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.

Academic Programs

Northwestern's specialized academic programs in transportation are thorough, with a program structure that balances highly technical quantitative training in engineering and mathematics with theories and applications drawn from relevant disciplines such as economics, management, finance, marketing, energy, and the social sciences. Each section involves rigorous coursework, opportunities to become involved in research, and exposure to real-world learning experiences in industry.

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 and 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 and 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.

Application areas range from traditional uses of industrial engineering in manufacturing firms to the broader variety of management science models in the service sector, finance, and public policy, including supply-chain management and logistics.

Master of Science in Civil Engineering-Transportation (MSCE)

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

Master of Management in Manufacturing (MMM)

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

The MMM Program works to develop whole-brained innovators by providing an analytical foundation coupled with a qualitative human



NUvention Transportation BUSINESS DEVELOPMENT COURSE

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 will look at the evolutionary and revolutionary changes that are recreating the face of transportation, and will provide 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.

“I’m thrilled to be partnering with Mark again and building on the success of last year’s inaugural NUvention: Transportation class. Transportation is a hotbed for innovative ideas and this fall’s class is off to a great start.” — **Bret Johnson**, Associate Director, NUTC

The quarter-long course sponsored by Boeing, and created by the Farley Center for Entrepreneurship and Innovation with NUTC, challenges students to create a transportation-oriented startup before pitching their ideas to potential investors.

Faculty

Bret Johnson, Associate Director, NUTC

Mark Werwath, Entrepreneur; Co-Director, Farley Center

Program Advisory Board

Iqbal Arshad, Former Senior Vice President Engineering, Global Product Development, Motorola

Patricio Azcunaga, Director of Intermodal Operations, Mexico, Union Pacific

Tony Belkin, Head of Traffic and Dynamic Content, HERE

Joe Burns, CEO, Sensurion Aerospace

Mark Johnson, Vice President, Smarter Grid Solutions

John Kwant, Vice President, City Solutions, Ford Motor Company

Marco McCottry, General Manager, Uber

Chacko Poothicote, IT Leadership Program, Ford Smart Mobility, City Solutions

Paul Pebbles, CTO, Urban Active, General Motors

Bob Perrin, President and 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

Jason Schmitt, Special Advisor, EPIC Academy Charter School

Chad Strader, Co-Founder & Partner, Red Arts Capital

Suresh Sunderrajan, Director of Technology Development and Commercialization; Chief Commercialization Officer, Argonne National Laboratory

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



(left to right) Professor Ian Savage; June 2016 T&L Minor Graduates: Emily Lichtenberg (Economics) "Airline market power and the effect on flight delays"; Tessa Swanson (Industrial Engineering) "The impact of self-distribution laws on the craft beer interstate distribution network"; Kayla Brackett (Economics) "Potential corridors of high speed rail in the United States: A gravity based model of city pairs"; Professor Hani Mahmassani.

NUTC Dissertation Year Fellowships (DYF)

NUTC awards Dissertation Year Fellowships (DYF) to PhD Candidates in their final year of study, conducting dissertation research on transportation or logistics-related topics. NUTC is proud to present the DYF recipients for 2016–17 and 2017–18.

DYF 2017–2018



Michael Hyland

Civil & Environmental Engineering – Transportation Systems Analysis & Planning

Advisor: Hani Mahmassani

Topic: *Real-time Operation of Shared-use Autonomous Vehicle Fleets: Modeling, Optimization, Simulation, and Analysis*



Fiorella Mete

Civil & Environmental Engineering – Transportation Systems Analysis & Planning

Advisor: David J. Corr

Topic: *Assessment of Bridge Performance Through Data Science Techniques*

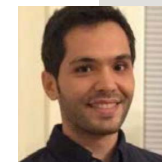


John Miller

Civil & Environmental Engineering – Transportation Systems Analysis & Planning

Advisor: Yu (Marco) Nie

Topic: *Integrating Dynamic Probabilistic Profitable Tours into the Truck Assignment Problem for User Equilibrium and System Optimal Solutions*



Saeed Rahimi-Aghdam

Civil & Environmental Engineering

Advisor: Zdenek P. Bazant

Topic: *Long Term Deformation of Concrete Infrastructures*

DYF 2016–2017

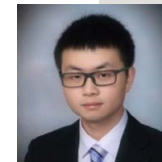


Mehmet Basdere

Industrial Engineering & Management Science

Advisors: Karen Smilowitz & Sanjay Mehrotra

Topic: *Models & Approaches to Multiobjective Arc Tour Problems with an Application to Marathon Course Design*



Hongyu Chen

Civil & Environmental Engineering

Advisor: Yu (Marco) Nie

Topic: *On-Demand Personal Mobility Services in the Era of Mobile Computing: Physics, Economics & Regulatory Policies*



Zihan Hong

Civil & Environmental Engineering

Advisor: Hani Mahmassani

Topic: *Traffic Systems Under External Interventions: Characterization, Modeling & Active*



Lama Bou Mjahed

Civil & Environmental Engineering

Advisor: Hani Mahmassani

Topic: *Cohort Effects & Technology Engagement in Connected User's Sustainable Activity & Travel Behavior*



Yagci Sokat

Industrial Engineering & Management Science

Advisors: Karen Smilowitz & Irina Dolinskaya

Topic: *Transportation & Logistics in Resource-Limited Settings*

NUTC Helps Build a Foundation for Supply Chain Education

- 4,178 Students completing a grant-funded program of study
- 1,589 Students completing credit hours
- 5,338 Credit hours completed
- 2,703 Students earning certificates/degrees
- 7,527 Degrees and certificates earned

From 2013 to 2017, NUTC served as an integral partner in the Leveraging, Integrating, Networking, Coordinating Supplies (LINCS) in Supply Chain Management (SCM) consortium, a national supply chain management education and certification program funded by a U.S. Department of Labor (DOL) TAACCCT grant. The national program team was led by Broward College in Florida, with nine community college and three national university partners that included: Columbus State Community College (OH), Essex County College (NJ), Florida State College at Jacksonville (FL), Harper College (IL), Long Beach City College (CA), San Jacinto College (TX), St. Petersburg College (FL), Union County College (NJ), Georgia Institute of Technology, Northwestern University, and Rutgers University.

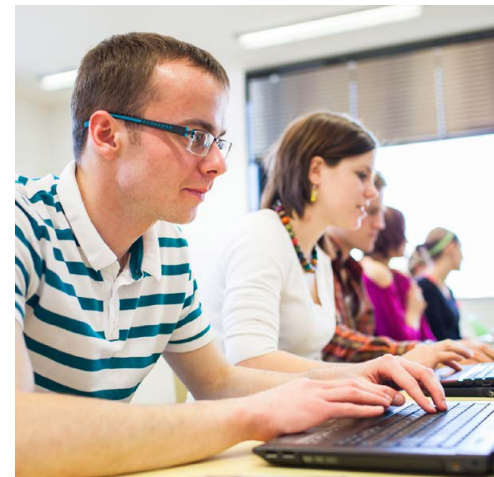
Through the support of DOL, the Consortium developed plans and certifications for eight supply chain management course tracks, including:

- **Supply Chain Management Principles**
- **Warehousing Operations**
- **Customer Service Operations**
- **Transportation Operations**
- **Demand Planning**
- **Manufacturing & Service Operations**
- **Inventory Management**
- **Supply Management & Procurement**

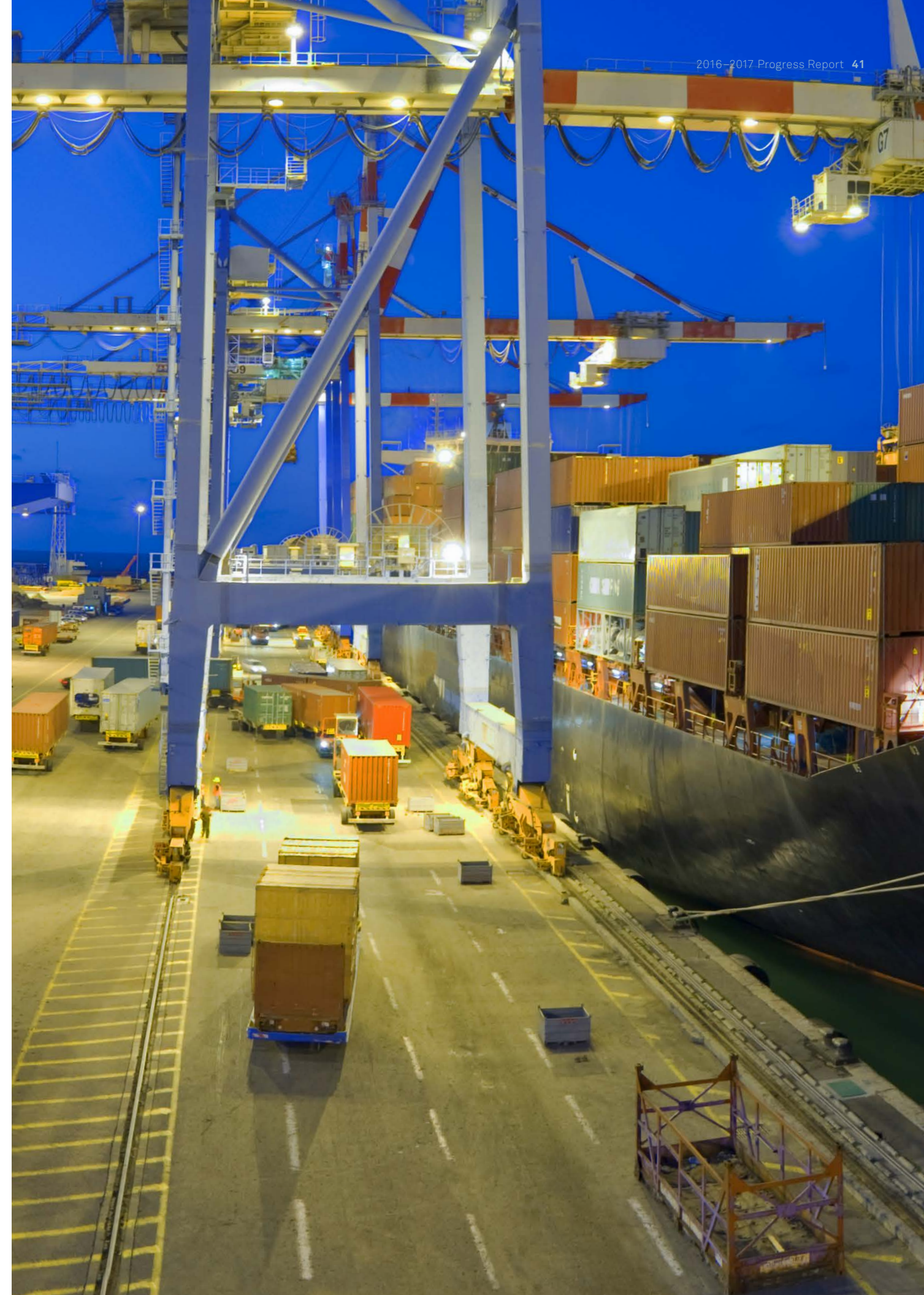
The deployment of the courses varies from college to college across the Consortium, with some colleges offering all courses, and some providing targeting offerings for their regional industry needs. Course delivery also varies from online offerings to in-person instructor led versions, as well as from certificate based

to associates degree track classes. In all cases, course certification is available to all students through the Council for Supply Chain Management Professionals (CSCMP), which serves as the official LINCS industry partner and certifying body for the supply chain subject areas. By December 31, 2016, the Consortium had the following impact:

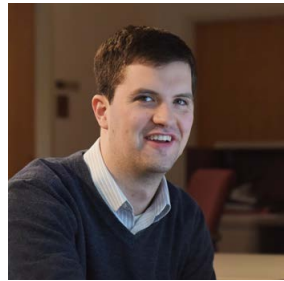
- 4,178 Students completing a grant-funded program of study
- 1,589 Students completing credit hours
- 5,338 Credit hours completed
- 2,703 Students earning certificates/degrees
- 7,527 Degrees and certificates earned



During the final year of the DOL grant, Bret Johnson served as co-chair of the Consortium's Academic Advisory Council (AAC) in partnership with co-chair, Lisa Smith, Supply Chain Management Program Coordinator and faculty member at Harper College. In their roles, Johnson and Smith worked closely with Vic Obringer, who served as the National Workplace Competencies Director at Broward College. Obringer led an effort to revise and refresh all eight supply chain course materials based on feedback from the eight colleges offering the curriculum. Johnson and Smith with the AAC, Obringer, and other Broward College staff, reviewed and then certified the course revisions.



NUTC Student Awards



Michael Hyland

Eisenhower Fellowship

Congratulations to NUTC PhD candidate Michael Hyland on his fellowship from the Dwight David Eisenhower Transportation Fellowship Program (DDETFP), which awards fellowships to students pursuing degrees in transportation-related disciplines.

This program aims to advance the transportation workforce by attracting “the nation’s brightest minds to the field of transportation.” The DDETFP Graduate Fellowship, in particular, provides funding for students like Michael to pursue his transportation-focused doctoral degree.



Lama Bou Mjahed

PhD Dissertation Defense

Congratulations to Lama Bou Mjahed who successfully defended her PhD dissertation on November 9, 2017. The dissertation titled, “Toward Sustainable Travel Behavior and Activity Engagement: Connected Users, Technology Engagement and Cohort Effects,” was completed under the supervision of NUTC’s director, Dr. Hani Mahmassani.



Helen Pinto

IRF Road Scholar

The IRF Fellows Road Scholar Orientation Program is a very competitive and prestigious program and, this year each university was limited to only one Fellow. Congratulations to NUTC PhD Candidate Helen Pinto on being named an IRF Fellow for the Class of 2018.

Pinto was invited to participate in the IRF Fellows 2018 Road Scholar Orientation Program by Patrick Sankey, the President & CEO of the International Road Federation. The 2018 IRF Fellows Road Scholar Orientation Program took place January 7-12, 2018 in Washington, DC, held in conjunction with the Transportation Research Board (TRB) Annual Meeting.



TRF AWARDS NUTC STUDENTS

April 20 – 21, 2017

The 58th Annual Transportation Research Forum (TRF) was held at the University of Illinois, Chicago. TRF 2017 program co-chairs were Northwestern Professor Ian Savage and Northwestern alumnus Joseph Schwieterman.

2017 TRF Award, Runner Up in Best Student Paper Competition

Paper: A Hybrid Cluster-Regression Approach to Forecast Ridership at Bikeshare Stations: Case Study of Chicago’s Divvy System

Michael Hyland, Zihan Hong, Helen Karla Ramalho de Farias Pinto, Ying Chen



Education Executive Programs

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.

Executive Programs

FREIGHT TRANSPORTATION & LOGISTICS

MAY 22–24, 2017 Transportation and logistics industry professionals gathered at Northwestern for the NUTC Spring 2017 Executive Education Series' Freight Transportation & Logistics Program:

Navigating the Growing Challenges from the First Mile to the Last Mile in Transportation.



The 2017 executive program addressed the premise: “the global transportation and logistics market is changing before our eyes.” The challenges to managers included slowing trade, anemic domestic economies, growing regulation, looming talent shortages, aging infrastructure, and many more. At the same time, many opportunities were available to exploit, such as inexpensive fuel, more efficient vehicles, improved systems and an explosion of useful apps, greater use of mobile technology, nimble business models, new capital flows, and widespread deployment of analytics and software tools. However, the advent and rapid expansion of e-fulfillment stressed the transportation system—the network, service levels, economics, etc.—from the first to the last mile.

The playbooks of the past that gave us higher productivity in transportation, lower costs and cheaper rates for shippers were ripe for transformation.

NUTC offered this course to help executives navigate this dynamic, changing landscape. The course examined both domestic and international shipping modes and corresponding impacts on each. The course also shared useful methods and tools for coping with that change—for operators, shippers, investors and others—in a format that combined lecture, case studies and interactive sessions.

FREIGHT TRANSPORTATION & LOGISTICS

MAY 9–11, 2016 An experienced class of industry managers and executives attended the Transportation Center's fifth annual executive course in Freight Transportation and Logistics in 2016. The theme addressed in this iteration of the course was:



Managing in a World of Rapidly Advancing Technology.

The course, moderated by NUTC Business Advisory Council (BAC) member and Managing Director of Zubrod

& Company, Justin Zubrod, provided insight into the rapidly changing domestic and international transportation industry as impacted by new technology and trends, including air, rail, truck, marine, package, third party logistics, and other non-asset sectors such as brokerage.

Northwestern faculty contributing to the program included Sunil Chopra, IBM Distinguished Professor of Operations Management & Information Systems, Kellogg School of Management, who provided timely information on omni-channel retailing impacts on logistics decisions and participated in a panel discussion on e-fulfillment technology and trends. Hani Mahmassani, W.L. Patterson Distinguished Chair in Transportation, addressed transportation data and analytics. Jan Van Mieghem, Harold L. Stuart Professor of Managerial Economics, Kellogg School of Management, challenged the group with his highly rated global sourcing and simulation exercise. And Mike Watson, adjunct faculty in Industrial Engineering and Management Sciences, discussed trends in supply chain network design.

The course also featured industry experts from NUTC's Business Advisory Council member companies including: Rick Blasgen, President & CEO, Council of Supply Chain Management Professionals; Mike Brennan, President & Chief Operating Officer, Vosges Haut-Chocolat; Brian Buchanan, Manager, Network Strategies, CN; Sean Burke, Senior Vice President of Business Development, Echo Global Logistics; Lee Clair, Partner, Transportation and Logistics Advisors; Shawn McWhorter, President, Americas Region, Nippon Cargo Airlines; Woody Richardson, Senior Vice President Global Commercial Services, Schneider National, Inc.; Steve Rothberg, Founding Partner, Mercator International; and Marty Wadle, SVP Supply Chain Solutions, Ruan Transportation.

CHALMERS UNIVERSITY EXECUTIVE PROGRAM Supply Chain Management (SCM) US Module:

Managing Interfaces

APRIL 11–24, 2016 Every year, NUTC welcomes colleagues from Chalmers University in Gothenburg Sweden to Northwestern University for the US-based portion of their SCM Executive Program. The 10-day executive program is spread across three separate modules, hosted in three different locations around the world.

Program content comes from the knowledge and resources in logistics and transportation from Chalmers University and their greater, international network (including Northwestern University) of leading academics, experienced business practitioners, and management consultants. SCM mixes state-of-the-art academic research results with practical experiences from successful companies with specific management philosophies. The director of SCM is Ola Hultkrantz, Assistant Professor in Supply Chain Management at Chalmers University.

Participants of the program typically hold the position of Supply Chain Manager, Purchasing or Production Manager with several years of experience. They are, or will soon be, responsible for operations as well as design and the development of future logistic solutions for their company. They are open-minded and eager to learn about matters closest to their professional goals—such as improving logistics knowledge and enhancing professional competencies.

By agreement, BAC members are invited each year to participate in the week-long US-based module.

The information-packed week offers BAC members unique networking opportunities and access to international networks with the latest supply chain theories and best practices for international logistics.

A highlight of the NUTC-hosted, US-based module is the full day reserved for visiting local companies in and around the Chicago area where program participants can gain regionally specific, supply-chain expertise.

Attendees visited the UPS Chicago Area Consolidation Hub (CACH) Facility, the BNSF Railway Intermodal Facility, and the Caterpillar Inc. Heavy Equipment Facility in Illinois. At each facility, they had the opportunity to meet company managers and inquire about operation strategies, standard practices and issues impacting operations.

Program faculty are experts in their industry and leaders in academia, on par with participating faculty Sunil Chopra, Eric Anderson and Gad Allon from Kellogg School.

Topics covered at SCM:

- Performance Measurements in SCM
- Sourcing & Risk in the Supply Chain
- SC Contracting & Incentive Design
- SC Social Responsibility
- Marketing Channels
- Lean Operations and/or SCM Strategy

NU Participating Faculty

Sunil Chopra, Kellogg School of Management
Eric T. Anderson, Kellogg School of Management
Gad Allon, Kellogg School of Management

Business Advisory Council (BAC)

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 framed by four distinct 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.

BAC 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.



Leadership Members



Jason Birnbaum
Vice President,
Operations Technology,
United Airlines



Kate Gebo
Senior Vice President,
Network Operations,
United Airlines



Robert M. Knight, Jr.
Chief Financial Officer,
Union Pacific Railroad



Mike Macyauski
Vice President,
Operations Planning &
Engineering,
FedEx Express



Joe Picone
President,
Corporate
Transportation,
UPS



Dov Shenkman
Group VP, Supply Chain
Global Inventory &
Transportation,
Walgreens Co.



Frank Bush
Analytic Business
Consulting Practice
Director, Travel &
Transportation,
Teradata



Kenji C. Hashimoto
Senior Vice President,
American Eagle,
American Airlines



Jan Kreams
President,
United Cargo,
United Airlines



Robert Martinez
Vice President,
Business Development
Norfolk Southern Corp.



Matthew K. Rose
Executive Chairman,
BNSF Railway Company



Jeff Silver
Co-Founder & CEO,
Coyote,
a UPS Company



Jim W. Butler
Senior Vice President,
International & Cargo,
American Airlines



Edward Jenkins
Vice President,
Market Strategy
E-Business,
CSX Corp.



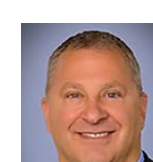
John Larkin
Managing Director,
Investment Banking,
Transportation and
Logistics,
Stifel Financial Corp.



Roger Nober
Executive Vice President,
Law & Corporate Affairs,
& Chief Legal Officer,
BNSF Railway Company



**Eugene (Gene)
D. Seroka**
Executive Director,
Port of Los Angeles



Douglas Waggoner
Chairman & CEO,
Echo Global Logistics



Rick Elieson
President,
American Airlines Cargo,
American Airlines



Peeter Kivestu
Transportation and
Logistics Industry
Consultant,
Teradata



Tracy Lee
Vice President,
Network Operations,
United Airlines



Paul Pebbles
Chief Technology Officer,
Maven,
General Motors Company



David Seymour
Senior Vice President,
Integrated Operations,
American Airlines



Phillip D. Yeager
Executive Vice President,
Account Management and
Intermodal Operations,
Hub Group

Sustaining Members



Billy Ainsworth
President and Chief Executive Officer, Progress Rail Services



Richard Craig
President & CEO, MOL (America) Inc.



Eli Gross
Managing Director and Global Head - Transportation, Logistics and Infrastructure Group, Morgan Stanley



Rob Levin
Founder & CEO, Republic Partners, LLC



Jean Regan
President, CEO & Chairman of the Board, TranzAct Technologies, Inc.



Jeff Starecheski
Vice President, Transportation, CVS Health



Israel E. Alguindigue
Senior Vice President, Industrial Analytics Practice, Uptake Technologies



Jim A. Davis
CEO, AccuFleet International



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



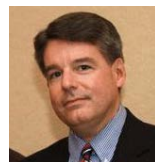
Regis Luther
Vice President, Technology & Engineering, AM General



Steven Rothberg
Founding Partner, Mercator International LLC



Charmin Tillman
Chief Marketing Officer, GE Transportation



David T. Arganbright
Vice President of Government Affairs, OmniTRAX, Inc.



Keith W. Dierkx
Global Industry Leader, Rail, and Director of the IBM Global Rail Innovation Center, IBM Industry Academy, IBM



James R. Hertwig
President and CEO, Florida East Coast Railway Company



Benjamin J. McLean
Chief Executive Officer, Ruan Transportation Management Systems, Inc.



Gilles Roucolle
Partner, Global Transportation Practice, Oliver Wyman



Thomas Tisa
Director - Corporate Development, Canadian National Railway Company



Andrew Boyle
Executive Vice President & CFO, Boyle Transportation



Ann Drake
Chairman & Chief Executive Officer, DSC Logistics



David A. Horwitz
Vice President & Executive Director, Fleet Portfolio Management, GATX Corporation



Shawn McWhorter
President, Americas Region Nippon Cargo Airlines



Ken Sain
CEO & VP, Digital Aviation & Analytics, Jeppesen, a Boeing Company



Jeffrey Walker
Chief Executive Officer, CIMC Capital, Inc.



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



Bill Driegert
Director, Uber Freight



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



D. Stephen Menzies
Group President, Trinity Rail, Senior Vice President, Trinity Industries, Inc.



Andrew J. Schmidt
Senior Vice President, Intelligent Solutions, AAR Corporation



Thomas F. Wells
President & CEO, TTX Company



Perry A. Cantarutti
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Reggie Dupré
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Amos Kazzaz
Senior Vice President Financial Planning & Analysis, Air Canada



Dennis Mooney
Group Vice President, Global Product Development, Navistar, Inc.



Paul J. Schneider
Managing Director, Schneider



Barbara W. Wilson
President, Wells Fargo Rail



Grace Cerocke
Vice President, Finance, Matson Logistics Inc.



Edmund J. Feeley
Managing Director, Littlejohn & Co. LLC



Chris Kettering
Chief Engineer, Aeromechanics Technology, Boeing



Dennis Nash
Chairman & CEO, Kenan Advantage Group, Inc.



Alexander Setness
Managing Director, Bank of America Merrill Lynch



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



Robert M. Chapman
Chief Executive Officer, CenterPoint Properties Trust



William Flynn
President & CEO, Atlas Air Worldwide Holdings, Inc.



Brad Keywell
Co-Founder & CEO, Uptake Technologies



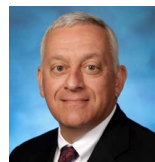
Aurelio Perez Alonso
Associate Director and CFO, Grupo ADO S.A. De C.V.



Monali Shah
Director, Global Intelligent Transportation, HERE



Mike Wychocki
Chairman & Chief Marketing Officer, EagleRail Container Logistics



William Cook
Director, Logistics and Customs FCA US LLC



Andrew Fox
Managing Director, Anacostia Rail Holdings



H. Merritt Lane, III
President & CEO, Canal Barge Company, Inc.



Nathaniel J. W. Pieper
Senior Vice President, Europe, Middle East & Africa, Delta Air Lines Inc.

Individual Members



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Partner,
Lynwood Capital
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L. Price Blackford
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Group Head,
Transportation & Logistics
Scott-Macon, Ltd.



John Bove
Principal,
American Maritime
Group, LLC



Michael Brennan
President & COO,
Vosges Haut-Chocolat



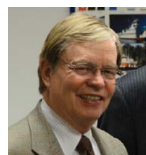
Vicki Bretthauer
Independent Consultant



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



James H. Burnley IV, Esq.
Partner,
Venable LLP



Norman Carlson
Chairman,
Carlson Consulting
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Lee Clair
Managing Partner,
Transportation and
Logistics Advisors
LLC (TandLA)



Robert W. Hart
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Rob Hart Transportation
Funding, LLC



Adam Inselbuch
Managing Director,
South Street Ventures,
LLC



Charles B. Lounsbury
Former Senior Vice
President,
Ryder System



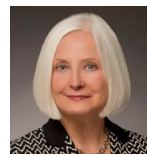
Craig E. Philip
Former CEO,
Ingram Barge



Clifford J. Porzenheim
COO, FarmLogix, LLC



James Rankin
President & CEO,
JPRankin Aviation
Advisors, LLC



Kathleen L. Ross
Former Senior Vice
President,
Bank of America
Merrill Lynch



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



Andy Sze
Principal,
Fastraxx Group, LLC

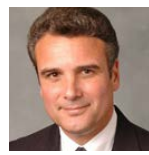


Justin F. Zubrod Sr.
Managing Partner,
Justin Zubrod &
Company, LLC

Association Members



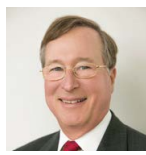
Andrew Bata
Regional Manager
– North America,
International
Association of
Urban Transport



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



Linda Bauer Darr
President,
American Short Line &
Regional Railroad
Association



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



Jennifer Hedrick
Executive Director,
National Industrial
Transportation
League



Chris Spear
President & CEO,
American Trucking
Associations

BAC Member Logos



BAC Meeting May 2017

The May 2017 BAC Meeting spotlighted rapidly emerging “block-chain” technology, which promises increased financial and logistical transparency in the supply chain network. Several Northwestern University economists and industry analysts talked about the state of uncertainty in US international trade policy and its effects on the transportation industry. NUTC Director Hani Mahmassani highlighted recently completed research for the city of Chicago on the safety of its red light camera system.

Jeff Silver, BAC Chair, introduced Richard Lueptow, Senior Associate Dean for Operations and Research, McCormick School of Engineering and Applied Science. Rich Lueptow welcomed the BAC members and thanked them for their continued support of NUTC and the University.



Lueptow addressed the integration of design engineering, and left brain and right brain thinking, across both undergraduate and graduate programs at the McCormick School, and noted how these programs also cross over to other schools to Northwestern. He highlighted many of the programs and centers housed in the Ford

Design Center – the location of the Spring BAC meeting, such as the Segal Institute for Design and the Farley Center for Entrepreneurship and Innovation. He also discussed the entry level design curriculum for freshman engineering students that puts them in direct contact with “customer” from the very beginning of their experience at Northwestern.

Hani Mahmassani’s spring 2017 Director’s Report, “Bridging the Future,” welcomed a diverse group of new BAC member companies, including Stifel as a new Leadership member, AAR Corporation, Atlas Air, Columbia Helicopters, Uber Freight, and Wells Fargo Rail as new Sustaining members, and UITP as a new Association Member.

Hani highlighted NUTC’s industry partnerships in research and education during the 2016-2017 academic year. Outgoing Boeing BAC representative Allen Adler, HERE BAC representative Tony Belkin, and members of Coyote Logistics actively participated in the

inaugural NUvention: Transportation class in fall 2016, an entrepreneurship course focused on the transportation industry offered through a partnership between NUTC and the Farley Center for Entrepreneurship and Innovation at the McCormick School of Engineering.

In the area of urban transportation, Mahmassani summarized a significant study that NUTC completed for the City of Chicago involving the evaluation of the safety benefits of Chicago’s red light camera system deployed through the city road network. The study identified the safety benefits of Chicago’s camera system, provided a methodology for reviewing safety performance at intersections, and provided recommendations for enhancing the city’s overall safety program.

Mahmassani also recognized and thanked NUTC’s 2017 William A. Patterson lecturer, Lance Fritz, Chairman, President and CEO of Union Pacific (and Kellogg School of Management alumnus).

THE GREAT RECESSION, MACROECONOMIC EARTHQUAKES, AND THE CURRENT STATE OF DOMESTIC AND INTERNATIONAL TRADE The session was led off by Larry Christiano’s (Alfred W. Chase Professor; Chair, Department of Economics, Northwestern University) discussion of the great recession – its origins, impact and lessons learned. In particular, he highlighted the shocks to global trade – an absolute reduction in recent years and slower growth going forward. Trade has been a major driver of the transportation sector in North America and globally for decades.

Justin Zubrod, Managing Director, Zubrod & Company, led a panel discussion on trade



with: Richard Craig, President & CEO, MOL (America) Inc.; John Larkin, Managing Director and Head of Transportation Capital Markets Research, Stifel Financial Corp.; and Phil Levy, Adjunct Professor of Strategy, Kellogg School of Management and Senior Fellow, Chicago Council on Global Affairs. Phil Levy discussed the current policy uncertainty and policy choices by the new administration in the trade arena, with the resulting potential impact on key sectors, the jobs they represent at home and possible retaliation overseas. Dick Craig addressed the turmoil — losses, price declines, overcapacity, bankruptcies, mergers, alliances and more — the key trade link of ocean shipping and the critical need to focus on improving productivity, lowering costs and eliminating excess capacity. John Larkin indicated that the potential lack of trade growth will force the transportation industry to “do more with less” including the use of new technology and eased regulations.

BLOCKCHAIN TECHNOLOGY: WHAT IS IT AND WHY DO YOU NEED TO KNOW? Keith Dierkx, Global Industry Leader in Travel and Transportation – Rail, Freight and Logistics at IBM, led a presentation and panel discussion on the rapidly developing “blockchain technology” with Moran Cerf, Professor of Strategy, Kellogg School of Management; Sebastian de Meel, Partner, PricewaterhouseCoopers (PwC) Advisory, LLC; and Srinivasan Sriram, Founder & CEO, Skuchain. Sebastian provided a primer on block chain technology, defined as a decentralized ledger of all transactions in a network. The technology was described as evolving from a trusted verification technology for Bitcoin transactions to other multi-party transactional environments, including supply chain logistics and payment verification. In these emerging applications, Sebastian noted that blockchain may provide benefits of operational and cost efficiencies, proven security and resilience, and improved audit trail records.

Sriram’s company is developing a software and shared network platform to enable real-time transparency into supply chain transactions



throughout the entire process. Using blockchain technology, Sriram promised increased visibility into the supply chain network, including, for example, real-time tracking of intermodal hand-offs and the automatic initiation of payments among business partners at all stages of transit of goods. Keith presented IBM’s vision for moving from paper to digital transactions in the workflow process. In a few examples of this transformation, Keith highlighted the application of blockchain technology to enable “shared visibility” among partners for container shipments, farm-to-fork food traceability, and enhanced financing arrangements with IBM’s information technology suppliers, distributors, and partners.

All panelists, including Professor Moran who addressed security benefits of blockchain, agreed blockchain is a potentially disruptive innovation that must be tracked and followed.

INFRASTRUCTURE & INCLUSIVE GROWTH: OVERCOMING DISCORDANT DEVELOPMENT Professor Richard Joseph, John Evans Professor of International History and Politics, Faculty Affiliate, Buffett Center of International and Comparative Studies, and Senior Fellow at the Brookings Institution discussed the development challenges in Africa, with a particular emphasis on the role of transportation infrastructure and the opportunities for improved transportation and logistics systems to help drive development in a positive direction.

IFM – INTELLIGENT FLYING MACHINES FOR AUTOMATED INDOOR DATA CAPTURE Marc Gyongyosi (EECS, ’16) is the CEO of IFM Technologies, a “data analytics company using machine learning, computer vision and robotics to automate indoor data capture. IFM had a year-long residence in Northwestern’s “Garage” incubator space, before graduating to a new business location in Chicago in the summer of 2016. Subsequent to the BAC meeting, Marc’s company won Northwestern’s VentureCat student business plan and pitch competition, taking away a \$30,000 grand prize.

BAC Meeting October 2017

With the theme, “Research that Moves You,” the October 2017 BAC Meeting began with NUTC Director Hani Mahmassani’s report on growing research efforts in connected and autonomous vehicle systems, machine learning, and data analytics. BAC member panel presentations delved into automation throughout the supply chain from fulfillment to delivery and digitization projects in aviation, at ports, and in supply chain networks that are being rolled out simultaneously with cybersecurity tools to protect data.

Hani Mahmassani welcomed new BAC member companies, including General Motors as a new Leadership member; AM General, EagleRail Container Logistics, and Jeppesen as new Sustaining members; and the American Short Line and Regional Railroad Association as a new Association member.

Mahmassani honored four new Dissertation Year Fellows for the 2017-2018 academic year, Mike Hyland, Fiorella Mete, John Miller and Saeed Rahimi-Aghdam, who earned financial support for their final year of PhD study. He also welcomed four visiting professors: Yoram Shiftan, Technion, Civil and Environmental Engineering; Nikolas Geroliminis, École polytechnique fédérale de Lausanne, Urban Transport Systems Laboratory; Alejandro Molnar, Vanderbilt University, Economics; and KeHu Tan, Beijing Jiaotong University, School of Economics, demonstrating NUTC’s reputation as an intellectual and applied research hub for freight and passenger transportation research.

Mahmassani’s report summarized many public and private research activities, and specifically identified growing research efforts in connected and autonomous vehicle (CAV) systems, machine learning and data analytics. One notable project was a recently launched international collaboration on CAV impacts, led by Technical University of Munich (Global Fund Initiatives) in partnership with NUTC and UC-Santa Barbara. Mahmassani noted a new course now established on Data Analytics and Machine Learning for Transportation and Infrastructure Systems that he described as an “essential contribution to graduate students’ methodological toolkit.”

AUTOMATION IN TRANSPORTATION AND LOGISTICS

In one of two featured panel discussions, Bill Driegert, Director, Uber Freight addressed the steady adoption of automation technologies throughout the supply chain from fulfillment to delivery with speakers Mike Dektas, Marketing Manager, Workhorse; Joe Hutter, Sr. VP Business Development, Daifuku; and Jarvis Schultz, Associate Director, MS in Robotics, and Assistant Professor of Instruction, Department of Mechanical Engineering, Northwestern University. The industry panelists shared multiple examples and videos that demonstrated cutting edge automation currently deployed in warehouses, fulfillment centers, and port facilities, as well as others that showcased the possible, near future of autonomous vehicles and drones, including drones for package delivery. Schultz provided insights from academic research on robotics, machine learning, cyber-physical security, and robotics in the cloud.

DIGITALIZATION AND CYBERSECURITY

Session moderator Israel Alguindigue, Senior Vice President, Industrial Analytics, Uptake led a provocative discussion with Christine Izuakor, Manager of Global Security Strategy and Awareness, United Airlines; Doug Reese, Chief Strategy and Growth Officer, GE Transportation – Digital Solutions; Ken Sain, CEO, Jeppesen; and Gene Seroka, Executive Director, Port of Los Angeles. Presenters described digitalization projects and programs in aviation, ports and supply chain networks. The transition from paper manuals to iPads signified a major digitalization impact that Sain observed in the airline industry. The motivation for this initiative, as with other digitalization efforts, was and is about providing the right information at the right time for enhanced decision making. Seroka highlighted data sharing among port customers and users through secure channels as a key driver of change, driven by trust and strong industry relationships. Reese discussed using data to connect supply chain systems across choke points and optimization across networks, systems and participants. Izuakor noted that cybersecurity is evolving as rapidly as the digital transformation itself. She emphasized the need for heavily layered data and system protection strategies, as security is only as good the weakest link in the system. The ultimate challenge is balancing data availability and support of digitalization, with good security practices.

THE SENTIENT ENTERPRISE

Professor Mohanbir S. Sawhney, McCormick Foundation Chair of Technology, Clinical Professor of Marketing, and Director, Center for Research in Technology & Innovation, provided an in-depth discussion of the principles found in his book, *The Sentient Enterprise*, that he co-authored with Oliver Ratzesberger, executive vice president and chief product officer of Teradata.



HURRICANE HARVEY’S MARINE SUPPLY CHAIN DISRUPTION - EXERCISING BUSINESS CONTINUITY IN A POST STORM ENVIRONMENT

Mason Eustis, Fleet Optimization & Customer Service Manager, Canal Barge Company, shared his and his company’s assessment of the Gulf Coast’s supply chain recovery from Hurricane Harvey. Many services were unavailable for weeks and took months to fully come back online.



BAC Meeting April 2016

With the theme, “Beyond 60 Years,” the April 2016 BAC meeting marked the first meeting post the 60th anniversary celebration of the Northwestern University Transportation Center. BAC Chair Justin Zubrod led a discussion on volatility in global economics, energy, and pricing and the effects on the freight demand environment. Participants also learned about forward-thinking research initiatives by NUTC in support of the transportation industry and sat in on BAC member presentations on leading edge technologies in supply chain management and logistics, automated and connected vehicles, last-mile logistics and smart cities.

Justin Zubrod called his last meeting as chair to order, after 11 years of service as the BAC chair, and introduced McCormick School of Engineering and Applied Science Dean Julio Ottino. Dean Ottino thanked members for their support of NUTC, and especially thanked Justin Zubrod for his dedication to NUTC. He recalled many meetings that he and Justin had together to move the NUTC through leadership transitions early in Justin’s tenure as BAC chair, and noted that with Justin’s and Hani’s leadership NUTC is on solid ground, in a strong position for growth.



PASSING OF THE GAVEL: INTRODUCTION OF NEW BAC CHAIR, JEFF SILVER Dean Ottino and Hani Mahmassani praised Justin Zubrod for his years of BAC Chair leadership and presented him with a plaque acknowledging his years of service, as well as a Northwestern tie. After thanking the membership for the honor to lead the BAC, Justin passed the gavel to Jeff Silver, as the new chair.

DIRECTOR’S REPORT Presenting the theme “Beyond 60 years,” Hani highlighted a strong research portfolio of active projects and unveiled the Center’s 2015 Progress Report. In his remarks, Hani featured a study on vertical takeoff aircraft for cargo distribution for

Boeing, a study on grain logistics supported by BNSF, and a series of white papers on a vision for transportation infrastructure in 2050 supported by the Association of Equipment Manufacturers. He also welcomed five new member companies to the BAC, including HUB Group and Walgreens, both new Leadership members, as well as Air Canada, CVS and Skyteam as new Sustaining members.

After noting several awards received by faculty and events held during the year, Hani concluded his remarks emphasizing with a look to future research trajectories for NUTC, including: pushing the limits on logistics and supply chain operations; automated and connected vehicles and trucks; last mile supply chain logistics; and Internet of Things and smart cities.

THE CHANGING ENVIRONMENT FOR PACKAGE DELIVERY Timothy Jones (Timothy Jones and Associates) led a panel discussion on *The Changing Environment for Package Delivery* with panelists from United States Postal Service (Dennis Nicoski), an early-stage crowd sourced delivery company (Marc Gorlin, CEO), and Northwestern (faculty member). The panel explored the dramatic changes taking place with B2C package delivery in the US. The panelists cited the explosive growth of B2C deliveries, large shifts in consumer behavior—buying more online or via mobile than from brick and mortar stores, tension caused by Amazon with free two-day shipping and its “Prime” services, and great need for better analytics and tools to manage package delivery. Deliveries occurring six days a week are becoming the norm, with Sunday deliveries becoming



more prevalent. In fact, USPS made 4 million deliveries on one Sunday during the 2015 holiday season. All aspects of package delivery are being optimized, driving the need for new tools and analytics. Two key challenges were cited for further exploration: 1) Can we develop tools to better predict demand? and 2) How do orders get entered into the process earlier to help manage demand and delivery, especially during peak demand?

ECONOMIC, ENERGY AND PRICING TRENDS

Justin Zubrod discussed the recent economic, energy and pricing trends and outlook for the future with panelists Brian Wesbury, Chief Economist, First Trust Advisors; Jon Efken, Director, GCB Head of Commodities Sales, Bank of America Merrill Lynch; Amos S. Kazzaz, Senior Vice President, Financial Planning and Analysis, Air Canada, Eric Jakubowski, Chief Commercial Officer, Anacostia Rail Holdings;

and Dave Menzel, President and COO, Echo Global Logistics. All emphasized a very anemic freight demand environment in spring 2016 with adequate capacity supply and relatively stable pricing in most sectors, with the outlook through year-end

remaining the same. A component of the demand slump driven by the severe decline in many areas of the oil patch—both in the US shale gas basins and in the Canadian western provinces. Although the oversupply and its impact on the cost of fuels—impacting both operating costs and the top-line (fuel surcharges)—were highlighted, it was noted that in the early weeks of spring 2016 the cost of oil per barrel was rising. Further, the oil producing parties around the world did not seem to be able to agree on how to manage production levels and supply enough to force a rapid increase in fuel costs. However, there was general consensus at the time that costs increases would continue—and patterns would remain somewhat volatile—as demand grew in both the developed and emerging economies causing the surpluses to begin to disappear.

BAC Meeting October 2016

Newly named chair Jeff Silver, CEO of Chicago-based Coyote Logistics, oversaw the October 2016 BAC meeting. The day featured dynamic presentations by industry experts in the areas of autonomous trucking, the “Amazon Effect,” and airline alliances. Participants also heard from Ron Braeutigam, Associate Provost for Undergraduate Education at Northwestern University, about efforts to grow undergraduate research funding and the successful launch of a 5th year program for undergrads to earn an MS in Management Science from the Kellogg School.

Braeutigam described two key initiatives: (1) growing undergraduate research funding from \$1 million to \$3 million annually, and (2) a new 5th year program for Northwestern undergraduate students to enroll in Kellogg and receive an M.S. in Management Science, essentially the first year of the two-year MBA program. Eighty students were registered in this program for the 2016-2017 academic year.

DIRECTOR’S REPORT In his fall 2016 remarks, Hani Mahmassani highlighted the strong position of NUTC and the strong foundation of the BAC—in membership, in active participation, and in support. He noted the release of three research reports on grain industry dynamics and rail service, supported by BNSF Railway, and the release of a report produced for the Association of Equipment

Manufacturers, Mobility 2050: A Vision for Transportation Infrastructure. He welcomed new BAC members from CIMC Group, Republic Partners, LLC, and Uptake, announced Norm Carlson's appointment as Board Chair of METRA (Chicago's commuter rail system), and announced that Jeff Silver was named the Illinois Technology Association's ITA CityLIGHTS 2016 CEO of the Year.

Mahmassani also introduced NUTC's new, diverse class of dissertation year fellowship students: Mehmet Basdere, Hongyu Chen, Zihan Hong, Lama Bou Mjahed, and Yagci Sokat.



AUTONOMOUS TRUCKING Andrew Boyle kicked off a panel session on autonomous trucking by sharing Otto's self-driving promotional video, a collaboration with Budweiser, that had been released earlier in the week. Boyle identified three potential benefits of self-driving trucks: better asset utilization; potential changes to hours of service regulations; and an opportunity to better serve the driver community. Following his introduction, he challenged the panelists, Tony Cook of Navistar, Dan Murray of ATRI, and Steve Sheffey of Allstate, to weigh in on the future of autonomous trucks.

Tony Cook, given his deep technical perspective at Navistar, identified the complexity associated with integrating technologies from several different suppliers to develop and build reliable, autonomous trucks. The autonomous systems ultimately have to make algorithmic "ethics" decisions—"whether to hit the dog or hit the cat" as he put it—further noting that many of the ethical, safety and other challenges remain to be solved. He mentioned that recent policy studies point to a minimum of 100 million miles driven for

testing self-driving technologies. (However, an appropriate testing regime for failure prediction remains unresolved.) In addition to an appropriate regulatory framework, driver and public acceptance of the trucks are key factors to address from his perspective. Furthermore, Tony noted that Otto's current windshield-mounted system would violate environmental regulations in the trucking industry.

Dan Murray illustrated the benefits associated with onboard safety systems, and suggested self-driving technologies as a way to attract younger, tech-savvy drivers into jobs as truck "pilots." Dan expressed concern about V2V and V2I communication being developed to a standard that may become obsolete by the time the technology is approved for commercial use. As to "when" self-driving technologies become adopted, Dan pointed to legislators and regulators as the primary impediments.

Steve Sheffey indicated that safety systems in general have reduced risk for operators and insurers. However, the insurance industry will likely take a "wait and see" approach to underwriting completely self-driving vehicles, since insurers typically need years of loss history to calculate premiums.

THE AMAZON EFFECT One of the most frequent topics requested for the BAC meeting discussions is Amazon—what are they doing, where are they going? Recognized industry analyst David Vernon of Sanford C. Bernstein and Matt Mullarkey of Centerpoint Properties joined former BAC chair, Justin Zubrod, to address these questions.

The presentations to and discussion with the BAC pointed out that the costs of Amazon and others in the e-commerce space will rise in response to many pressures. According to Vernon, e-commerce and last mile customer service is a "land grab" subject to consumer behavior, and is incredibly inefficient on many levels (e.g., inventory management, real estate demands, etc.). Mullarkey predicted that at some point Amazon's business model should scale to profitability after it slows down its investments in capital (infrastructure); but posited the company is desperate to take costs out of its transportation moves. Right now, according to Mullarkey, Amazon's game is about increasing service levels to capture customer attention and "beat their competitors." Few if any

companies, including Amazon, are profitable with e-commerce logistics, as e-commerce is still adapting and adjusting rapidly to consumer patterns, requiring investments in facilities, capabilities, technology and more. For example, Vernon noted that Amazon's video services and cloud storage businesses are high margin, whereas its fulfillment business is low-margin and e-commerce operations are costly. Yet, he explained further, Amazon's e-commerce business is growing at 30 percent and gaining further momentum.

AIRLINE ALLIANCES: ARE THE WINDS SHIFTING? Professor Ian Savage introduced the subject and provided some background basics about alliances. Alliances were born following the 1944 Chicago Convention that organized civil aviation after the Second World War, when airlines from a given country were generally not permitted to operate domestic service in another country ("cabotage"). Three main alliances (Star Alliance, oneworld, SkyTeam) emerged in the late 1990s. In general these are marketing alliances to allow international itineraries to be booked and to give reciprocity in airline loyalty programs and lounges. However, in some cases—especially when there are "open skies" allowing entry to international travel between two countries—pairs of international airlines are granted anti-trust immunity to coordinate pricing and schedules. Each of the three main alliances has between 15 to 25 members, and typically these are "full service" airlines. Most low cost carriers exist outside of these alliances. Emirates, the fourth largest airline in the world, has also remained outside an alliance, although it has a bilateral agreement with Qantas, a member of the oneworld alliance. Etihad has also remained outside of a formal alliance.

Kenji Hashimoto, who previously managed alliances for American Airlines within the

oneworld alliance, and Amos Kazzaz who has experience with the Star Alliance with United and Air Canada, described the benefits, challenges and governance of these alliances. In discussing the alliances structure, Kenji and Amos reflected on the challenges to coordinate between firms when there are marked cultural and operational differences. The most common alliances have been between North American and European airlines, as the European Union operates as a single market with "open skies" over the Atlantic, albeit that cabotage by non-EU airlines is not allowed within Europe. The lack of such a common market and much less liberal bilateral international flight restrictions in Asia has meant that anti-trust immunity is more of a trans-Atlantic rather than trans-Pacific phenomenon. While the two main Middle East Airlines (Emirates and Etihad) have grown outside the alliance structure, both have agreements with members of various alliances.

CENTER FOR OPTIMIZATION AND STATISTICAL LEARNING Professor Jorge Nocedal, David A. and Karen Richards Sachs Professor of Industrial Engineering and Management Sciences; Chair, IEMS gave a presentation about the Center for Optimization and Statistical Learning (OSL), a relatively new research center at Northwestern, founded by NUTC faculty affiliate, David Morton in 2015. OSL brings together faculty and students to address three primary organizational goals: (1) optimization techniques (models, methods, software); (2) statistical learning (models, methods, software); and (3) applications for intelligent systems. The Transportation Center foresees synergies with OSL on future transportation system research problems, providing additional capabilities for industry and public sector research sponsors.



(left to right) Kenji Hashimoto, Amos Kazzaz, Ian Savage

50+
EDUCATIONAL,
RESEARCH, AND
SOCIAL EVENTS

Events Lectures

Beyond its world-class research and education, NUTC is first and foremost about community—a community of students and faculty, 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.

William A. Patterson Transportation Lecture

38th Patterson Lecture: May 3, 2017



Connecting People, Creating A Better Future: Why International Trade Benefits America

Lance Fritz
Chairman, President, & CEO
Union Pacific

In an effort to stitch together a fractured country during the American Civil War, President Abraham Lincoln signed the 1862 Pacific Railway Act. As a part of the bill, the US government committed to funding its first transcontinental railroad, connecting Missouri to California.

“We like to think of Abraham Lincoln as Union Pacific’s employee number one,” joked Lance Fritz. He discussed the secrets behind Union Pacific’s enduring success as well as the importance of global trade during NUTC’s 38th Annual William A. Patterson Transportation Lecture on May 3rd at the Allen Center.



37th Patterson Lecture: April 21, 2016



No Excuses: Technology and Culture Meet a New Era of Expectation

Jeff Silver
Co-Founder & CEO
Coyote, A UPS Company

In 2006, Silver left a PhD program in Northwestern Engineering’s Department of Industrial Engineering and Management Sciences to start Coyote. He had left the 3PL industry six years earlier and found reentry intimidating. But he was pulled to build a company with a strong commitment to service. At the time, 3PL companies often committed to move loads for a shipper but only followed through 80 percent of the time.

“We knew we had to do something different,” Silver said. “We had to get customers to stop seeing us as a broker and start seeing us as a real carrier. We decided to move every load that we were committed to.”



Leon N. Moses Distinguished Transportation Lecture

2017 Moses Lecture: October 18, 2017



Outlook for the U.S. Economy: Is this as good as it gets?

Martin Eichenbaum
Charles Moskos Professor of Economics,
Northwestern University, Co-Director, Center
for International Macroeconomics

Martin Eichenbaum is the Charles Moskos Professor of Economics at Northwestern University and the co-director of the Center for International Economics at Northwestern University. He has been at Northwestern University since 1988. He has also taught at the University of Chicago and the Wharton School, University of Pennsylvania.

Eichenbaum earned his PhD in economics from the University of Minnesota. He served as the co-editor of the American Economic Review from 2011 to 2015 and is currently the co-editor of the NBER Macro Annual. He is a fellow of the American Academy of Arts and Sciences, a fellow of the Econometric Society, and a Research Associate of the National Bureau of Economic Research.

He is currently a consultant to the Federal Reserve Banks of Atlanta and San Francisco. In addition he serves on the advisory council of the Global Markets Institute at Goldman Sachs and the academic advisory council of the Federal Reserve Bank of Chicago. Finally, he is on the Board of Directors of the Bank of Montreal.

The Leon N. Moses Distinguished Lecture in Transportation is named in honor of noted transportation economist and former NUTC director, Leon N. Moses, who passed away on October 12, 2013.



Aaron J. Gellman Memorial

April 21, 2016

NUTC and the greater Northwestern community held a Memorial at the Vail Chapel for former NUTC Director Aaron Gellman who passed away January 11, 2016.

In demand by the government, industry and the media for his wide-ranging expertise, Gellman had more than 50 years of experience as an economist, strategist, consultant and academic in the transportation industry. His research focused on transportation economics, regulation, and policy.

Gellman was a professor of management and strategy at Northwestern’s Kellogg School of Management and a professor of industrial engineering and management sciences at the McCormick School of Engineering and Applied Science. He joined the Northwestern faculty in 1992 and retired in 2014.

“He also was an influential mentor and friend to many. Aaron will be missed by his friends, colleagues and the wider transportation community who valued his expertise and enthusiasm,” said Mahmassani, who also is the William A. Patterson Distinguished Chair in Transportation.

Gellman served as director of the University’s Transportation Center from 1992 to 2000. Under his leadership, Chambers Hall, the present home for NUTC, was built and inaugurated in 1999. After his tenure as director, he became a professor of transportation at NUTC.

“Aaron was an intellectual powerhouse and a visionary with a deep appreciation of the interplay of technology, economics and policy in the transportation industry.”

— Hani Mahmassani, NUTC Director

Events Roundtable, Symposia

Lipinski Roundtable September 2016

The Road Ahead: Developing Technology and Policy to Accelerate the Safe Deployment of Connected and Driverless Cars



(left to right) Steven Sheffey, Hani Mahmassani, Brenna Berman, Congressman Dan Lipinski, Monali Shah, Jim Barbaresso, Ann Schlenker

Recognizing the transformative role that autonomous and connected vehicle technologies will play in our transportation system, US Representative Dan Lipinski hosted a roundtable discussion, “The Road Ahead: Developing Technology and Policy to Accelerate the Safe Deployment of Connected and Driverless Cars.” Lipinski is a ranking member of the House Committee on Science, Space and Technology, and also member of the Committee on Transportation and Infrastructure.

Director Hani Mahmassani joined Representative Lipinski and five other technology and policy experts, including: Jim Barbaresso, Intelligent Transportation System National Practice Leader, HNTB; Brenna Berman, Department of Innovation and Technology Commissioner, City of Chicago; Ann Schlenker, Center for Transportation Research Director, Argonne National Lab; Monali Shah, Global Intelligent Transportation Solutions Director, HERE; and Steven Sheffey, Public Policy Development Corporate Counsel, Allstate, to discuss relevant policy and legal issues, research and development priorities, infrastructure requirements, and impacts on the future of cities. Congressman Lipinski’s goal for the Roundtable was “to identify challenges and opportunities which could be addressed by effective federal policymaking in order to accelerate the safe deployment of connected and driverless cars on our roads.” Mahmassani urged the Chicago region to take a leadership role in the deployment of autonomous vehicles through the effective planning for their integration into the transportation system.



Experts Discuss the Future of Infrastructure May 2016

Mobility 2050: A Vision for Transportation Infrastructure and How We Can Get There

From autonomous vehicles to a diversity of ride-sharing forms, US transportation is guaranteed to change within the next 30 years. These changes will require adaptation of current infrastructure—but in what way? And how can we help encourage these changes?

A new Northwestern-led study attempts to answer these questions by exploring how future trends and opportunities will influence US transportation infrastructure by the year 2050. The comprehensive study was unveiled yesterday at “Mobility 2050: A Vision for Transportation Infrastructure and How We Can Get There,” a symposium that featured scholars, policymakers, and industry leaders.

Northwestern’s Transportation Center conducted the interdisciplinary study at the request of the Association of Equipment Manufacturers (AEM). Northwestern engineering professors who participated in the study include Fabian Bustamante, Gianluca Cusatis, Kimberly Gray, Hani Mahmassani, and Joseph Schofer.

“When we were contacted to do this study with the AEM, it was the perfect opportunity for us to join forces for a common objective,” said Julio M. Ottino, dean of Northwestern Engineering. “We were delighted to help produce a report that outlines future challenges.”

“Everyone in this room shares a common objective,” said Ron De Feo, CEO of Kennametal and chairman of the AEM’s Infrastructure Vision 2050 Task Force. “We want to leave our children and successors with a better world than we have today. I’m proud to help start this discussion.”

In the keynote speech, Victor Mendez, deputy secretary of the US Department of Transportation, discussed how infrastructure will need to adjust to growing populations,



increased freight travel, and extreme weather conditions.

“If we do nothing, there will be more congestion, and we’ll lose more time waiting in traffic,” Mendez said. “Greenhouse gases will also increase.”

Mendez said that technology will offer many solutions for the future, including autonomous vehicles, which could increase safety and reduce traffic-related deaths. He also called for improved infrastructure for underserved areas, which are often cut off from the larger community due to lack of transportation. New bus or train services, for example, can connect these areas to opportunities and improve the community as a whole.

Mahmassani, along with Gray and Schofer, presented major findings from the Mobility 2050 report. Mahmassani, the William A. Patterson Distinguished Chair in Transportation, said that a major challenge will be the increasing diversity in transportation methods. In addition to autonomous vehicles, more vehicles will be connected directly to the Internet. He also said there will also be an increase in car



Ron de Feo, CEO, Kennametal, and Chair of the Association of Equipment Manufacturers’ Infrastructure Vision 2050 Task Force, introduces the Task Force’s mission and goals.

Victor Mendez, Deputy Secretary, US Department of Transportation.

sharing and walking. “Major improvements will be required to accommodate mixed traffic,” said Mahmassani. “Infrastructure is no longer just thinking about pavement. We will have to combine mobility with the electric grid and telecommunications. New software programs will be needed for connected vehicles and smart cities.” Gray added that change will happen most rapidly in cities and advocated for smart, sustainable cities, which integrate information and communication technologies and are driven by social and environmental issues rather than by the market. Transportation is very important for a city’s many needs, including people, materials, food, and water, but current infrastructure is deteriorating, outdated, and vulnerable to unpredictable collapse. Cities need more dynamic, sustainable transportation systems that will prepare them for the future.



“Business-as-usual tends to be the route we’re on,” said Gray, professor and chair of civil and environmental engineering. “I hope we’ll be able to nudge our behavior to a different route because there is danger in inaction.”

Schofer said that in order to meet future goals, infrastructure needs steady, sufficient funds and strategy and metrics for making informed decisions.



“It’s not just a matter of having more money,” said Schofer, associate dean of Northwestern Engineering and professor of civil and environmental engineering. “We need to make better decisions that help us save money and save time without damaging the environment or sacrificing our values.”

Although the driving population is swelling and travel is increasing, highways are collecting less money than in the past. This is mostly because motor vehicles have become substantially more fuel efficient, and construction costs have doubled since the federal gas tax was last increased. Drivers of electric vehicles, a segment expected to grow in the future, are also not contributing to road network maintenance through fuel taxes. Schofer proposed a mileage-based usage fee to make road usage fees more equitable and provide long-term funding.

Schofer then moderated a panel discussion with De Feo, Gray, Randall Blankenhorn, secretary of the Illinois Department of Transportation, and Austin Ramirez, CEO of Husco International. The group discussed how to increase funding, make room for technology, and depoliticize infrastructure projects.

“As engineers, we tend to think that technology will save us,” Gray said. “The technology exists, so that’s not our major obstacle. The obstacle is behavior.”

ISTTT22 The 22nd International Symposium on Transportation & Traffic Theory

Pre-Conference Workshop July 23, 2017

Getting There From Here: Traffic Modeling, Data Streams, & Prediction For Connected / Automated Vehicle Systems Planning & Operations

Transportation experts gathered at Northwestern’s Norris University Center on July 23, 2017, for a pre-conference workshop moderated by NUTC director Hani Mahmassani.

The workshop was sponsored by the US Department of Transportation and organized to bring together researchers, model developers and advanced users of transportation planning and traffic operations tools to (1) identify gaps with regard to incorporating

CAV’s in simulation and network modeling tools; (2) discuss ongoing developments and advances in the US and internationally in terms of models and applications related to the impact of CAV’s; and (3) identify challenges and opportunities in terms of fundamental and applied research to move the process forward.



ISTTT22 Symposium July 24 – 26, 2017

ISTTT22 Symposium attendees came from around the globe to present and discuss all scientific aspects of transportation and traffic, covering all modes of transport—public and private—including freight, air and maritime.

Special thanks to the following sponsors for making the symposium possible:

- The National Science Foundation
- Northwestern University Transportation Center
- Transportation Research Board of the National Academies
- US Department of Transportation, Federal Highway Administration.



22nd International Symposium on Transportation & Traffic Theory



The symposium featured expert presentations, poster sessions, and social gatherings.

TSL Conference July 26–29, 2017

NUTC and ISTTT22 continue collaborations at the INFORMS Transportation and Logistics Society First Triennial Conference

NUTC Faculty members Hani Mahmassani, Marco Nie and Karen Smilowitz attended, helped organize and co-hosted the welcome reception for INFORMS Transportation Science and Logistics Society (TSL) Conference, which took place at Loyola University, Chicago.

Smilowitz is the President of TSL and a co-organizer for the conference, in addition to serving as co-chair for ISTTT22 with Nie and Mahmassani. Mahmassani served on the

scientific committee for the TSL Conference and NUTC co-hosted the welcome reception for TSL Conference attendees.

On Wednesday, July 26, ISTTT22 attendees joined TSL attendees for a special joint session in Chicago, chaired by NUTC's Smilowitz (pictured with TSL and ISTTT22 attendees below).



Events Workshop

Every year, NUTC and the Center for the Commercialization of Innovative Transportation Technology (CCITT) co-host two Industry Technical Workshops in conjunction with each of the Fall and Spring Business Advisory Council (BAC) meetings. These workshops are co-chaired by Hani Mahmassani, NUTC director, and Breton Johnson, NUTC associate director and CCITT director.

Industry Technical Workshop on Public-Private Partnerships May 2017

Bridging the Future: Innovation in Large-Scale Infrastructure Development

“Bridging the Future: Innovation in Large-scale Infrastructure Development” addressed how public-private partnerships can bridge the growing gap in federal funding required to update the country’s aging bridges, highways, and other transit systems. While state and local municipalities have attempted



Spring 2017
INDUSTRY WORKSHOP

CASE STUDY PRESENTERS

Robert Martínez, Vice President, Business Development & Real Estate, Norfolk Southern Corporation: “Norfolk Southern, The Crescent Corridor, Infrastructure and the Future of Rail”

Jamie McCurry, Chief Administrative Officer, Georgia Ports Authority: “The Savannah Harbor Expansion Project: Critical Infrastructure Expansion for the United States”

David Pennington, Managing Director, Power, Energy & Infrastructure, BMO Capital Markets: “Transportation P3s: Case Studies Contrasting the Canadian and U.S. Approaches”

Robert L. Peskin, Senior Consulting Manager, Strategic Planning Services, Planning, Americas Transportation, AECOM: “Denver Union Station: Creating (and Capturing) Value”

FEATURED SPEAKER

Joseph Szabo, Executive Director, Chicago Metropolitan Agency for Planning (CMAP)

EVENT CO-CHAIRS

Hani Mahmassani, William A. Patterson Distinguished Chair in Transportation; Director, NUTC

Bret Johnson, Director, Center for the Commercialization of Innovative Transportation Technology



narrow the shortfall through gasoline taxes and highway tolls, the need for new infrastructure projects continues to exceed the available funding.

“Financing is a major obstacle to overcome in order to ensure that transportation systems meet the economic and social needs of today and tomorrow,” said Joseph Schofer, associate dean, professor of civil and environmental engineering, and the moderator for the session. “The good news is that the private sector has been chasing transportation infrastructure investment opportunities for a long time.”

WORKSHOP LEADER

Joseph L. Schofer, Associate Dean, Faculty Affairs; Professor, Civil & Environmental Engineering, McCormick School of Engineering, Northwestern University

Fall 2017
INDUSTRY
WORKSHOP

Industry Technical Workshop on Innovations and Best Practices October 2016

Making the Customer Happy: Innovation and Best Practices

Through case study presentations and a panel discussion, a varied group of speakers from Northwestern and the greater transportation industry examined innovations and best practices in customer service, experience and loyalty.

SPEAKERS:

Julius Jung, Managing Director, FeedbackNow USA

Tom Collinger, Associate Professor; Executive Director of Medill IMC Spiegel Digital & Database Research Center, Northwestern

Thomas O'Toole, Clinical Professor of Marketing, Senior Fellow, Kellogg School of Management, Northwestern

Walter Herbst, Charles Deering McCormick Distinguished Clinical Professor; Director of the Master of Product Development Program, Northwestern

Jodi Navta, Chief Marketing Officer, Coyote Logistics, A UPS Company



Workshop in Warsaw, Poland Co-Hosted by Warsaw School of Economics and Loyola University Chicago June 2017

Route Optimization/Vehicle Routing (ROVER) Workshop

On June 12-13, 2017, the Warsaw School of Economics and Loyola University Chicago co-hosted the Route Optimization/Vehicle

Routing (ROVER) Workshop in Warsaw, Poland. NUTC Faculty Mike Hewitt, Hani Mahmassani, Maciek Nowak and Karen Smilowitz traveled to Warsaw for this workshop, during which numerous future directions for route optimization and vehicle routing were discussed. Additionally, Mahmassani presented a paper he co-authored with NUTC PhD candidate Michael Hyland: Autonomous Vehicle Fleet Operations: Business Models and Optimization Approaches for Shared Mobility.



(left to right) Karen Smilowitz, Maciek Nowak, and Hani Mahmassani in Warsaw in June 2017.

Industry Technical Workshop Tackles Healthcare Biologistics April 2016

Biologistics in a Changing Healthcare World

On April 20, 2016, NUTC and the Center for the Commercialization of Innovative Transportation Technology co-hosted Biologistics in a Changing Healthcare World. This technical workshop examined changes occurring across the supply chain in the biologistics industry, including impacts from: the change in landscape of and with the healthcare providers; the establishment of group buying organizations forming distribution centers to service affiliated hospitals; communication protocols, or lack thereof, across the healthcare supply chain; evolving cold chain supply chain management

requirements; and the use of analytics to better stage (store) products for deliveries to the right location at the right time.

WORKSHOP LEADER

David Torma, Director, Logistics & Global Transportation, Baxter Healthcare

CASE STUDY PRESENTERS

Dave Bode, Vice President, Health Care Solutions, DSC Logistics: "Health Care Logistics, an Enabler of Change"

Bill Spillane, Executive Director, Supply Chain Management, Astellas Pharma: "Supply Chain Strategies for Pharmaceutical Product Integrity"

Andrew Boyle, Co-Owner, Boyle Transportation: "Carrier Perspective on Serving the Life Science Market"

Jerry Beyl, Vice President, Health Care Sales, FedEx: "Global Trends Impacting Logistics across the Healthcare Industry"

EVENT CO-CHAIRS

Hani Mahmassani, William A. Patterson Distinguished Chair in Transportation; Director, NUTC

Bret Johnson, Director, Center for the Commercialization of Innovative Transportation Technology



Fall 2016
INDUSTRY
WORKSHOP

Industry Technical Workshop Describes Future of Transportation October 2016

Three Ways Machine Learning Will Disrupt Transportation

According to *Business Insider*, 10 million self-driving cars are expected to hit the road by 2020. For many, the prospect of taking trips with unmanned vehicles may seem akin to magic, but the capability is actually the result of machine learning, a form of artificial intelligence that uses algorithms designed to learn from and respond according to the data it receives.

In the transportation industry, machine learning is the driving force behind many burgeoning technological advances. In October 2016 industry and academic experts gathered in Northwestern's McCormick Auditorium for "Machine Learning in Transportation," a technical workshop hosted by the NUTC and Northwestern's CCITT that featured speakers from Northwestern, BMW, IBM, and more.

"Machine learning allows us to tackle tasks that are too difficult to solve with fixed programs written and designed by human beings," said Aggelos Katsaggelos, Joseph Cummings Professor of Electrical Engineering and Computer Science at the McCormick School of Engineering. "Still, there is a give-and-take involved. We teach the machines how to learn, but analyzing how they perform informs our own learning on the subject. Transportation problems are rich in applying machine learning techniques."

1 Machine learning can be used to track congestion and save drivers time and headaches.

One area of transportation that has benefitted from machine learning is video surveillance. Katsaggelos shared a case study from his research where he developed an intelligent video surveillance system capable of

recognizing traffic anomalies on its own. Using machine learning algorithms, the system can detect and track moving cars during normal traffic flow and pinpoint anomalies like congestion, accidents, or pedestrians on the road. He believes intelligent surveillance systems can save humans valuable time.

"You can't rely on a human to analyze hours and hours of video data," said Katsaggelos. "But an intelligent video system can look at video data of traffic and be able to identify abnormal behavior."

2 By 2030, self-driving cars will make our commutes less stressful, more entertaining.

Alvin Chin, senior researcher for BMW Technology Corporation, highlighted the car company's use of machine learning to further develop connected cars. The company's machine learning app for smartphones—BMW Connected—pulls data from BMW cars to improve the driving experience. In addition to automatically analyzing frequent routes drivers take, the app also predicts future trips and provides notifications of when to leave based off of traffic and weather conditions.

Chin said incorporating machine learning in the automobile industry has only just begun, but widespread adoption will happen quickly. He expects there to be 381 million connected cars in use by 2021, with many featuring autonomous driving.

"Today, we use one vehicle for every trip purpose. If you own a car, you take it to work, to go shopping, and to go on vacation," said Chin. "By 2030, there will be a solution for each unique transportation purpose. Instead of commuting to work and stressing about finding parking, you can take a ride-sharing service. For more leisurely trips, self-driving cars will be able to handle transportation while you relax and watch a movie."

3 Insurance rates of the future will be based on real-time data.

Shifting the perspective to automobile insurance companies, Mo Patel, practice

director, artificial intelligence and machine learning at Teradata, explained that machine learning is changing how insurers evaluate drivers. Instead of determining a consumer's policy based off of the number of miles they have driven historically, Patel predicts machine learning technologies will allow insurance companies to establish insurance rates by using real-time data.

"Your smartphone and connected car could collect a ton of data, from location information to engine RPM cycles and accelerometer readings," said Patel. "All of that data is allowing insurance companies to build behavior models and set rates based off of the driver. Instead of paying as you drive, you will pay how you drive."

SESSION 1: PERSONAL TRAVEL

Aggelos Katsaggelos, Joseph Cummings Professor of Electrical Engineering and Computer Science, Northwestern University: "On Machine Learning, Anomalous Event Detection from Surveillance Video"

Alvin Chin, Senior Researcher, BMW Technology Corporation: "The Ultimate Smart Driving Machine: Powering the

Connected Car with Machine Learning"

Mo Patel, Practice Director, Artificial Intelligence & Machine Learning, Teradata: "Real-Time Machine Learning for Car Insurance Applications using Telematics Data"

Moderator: **Tony Belkin**, Head of Traffic and Dynamic Content, HERE

SESSION 2: AIR & FREIGHT TRANSPORTATION

Keith Dierkx, Global Travel and Transportation Rail Leader, IBM: "Cognitive Computing in Transportation. Use of Augmented Intelligence in Maintenance"

Joe Becker, Field Services Manager, Uptake: "On Track to Improved Reliability: From Rules to Predictions"

Ted Gifford, Distinguished Member of Technical Staff, Schneider: "Machine Learning Opportunities in Freight Transportation Operations"

Moderator: **Mr. Frank Bush**, Senior Consultant, Teradata



Bret Johnson introduces the machine learning workshop participants.

Transportation Research Forum (TRF) April 2017

NUTC Faculty and Alumnus Co-Host 58th Annual TRF Meeting in Chicago

The Transportation Research Forum is an independent organization of transportation professionals that provides an impartial meeting ground for carriers, shippers, government officials, consultants, university researchers, suppliers, and others seeking an exchange of information and ideas related to both passenger and freight transportation.

The 58th TRF Meeting took place April 20–21, 2012, at the University of Illinois, Chicago. The local organizing committee was headed by

NUTC Hosts Special Session as Part of Public Forum March 7, 2017

African Labyrinths: Corruption, Democracy, and Insecurity

The session, part of the public forum titled “Democracy and Insecurity in Africa,” and hosted by NUTC at Chambers Hall, focused on the modernization and growth of important infrastructure systems and networks including their transportation systems, electrical and water systems and other vital public sector networks and how corruption in Africa impacts every aspect of African life and development.

Bringing together prominent Africa experts including Transportation Center faculty affiliate, Richard Joseph, Northwestern’s John Evans Professor of International History and Politics, scholars discussed the strengthening of African Democracy amidst rising global uncertainty and insecurity. The event was supported by Northwestern’s Transportation Center, Center for International Human Rights, and Department of Political Science, Program of African Studies; and by the Chicago Council on Global Affairs, the Center for Global Health and Institute of Politics of the University of

NUTC faculty member Ian Savage and NUTC alum Joe Schwieterman.



The keynote speaker was Samuel K. Skinner, former United States Secretary of Transportation (1989-1991) and White House Chief of Staff under President George H.W. Bush.

TRF AWARDS NUTC STUDENTS

Congratulations to Northwestern researchers, Michael Hyland, Zihan Hong, Helen Karla Ramalho de Farias Pinto and Ying Chen, who received Runner Up in Best Student Paper Competition for “A Hybrid Cluster-Regression Approach to Forecast Ridership at Bikeshare Stations: Case Study of Chicago’s Divvy System.”

Chicago, and the John D. and Catherine T. MacArthur Foundation.

PRESIDING

Wale Adebani, Professor of African American & African Studies, University of California, Davis

RESPONDENTS

John Campbell, Former Ambassador to Nigeria and Ralph Bunche Senior Fellow for African Policy Studies at the Council on Foreign Relations

Juliet Sorensen, Professor of International Law, Center for International Human Rights, Northwestern Pritzker School of Law

Richard Joseph, John Evans Professor of International History and Politics, Northwestern, and NUTC Faculty Affiliate



(left to right) Wale Adebani, John Campbell, Juliet Sorensen, and Richard Joseph.

TC Seminar Series

The NUTC Seminar Series allows students, faculty, and the community to learn from the real-world experiences of seasoned industry professionals and researchers in the field. The series is designed to enhance the student classroom experience and learning. Each year the series features a wide variety of academic speakers, transportation professionals and researchers examining topics relevant to their course of study and future professions.

2016 SEMINARS

Date	Title/Presenter
January 21, 2016	<i>Beyond Transport Time: Modeling Time Use, Understanding Time Values</i> Sergio Jara-Diaz , Professor of Transport Economics, Universidad de Chile
February 4, 2016	<i>An Integrated Urban Model of Transportation, Land-Use, Energy, and Environment</i> Abolfazl Mohammadian , Professor of Civil & Materials Engineering, University of Illinois at Chicago
February 11, 2016	<i>Location-Based Social Network (LBSN) Data: Emerging Big Data Sources for Travel Demand and Activity Modeling</i> Jing (Peter) Jin , Assistant Professor of Civil & Environmental Engineering, Rutgers, The State College of New Jersey
February 25, 2016	<i>Modernizing Freight Rail Regulation—The 2015 Transportation Research Board Recommendation to Congress</i> Ken Boyer , Professor of Economics, Michigan State University
April 14, 2016	<i>German American Chamber of Commerce of the Midwest, Inc. — Innovation Seminars on Energy Efficient Transportation Systems, featuring expert speakers from the German transportation sector</i> Bernhard Kleine , Director, Trade Lane Development Trans Atlantic for EMEA and Indian Subcontinent, Schenker Inc. Thomas Reinacher , Regional Manager North America, Zöllner Signal GmbH Jeremy Goldstein , Logistics Coordinator, Peapod LLC Professor Christian Prehofer , Internet of Things & Services, Research Group Leader, Fortiss GmbH
April 28, 2016	<i>The Air Transport Industry: Structure, Economics, Operations: An Overview of the Aviation Industry and its Key Players</i> Peter L. Smith , Former Project Director, Customer Value of Aviation Services, Marketing & Business Strategy, Boeing Commercial Airplanes
May 5, 2016	<i>Transit Accessibility, Last Mile Issues & Equity: Assessment using Chicago as a Case Study</i> Nebiyu Y. Tilahun , Assistant Professor of Urban Planning & Policy, University of Illinois at Chicago
May 19, 2016	<i>Simulating the Dynamic Effects of Horizontal Mergers: U.S. Airlines</i> John Lazarev , Assistant Professor of Economics, New York University, Visiting Scholar of Economics Northwestern University
May 26, 2016	<i>Simulating and Visualizing Planning for Sustainable Development</i> Paul Waddell , Professor of City & Regional Planning, University of California, Berkeley
September 29, 2016	<i>Big Data to Tackle Urban Mobility Challenges</i> Marta C. Gonzalez , Associate Professor, Civil & Environmental Engineering, MIT
October 6, 2016	<i>Public-Private Partnership for Transportation Safety: Case Studies in Air & Rail</i> Laurence Audenaerd , Lead Engineer, Center for Advanced Aviation System Development, The MITRE Corporation
October 13, 2016	<i>CTA Red & Purple Modernization (RPM): A Core Capacity Expansion</i> Carole A. Morey , Chief Planning Officer, Chicago Transit Authority (CTA)
October 20, 2016	<i>Green Urban Freight Strategies in the New Mobility Era</i> Richard Arnott , Professor of Economics University of California, Riverside
October 27, 2016	<i>Connecting e-Hailing to Mass Transit Platform</i> Yu (Marco) Nie , Associate Professor, Civil & Environmental Engineering, Northwestern University
November 17, 2016	<i>Planning Service Facilities Under Continuous Traffic Equilibrium</i> Yanfeng Ouyang , Endowed Faculty Scholar, Civil & Environmental Engineering University of Illinois, Urbana-Champaign (UIUC)
December 1, 2016	<i>An Overview of Regional Transportation Planning in Chicago</i> Kermit W. Wies, Ph.D , Senior Research Fellow & Adjunct Professor, Northwestern University
December 6, 2016	<i>North American Freight Rail in the ‘Post-Coal’ Era: A Year 1 Report Card</i> Anthony B. Hatch , Senior Transportation Consultant, ABH Consulting

2017 SEMINARS

Date	Title/Presenter
February 9, 2017	<i>Effects of the Light Rail Transit Development & Neighborhood Design on Travel Behavior</i> Jason Cao , Associate Professor, University of Minnesota
February 23, 2017	<i>How to Fundraise for Operational Expenditures in International Humanitarian Aid</i> Giovanni Circella , Senior Research Engineer, Georgia Institute of Technology; UC Davis
March 2, 2017	<i>The Right to Travel—Little Recognized Aspects & Impediments</i> Richard Sobel , Visiting Scholar & Faculty Affiliate, Northwestern University
March 9, 2017	<i>Anticipatory Pricing to Manage ‘Flow Breakdown’</i> Ian Savage , Associate Chair, Department of Economics, Professor of Instruction, Weinberg School of Arts & Science, Northwestern University
March 30, 2017	<i>Multidimensional Network Analysis of Customer Preferences in Engineering Design</i> Wei Chen , Wilson-Cook Professor in Engineering Design, Director of Graduate Studies, Mechanical Engineering, Northwestern University
April 13, 2017	<i>Using Automated Data Sources to Improve the Performance of Public Transport Systems: A Framework and Applications</i> Nigel Wilson , Professor, Civil & Environmental Engineering, Massachusetts Institute of Technology (MIT)
April 27, 2017	<i>Delivering Sustainability: Transporting Goods in Urban Spaces</i> Anne Goodchild , SCTL Director, Associate Professor, Civil & Environmental Engineering, University of Washington
May 25, 2017	<i>Research, Practice, and Future Directions of Dynamic Ridesharing</i> Maged Dessouky , University of Southern California
October 5, 2017	<i>A Tale of Two Stations: Civil Engineering and Design of the CTA Wilson & 95th Street Stations</i> Chris Bushell , Chief Infrastructure Officer, Chicago Transit Authority (CTA)
October 12, 2017	<i>Efficiency from User-driven Service Order Adjustments in Collaborative Consumption of Supply in Transportation</i> R. “Jay” Jayakrishnan , University of Southern California
October 26, 2017	<i>The Marginal Congestion of a Taxi in New York City</i> Alejandro Molnar , Assistant Professor of Economics, Vanderbilt University
November 2, 2017	<i>Agent-Based Activity/Travel Microsimulation: What’s Next?</i> Eric Miller , Professor, Department of Civil Engineering, Director, University of Toronto Transportation Research Institute (UTTRI), University of Toronto
November 9, 2017	<i>Models and Approaches to Multi-Objective Arc Tour Problems with an Application to Marathon Course Design</i> Mehmet Basdere , PhD Candidate, Industrial Engineering & Management Sciences, Northwestern University
November 14, 2017	<i>Digitalization of Transport Management—A Voyage, Not a Destination</i> Gunnar Stefansson , Professor, Logistics & Transport Management, Chalmers University of Technology, Gothenburg, Sweden; University of Iceland, Reykjavik, Iceland
November 16, 2017	<i>A Universal Methodology for Learning Cascading Failure Dynamics in Interdependent Networks</i> Cynthia Chen , Professor, Civil & Environmental Engineering, University of Washington-Seattle, Director, THINK (Transportation-Human Interaction-and-Network Knowledge) Lab



Sandhouse Rail Group

THE HAGESTAD SANDHOUSE RAIL GROUP is a railroad discussion group that aims to explore rail-related issues and link active practitioners with students and academics at Northwestern.

Date	Title/Presenter
December 5, 2017	<i>The Railroad Renaissance at 18: Alive but Challenged, both External (trade), Internal (service/capex) and Possible (AV Trucks?)</i> Anthony Hatch , ABH Consulting
October 5, 2017	<i>A Tale of Two Stations: Construction Challenges Associated with the New CTA Wilson and 95th St. Stations</i> Chris Bushell , Chief Infrastructure Officer, Chicago Transit Authority (CTA)
June 8, 2017	<i>Railroad Freight Traffic: What Went Wrong and Can It Be Fixed?</i> Michael Blaszak , Attorney & Author
April 27, 2017	<i>Rail/Air Competition in the New York-Chicago Market 1945–1970</i> George Hamlin , President, Hamlin Transportation Consulting
March 28, 2017	<i>Forty Years as Railroad Counsel</i> William C. Sippel , Retired Partner, Fletcher & Sippel, LLC
February 16, 2017	<i>CHICAGO: America’s Railroad Capital</i> David Lassen , Associate Editor, <i>Trains Magazine</i> , Jim Wrinn , Editor, <i>Trains Magazine</i>
January 19, 2017	<i>METRA: Looking Ahead to 2017 & Beyond</i> Donald A. Orseno , Executive Director & CEO, METRA, Bruce Marcheschi , Chief Engineering Officer, METRA, Lynnette H. Ciavarella , Senior Division Director, Strategic Capital Planning, METRA
December 6, 2016	<i>North American Freight Rail in the ‘Post-Coal’ Era: A Year One Report Card</i> Anthony B. Hatch , Senior Transportation Consultant, ABH Consulting
November 10, 2016	<i>A Transportation Miracle</i> Norman Carlson , Carlson Consulting International, LLC, Moderator, Sandhouse Rail Group
October 13, 2016	<i>CTA Red and Purple Modernization (RMP): A Core Capacity Expansion</i> Carole A. Morey , Chief Planning Officer, Chicago Transit Authority (CTA)
October 6, 2016	<i>Public-Private Partnership for Transportation Safety: Case Studies in Air & Rail</i> Laurence Audenaerd , Lead Engineer, Center for Advanced Aviation System Development, The MITRE Corp.
September 15, 2016	<i>Representations of Railroadings</i> Scott Lothes , President & Executive Director, Center for Railroad Photography & Art
June 8, 2016	<i>Life Is Hard and the Train is Easy, along the South Shore Line</i> Michael Noland , General Manager, NICTD, Donald Orseno , Executive Director, METRA
May 12, 2016	<i>Delivering Private Intercity Passenger Rail Service in Florida</i> Myles L. Tobin, Esq. , General Counsel, All Aboard Florida
February 25, 2016	<i>Modernizing Freight Rail Regulation: The 2015 Transportation Research Board Recommendation to Congress</i> Ken Boyer , Professor, Economics, Michigan State University
January 20, 2016	<i>METRA: Building on the Successes of 2015 for the Future</i> Donald A. Orseno , Executive Director & CEO, METRA, Jim Derwinski , Chief Mechanical Officer, METRA, Bruce Marcheschi , Chief Engineer, METRA



Transportation Research Board (TRB)

TRB Annual Meeting

JANUARY 8 – 12, 2017

The 96th Annual Meeting was held January 8–12, 2017, at the Walter E. Washington Convention Center, in Washington, DC. The information-packed program attracted more than 13,000 transportation professionals from around the world, including dozens of talented researchers from NUTC!

The TRB Executive Committee welcomed NUTC-affiliated students, faculty and researchers to the annual meeting in Washington, DC this year. More than 5,000 presentations addressed topics of interest to policy makers, administrators, practitioners, and researchers, from government, industry, and academic institutions. NUTC researchers, faculty and students shared their latest research findings in presentations, poster sessions, and committee meetings.

The five-day program featured more than 800 sessions and workshops on all aspects of transportation, including some 36 on this year's spotlight theme, "Transportation Innovation: Leading the Way in an Era of Rapid Change." More than 130 sessions and workshops also addressed TRB's hot topics of transformational technologies, transportation and health, and transportation.

JANUARY 10 – 14, 2016

NUTC faculty, staff and students also attended the Transportation Research Board (TRB) 95th Annual Meeting on January 10–14, 2016, in Washington, DC. The program attracted more than 12,000 transportation professionals from around the world.

NUTC researchers, faculty and students shared their latest research findings in presentations, poster sessions, and committee meetings.

TRB Reception and NUTC Alumni Reunion

The annual TRB meeting also provides an opportunity to re-connect with Northwestern University alumni. NUTC hosted its annual receptions to provide an opportunity for current faculty, staff, and students to engage with alums from across the country.



NUTC Community

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, the NUTC fosters this community by means of networking events, speaker forums, clubs, and social gatherings.

NUTC Welcome Reception

Each year, NUTC faculty, students, staff and friends attend a Welcome [Back] Reception at the Ryan Field Stadium Club. Attendees toast to the upcoming year of academic achievements while enjoying beautiful sunset views and catered treats in the box seats above Ryan Field.



End-of-Year BBQ

In June 2016, despite rainstorms and high winds, students, faculty, staff and friends gathered together in the lower level of Chambers Hall for NUTC's annual End-of-Year BBQ. The event consistently draws colleagues from across Northwestern University's campus, the surrounding Evanston and Chicago areas, and beyond. The indoor BBQ put a positive spin on an otherwise grey-weather day—especially thanks to Sandhouse Group member Mark Walbrun, who presented staff with a beautiful (and delicious) "Congratulations NUTC" cake to close the event.



McCormick School's Solar Eclipse Day



NUTC Holiday Lunch



Transportation Clubs: NTC & Kellogg

The NTC (or NUTC) and Kellogg Transportation Clubs engage students in the airline, aerospace, railroad, ocean shipping and logistics (supply chain) industries. Both clubs were created to raise student awareness and provide resources related to management opportunities with companies in these industries. The NTC Club was established in 2016 for non-Kellogg students in TRN, the T&L Minor, CEE and IE.



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 dozens of social gatherings and informative events where all transportation enthusiasts are welcomed.

Transportation Club Events

APRIL 2016 - American Airlines O'Hare International Airport Tour

MARCH 2017 - UPS CACH Tour (Chicago Area Consolidation Hub & BNSF Railway Intermodal Yard) Though the UPS tour size was limited, the

Kellogg Transportation Club offered 5 spots to NUTC Transportation Club students, and the group traveled via bus to the UPS facility together. The bus left campus at 8:00 am so students could get to UPS in time for the morning sort and receive an informational briefing from UPS operations managers. The group was also able to visit the adjacent BNSF Intermodal facility and control tower during their visit.

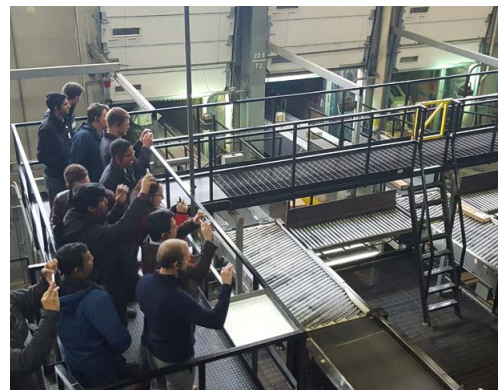
UPS processes (sorts) approximately 1.3 to 1.5 million packages per day at the CACH—located in Hodgkins, IL. The 1.5-million-square-foot facility employs 5,700 people. The CACH facility has over 65 miles of belts and conveyors and uses automated equipment to sort packages.

APRIL 2017 - NTC Kick-Off Event, Chambers Hall

JUNE 2017 - American Airline Maintenance Facilities Tour at O'Hare

SEPTEMBER 2017 - Bike Tour Along Chicago's Lakefront Trail; Bowling at Diversy River Bowl

OCTOBER 2017 - Lunch Seminar: The Smartphone as Transportation: Making Uber Work in New York City, Drew B. Austin, Operations & Logistics Officer, Uber Technologies



Icarus Aviation Society

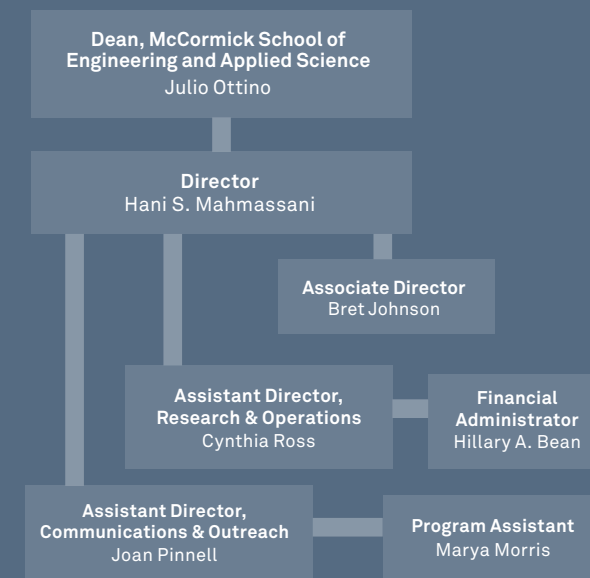
Formed in 2006, the NUTC's Icarus Society promotes in-depth dialogue about airlines, aircraft manufacturing, aviation services, technology, government oversight, and significant elements of business aviation.

NUTC's Icarus Society, or Icarus Aviation Forum, is a public forum created for the discussion and dissemination of all issues relating to aviation and sharing knowledge, new ideas with all interested parties.

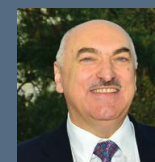


Northwestern University Transportation Center

Organizational Structure



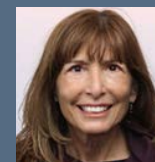
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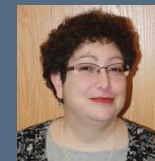
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