NEXTOR 20th Anniversary Workshop

George Mason University

Georgia Institute of Technology

Massachusetts Institute of Technology

The Ohio State University

Purdue University

University of California, Berkeley

University of Maryland

Virginia Polytechnic Institute and State University

Sept. 29–30, 2016
College Park Marriott and Conference Center
Adelphi, Maryland

Workshop sponsored by

Federal Aviation Administration

GRA, Incorporated

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Welcome!

Dear Friends:

We are pleased to welcome you to the NEXTOR 20th anniversary workshop. NEXTOR began in 1996 as a 4-University FAA center of excellence and has since grown into an 8-University FAA-sponsored consortium with a rich history of activities and accomplishments. In the past twenty years NEXTOR faculty and students have worked closely with the FAA and other government sponsors and several industry partners. This workshop brings together those faculty and present and former students as well as our sponsors and industry partners. We hope that it provides an opportunity to celebrate both NEXTOR research accomplishments and, perhaps more importantly, the rich legacy of alumni who have graduated from the NEXTOR programs. These alumni represent the next generation of leaders in air transportation.

We are very pleased that Randy Park, the Deputy Chief Operating Officer of the FAA Air Traffic Organization, and Norm Fujisaki, the first FAA NEXTOR program officer, have agreed to deliver keynote addresses. Each of the six technical sessions contains one presentation on past NEXTOR research, one presentation on current research and a discussion panel on future research directions. We hope that these provide a perspective on the richness of past and present NEXTOR research and also offer an opportunity for lively discussion of the future of aviation and aviation research.

Thank you for attending the workshop.

Mike Ball, Thea Graham, Mark Hansen, John Hansman, Tony Trani—Organizing Committee

NEXTOR Facts

Origins: Founded in 1996 as the FAA National Center of Excellence in Aviation Operations Research. Renewed in 2011 as an eight-university consortium.

Mission: *To be leaders within the aviation community by advancing new ideas and paradigms for aviation operations, promoting knowledge exchange among industry, government, and academic leaders, and educating and training aviation professionals.*

Core University Members: George Mason University, Georgia Institute of Technology, Massachusetts Institute to Technology, Ohio State University, Purdue University, University of California, Berkeley, University of Maryland and Virginia Polytechnic Institute and State University

Affiliate Members: A number of other universities are regular partners on NEXTOR research activities, primarily because of NEXTOR alumni who are now on the faculty at those universities. These schools include Dartmouth College, Embry Riddle Aeronautical University, San Jose State University, University of Colorado, University of Pennsylvania, University of South Florida, and University of Texas at Austin.

Education: Over its 20 year history, the NEXTOR universities have awarded ***more than 105 Ph.D. degrees and 138 masters degrees*** to students involved in NEXTOR research projects. NEXTOR alumni have faculty positions at several prestigious universities and a very wide set of organizations within the aviation community.

Faculty: Over 50 individual faculty members from the core universities have participated in NEXTOR research projects.

Research: Faculty and students at NEXTOR universities, together with industry partners, have completed dozens of successful research projects on topics including air traffic flow management, economics and policy, air traffic safety, simulation and predictive modeling, metrics and data analysis, new technology assessment, and benefits analysis. A unique feature of many NEXTOR projects is close collaboration with industry and public sector stakeholders, for example a live test of how a new security measure would affect airline operations and gaming exercises involving real airline schedulers to see how pricing and auctions would affect flight schedules and delay.

Outreach: NEXTOR holds regular workshops and short courses that engage the larger national and world aviation communities on topics such as aviation system performance, market mechanisms for slot allocation, aviation infrastructure management, and airport planning and design. The most recent workshop, held in Tianjin, China, featured researchers and service providers the North America, China, and Europe.

Program

Thursday, September 29

Please note: All sessions are in Potomac Salon 1 unless otherwise indicated.

7:30 a.m. Registration and Breakfast
(Potomac Foyer)

9:30 a.m. Opening Session

Chair: Michael Ball
Co-Director, National Center of Excellence for Aviation Operations Research
Professor, Robert H. Smith School of Business and Institute for Systems Research
University of Maryland

Welcome and Introductory Remarks

Reza Ghodssi
Director, Institute for Systems Research
University of Maryland

David Chin
Director, Performance Analysis and NEXTOR sponsor
Federal Aviation Administration

9:45 a.m. Keynote Session

NEXTOR and the Federal Aviation Administration—Accomplishments and Future Challenges

Randy Park
Deputy Chief Operating Officer
Air Traffic Organization
Federal Aviation Administration

10:30 a.m. Safety & Security Session (1)

Chair: Edward Johnson
Chief Scientific and Technical Advisor for Wake Turbulance
Federal Aviation Administration

10:30 a.m. From Positive Passenger Bag Matching to Flight Safety Metrics: a Brief History of NEXTOR Research on Safety and Security

Arnold Barnett
George Eastman Professor of Management Science
Professor of Statistics
Massachusetts Institute of Technology

10:55 a.m. Wake Modeling for NextGen Trajectories

John Shortle
Associate Professor
Systems Engineering and Operations Department
George Mason University

11:20 a.m. Discussion

Douglas Swol
Lead Systems Engineer
MITRE

Sathya Silva
Human Performance Investigator
National Transportation Safety Board

Aswin Gunnam
Aviation Consultant
Federal Aviation Administration/GRA, Inc.

Firdu Bati
Mathematician and Data Scientist
Federal Aviation Administration

Frank Ketcham
University of California, Berkeley

12:00 p.m. Lunch
(Potomac Ballroom Salon 2)

1:00 p.m. CDM and Air Traffic Flow Management Session (2)

Chair: Robert Hoffman
Senior Technical Director, Metron Aviation

1:00 p.m. NEXTOR CDM Research Contributions

Michael Ball
University of Maryland

1:25 p.m. Modeling Oceanic Traffic Flows

Antonio Trani
Professor, Civil and Environmental Engineering
Virginia Polytechnic Institute and State University

1:50 p.m. Discussion

William Hall
Managing Director, Commercial Applications and Services
Mosaic ATM/Mosaic Data Science

Mark Hopkins
Director, ATM/CDM
Delta Air Lines

James Wetherly
Manager, Systems Engineering
Federal Aviation Administration

Craig Wanke
Senior Principal Engineering
MITRE

Dengfeng Sun
Associate Professor
School of Aeronautics and Astronautics
Purdue University

2:30 p.m. Break

2:45 p.m. Airport Congestion Management Session (3)

Chair: Frank Berardino
President, GRA, Inc.

2:45 p.m. NEXTOR New York Airport Congestion Management Project

Karla Hoffman
Professor, Systems Engineering and Operations Research Department
George Mason University

3:10 p.m. Schedule Improvements at Congested Airports

Amedeo Odoni
Professor Emeritus of Aeronautics and Astronautics, and Civil and Environmental Engineering
Massachusetts Institute of Technology

3:35 p.m. Discussion

Vikrant Vaze
Assistant Professor of Engineering
Dartmouth College

Patricia Clark
Senior Advisor to the Aviation Director
Port Authority of New York & New Jersey

Alexandre Jacquillat
Assistant Professor, Operations Research/Public Policy
Carnegie Mellon University

4:15 p.m. Break

4:30 p.m. NEXTOR History Session

Chairs: Norman Fujisaki, Strategy Advisor, Norman T. Fujisaki, LLC; **Scott Simcox**, President, ATAC

4:30 p.m. Discussion

Michael Ball
University of Maryland

Arnold Barnett
Massachusetts Institute of Technology

Mark Hansen
Professor, Civil and Environmental Engineering
University of California, Berkeley

Amedeo Odoni
Massachusetts Institute of Technology

Lance Sherry
Director, Center for Air Transportation Systems Research
Associate Professor, Systems Engineering and Operations Research Department
George Mason University

Patricia Watts
National Program Director, Centers of Excellence
Federal Aviation Administration

5:30–6:00 p.m. Break

6:00 p.m. Evening Session

6:00 p.m. Reception & Poster Session 9Potomac Ballroom)

7:00 p.m. Dinner (Potomac Ballroom Salon 2)

Dave Lovell
Co-Director, National Center of Excellence for Aviation Operations Research
Professor, Civil and Environmental Engineering and Institute for Systems Research
University of Maryland

Megan Ryerson
Assistant Professor, City and Regional Planning; Electrical and Systems Engineering
University of Pennsylvania

Thomas Vossen
Associate Professor
Management and Entrepreneurship
University of Colorado, Boulder

Friday, September 30

7:30 a.m. Breakfast (Potomac Foyer)

8:30 a.m. Keynote Session

Chair: Mark Hansen
University of California, Berkeley

8:30 a.m. Keynote: Future Research Challenges

Norman Fujasaki
Strategy Advisor
Norman T. Fujisaki, LLC

9:15 a.m. Economic Analysis Session (4)

Chair: Dres Zellweger
Aviation Consultant

9:15 a.m. Total Delay Impact Study

Mark Hansen
University of California, Berkeley

9:40 a.m. A Multi-Level Modeling and Simulation View on Air Transportation Evolution

Daniel DeLaurentis
Professor; President's Fellow for Defense Initiatives
School of Aeronautics and Astronautics
Purdue University

10:05 a.m. Discussion

Kevin Neels
Principal
The Brattle Group

Prem Swaroop
Altisource Labs

Joseph Post
Deputy Director
NAS Systems Engineering and Integration
Federal Aviation Administration

Rich Golaszewski
Executive Vice President and Owner
GRA, Inc.

Lauren Bowers
Consultant

10:45 a.m. Break

11:00 a.m. Analysis of New Operational Systems Session (5)

Chair: Andrew Churchill
Principal Data Scientist
Mosaic ATM/Mosaic Data Science

11:00 a.m. Research and Development of Efficient Descent Trajectories

John-Paul Clarke
College of Engineering Dean's Professor
School of Aerospace Engineering
Georgia Institute of Technology

11:25 a.m. Benefits Case for Oceanic ADSB

John Hansman
Professor, Aeronautics and Astronautics
Massachusetts Institute of Technology

11:50 a.m. Discussion

Dorothy Robyn
Principal, The Brattle Group

Fabrice Kunci
General Atomics

Jim Evans
Senior Staff, MIT Lincoln Laboratory

Senay Solak
Associate Professor
Operations and Information Management
University of Massachusetts, Amherst

Jasenka Rakas
Deputy Director, NEXTOR
University of California, Berkeley

12:30 p.m. Break with Box Lunches

12:45 p.m. Metrics and Performance Analysis (6)

Chair: John Gulding
Operations Researcher
Federal Aviation Administration

12:45 p.m. Passenger Delay Modeling

Lance Sherry
Associate Professor, Systems Engineering and Operations Research
George Mason University

1:10 p.m. Predictability Metrics

David Lovell
University of Maryland

1:35 p.m. Discussion

Megan Ryerson
University of Pennsylvania

David Knorr
Senior FAA Representative, Paris
Federal Aviation Administration

Monica Alcabin
Associate Technical Fellow
The Boeing Company

Bo Zou
Assistant Professor
Civil and Materials Engineering
University of Illinois–Chicago

Amy Kim
Assistant Professor, Transportation Engineering
Civil and Environmental Engineering
University of Alberta

2:15 p.m. Closing Session

Michael Ball
University of Maryland

David Chin
Federal Aviation Administration

Keynote speakers

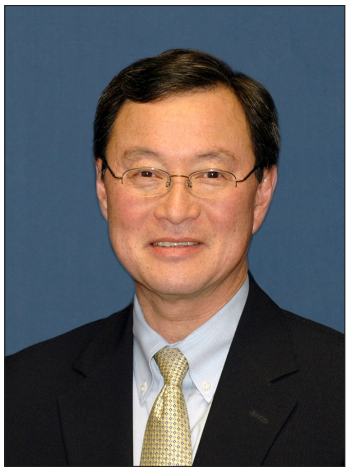
Randy Park

Randy Park was named Deputy Chief Operating Officer of the Federal Aviation Administration's Air Traffic Organization in June 2015. As Deputy Chief Operating Officer, Randy is responsible for ensuring the safety, efficiency and security of the air traffic operation across the entire National Airspace System. The scope of his responsibilities includes strategic leadership and direction of all service units within the Air Traffic Organization.

Randy provides leadership for the organization and plays a critical role in realizing a number of key ATO and FAA achievements, including the successful completion of the ERAM baseline program and delivering on several commitments that support the FAA's Strategic Initiatives and transition to NextGen. In addition, Randy is instrumental in moving forward with training and tools to provide ATO managers with the resources to become more effective leaders.

Randy began his career in the USAF as an Air Traffic Controller in 1974 and joined the FAA in 1981 at Oakland ARTCC where he gained years of technical and managerial experience. He served in several leadership roles at Oakland ARTCC over the years, including Assistant Air Traffic Manager and ultimately Air Traffic Manager, as well as key leadership positions at some of our busiest Air Traffic Control facilities. Randy holds a Bachelor of Science degree in Aerospace Management from Embry Riddle Aeronautical University.

Norman Fujisaki



Norm Fujisaki is a management consultant specializing in corporate strategies for long-term performance in the face of uncertainty. He assists in analyzing future markets, customer needs, technology trends, and solution alternatives. Fujisaki helps clients take smart, modest actions today that result in major competitive and business advantages in the long term.

Previously, Fujisaki served as Metron Aviation, Inc.'s chief strategy officer and president. In these positions, he developed corporate strategies to provide global customers with analyses of complex operational environments and focused solutions to their costliest problems. He also provided leadership to strengthen performance on key Federal Aviation Administration contracts for Air Traffic Flow Management and surface management. In addition, he secured the future of the company through winning crucial federal government contracts, and guided its expansion into commercial and international markets.

He also worked for the Federal Aviation Administration for 25 years, rising to the position of vice president for operations planning in its Air Traffic Organization. Here he was responsible for business planning, performance analysis, systems engineering, R&D, the William J. Hughes Technical Center, the Operational Evolution Plan, and international relations. He also held senior executive leadership positions in systems engineering, operations research, investment analysis, and major systems acquisition for communications, navigation, surveillance and ATM automation systems. Fujisaki led the creation of the agency's investment analysis and decision-making process under Acquisition Reform of the Federal Aviation Administration and formed the Center of Excellence for Aviation Operations Research (NEXTOR). In the mid-1990s, brought the airline industry and Federal Aviation Administration together to start collaborative decision-making (CDM).

Fujisaki has served on the advisory committee for Systems Engineering and Operations Research and the Dean's Advisory Board of the Volgenau Engineering School at George Mason University. He completed undergraduate work in electrical engineering at California Polytechnic, graduate work in industrial engineering at Texas A&M and public administration at The American University.

Poster session

Air Traffic Flow Management under Uncertainty using Chance-Constrained Optimization

Jun Chen
Purdue University

To efficiently balance traffic demand and capacity, optimizations of Air Traffic Flow Management (ATFM) rely on accurate predictions of future capacity states. However, these predictions are inherently uncertain due to factors such as weather.

This poster presents a novel computationally efficient algorithm to address uncertainty in ATFM by using a chance-constrained optimization method. First, a chance-constrained model is developed based on a previous deterministic Integer Programming model of ATFM to include probabilistic sector capacity constraints. Then, to efficiently solve such a large-scale chance-constrained optimization problem, a polynomial approximation-based approach is applied. The approximation is based on the numerical properties of the Bernstein polynomial that is capable of effectively controlling the approximation error for both function value and gradient. Thus a first-order algorithm is adopted to obtain a satisfactory solution which is expected to be optimal. Numerical results are reported to evaluate the approximation-based approach by comparing with a brute-force method.

Moreover, since there are massive independent approximation processes in the approximation-based approach, a distributed computing framework is designed for this method's computation. This chance-constrained optimization method and its computation platform are potentially helpful for several other domains in air transportation, such as airport surface operations and airline management under uncertainties.

Introducing Critical Pair Identification and its Metrics

Zixu Zhang
Purdue University

Critical Pair Identification(CPI) works as a potential assistive tool for human air traffic controller to better detect and resolve conflicts which are difficult to be identified by today's separation assurance system. This concept specifically considers conflicts caused by one aircraft in the pair unexpectedly deviate from its flight path in the near future. Five metrics of CPI concept, Critical Pair Count, Time to Risk Exposure, Lead Time, Risk Exposure Duration and Blender Sensitivity Index, have also been developed and mathematically defined to potentially characterize the safety level of the aircraft pair or current air space. Metrics are calculated in Multi-aircraft test scenarios. The results suggest further and deeper investigation of how to utilize these metrics should be taken in the future work.

Characterizing Scenarios for Improvements in North Atlantic Operations for a Profit-Seeking Airline

Kolawole Ogunsina
Purdue University

The North Atlantic Organized Track System (NAT-OTS), popularly known as North Atlantic (NAT) Tracks, is a framework for transatlantic flight routes that stem from the northeast of North America to western Europe across the Atlantic Ocean. Due to the inherent elevated safety and efficiency in the NAT, new technologies and operational procedures must be proven safe and economically auspicious before they can be implemented. Hence, NAT stakeholders utilize investment analysis to assess the cost benefits and service quality of a prospective new technology or procedure. Previous work by Reddy and DeLaurentis used phone interviews to examine the uncertainty associated with the adoption of space-based ADS-B and in-trail procedures in the NAT. The current work presented articulates plausible scenarios based on interview findings from previous work and pertinent policies, such as the EU Emissions Trading Scheme (EU-ETS), that affect NAT operations. In one scenario, the Fleet Level Environmental Evaluation Tool (FLEET) was used to explore the response of a profit-seeking airline to different plausible benefits from space-based ADS-B based on projected estimates from an ADS-B service provider on NAT routes. Another scenario, modeled using FLEET, investigated the inclusion of international aviation into the EU-ETS, and its economic and environmental impacts for an airline operating in the NAT. The methods used to represent each scenario in FLEET and their corresponding results are subsequently discussed.

Multivariate Analysis of Flight En Route Efficiency

Yulin Liu
University of California, Berkeley

Attaining efficient en route trajectories is an important goal for the aviation community. We therefore apply several statistical methods to quantitatively understand

the causal reasons behind the differences in efficiency among flight routes. A flight level trajectory dataset obtained from Federal Aviation Administration Traffic Flow Management System (TFMS) shows significant clustering and patterns in route structure for given airport pairs. By applying principle component analysis and the DBSCAN algorithm, we classify each flight trajectory into a distinct cluster, or the outlier group, which includes flights with abnormal flight paths. By determining the representative trajectories for each cluster, we are able to on quantify causal factors such as convective weather and traffic congestion for each trajectory group, and further build statistical models to quantify how TMIs, weather and terminal effects influence the en route flight efficiency. Our models indicate that flights during summer seasons are more efficient than the others, but seasonal effects only explain 2 – 6% of overall variations in flight en route inefficiencies, while cluster membership account for 60%. In addition, the presence of convective weather along a route is found to have a strong deterrent effect on route selection.

Application of Common Cause Failure Methodology to Aviation Safety Assessment Model

Seungwon Noh
George Mason University

The Integrated Safety Assessment Model (ISAM, Federal Aviation Administration) provides a baseline risk assessment for the National Airspace System and to evaluate the safety impact of proposed changes to the system. ISAM consists of a set of event sequence diagrams and underlying fault trees for various accident scenarios. In the current model, all basic events in the fault trees are assumed to be independent. However many basic events throughout the model appear with the same descriptive label. Such events might have some dependence, rather than being completely independent as is currently assumed. This paper evaluates the dependency between basic events having the same label in order to see the overall impact on accident risk. A common cause failure (CCF) methodology is applied to the event sequence diagrams (ESDs) in ISAM. A modified beta-factor model is applied, and a binary decision diagram method is implemented to evaluate end-state frequencies of an ESD. Accounting for CCFs, this paper observes a wide range of changes in accident frequency relative to the current assumption of independent events. Results for different ESDs range from a decrease in accident frequency by 20% to an increase by more than a factor of 1,000.

Predictive Models of Departure and Arrival Runway Occupancy Time and Take-Off Distance

Thomas Spencer
Virginia Polytechnic Institute and State University

Runway occupancy time has long been recognized and utilized as one of the critical determinants of runway operational capacity. Consequently, departure and arrival runway occupancy times are utilized in many air transport simulation models in their analyses of airport capacity (LeighFisher, 2012). Oftentimes, air transport simulation models are capable of detailed analyses at the individual aircraft level. However, due to the considerable expense of ROT field collection, data for runway occupancy times are either unavailable or solely available at the aggregate level. Thus, there currently exists a need for reliable runway occupancy time that can be applied by individual aircraft level.

In recognition of this need, we endeavored to produce models of both departure and arrival runway occupancy time that can be readily utilized by analysts and have strong predictive power. Each model is based on more than 400,000 records of aircraft track data collected by a multilateration surveillance system (ASDE-X). Distributions of occupancy times by aircraft type are presented and cross validation of the models demonstrated an expected prediction error that was generally within 10 percent of both average departure runway occupancy times and arrival runway occupancy times at the airports for which data were collected.

Generating Representative Traffic Management Initiatives

Alexander Estes
University of Maryland

Currently, it is difficult for decision makers at the Federal Aviation Administration to access historical data that could help them to plan and evaluate traffic management initiatives. We are currently developing a tool that would make this data more accessible. This tool would identify days that are similar to a reference day in their weather and traffic. The tool would also identify the TMIs that occurred on these days. If there are many days that are similar to the reference day, it could be difficult for the decision maker to view all of these days and their corresponding TMIs. We present a method that would reduce the set of TMIs to a set of representative TMIs. The set of representative TMIs exhibit the variety of the full dataset as well as possible while still being small enough to be easily examined. This offers a wide variety of options for the decision maker to choose from with a basis in historical actions.

Mining NTML Data for Automated Graph Generation and Trend Analysis

Cara Chuang
University of Maryland

The National Traffic Management Log (NTML) is a comprehensive system for coordinating, logging, and communicating traffic management initiatives (TMIs). In cooperation with the Federal Aviation Administration (Federal Aviation Administration), we extracted this NTML data to create graphical, interactive dashboards that enable operators to analyze historical data trends and spatial patterns. Dashboards allow untrained users to instantaneously filter and interpret large amounts of data based on customized needs and will be practical for automatic report generation in the future. Our initial dashboard design looks at miles-in-trail (MIT) restrictions for the years 2009 through 2016. We used the daily average for count (the number of restrictions initiated), duration (the number of hours that the restriction was in place), and stringency (the duration multiplied by the MIT) as metrics to evaluate performance.

Potential Safety Benefits of RNP Approach Procedures

Sandro Salgueiro
Massachusetts Institute of Technology

Required Navigation Performance (RNP) approach procedures have been a recent focus of NextGen efforts to modernize navigation in the NAS. With the recent increase in implementation and usage of RNP procedures, real tracking data can now be more easily obtained for flights that make use of these approaches. In this study, we aim to evaluate the potential safety benefits of RNP procedures using airport surveillance data such as ASDE-X. Of specific interest are potential improvements in approach stability, defined by parameters such as deviation from target glideslope and approach speed.

A Multi-Attribute Airport Capacity Model: A System Level Study of Runway Throughput Components and New Wake Vortex Separation Concepts

Tamas Kolos-Lakatos
Massachusetts Institute of Technology

As air travel demand continues to grow, there is a greater need to introduce new procedures that can increase airport capacity without adding new infrastructure. For most congested airports, the airport capacity is most tightly constrained by runway capacity. Runway capacity at an airport can be limited by a number of factors. This research work analyzes the various factors affecting runway capacity, identifies the interactions and multidimensional tradeoffs between them, and quantifies their impact with a focus on new wake vortex separation procedures. A fast-time Monte-Carlo simulation based runway capacity model is built for this purpose that is capable of evaluating new static and dynamic concepts, as well as distance-based and time-based wake separation rules.

Improvement to Global Oceanic Model (GOM)

Arman Izadi, Antonio A. Trani, Yanqi Liang, Nick Hinze
Virginia Polytechnic Institute and State University

This poster is going to demonstrate some of the recent improvements to GOM which can be categorized in two main aspects. First, GOM has enabled detecting and resolving potential strategic violations with more intelligent logics. These logics attempt to estimate time, distance and fuel from origin airport to the North Atlantic oceanic boundary with higher accuracy and detect the potential strategic violations by checking the headways and lateral separations. Then, sufficient amount of scenarios with special sequences in changing cruise flight level and speed Mach number are applied to resolve these violations before entering the oceanic boundary. Second, random flights which are eligible to utilize the track system are assigned with their optimal OTS track and flight level considering their desirable flight plan intersecting with other OTS tracks. These improvements make the Global Oceanic Model to be more realistic dealing with real world practice.

Queuing Model of Passengers at Sydney International Airport Immigration Services

Harold Nikoue
Georgia Institute of Technology

We present a statistical analysis and simulation of passenger movements from gates to immigration at Sydney International Airport. The parameters of the walk speed distribution are estimated using Wi-Fi observations at the airport. The queuing model is trained on one year of operational data in 2012.