Graduate Research Award Program on Public-Sector Aviation Issues: 2012

DETAILS

18 pages | | PAPERBACK
ISBN 978-0-309-41137-0 | DOI 10.17226/22826

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January 2012

AIRPORT COOPERATIVE RESEARCH PROGRAM
Sponsored by the Federal Aviation Administration

Responsible Senior Program Officer: Lawrence D. Goldstein

Research Results Digest 14

GRADUATE RESEARCH AWARD PROGRAM ON PUBLIC-SECTOR AVIATION ISSUES

This digest summarizes the results of the initial four years of the Graduate Research Award Program on Public-Sector Aviation Issues (ACRP Project 11-04). This program, sponsored by the FAA and administered by the ACRP, is designed to encourage applied research on airport-related aviation system issues and to foster the next generation of aviation community leaders. Under the program, up to ten awards of $10,000 each are made to full-time graduate students for successful completion of a research paper on public-sector airport-related aviation issues during the academic year. Candidates must be full-time students enrolled in a graduate degree program at an accredited institution of higher learning during the academic year. Successful papers are presented at the TRB Annual Meeting following completion of the program; and exceptional papers have been published in subsequent volumes of the *Transportation Research Record: Journal of the Transportation Research Board*. The academic years covered in this digest begin with 2008–2009 and extend through 2011–2012.

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INTRODUCTION

An original FAA-sponsored, TRB-administered Graduate Research Award Program on Public-Sector Aviation Issues began during the 1986–1987 academic year and continued through 1995–1996. At that time, funds were discontinued and the program was allowed to end. In mid-2007, a decision was made to reintroduce the program within ACRP beginning with the 2008–2009 academic year, and ACRP funds were allocated to accommodate up to ten individual awards of $10,000 each, awarded annually.[1] An important emphasis for the program was that research should be problem-solving and practical, applicable to airports, and useful to airport operators and other airport and aviation industry participants.

To help implement and manage the reinstituted program, a panel of ten experts was selected. Panel members included individuals representing the academic world, airport operators, research specialists, private airport/aviation consultants, aircraft manufacturers, FAA liaisons, and state aviation experts. The panel began meeting in January 2008 to formulate the program, prepare the application materials, put together a program announcement and dissemination effort, and select student participants following submission of applications.

The composition of the panel may change as individuals rotate and new members join as replacements. Because panel members' expertise cannot be all-encompassing, it was recognized from the outset that additional assistance might be necessary to cover review of topic areas outside of the particular experience of the panel members. Thus, in addition to

[1] FAA has elected to fund more than ten awards in some years.

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selection of proposals, each year the panel identifies and recruits mentors to assist overseeing the students' research. The participation of mentors has proved to be an important asset of the program.

From the beginning, a broad approach to airport and aviation research was incorporated into the program design to meet the objective of stimulating future participation by graduate students in the field. Several areas of interest were identified to guide the initial selection of candidates. These areas of interest continue to frame the program, which seeks to stimulate research addressing a broad array of topics of interest relating to public-sector aviation issues. In general, research completed under the program is expected to

- attract the interest of U.S. airport managers and operators;
- address problems that are shared by airport operating agencies but are not adequately addressed by current research efforts, with applied research including problems that airport operators experience but cannot easily solve on their own;
- address broad analytical areas, such as airport development, capital investment, demand forecasting, safety planning, environmental issues, airline/airport interaction, operational and institutional issues and analyses to help inform policy and decision making;
- address airport/airspace system issues, with an emphasis on improving system performance, safety, and security; and
- build on existing research, such as previously completed ACRP research reports that raise additional issues not funded by the completed research efforts.

Via an open call for proposals, students enrolled in a full-time graduate program leading to a degree in a subject related to airports and aviation are invited to submit applications. Students are encouraged to select a research topic that will contribute to completion of their degree requirements. A detailed application form is offered through the TRB website. Submission requirements include details about the student's background; long-term career goals; writing samples; past academic achievements; and, of major importance, recommendations from academic advisors and others familiar with the student's work.

When the program resumed in 2008, solicitation of applications began during the spring, with the first group of students selected early that summer. Subsequent program solicitations have begun early each calendar year, with submissions due in late spring. Selections are made during the summer, in time for program initiation with the beginning of each new academic year. Student participants are invited to attend the TRB Annual Meeting. In the four years since the program reemerged, 42 students have participated representing 25 different universities (Table 1).

Table 1 Universities represented in the Graduate Research Award Program since 2008.

1. Arizona State University
2. Cranfield University–Bedfordshire, United Kingdom
3. George Mason University
4. Georgia Institute of Technology
5. Harvard University
6. Massachusetts Institute of Technology
7. Mississippi State University
8. Missouri University of Science & Technology
9. Northcentral University
10. Oregon State University
11. Purdue University
12. Southern Illinois University
13. Stanford University
14. Texas A&M University
15. The George Washington University
16. The University of Oklahoma
17. University of California–San Diego
18. University of Illinois at Urbana-Champaign
19. University of Maryland
20. University of South Florida
21. University of Texas at Austin
22. Utah State University
23. Vanderbilt University
24. Wake Forest University School of Law
25. Washington University in Saint Louis

ACADEMIC YEAR 2008–2009

During the first year of the program, the application deadline was in June 2008. Twenty-five submissions were received from students representing 18 different universities. The panel met in Washington, D.C. for two days in late July to evaluate the submittals. Ten applicants were selected, each of whom would receive a stipend of $10,000 for successful completion of a research paper on the subject chosen by the applicant (Table 2). Completed papers would be considered for presentation at the TRB Annual Meeting, and outstanding papers would also be considered for publication in the *Transportation Research Record: Journal of the Transportation Research Board.*

Table 2 Research papers selected for academic year 2008–2009.

Student	Degree	Research Topic	University
Elizabeth Black	PhD	Lung Deposition of Jet Engine Exhaust Particulate Matter	Missouri University of Science & Technology
Dan Boedigheimer	PhD	Exploring the Pilot Reliability Certification Program and Changing Attitudes on Reducing Pilot Errors: Pilots Covered by Federal Aviation Regulations 91 and 135*	Northcentral University
Daniel Favarulo	MS	Understanding Nonfiscal Barriers to Airport Development and Exploring Federal Policy Solutions*	George Mason University
Haomiao Huang	PhD	Hybrid System Model of Air Traffic Controller Cognition*	Stanford University
Hernando Jimenez	PhD	Strategic Development of Airport Systems for Capacity Enhancement and Environmental Impact Reduction	Georgia Institute of Technology
Adrian Lee	PhD	An Optimal, Closed-Loop Passenger Screening Strategy for Enhancing Aviation Security	University of Illinois at Urbana-Champaign
Stacey Mumbower	PhD	Using Online Data to Explore Competitive Airline Pricing Policies: Case Study Approach*	Georgia Institute of Technology
Christian Salmon	DSc	Quantifying Metrics of External Airport Risk Exposure in Vicinity of Public Use, Nontowered Airports*	The George Washington University
Dujuan Sevillian	PhD	A Human Factors Study Investigating the Effect of Airport Ramp Personnel's Years of Experience and Training on Airport Ramp Aircraft and Equipment Damages in Ramp Airline Operations	Cranfield University–Bedfordshire, United Kingdom
Ioannis Simaiakis	PhD	Impact of Congestion on Taxi Times, Fuel Burn, and Emissions at Major Airports*	Massachusetts Institute of Technology

*Published in *Transportation Research Record: Journal of the Transportation Research Board, No. 2184,* Transportation Research Board of the National Academies, Washington, D.C., 2010.

PUBLISHED PAPERS 2008–2009

Six student papers from the 2008–2009 academic year were published in the *Transportation Research Record: Journal of the Transportation Research Board, No. 2184.* The following copy presents abstracts for the published papers. For each paper, the names that follow the lead (student) author represent the student's academic advisors and others who made specific contributions to the paper.

1. Using Online Data to Explore Competitive Airline Pricing Policies—A Case Study Approach

Stacey Mumbower and Laurie A. Garrow

Abstract. Since the mid-2000s, the airline industry has seen volatile fuel prices, a record number of carriers ending service, and a merger between two major airlines. In a time of such turmoil in the industry, it is increasingly important to understand the relationship between airline consolidation and competitive pricing policies, because this relationship directly affects the formation of new airline policies associated with competition policy (antitrust), deregulation, and mergers. However, there is a lack of consensus about market concentration and its influence on airfares, mainly because of data limitations of past research. Given the emergence of online booking engines, there is a new opportunity to collect detailed fare data. This project uses disaggregate online airfare data to study the relationship between market concentration and pricing policies. The data set includes 62 markets that cover a broad range of market structures. A case study approach is used to analyze the data. Using disaggregate fare data, this study finds low price dispersion can be associated with both low and high levels of market concentration. As the day of departure approaches, price dispersion is observed to increase or decrease, depending on the market. Additionally, peak and off-peak periods demonstrate different pricing strategies. Markets with codeshares sometimes exhibit unusually high price dispersion.

2. Hybrid System Model of Air Traffic Controller Cognition

Haomiao Huang and Claire J. Tomlin

Abstract. Increased automation in air traffic control has many benefits, but to incorporate advanced automation tools safely and effectively requires careful analysis of their impact on human controllers. The literature on cognitive psychology and human factors has produced many qualitative models that describe the cognitive processes of controllers as well as a variety of computational models that attempt to reproduce the way controllers make decisions. The work presented here uses these results to form a novel hybrid system framework for modeling human cognition and describes a model of air traffic controller cognition based on this framework. The thought process is modeled as a set of critical variables that represent the human controller's picture of a given air traffic situation, with the evolution of these variables described by a set of hybrid dynamics where the discrete variables correspond to different thought processes and cognitive tasks. The primary contribution of this paper is to place the cognitive model within the formal mathematical framework of hybrid systems theory, allowing verification and online estimation and control with the tools of hybrid systems.

3. Impact of Congestion on Taxi Times, Fuel Burn, and Emissions at Major Airports

Ioannis Simaiakis and Hamsa Balakris

Abstract. Taxiing aircraft contribute significantly to fuel burn and emissions at airports. This paper provides a comprehensive assessment of the impact of surface congestion on taxi times, fuel burn, and emissions through analysis of the departing traffic data from four major U.S. airports. Several metrics based on airport throughput and taxi-out times are introduced and studied, including one that considers the number of flights that encounter a congested airport, a second metric that compares the observed taxi-out times with the unimpeded ones, and a third that evaluates them in conjunction with the airport throughput.

4. Quantifying Metrics of External Airport Risk Exposure in Vicinity of Public Use, Nontowered Airports

Christian M. Salmon, Vahid Motevalli, John Harrald, and Johan René van Dorp

Abstract. This paper presents research conducted in modeling specific exposure metrics of communities in the vicinity of public use, nontowered airports to

aviation accidents that result in crash sites outside the immediate confines of a runway (termed external airport risk). Two exposure metrics are explored: a relative exposure (termed crash hazard), defined as the probability that a crash site will be located in a specific area if a crash were to occur at an airport, and an absolute exposure (termed crash risk), defined as the expected number of crashes per year within any defined area. Results of this research are presented as a series of choropleth maps that define boundaries as contours, within which these metrics exceed some defined threshold. A specific application of this research is presented within the context of a model airport.

5. Understanding Nonfiscal Barriers to Airport Development and Exploring Federal Policy Solutions

Daniel Favarulo

Abstract. Airport development projects are vulnerable to an array of nonfiscal challenges that can significantly delay or prevent projects. Through a survey of 20 airports, this research paper identifies important nonfiscal barriers to airport development and analyzes their characteristics and potential effects on the development process. In addition, a thorough literature review as well as meetings with industry professionals and FAA staff was used to explore resulting challenges and examine potential federal policy solutions. Research findings have revealed that community opposition, political opposition, airport stakeholder opposition, land availability, and environmental requirements are the most frequent nonfiscal challenges to airport development. These nonfiscal challenges have resulted in a lengthy and highly complex process in which runway expansion projects take a significant amount of time to complete. The impact on the national aviation system warrants a serious commitment by the federal government to address these nonfiscal challenges. Specifically, the federal government needs to tackle these obstacles more aggressively by expanding programs and reforming policies. By acquiring a better understanding of the nonfiscal challenges to airport development and exploring federal policy solutions, aviation system planners can move closer to achieving capacity, safety, and environmental goals.

6. Exploring the Pilot Reliability Certification Program and Changing Attitudes on Reducing Pilot Errors: Pilots Covered by Federal Aviation Regulations 91 and 135

Dan Boedigheimer

Abstract. The greatest opportunity to improve aviation safety is to focus on reducing human errors in the cockpit. This research evaluated whether there was knowledge gain and difference in attitudes toward reducing human error in the cockpit after implementation of the Pilot Reliability Certification (PRC) program at Federal Aviation Regulation (FAR) 135 air carriers and FAR 91 corporate flight departments. The program is a human factors training curriculum focused on personal vulnerabilities to human error and countermeasures in support of aviation safety. Three levels of measurement were used: reactions to training, a knowledge test, and a modified version of the cockpit management attitudes questionnaire to assess attitude change. A mixed-method approach was used with quantitative data to measure knowledge gain and attitude change along with qualitative data to explore pilot reactions to the training. A quasi-experimental group (n = 41) that completed the 2-day course was compared with a control group (n = 62). The control group showed no significant improvement in attitude related to crew resource management skills or the PRC objectives. The quasi-experimental group had significantly improved attitudes and knowledge gain. Reaction to training was positive, with pilots citing a strengthened human factors knowledge base as the greatest benefit. They thought that the training differed from previous human factors training by being more detailed and in depth. After taking the course, pilots said that they would be more conscious of evaluating themselves, their flying partners, and their attitudes.

ACADEMIC YEAR 2009–2010

Applications for the academic year 2009–2010 were due in May 2009. Forty-three submissions were received from students representing 28 different universities. The applicant pool included 27 PhD candidates, 15 master's degree candidates, and 1 law degree candidate. Of the 11 students selected, 7 were PhD candidates, 3 were master's degree candidates, and 1 was a law school candidate. As in the first year, each applicant selected would receive a stipend of $10,000 for successful completion of a research paper on the subject chosen by the applicant (Table 3). FAA provided an additional grant to cover the 11th student so that a research subject of particular interest could be included in the program. As was true for the first year, it was understood that completed papers would be considered for presentation at the TRB Annual Meeting following submission, and outstanding papers would be considered for publication in the *Transportation Research Record.*

Table 3 Research papers selected for academic year 2009–2010.

Student	Degree	Research Topic	University
Gabriela DeFrancisci	PhD	Low-Velocity, High Mass, Wide-Area Blunt Impact on Composite Panels	University of California–San Diego
Douglas Fearing	PhD	Evaluating Air Traffic Flow Management in a Collaborative Decision-Making Environment	Massachusetts Institute of Technology
Ben Hwan Kyun Lee	PhD	Reactive Chemistry in Aircraft Exhaust: Implications for Air Quality	Harvard University
Brittany Luken	PhD	Multiairport Choice Models for the New York Metropolitan Area: Application Based on Ticketing Data	Georgia Institute of Technology
Matthew Manley	PhD	Modeling Emergency Evacuation of Individuals with Disabilities in a Densely Populated Airport	Utah State University
Boo Hyun Nam	PhD	Transition of the Rolling Dynamic Deflectometer from a Screening Tool to an Evaluation Tool for Airfield Pavement Projects	University of Texas at Austin
Nagesh Nayak	Master's	Estimation and Comparison of Impact of Single Airport Delay on National Airspace System with Multivariate Simultaneous Models	University of South Florida
Dominique Pittenger	Master's	Evaluating Sustainability of Selected Airport Pavement Treatments with Life-Cycle Cost, Raw Material Consumption, and Greenroads Standards	University of Oklahoma
Nikolas Pyrgiotis	PhD	Public Policy Model of Delays in a Large Network of Major Airports	Massachusetts Institute of Technology
Maulik Vaishnav	Master's	Opportunities and Obstacles in Obtaining Air Connectivity for Residents of Federally Designated Essential Air Service Communities	University of Illinois at Urbana-Champaign
Timothy Wyatt	JD	Balancing Airport Capacity Requirements with Environmental Concerns: Legal Challenges to Airport Expansion	Wake Forest University School of Law

PUBLISHED PAPERS 2009–2010

All eleven student papers from the 2009–2010 academic year were published in the *Transportation Research Record: Journal of the Transportation Research Board, No. 2206.* The following copy presents abstracts for the published papers. For each paper, the names that follow the lead (student) author represent the student's academic advisors and others who made specific contributions to the paper.

1. Low-Velocity, High-Mass, Wide-Area Blunt Impact on Composite Panels

Gabriela K. DeFrancisci, Zhi M. Chen, and Hyonny Kim

Abstract. Impact damage caused by ground vehicles and equipment colliding with the structural components of aircraft is a significant source of damage to commercial aircraft that may go unreported. Most common are blunt impacts from ground maintenance and service vehicles and equipment with attached elastomeric bumpers that protect the aircraft to some degree but may not leave externally visible evidence of an impact. This research examines the types of impact threats to a composite airplane fuselage, impact testing of composite specimens that simulate airplane fuselage specimens, and the visible detectability of the damage. The test program has two distinct aspects: (a) prediction through analysis and (b) small- and large-scale quasi-static indentation testing.

2. Evaluating Air Traffic Flow Management in a Collaborative Decision-Making Environment

Douglas Fearing and Cynthia Barnhart

Abstract. The collaborative decision-making (CDM) framework introduced into ground delay programs in the late 1990s is an integral component of FAA's traffic flow management (TFM) procedures. CDM allows FAA to act as a mediator when managing TFM programs, transferring as much decision making as possible to the individual airlines. Although this approach has been highly successful in practice, it creates a new question for the research community: How should proposed enhancements to TFM be evaluated in a CDM environment? A sequential evaluation procedure, developed in this paper, addresses this question. The procedure includes airline disruption responses and a quasi-compression operation, attempting to mimic the three-stage CDM process. To model airline disruption responses, an integer optimization model was developed to balance operational and passenger considerations in determining which flights to cancel, swap, or delay. The value of this procedure is demonstrated by analyzing an optimization-based TFM approach in the CDM environment.

3. Reactive Chemistry in Aircraft Exhaust: Implications for Air Quality

Ben H. Lee, Ezra C. Wood, Richard C. Miake-Lye, Scott C. Herndon, J. William Munger, and Steven C. Wofsy

Abstract. Exhaust emitted from jet engines contains high concentrations of combustion by-products, some of which are damaging to human and ecosystem health. As these pollutants mix with the surrounding air, they undergo chemical reactions that eventually break them down to their water-soluble or inert forms. To date, the reactivity of aircraft exhaust has been largely unexplored, and it is not known whether state-of-the-art models account for chemistry at the plume level, which directly relates to air quality downwind of airports. To a large extent, the concentrations of hydroxyl (OH) and hydroperoxyl (HO_2) radicals—collectively called HO_x—present in emitted plumes determine the rate at which components of the exhaust are oxidized. In January 2009, the authors quantified emissions of all HO_x precursors including nitrous acid (HONO), formaldehyde (HCHO), acetaldehyde (CH_3CHO), and ozone (O_3) at the Alternative Aviation Fuels Experiment in Palmdale, California. The results indicate that (a) HO_x production rate due to direct emission of these precursors is orders of magnitude faster in the exhaust plume than in "normal" urban air; (b) the concentration of pollutants in plumes does not reach typical ambient levels until it has been diluted by a factor of about 6,000; and (c) photolysis of HONO in these plumes is by far the biggest source of HO_x during daytime. Analyses of the reactions involving HO_x demonstrate that propagation of these radicals is favored over termination, which indicates that chemical reactivity will continue to

be enhanced in these plumes even after being diluted to ambient levels.

4. Multiairport Choice Models for the New York Metropolitan Area: Application Based on Ticketing Data

Brittany L. Luken and Laurie A. Garrow

Abstract. This study examines the potential to use online ticketing data to model airport choice for domestic flights originating in one of the three major airports located in the New York City area. Results indicate that airport accessibility and level of service influence airport choice. Results also suggest that capacity constraints—reflected in sold-out flights and higher fares—may lead to more switching across airports as the flight departure dates approach. This underscores the importance of incorporating the actual flights available and the actual prices seen by consumers at the time that they ticket into multiairport choice models.

5. Modeling Emergency Evacuation of Individuals with Disabilities in a Densely Populated Airport

Matthew Manley, Yong Seog Kim, Keith Christensen, and Anthony Chen

Abstract. Emergency evacuation from airports is an important consideration, given the continuing occurrence of natural and human-caused disasters affecting these locations. These incidents have focused attention on the needs of individuals with disabilities, who are more likely to suffer during emergency situations. The agent-based model presented in this paper can be used by engineering and management professionals in design and planning efforts to estimate the evacuation performance of heterogeneous populations from airports. The model classifies the environment according to accessibility characteristics encompassing various conditions that have a disproportionate effect on the behavior of individuals with disabilities during an evacuation. The results of a simulation experiment demonstrate some of the limitations of the pier airport design and identify which individuals are most at risk: those with lower stamina and those using wheelchairs. The results also reveal areas of the airport that are prone to bottlenecks or clogging.

6. Transition of the Rolling Dynamic Deflectometer Device from a Screening Tool to an Evaluation Tool for Rigid Airfield Pavement Projects

Boo Hyun Nam

Abstract. For the past decade, the rolling dynamic deflectometer (RDD), a continuous deflection measurement device, has been used as a screening tool in identifying problematic airport pavements for repair. The RDD has not seen much use, however, as an evaluation tool to measure characteristics such as moduli of pavement layers and load-transfer efficiency (LTE). The primary goal of this research was to develop the hardware and software to take the RDD from a screening tool to an evaluation tool for airport pavement projects. In this study, the RDD as an evaluation tool could obtain (a) continuous measurement of rolling deflection basins (for the backcalculation of layer moduli to be studied) and (b) continuous evaluation of joint LTEs. Four subtasks were conducted: (a) investigation of parameters affecting the RDD measurements, (b) use of an increased number of rolling sensors, (c) improvement of RDD data processing (distance-based deflection profile with increased spatial resolution), and (d) a series of field tests with the RDD on a rigid airfield pavement. With all five sensors continuously monitored during rolling, the software that was developed was capable of selecting a zone of lateral uniformity over which it was appropriate to construct deflection basins. The improved data processing identified accurate locations of joints and properly positioned two rolling sensors on opposite sides of the adjacent slabs in the continuous deflection profile, producing a continuous LTE evaluation along the pavement. The RDD measurements (continuous deflection basins and LTEs) were compared with falling weight deflectometer measurements, and the comparison provided promising results.

7. Estimation and Comparison of Impact of Single Airport Delay on National Airspace System with Multivariate Simultaneous Models

Nagesh Nayak and Yu Zhang

Abstract. U.S. air transport is under significant stress, experiencing frequent delays and high levels of congestion. At certain times, individual airports become

bottlenecks within the National Airspace System (NAS). Major causes of flight delay at airports include overscheduling, en route convective weather, reduced ceiling and visibility around airports, and upstream delay propagation. Delay at one airport can be passed on to other airports in the NAS. Hence, to allocate resources for airport capacity expansion in an optimal way, the impact of single airport delay to the NAS and vice versa must be quantified. This research applies multivariate simultaneous regression models to quantify airport delay spillover effects across 34 of the 35 Operational Evolution Partnership airports and the rest of the NAS. This analysis considers such contributing factors as average daily arrival delay, deterministic queuing delay, weather patterns, aircraft equipment type, and others. The three-stage least-square method is used to regress the models and obtain coefficients for the multivariate equations. The outcomes are used to explain the interactions among airports in the NAS and to identify the major delay contributors at each.

8. Evaluating Sustainability of Selected Airport Pavement Treatments with Life-Cycle Cost, Raw Material Consumption, and Greenroads Standards

Dominique M. Pittenger

Abstract. In the global aviation community, sustainability increasingly is becoming a priority for airport projects as a foundation for future prosperity. Pavement structures are an airport's greatest asset and greatest liability. Pavement management systems involve an intensive and expensive enterprise, and pavement maintenance projects consume massive amounts of nonrenewable resources at every airport in the nation. Little research has been conducted to assist airport pavement managers in reducing the environmental, economic, and social impacts of pavement maintenance and preservation processes. The old cliché of "what is not measured is not managed" applies, and a performance metric therefore is needed to permit pavement managers to measure sustainability. No standard, quantitative performance metric for sustainability is now in use by pavement managers assessing pavement treatment alternatives. This paper demonstrates how airport pavement managers can quantitatively analyze typical pavement treatments with a life-cycle cost analysis, quantification of raw material consumption, and the recently developed Greenroads standards to measure the environmental, economic, and social impact of the treatments for a given pavement project to enhance the overall sustainability of their programs.

9. Public Policy Model of Delays in a Large Network of Major Airports

Nikolas Pyrgiotis

Abstract. As more airports in the United States and in Europe become congested, it is increasingly common for delays at one or more airports to spread to other parts of the network. This paper describes an analytical model developed to study this complex phenomenon. The Approximate Network Delays (AND) model computes the delays from local congestion at individual airports and captures the "ripple effect" that leads to the propagation of these delays to other airports. AND can be used to explore at a macroscopic level the implications of a large number of policy alternatives and future scenarios on systemwide delays and associated costs. It has been fully implemented for a network consisting of the 34 busiest airports in the continental United States and for a network of the 19 busiest airports in Europe. An analysis is presented of the estimation of ground slack in the scheduled turnaround times and its strong relation with the spreading of delays. Furthermore, AND shows the effect of delay propagation in an airport network and, for that reason, a comparison is made between the two main hubs in the European and U.S. airport networks, Frankfurt International in Germany and Chicago O'Hare in Illinois. The comparison shows that higher local delays and more short-haul flights in Chicago cause stronger delay propagation than in Frankfurt. Finally, by using AND, the modernization program at Chicago O'Hare could achieve an 80% reduction of delays locally and a 5% reduction in networkwide delays under visual flight rules conditions.

10. Opportunities and Obstacles in Obtaining Air Connectivity for Residents of Federally Designated Essential Air Service Communities

Maulik Vaishnav

Abstract. The Essential Air Service (EAS) program was established in 1978 to guarantee air connectivity

for residents of small communities to the national air transportation system. Currently, more than half of EAS communities are within 70 highway miles of another airport, leading to passenger leakage at EAS airports and rising program costs. Five case studies of EAS communities examine the reasons for local support of air service that is rarely used. The case studies present three main findings: (a) the EAS program is a gateway to the federal airport infrastructure funds of the Airport Improvement Program; (b) there is an information gap between the U.S. Department of Transportation and the EAS communities regarding the existing risky alternate programs; and (c) local politics and airport administrators' concern about their professional future sustains support for local air service. EAS communities in a multiairport region, therefore, are most susceptible to passenger leakage and continue to struggle in the program. The obstacles also deter the establishment of transportation options that best fit communities and their residents. The study provides insights into policy changes that address the importance of small airports and rural air connectivity.

11. Balancing Airport Capacity Requirements with Environmental Concerns: Legal Challenges to Airport Expansion

Timothy R. Wyatt

Abstract. Regulatory agencies such as the Federal Aviation Administration must balance the need to expand airport capacity with concerns about environmental impact. This balance is governed by the National Environmental Policy Act (NEPA), which establishes the environmental review procedures governing airport development activities that receive federal funding. This paper presents a comprehensive study of legal challenges to airport expansion, focusing on the influence of environmental procedural statutes such as NEPA. All known reported court opinions since the enactment of NEPA involving environmental challenges to physical airport expansion were reviewed and characterized with respect to the factual background of each case, the form of the legal challenge, and the disposition of the reviewing court. A regression analysis was performed to determine which factors influence a court's decision to approve the environmental review or to enjoin airport expansion pending further environmental review.

ACADEMIC YEAR 2010–2011

For the academic year 2010–2011, the panel received 31 submissions from students representing 25 different universities. The applicant pool included 23 PhD candidates and 8 master's degree candidates. Ten applicants were selected, each of whom would receive a stipend of $10,000 for successful completion of a research paper on the subject chosen by the applicant (Table 4). Of the ten students selected, seven were PhD students and three were master's degree students.

Table 4 Research papers selected for academic year 2010–2011.

Student	Degree	Research Topic	University
Regina Clewlow	PhD	Interaction of Air Transportation and High-Speed Rail: Exploring Air-Rail Connectivity	Massachusetts Institute of Technology
Francisco Evangelista	PhD	Prediction of Potential Cracking Failure Modes in Airfield Rigid Pavements Due to New Generation Aircrafts and Environmental Loadings	University of Illinois at Urbana-Champaign
Josephine Kressner	PhD	The Influence of Demographic and Socio-Economic Factors on Air Travel in Atlanta	Georgia Institute of Technology
Sameer Kulkarni	Master's	Dynamic Airspace Configuration Using Approximate Dynamic Programming: An Intelligence-Based Paradigm	George Mason University
James Morrison	Master's	Transitioning the US Air Transportation System to Higher Fuel Costs: Investigation of Policies to Reduce the Uneven Distribution of Carbon and Fuel Price Impacts	Massachusetts Institute of Technology
Quentin Noreiga	PhD	Parsimonious Modeling and Uncertainty Quantification for Transportation Systems Planning Applied to California High-Speed Rail	Vanderbilt University
Jeffrey Stempihar	PhD	Use of Fiber-Reinforced Asphalt Concrete as a Sustainable Paving Material for Airfields	Arizona State University
Vikrant Vaze	PhD	The Role of Airline Competition in Airport Congestion Mitigation Using Demand Management	Massachusetts Institute of Technology
Jinfeng Wang	PhD	Development of Bird Strike Threat Assessment Using Avian Radar Information	University of Illinois at Urbana-Champaign
Kai Yin	Master's	Taxiway Aircraft Traffic Analysis at the Houston Airports	Texas A&M University

PAPERS BEING CONSIDERED FOR PUBLICATION, ACADEMIC YEAR 2010–2011

At publication of this *Research Results Digest,* final versions of papers submitted in September 2011 were being reviewed and considered for publication in the *Transportation Research Record: Journal of the Transportation Research Board, No. 2266.* The following copy presents abstracts for the candidate papers. For each paper, the names that follow the lead (student) author represent the student's academic advisers and others who made specific contributions to the paper.

1. Interaction of High-Speed Rail and Aviation: Exploring Air-Rail Connectivity

Regina R. L. Clewlow, Joseph M. Sussman, and Hamsa Balakrishnan

Abstract. U.S. airports face significant congestion problems, particularly in major metropolitan areas with continued population and economic growth. Growth in air travel demand and frequent short-haul flights on routes of less than 500 miles contribute to airport congestion. The potential for high-speed rail (HSR) to serve as a substitute for aviation on these short-haul routes is well documented; however, there is a need to explore how rail can also serve in a complementary mode, relieving congestion at airports by providing short-haul services in support of longer haul airline services. The primary objective of this research project is to examine the role of cooperation between HSR and aviation to improve the aviation system planning process. This study addresses the following key questions:

- How have airports, airlines, and rail operators cooperated to enable airport-HSR connectivity?
- What are the service characteristics of airport-HSR connectivity?
- What are the unique challenges associated with airport-HSR connectivity?
- How has air transportation demand evolved in the presence of airport-HSR connectivity?

2. Prediction of Potential Cracking Failure Modes in 3-D Airfield Rigid Pavements with Existing Cracks and Flaws

F. Evangelista, Jr., J. R. Roesler, C. A. Duarte

Abstract. This paper predicts the potential for crack propagation in concrete pavements under aircraft loading given a starter fatigue crack on the bottom of the concrete slab or a surface-initiated shrinkage crack on the top of the slab. The generalized finite element method was used to evaluate the stress intensity factors (SIFs) for quarter elliptical cracks placed at the critical top and bottom tensile stress locations. The pavement was loaded with a single triple dual tandem (TDT) and two TDTs accounting for the entire belly gears. When loaded with the two TDT gears configuration, the analyses showed significantly higher K_I values for surface-initiated cracks than for bottom-initiated cracks of the same crack size. Therefore, concrete slabs with preexisting surface cracks are more likely to exhibit top-down crack growth despite being designed for bottom-up fatigue cracking under certain loading conditions. The theoretical framework provided in this paper allows for better assessment of the fracture susceptibility of concrete slabs under aircraft loading, specifically the potential for top-down over bottom-up cracking.

3. Using Lifestyle Segmentation Variables to Predict Home-Based Trips for Hartsfield-Jackson Atlanta International Airport

Josephine D. Kressner and Laurie A. Garrow

Abstract. This research investigated the influence of demographic and socioeconomic factors on air travel demand using a unique dataset purchased from a credit reporting agency. Linear regression models based on lifestyle segmentation variables were used to predict air passenger trips for Hartsfield-Jackson Atlanta International Airport. The study focused on predicting trips that originated from or terminated at residences in Atlanta's 13-county metropolitan area. The lifestyle regression models were compared to regression models based on income, as the latter are similar to the regression models currently used by the Atlanta Regional Commission to predict home-

based airport passenger trips. The results provide directional evidence for using lifestyle clusters over income groups in predicting airport passenger trips, which suggests that alternative data sources with adequate information for lifestyle segmentation can improve airport passenger models.

4. Dynamic Airspace Configuration Using Approximate Dynamic Programming: An Intelligence-Based Paradigm

Sameer Kulkarni, Rajesh Ganesan, and Lance Sherry

Abstract. The Next Generation Air Transportation System (NextGen) envisions an airspace that is adaptable, flexible, controller friendly, and dynamic based on conditions of weather and/or high traffic. The current-day sector geometries have been developed over the years based on average traffic patterns and have remained structurally static, with occasional changes in the geometries owing to the limited sectorization currently in practice. Dynamic Airspace Configuration (DAC) is a new paradigm for airspace that aims at migrating from a rigid airspace structure to a more flexible airspace. Efficient management of airspace capacity is important to ensure safe and systematic operation of the United States National Airspace System (NAS), which will eventually result in maximum benefit to stakeholders. The primary objective is to strike a balance between airspace capacity and air traffic demand. Current imbalances in capacity and demand are resolved using initiatives like the Ground Delay Program (GDP) or by rerouting; however, these approaches often result in systemwide delays. This paper is a proof of concept for the dynamic programming (DP) approach to DAC by static sectorization. The purpose of this paper is to address the issue of static sectorization by partitioning airspace based on controller workload (i.e., airspace is partitioned such that the controller workload between adjacent sectors is balanced). This paper applies the DP technique to generate sectors in the Fort Worth Air Route Traffic Control Center (ZFW ARTCC) and compare them with the current-day sectors, laying a foundation for future work in dynamic resectorization. Initial results of the DP methodology show promising results in terms of sector shapes and the number of sectors that are comparable to current-day operations.

5. Transitioning the U.S. Air Transportation System to Higher Fuel Costs

James K. D. Morrison, Brian Yutko, and R. John Hansman

Abstract. The air transportation system enables economic growth and provides significant social benefits. Future increases and volatility in oil prices, as well as climate change policies, likely will increase the effective cost of fuel. This paper investigates expected impacts of higher fuel costs on the U.S. domestic air transportation system and discusses policy options to reduce negative economic and social effects. The 2004–2008 fuel price surge is used as a historical case study. A stochastic simulation model is developed using price elasticity of demand assumptions and flight leg fuel burn estimates to understand the impacts of higher fuel costs. Findings include that a 50% increase in fuel prices is expected to result in a 12% reduction in available seat miles (ASMs) if all cost increases pass through to passengers. System revenues are expected to decrease marginally for fuel price increases up to 50%, but higher increases may result in significant revenue reductions. Small airports are expected to experience relatively larger decreases and greater volatility in traffic. Older aircraft flying sectors significantly below their optimal fuel efficiency range are expected to experience the greatest reductions in capacity. An airline case study demonstrates that a regional carrier may be less sensitive to increased fuel prices than other business models. Policy options to maintain small community access, to manage airport traffic volatility, and to improve fleet fuel efficiency are discussed. To transition the U.S. air transportation system to higher fuel costs, stakeholder action will be required.

6. Parsimonious Modeling and Uncertainty Quantification for Transportation Systems Planning Applied to California High-Speed Rail

Quentin Noreiga and Mark McDonald

Abstract. This paper presents a parsimonious travel demand model (PTDM), derived from a more-detailed

and proprietary parent travel demand model developed by Cambridge Systematics (CS) for the California High-Speed Rail (HSR) system. The purpose of the PTDM is to reduce computational expense when conducting model simulations, optimization and sensitivity analysis, and other repetitive analyses. The PTDM is used to quantify the significance of various parameter uncertainties using Mean Value First Order Second Moment (MVFOSM) methods for uncertainty quantification and sensitivity analysis. The PTDM changes the model resolution of the parent travel demand model from a traffic analysis zone to a county-level analysis. The PTDM is a three-step model containing trip frequency, destination choice, and main-mode choice models and is calibrated to match the results of the CS model. The main-mode choice model predicts primary mode choice results given four modes of transportation: car, commercial air, conventional rail, and HSR. The PTDM uses data and models that are similar to the parent models to illustrate how uncertainty in travel demand model predictions can be quantified. This paper does not attempt to assess the reliability of the parent model forecasts, and the results in this paper should not be used to evaluate the uncertainty in the California High-Speed Rail Authority's ridership and revenue forecasts. However, the uncertainty quantification methodology presented in this paper, when applied to the CS model, can be used to quantify the impact of parameter uncertainty on the forecast results.

7. Use of Fiber-Reinforced Asphalt Concrete as a Sustainable Paving Material for Airfields

Jeffrey J. Stempihar, Mena I. Souliman, and Kamil E. Kaloush

Abstract. Sustainability at airports has received much attention recently as owners work to incorporate sustainable practices into projects and daily operations. Several guides have been published by airport agencies to document sustainable practices. One potential sustainable practice involves the use of alternate paving materials for airfield pavements. Specifically, the use of fiber-reinforced asphalt concrete (FRAC) has shown promising results and has most recently been used to resurface Runway 1-19 at the Jackson Hole Airport in Jackson, Wyoming. This paper explores the feasibility of using FRAC as a sustainable paving strategy for airfields. The study included an extensive literature review, performance testing of an asphalt mixture, a cost-analysis, a sustainable credit summary, and a CO_2 emission comparison. Laboratory testing showed that the Jackson Hole Airport mixture performed better than a control mixture produced in the laboratory using similar materials. Further analysis concluded that a fiber-reinforced, porous asphalt friction course can qualify for several sustainable site credits. In addition, the minimal upfront cost of fibers makes this product attractive as the cost can be recouped by approximately a one-year extension in service life. The pavement design simulations performed indicated a reduction in equivalent CO_2 emissions through extension of service life. Recommendations for the use of FRAC on airfields are provided based on the findings of this study, and future research is identified.

8. The Role of Airline Frequency Competition in Airport Congestion Pricing

Vikrant Vaze and Cynthia Barnhart

Abstract. Airport congestion pricing often has been advocated as a means of controlling demand for airport operations and for achieving efficient resource allocation. Competition between airlines affects the extent to which airlines are willing to pay for airport slots. Accurate modeling of competition is crucial in order to determine the effectiveness of a congestion pricing mechanism. This project develops an equilibrium model of airline frequency competition in the presence of delay costs and congestion prices. The project uses a small hypothetical network to evaluate the impacts of congestion prices on the various stakeholders and to investigate the dependence of effectiveness of congestion pricing on the characteristics of frequency competition in individual markets. The research indicates that effectiveness of congestion pricing depends on three essential parameters of frequency competition. The results show that variation in the number of passengers per flight plays a vital role in determining the attractiveness of congestion pricing to the airlines. A significant part of the impact of congestion pricing cannot be accounted for using the models in prior literature, which are based on the assumptions of constant load factors and constant aircraft sizes. Further, the research suggests that, in comparison to flat pricing, marginal cost pricing is more effective in reducing congestion

without penalizing the airlines with exceedingly high congestion prices.

9. Bird-Aircraft Strike Risk Assessment at Commercial Airports: Sub-Model Development Accounting for Strike Occurrence and Severity at Seattle Tacoma International Airport

Jinfeng Wang and Edwin E. Herricks

Abstract. Bird strikes are a continuing problem in aviation. Despite the number and severity of reported bird strikes, quantification of the effects of contributory factors has been limited by the absence of data, particularly data on bird activity around airfields. The purpose of this study is to provide initial insight into this important problem by combining a number of databases and information resources available at Seattle Tacoma International Airport, including airplane operations, bird strike reports, and the avian radar data on bird movements. Logistic regression and multinomial regression models are used to analyze bird strike occurrence and strike severity. The results indicate that bird track density and airplane movement frequency significantly correlate with bird strike occurrence. High altitude and a cloudy weather condition increase the probability of serious damage. Airplanes with a weight less than 27,000 kg and those with turbofan engines, and struck positions including tail and light move the propensity toward minor damage, when compared with no damage. Factors such as single engine airplane, medium and large birds, and strikes occurring at engines and wings increase the likelihood of both serious and minor damage. The findings of this study potentially support changes in airport bird hazard management, airplane operations, and engineering designs of engines and airframes. The study also highlights the importance of managing accurate bird strike reports and applying new statistical approaches as more data become available.

10. Taxiway Aircraft Traffic Analysis at George Bush Intercontinental Airport

Kai Yin, Chunyu Tian, Bruce X. Wang, and Luca Quadrifoglio

Abstract. Serving one of the largest metropolitan areas in the United States, the George Bush Intercontinental Airport (IAH) is among the ten airports with the longest average taxi-out and taxi-in times. The first part of this paper assesses the congestion at IAH by analyzing taxi times and flight data during different hours of the day. The capacity of IAH is investigated by examining the number of departing flights on the ground. Results reveal that IAH is operating close to capacity most of the time. Given that increasing airport capacity can mitigate the congestion, the second part of this report uses the analyzed results to develop a surface operation model to achieve this aim. A mixed integer programming formulation is proposed to optimize total taxi times by finding the optimal taxi routes and related schedules. The model is then applied to a sample from real data.

ACADEMIC YEAR 2011–2012

Applications for the academic year 2011–2012 were due in May 2011. Thirty-one submissions were received from students representing 24 different universities. The applicant pool included 21 PhD candidates and 10 master's degree candidates. The selection panel met in Washington, D.C., for two days in late July to evaluate the submittals. Eleven applicants were selected, each of whom will receive a stipend of $10,000 for successful completion of a research paper on the subject chosen by the applicant (Table 5). For the first time, one stipend will be shared by two students who will be working together on one study.

At publication of this *Research Results Digest,* students were preparing the initial scopes of work to guide their research throughout the academic year. Following submission, completed papers will once again be considered for presentation at the TRB Annual Meeting and outstanding papers will be considered for publication in an upcoming volume of the *Transportation Research Record.*

In the near future, the program will survey past student participants, panelists, mentors, and student advisors to determine how many students have continued in the field of aviation, where they are working, and what positions they currently hold. This outreach will also include an effort to expand knowledge of the program at universities that sponsor graduate research in aviation and related fields.

Table 5 Research papers selected for academic year 2011–2012.

Student	Degree	Research Topic	University
Sakib Bin-Salam	Master's	Inter-Temporal Differences in Fares Across Markets Served by Southwest Airlines	Oregon State University
Kristin Biondi	Master's	Mammalian Risk to U.S. Civil Aviation	Mississippi State University
Yi Cao	PhD	Benefit and Tradeoff Analysis of Continuous Descent Approach in Normal Traffic Conditions	Purdue University
Stephen Feinberg	PhD	Refined Dispersion Modeling of Lead Emissions from Piston-Engine Aircraft at General Aviation Facilities	Washington University in St. Louis
Alexander Hainen*	PhD	Emerging Methods for Assessing and Improving Landside Airport Operations	Purdue University
Donald Katz	PhD	Continuous Scheduling: Beneficial for Airports and Airlines?	Georgia Institute of Technology
Fabrice Kunzi	PhD	Reduction of Collisions Between Aircraft and Surface Vehicles Through ADS-B Enabled Conflict Alerting on the Airport Surface	Massachusetts Institute of Technology
Stephen Remias*	PhD	Emerging Methods for Assessing and Improving Landside Airport Operations	Purdue University
Clayton Stambaugh	Master's	Social Media and the Nations Airports Relative to Their Marketing and Communication Strategies	Southern Illinois University
Prem Swaroop	PhD	Service Expectations Setting in Air Traffic Flow Management: A Consensus-Building Mechanism	University of Maryland
Kleoniki Vlachou	PhD	Equitable Resource Allocation Mechanisms During Reduced Airspace Capacity	University of Maryland

**Shared award*

APPENDIX: PROGRAM PARTICIPANTS

The following individuals have served as panel members and mentors and provided oversight of the research program beginning with the 2008–2009 academic year. Their assistance has been invaluable in attracting students, overseeing their research efforts, and preparing documents for presentation and publication.

Panel Members

Dr. Keith Mew (Chair), Aviation Program Director (Department of Technology), California State University, Los Angeles
Monica S. Alcabin, Associate Technical Fellow, Boeing Company
Dr. Eric Amel, Vice President, Compass Lexecon
Randall D. Berg, Director of Airport Operations, Salt Lake City Department of Airports
Michael T. Drollinger, Manager, Research and Data, Port of Seattle Aviation Planning, Seattle-Tacoma International Airport
John W. Fischer, Specialist in Transportation Policy Resources, Science and Industry Division, Congressional Research Service (Retired)
Richard Golaszewski, Principal, GRA Incorporated
John Heimlich, Vice President and Chief Economist, Air Transport Association of America, Inc.
Linda Howard, Director, Planning and Programming, Aviation Division, Texas Department of Transportation (Retired)
Dr. Annalisa L. Weigel, Professor of Aeronautics and Astronautics, Massachusetts Institute of Technology
Robert Samis (FAA Liaison), Economist, Federal Aviation Administration
Christine Gerencher (TRB Liaison), Senior Program Officer for Aviation, Transportation Research Board
Paul L. Friedman, ACRP Project Officer, Federal Aviation Administration

Mentors

Greg Albjerg, HNTB
Debbie Alke, Aeronautics Division Administrator, Montana Department of Transportation
Nick Atwell, Wildlife Manager, Aviation, Port of Portland
Dr. Michael Ball, Associate Dean for Faculty and Research and Orkand Corporation Professor of Management Science, Department of Decision, Operations and Information Technologies, Robert H. Smith School of Business, University of Maryland
Frank Berardino, President, GRA, Inc. Jenkintown, Pennsylvania
Dr. Dipasis Bhadra, Senior Quantitative Economist, Statistics and Forecast Branch, FAA
Dr. David Brill, FAA William Hughes Technical Center, Atlantic City International Airport
Michael Brennan, Chief Aviation Scientist, Metron Aviation
Matt Coogan, New England Transportation Institute, Vermont
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Tony Diana, Manager, Information Systems, FAA Office of Aviation Policy and Plans
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Dr. Rajesh Ganesan, Professor at George Mason University
Dr. Navneet Garg, Research Civil Engineer with the Federal Aviation Administration at the William J. Hughes Technical Center
Dr. Geoffrey Gosling, Principal, Aviation System Consulting, LLC, Berkeley, California
David Gray, Surveillance and Broadcast Services, FAA
Howard Hall, FAA Seattle Aircraft Certification Office
Paul Hamilton, Orion International Technologies
Robert Hazel, Partner, Oliver Wyman, Inc.
Dr. Irene Ioachim, Supervisor, Operations Research, GRA Inc., currently on assignment with FAA
Dr. Karla Hoffman, Professor at George Mason University
Dr. Robert Hoffman, Metron Aviation, Dulles, Virginia
Dr. Katharine Hunter-Zaworski, Director of the National Center for Accessible Transportation, Oregon State University
Timothy Karaskiewicz, Milwaukee County Principal Assistant Corporation Counsel
Mike Kenney, Vice President, KB Environmental Sciences, Inc.
Ted Kitchens, Newport News International Airport
Peter Kostiuk, President, Robust Analytics, Gambrills, Maryland

Albert Larkin, FAA Airport Technology R&D Branch, William J. Hughes Technical Center
Michael E. Levine, Distinguished Research Scholar and Senior Lecturer, New York University School of Law
Arne Lewis, Associate Technical Fellow and 787 Structures Service Engineer with Boeing
Mike Linnel, State Director APHIS/USDA, Salt Lake City, Utah
Dou Long, LMI Research Institute
Carl Ma, Engineer with FAA's Office of Environment and Energy
Peter Mandle, Director, LeighFisher
Dr. Avijit Mukherjee, Associate Research Scientist, University Affiliated Research Center, NASA Ames Research Center, California
Robert Nichols, En Route & Oceanic Service, Surveillance and Broadcast Services, FAA
Steve Osmek, Wildlife Program Manager, Port of Seattle–SEATAC
Dr. Clinton Oster, Jr., Professor, School of Public and Environmental Affairs, Indiana University
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David Peshkin, Principal and Vice President of Applied Pavement Technology
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Subscriber Category: Aviation

ISBN 978-0-309-21377-6
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