ACRP UNIVERSITY STUDENT PROGRAMS

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Abstracts

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Lung Deposition of Jet Engine Exhaust Particulate Matter

Elizabeth A. Black

ABSTRACT
Particulate matter (PM) from on-road vehicular traffic has been correlated to increases in mortality and morbidity as PM concentrations increase. Like vehicular exhaust PM, jet engine exhaust (JEE) PM falls within the size range of interest when considering health effects. Despite this, no information currently exists on the inhalation health impact of JEE PM. JEE PM has unique properties with respect to deposition, retention kinetics, and clearance pathways in the human respiratory system, and is composed of sizes that readily travel gas streamlines that penetrate the deepest regions of the lung; this is a concern as deposited JEE PM in these regions could potentially cross the blood-membrane barrier and migrate into the bloodstream. Using JEE PM data collected during plume studies performed down-wind of active runways at the Hartsfield-Jackson Atlanta and Oakland International Airports, lung deposition probabilities of JEE PM (as a function of particle size) can be determined using the International Committee of Radiological Protection (ICRP) lung deposition model. Surface area, however, is the characteristic PM parameter most strongly correlated with health impacts. Using the deposition probabilities and size resolved number distributions, a Surface Area Deposition Index (SADI) was developed. This new parameter, SADI, quantizes JEE PM lung deposition as the surface area of deposited PM per kilogram fuel burned. As constructed, SADI allows for equitable comparison among jet engine types while also proving a surface area metric for meaningful health impact correlations. Two interesting conclusions to this preliminary study are that statistically significant differences among engine types are not seen in SADI, and variations in SADI are not correlated with temporal changes or changes in meteorological conditions.

Exploring Pilot Reliability Certification Program and Changing Attitudes on the Reduction of Errors in FAR 91 and 135 Pilots

Dan Boedigheimer

ABSTRACT

The greatest opportunity for further improving aviation safety is to focus on reducing human errors in the cockpit. The purpose of this research was to evaluate if there was knowledge gain and difference in attitudes towards reducing human error in the cockpit after the implementation of the Pilot Reliability Certification (PRC) program at FAR 135 air carriers and FAR 91 corporate flight departments. The PRC 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 the training, a knowledge test, and a modified version of the Cockpit Management Attitudes Questionnaire to measure 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) who completed the two-day PRC course was compared to a control group (n = 62). The control group did not show a significant improvement in attitude related to CRM skills or the PRC objectives. The quasi-experimental group had a significant improvement in attitudes and knowledge gain. Reaction to the training was also positive with pilots citing the largest benefit was a strengthened human factors knowledge base. They felt the training differed from previous human factors training by being more detailed and in-depth. Pilots cited they would be more conscious of evaluating themselves, their flying partners and their attitude after taking the course.

Understanding Non-Fiscal Barriers to Airport Development and Exploring Federal Policy Solutions

Daniel Favarulo

ABSTRACT

Airport development projects are vulnerable to an array of non-fiscal challenges that can significantly delay or prevent projects. Through a survey of twenty airports this research paper identifies the non-fiscal barriers to airport development and provides an analysis of the characteristics and effects each has on the development process. In addition, a thorough literature review as well as meetings with industry professionals and Federal Aviation Administration staff was utilized to further explore these challenges and federal policy solutions. Research findings have revealed that community opposition, political opposition, airport stakeholder opposition, land availability, and environmental requirements are the most frequent non-fiscal challenges to airport development. These non-fiscal 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 of this on the national aviation system warrants a serious commitment by the federal government to address these non-fiscal challenges. Specifically, the federal government needs to more aggressively tackle these obstacles by expanding programs and reforming policies. By acquiring a better understanding of the non-fiscal challenges to airport development and exploring federal policy solutions, aviation system planners can move closer to achieving capacity, safety, and environmental goals.

A Hybrid System Model of Air Traffic Controller Cognition

Haomiao Huang

ABSTRACT

Increased automation in air traffic control has many benefits, but to safely and effectively incorporate advanced automation tools requires careful analysis of their impact on human controllers. The cognitive psychology and human factors literature have produced many qualitative models that describe the cognitive processes of controllers, as well as a variety of computational models that attempt to directly 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 upon 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 over time 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 to be performed using the tools of hybrid systems.

Strategic Development of Airport Systems for Capacity Enhancement and Environmental Impact Reduction

Hernando Jimenez

ABSTRACT
Enabling the long-term growth of air transportation is a vital endeavor supporting economic development and improving quality of life. However, this growth cannot be sustained if increasing air travel demand is not met with sufficient system capacity enhancements. Moreover, growing traffic volumes and the operational inefficiencies that result from insufficient capacity exacerbate the magnitude of aviation's environmental footprint and further thwart its growth. Though this observation is widely applicable across the entire system, nowhere else is it more pronounced and critical than at airports and their terminal airspace. Recognizing the systemic complexity inherent in airport performance, as well as the operational environmental interrelationship at its core, methodological shortcomings in the traditional strategic airport planning paradigm are inevitably revealed. In particular, the quantitative characterization of complex relationships between airport performance metrics and various exogenous and endogenous factors, as well as relevant terminal area improvements, can be made more transparent and explicit, readily revealing the interactions and sensitivities that provide greater insight and empower both analysts and decision-makers when exploring critical tradeoffs. To achieve this, the proposed methodological improvements leverage on recent advances on airport operations and environmental impact modeling, as well as on established statistical techniques that shed light on the significance of factors of interest and their mutual interactions with respect to airport performance metrics, while observing limitations on analytical and computational resources. The approach is illustrated as applied to Atlanta's Hartsfield-Jackson International Airport, for which a variety of representative results are described in detail.

An Optimal, Closed-Loop Passenger Screening Strategy for Enhancing Aviation Security

Adrian J. Lee

ABSTRACT
Passenger screening at aviation security checkpoints is a critical component in protecting airports and aircraft from terrorist threats. Recent developments in screening device technology have increased the ability to detect these threats; however, the average amount of time it takes to screen a passenger still remains a concern. This paper addresses the queueing process for a multi-level airport checkpoint security system, where multiple security classes are formed through subsets of specialized screening devices. A closed-loop assignment policy is obtained that balances the expected number of true alarms with the expected amount of time a passenger spends in the security system. Performance of a two-class system is compared to that of a security system containing primary and secondary levels of screening, where the selection process for passengers undergoing secondary screening is fine-tuned. The key contribution is that the optimal, closed-loop passenger screening strategy obtained herein allows airport security operations personnel to increase security and passenger throughput by efficiently and effectively utilizing available screening resources.

Using On-Line Data to Explore Competitive Airline Pricing Policies: A Case Study Approach

Stacey Mumbower

ABSTRACT
Since the mid 2000's, 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, as this relationship will directly impact the formation of future airline policies associated with competition policy (anti-trust), deregulation, and mergers. However, there is a lack of consensus about market concentration and its influence on airfares, mainly due to data limitations of past research. Given the emergence of on-line booking engines, there is a new opportunity to collect detailed fare data. This project uses disaggregate, on-line airfare data to study the relationship between market concentration and pricing policies. The dataset 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 seen to either increase or decrease, depending on the specific market. Additionally, peak and off-peak periods demonstrate differing pricing strategies. Also, markets with codeshares are shown to sometimes exhibit unusually high price dispersion.

Exposure at the Airport/Community Interface
Quantifying Metrics of Exposure in the Vicinity of Public-Use, Non-Towered Airports

Christian M. Salmon

ABSTRACT
This paper presents research conducted to model exposure of communities in the vicinity of public-use, non-towered airports to aviation accidents that results in crash sites outside the immediate confines of a runway. Two primary exposure metrics are explored: 1) a relative exposure, termed the *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 2) the absolute exposure, termed *crash risk*, defined as the expected number of crashes expected 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 either of these metrics exceed some defined threshold. A specific application of this research is presented within the context of a model airport.

Analysis and Control of Airport Departure Processes to Mitigate Congestion Impacts

Ioannis Simaiakis

ABSTRACT
Taxiing aircraft contribute significantly to the fuel burn and emissions at airports. This paper investigates the possibility of reducing fuel burn and emissions from surface operations through a reduction of the taxi times of departing aircraft. Data analysis of the departing traffic in four major US airports provides a comprehensive assessment of the impact of surface congestion on taxi times, fuel burn and emissions. For this analysis two metrics are introduced: one that compares the taxi times to the unimpeded ones and another that evaluates them in terms of their contribution to the airport's throughput. A reduction in taxi times may be achieved through the queue management strategy known as NControl, which controls the pushback process so as to keep the number of departing aircraft on the surface of the airport below a specified threshold. An earlier developed model is used to quantify the impact of N-Control on taxi times, delays, fuel burn and emissions at BOS. Finally, the benefits and implications of N-Control are compared to the ones theoretically achievable from a scheme that controls the takeoff queue of each departing aircraft.

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

Boo Hyun Nam

ABSTRACT

Over the past decade, the Rolling Dynamic Deflectometer (RDD), a continuous deflection measurement device, has been used as a powerful screening tool in identifying problematic airport pavements to be repaired. However, the RDD has not seen much use as an evaluation tool to measure characteristics such as moduli of pavement layers and load-transfer efficiency (LTE). The primary goal of this research is to take the RDD from a screening tool to an evaluation tool for airport pavement projects by developing the hardware and software. In this study, the RDD as an evaluation tool could obtain: (1) continuous measurement of rolling deflection basins (for the backcalculation of layer moduli to be studied) and (2) continuous evaluation of joint LTEs. Four subtasks have been conducted: (*a*) investigation of parameters affecting the RDD measurements, (*b*) increase the 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 being monitored during rolling, software developed was capable of selecting a zone of lateral uniformity over which it is 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, resulting in continuous LTE evaluation along the pavement. The RDD measurements (continuous deflection basins and LTEs) were compared with Falling Weight Deflectometer (FWD) measurements, and their comparison provided promising results.

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

Gabriela K. DeFrancisci

ABSTRACT
Impact damage resulting from collisions of ground vehicles and equipment with aircraft structural components is a significant source of damage to commercial aircraft that has potential to be unreported. Most commonly occurring are blunt impact threats such as ground maintenance and service vehicles, equipment, etc., which have attached elastomeric bumpers that, while protecting the aircraft to some degree, might not leave externally-visible evidence of an impact event. This research examines the types of impact threats to a composite airplane fuselage, impact testing of composite specimens that simulate airplane fuselage specimens and how the damage state relates to actual visible detectability. There are two distinct aspects to this test program; prediction through analysis and small scale and large scale quasi-static indentation testing.

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

Douglas Fearing

ABSTRACT
The Collaborative Decision-Making (CDM) framework introduced into Ground Delay Programs (GDPs) in the late 1990s is an integral component in the Federal Aviation Administration's (FAA's) Traffic Flow Management (TFM) procedures. CDM allows the FAA to act as a mediator when managing TFM programs, pushing as much decision-making as possible to individual airlines. Though 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? In our paper, we develop a sequential evaluation procedure to address this question. Our procedure includes airline disruption responses and a quasi-compression operation, attempting to mimic the three-stage CDM process. To model airline disruption responses, we develop an integer optimization model that balances operational and passenger considerations to make determinations on which flights to cancel, swap, or delay. We demonstrate the value of our procedure by analyzing an optimization-based TFM approach in the CDM environment.

Reactive chemistry in aircraft exhaust: implications on air quality

Ben H. Lee

ABSTRACT

There is growing concern regarding aviation emission and its impact on air quality, particularly given the projected increase in global air travel over the coming decades [1-3]. Plumes of exhaust emitted from jet engines contain high concentrations of combustion by-products, some of which may be damaging to human and ecosystem health. As these emitted 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 in and immediately downwind of airports. To a large extent, the concentrations of hydroxyl (OH) and hydroperoxyl (HO2) radicals – collectively called HOx – present in emitted plumes determine the rate at which components of the exhaust are oxidized. In January of 2009, we quantified emissions of all HOx precursors including nitrous acid (HONO), formaldehyde (HCHO), acetaldehyde (CH3CHO) and ozone (O3) at the Alternative Aviation Fuels Experiment in Palmdale, California. We report that 1) HOx production rate due to the direct emission of precursors from jet engines is orders of magnitude faster in the exhaust plume than in "normal" urban air, 2) Concentration of pollutants in plumes do not reach typical ambient levels until it has been diluted by a factor of about 6,000 and that 3) Photolysis of HONO in these plumes is by far the biggest source of HOx during daytime. Analyses of the reactions involving HOx demonstrate that propagation of these radicals is favored over termination, which indicate chemical reactivity will continue to be enhanced in these plumes even after it has been diluted down to ambient levels.

Multi-Airport Choice Models for the New York Metropolitan Area:
An Application Based on Ticketing Data

Brittany L. Luken

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 closer to flight departure dates. This underscores the importance of incorporating the actual flights available and the actual prices seen by consumers at the time they ticket into multi-airport choice models.

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

Matthew Manley

ABSTRACT
Emergency evacuation from airports is an important consideration given the continuing occurrence of both natural and human caused disasters affecting these locations. Such incidents have also 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 alike to estimate the evacuation performance of heterogeneous populations from airports in support of design and planning efforts. The model is unique because it classifies the environment according to accessibility characteristics encompassing various conditions which have been shown to have a disproportionate effect upon 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 wheel chairs. The results also reveal areas of the airport which are prone to bottlenecks or clogging.

Estimation and Comparison of the Impact of Single Airport Delay on the National Airspace System using Multivariate Simultaneous Models

Nagesh Nayak

ABSTRACT

U.S. air transport as we all know 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 causal factors of flight delay at airports include over-scheduling, 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 optimally allocate resources for airport capacity expansion, 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 Plan (OEP) airports and the rest of the NAS. In this analysis, delay contributors considered include average daily arrival delay, deterministic queuing delay, weather patterns, aircraft equipment type, and others. The three stage least square (3SLS) 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.

Evaluating Selected Airport Pavement Treatments' Sustainability Using Life-Cycle Cost, Raw Material Consumption and Greenroads Standards

Dominique M. Pittenger

ABSTRACT

Sustainability is increasingly becoming a priority for airport projects, as well as the foundation for future prosperity, in the global aviation community. Pavement structures are an airport's greatest asset and greatest liability. Pavement management systems, involve an intensive, 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 reduce the environmental, economic and social impacts of their pavement maintenance and preservation processes. The old cliché of "what is not measured is not managed" applies and so a performance metric is required to permit pavement managers to measure sustainability. There is no standard, quantitative performance metric for sustainability in use by pavement managers to assess pavement treatment alternatives. This paper demonstrates how airport pavement managers can quantitatively analyze typical pavement treatments using life-cycle cost analysis, quantification of raw material consumption and the recently developed Greenroads standards to measure the environmental, economic and social impact of those treatments for a given pavement treatment project to enhance the overall sustainability of their programs.

A 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 becoming increasingly common to observe delays at one or more airports spread to other parts of the network on a daily basis. In this paper we describe an analytical model developed to study this complex phenomenon. The Approximate Network Delays (AND) model computes the delays due to 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 of the implications a large number of policy alternatives and future scenarios on system-wide 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. We present an analysis on the estimation of ground slack in the scheduled turnaround times and its strong relation with the spreading of delays. Furthermore, we show, through AND, the effect of delay propagation in an airport network and for that reason we perform a comparison between the two main hubs in the European and US airport networks, Frankfurt International and Chicago O'Hare airports respectively. It was shown that higher local delays and more short haul flights in Chicago cause stronger delay propagation than in the Frankfurt. Finally, we show using AND that the modernization program of Chicago O'Hare can lead up to an 80% reduction of delays locally and a 5% reduction in network-wide delays under VFR conditions.

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, over half of EAS communities are within 70 highway-miles of another airport leading to passenger leakage at EAS airports and rising program costs. This paper presents five case studies of EAS communities to understand the reasons why local proponents support air service that is rarely used. The case studies present three main findings: the EAS program is a gateway to federal airport infrastructure funds of the Airport Improvement Program, there is an information gap between the US DOT and the EAS communities regarding the existing risky alternate programs, and local politics and airport administrators' concern about their professional future sustains support for local air service. Therefore, EAS communities in a multi-airport region that are most susceptible to passenger leakage continue to struggle in the program. The obstacles also deter establishment of transportation options that best fit communities and their residents. The study provides insights into policy changes that pay attention to the importance of small airports and rural air connectivity.

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 the 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.