8th USA / EUROPE Air Traffic Management
Research & Development Seminar

ATM Seminar 2009

Book of Abstracts

June 29 - July 2, 2009
Napa, California USA

FEDERAL AVIATION ADMINISTRATION

EUROCONTROL

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Track 1 -- Dynamic Airspace and Capacity Management (Room A)

Paper № 89 -- Feasibility of Mixed Equipage Operations in the Same Airspace
Paul Lee (San Jose State University)

The current study uses a human-in-the-loop simulation to examine the feasibility of mixed equipage operations in an automated separation assurance environment under higher traffic densities. The results show that mixed operations may be feasible, in the same airspace, if unequipped aircraft count is held to a workable level and that this level will decrease with increasing complexity. The results imply that integrated airspace configuration is feasible to a limit. The results also indicate that the conflict detection and resolution automation, equipage, and traffic density are important factors that will need to be considered for airspace configuration.

Paper № 105 -- An Efficient Airspace Configuration Forecast
David Gianazza (DSNA)

This publication is the continuation of previous research which aims at improving the predictability and the flexibility of the airspace management process by computing realistic forecasts of the airspace configurations in En-route ATC centers. In previous papers, we selected relevant complexity metrics to predict the controllers workload, using neural networks trained on historical data. We also introduced new algorithms to build optimally balanced airspace configurations, exploring all possible combinations of elementary sectors. These workload prediction model and airspace partitioning algorithms were tested on real recorded traffic. In this paper, airspace configurations are forecast from planned traffic, using the CATS/OPAS simulator to compute trajectories from flight plans. The efficiency of the resulting airspace configurations is assessed by comparing to the actual FMP (Flow Management Position) prediction. Some preliminary developments of an experimental HMI that will be used to test and tune our algorithms are also presented.

Paper № 85 -- A Comparison of Algorithm Generated Sectorizations
Shannon Zelinski (NASA AMES)

This paper discusses a comparison of several algorithms generated airspace boundary designs, known as sectorizations. Three algorithms are chosen that approach the airspace sectorization problem in different ways and produce radically different looking sectorizations due to the disparity in their methods. Simulations of air traffic using each of the sectorizations is completed and their resulting demand, capacity, complexity, and delay metrics are compared. Results identify strengths and weaknesses of each sectorization algorithm.

Paper № 128 -- Optimizing Airspace Sectors for Varying Demand Patterns using Multi-Controller Staffing
Shin-Lai Tien (University of Maryland)

A variety of design concepts have been implemented in sectorizing en route airspace, e.g. balancing controller workload, aligning sector shape with flow, and maintaining minimum dwell time. To efficiently serve demand variation over time and space and to increase efficiency, models for dynamic airspace management, e.g. frequently changing sector boundaries or re-organizing jet routes, have also been envisioned. In the U.S., a common way to deal with temporary demand peaks in a sector is to use multiple controller teams, e.g. a Radar-side controller plus a Data-side controller. In this study, we propose an optimization model to create airspace sector boundaries that takes traffic demand variations and multi-controller teams into account. We improve upon existing sectorization techniques by acknowledging that sector capacity can be increased by adding auxiliary controllers. By comparing a multi-controller policy with a single-controller policy, our numerical results confirm that when traffic demand patterns are steady over time, a single-controller policy is satisfactory. But when demand varies over time, sectors can be designed in a way that allows for strategic use of multi-controller teams. This makes effective use of controller workforce and circumvents the need to perform disruptive sector boundary changes during busy periods.

Monday, June 29, 2009

Track 1 -- Environmental Impacts in ATM System Design and Operation (Room A)

Paper № 122 -- Development of Flight Inefficiency Metrics for Environmental Performance Assessment of ATM

Tom Reynolds (University of Cambridge)

Air traffic management has a fundamentally important role in reducing the environmental impacts of air transportation. The potential causes of flight inefficiency are discussed, followed by the development of flight inefficiency metrics based on ground track extension and fuel burn to quantify the environmental performance of the system. These metrics are used with flight data to illustrate their utility. Lateral flight inefficiency metrics are found to be simple and compatible with current surveillance technologies, but they do not allow some important environmental performance characteristics to be identified. Fuel-based metrics are found to be far more effective in this regard, but suffer from significantly greater complexity in their implementation. The implications of the analyses for future ATM evolution strategies are discussed to show the insights that can be gained.

Paper № 48 -- Fuel consumption modeling in support of ATM environmental decision- making

David Senzig (Dept. of Transportation)

The FAA has recently updated the airport terminal area fuel consumption methods used in its environmental models. These methods are based on fitting manufacturers' fuel consumption data to empirical equations. The new fuel consumption methods have adequate fidelity in the terminal area to assist air transportation policy makers in weighing the costs and benefits of competing environmental and economic demands. Comparison with Flight Data Recorder information for in-service airline operations shows these new methods can accurately capture the consequences of different terminal departure and arrival procedures on airplane fuel consumption within a reasonable level of uncertainty.

Paper № 43 -- Evaluating the Environmental Performance of the U.S. Next Generation Air Transportation System

Terence Thompson (Metron Aviation)

The environmental impacts of several possible U.S. Next Generation Air Transportation scenarios have been quantitatively evaluated for noise, air-quality, fuel-efficiency, and CO2 impacts. Three principal findings have emerged. (1) 2025 traffic levels about 30% higher than 2006 are obtained by increasing traffic according to FAA projections while also limiting traffic at each airport using reasonable ratios of demand to capacity. NextGen operational capabilities alone enable attainment of an additional 10-15% more flights beyond that 2025 baseline level with negligible additional noise, air-quality, and fuel-efficiency impacts. (2) The addition of advanced engine and airframe technologies provides substantial additional reductions in noise and air-quality impacts, and further improves fuel efficiency. 2025 environmental goals based on projected system-wide improvement rates of about 1% per year for noise and fuel-efficiency (an air-quality goal is not yet formulated) are achieved using this new vehicle technology. (3) Overall air-transport "product", as measured by total flown distance or total payload distance, increases by about 50% relative to 2006, but total fuel consumption and CO2 production increase by only about 40% using NextGen operational capabilities. With the addition of advanced engine/airframe technologies, the increase in total fuel consumption and CO2 production can be reduced to about 30%.

Paper № 84 -- Assessment of the Aviation Environmental Design Tool
Rebecca Cointin (Federal Aviation Administration)

A comprehensive Tools Suite to allow for thorough evaluation of the environmental effects and impacts of aviation is currently being developed by the U.S. This suite consists of the Environmental Design Space (EDS), the Aviation Environmental Design Tool (AEDT), and the Aviation environmental Portfolio Management Tool (APMT). A key priority is that environmental analyses are informed with the associated uncertainty from the tools, inputs and assumptions used in the analysis process. As part of the development of the Tools Suite, an assessment of each tool and a system-wide analysis of the entire suite are being undertaken. This assessment includes sensitivity to inputs and fidelity analyses that will provide an indication of uncertainty in analyses performed using the Tools Suite. Completion of the assessment and evaluation effort described herein is a key element of the development process. This paper presents a summary of the Tools Suite assessment and evaluation effort as it pertains to the AEDT component. AEDT takes detailed fleet descriptions and flight schedules and produces estimates of noise, fuel burn and emissions at global, regional and local levels. The AEDT component of the suite will be a publicly available regulatory tool within the U.S. This paper conveys the work completed so far and provides some insight into some of the findings.

Track 2 – Network and Strategic Traffic Flow Optimization (Room B)

Paper № 149 -- The Area Flow Multi-Sector Planner: A Fast-Time Study of MSP Coordination Activities
Kenneth Martin (ISA Software)

The FAA is investigating changes in the working procedures for the en route air traffic controller. These investigations have resulted in the development of the Multi- Sector Planner (MSP) concept, where the MSP is a planning controller providing strategic planning to multiple radar controllers for a specific area of responsibility. A real-time simulation (RTS) of two different MSP concepts was conducted in 2006 [1] and upon analysis of the results as well as other research efforts [2], it was determined that the MSP acting in an Area Flow Manager role showed the most promise in relation to the mid-term objectives, and that the next phase of the analysis should consider coordination activities for multiple MSP controllers over a wider area. This report summarizes the findings of that analysis.

Paper № 143 -- 4D-Trajectory Deconfliction Through Departure Time Adjustment
Nicolas Barnier (ENAC)

As acknowledged by the SESAR programme, current ATC systems must be drastically improved to accommodate the predicted traffic growth in Europe. In this context, the Episode 3 project aims at assessing the performance of new ATM concepts, like 4D-trajectory planning and strategic deconfliction. One of the bottlenecks impeding ATC performances is the hourly capacity constraints defined on each en-route ATC sector to limit the rate of aircraft. Previous works were mainly focused on optimizing the current ground holding slot allocation process devised to satisfy these constraints. We propose to estimate the cost of directly solving all conflicts in the upper airspace with ground holding, provided that aircraft were able to follow their trajectories accurately. We present a Constraint Programming (CP) model of this large scale combinatorial optimization problem and the results obtained with the FaCiLe constraint library. We study the effect of uncertainties on the departure time and estimate the cost of improving the robustness of our solutions with the CATS simulator. Encouraging results were obtained without uncertainty but the costs of robust solutions are prohibitive. Our approach may however be improved e.g. with a prior flight level allocation and the dynamic resolution of remaining conflicts with one of CATS' module.

Monday, June 29, 2009

Paper № 152 -- Evaluating a New Formulation for Large-Scale Traffic Flow Management

Andrew Churchill (University of Maryland)

In this paper, we introduce a new aggregate air traffic flow management model. Our integer programming model uses as a starting point the model recently introduced by Bertsimas, Lulli and Odoni. It employs a new set of more general airspace constructs that allow both more complex airspace elements to be represented as well as more aggregate-level modeling. We provide experimental results that indicate both the computational effectiveness of this model and its potential for decision support. We also discuss and provide general insights into the role of aggregate models in supporting traffic flow management for future air traffic management systems such as NextGen and SESAR.

Paper № 147 -- Air Traffic Flow Management in the Presence of Uncertainty

Senay Solak (University of Massachusetts)

Deterministic air traffic flow management (TFM) decisions –the state of the art in terms of implementation– often result in "lost" airspace capacity, because the inherent uncertainties in weather predictions make it difficult to determine the number of aircraft that can be safely accommodated in a volume of airspace during a given period. As a result, there is a distinct need for TFM algorithms that utilize available stochastic weather information for improved decision making. To this end, we first develop a methodology to determine the stochastic capacity for a volume of airspace given the forecast weather and associated uncertainty. Then, we use this information as input to a dynamic stochastic optimization algorithm to determine the number of aircraft to send towards a volume, providing specific guidance for routing aircraft in the presence of the uncertainties of adverse weather.

Paper № 97 -- Resource Allocation in Flow-Constrained Areas with Stochastic Termination Times-Optimistic Approach

Moein Ganji (University of Maryland)

In this paper we address a stochastic air traffic flow management problem. Our problem arises when airspace congestion is predicted, usually because of a weather disturbance, so that the number of flights passing through a volume of airspace (flow constrained area – FCA) must be reduced. We formulate an optimization model for the assignment of dispositions to flights whose preferred flight plans pass through an FCA. For each flight, the disposition can be either to depart as scheduled but via a secondary route, or to use the originally intended route but to depart with a controlled (adjusted) departure time and accompanying ground delay. We model the possibility that the capacity of the FCA may increase at some future time once the weather activity clears. The model is a two-stage stochastic program that represents the time of this capacity windfall as a random variable, and determines expected costs given a second-stage decision, conditioning on that time. This paper extends our earlier work on this problem by allowing the initial reroutes to vary from pessimistic (initial trajectory avoids weather entirely) to optimistic (initial trajectory assumes weather not present). We conduct experiments allowing a range of such trajectories and draw conclusions regarding appropriate strategies.

Paper № 55 -- Airport CDM Network Impact Assesment

Eduardo Goni Modrego (EUROCONTROL)

The Airport CDM (Collaborative Decision Making) project aims to improve the overall efficiency of operations at an airport, with a particular focus on the aircraft turn-round procedures. One of the main outputs of the CDM process will be a very accurate Target Take Off Time which will not only enhance ground planning but can be used to improve en route planning as well. Munich Airport is the first airport to be considered fully Airport CDM compliant and has demonstrated the local benefits such as a reduction in average taxi times and an improvement in CFMU CTOT conformance. However, one of the aims of the Airport CDM project is to

supply the CFMU with accurate Target Take Off Times in order that the CFMU can use them to more accurately plan the management of the whole of the European airspace. The aim of this study was to measure what the affect would be on the network if more airports were to implement Airport CDM and provide the CFMU with accurate Target Take Off Times via DPI messages. The study conclude that, Munich Airport currently has the most accurate take off estimate of the 42 airports considered in the study and this accuracy was used as the baseline for those airports in order to evaluate the impact on sector capacities within the European area. The results show a potential sector capacity increase within the European area of up to 4% which equates to between 1-2 aircraft per sector. The impact of Airport CDM on delays has highlighted a room for improvement of between 33%-50%. The positive results recorded in this study show that the expected benefits of Airport CDM implementation could extend from the local airport environment to the Network.

Paper № 33 -- Hybrid Demand and Capacity Balance Model for the Future Air Traffic Management Concept of Operations
Juan José Rebollo (GMV Aerospace & Defence)

This paper presents a new Hybrid Demand and Capacity Balance model for the air traffic network optimization problem, in which Lagrangian air traffic measures are calculated for individual flights. The core of the algorithm is a Pseudo Eulerian-Lagrangian flow model, which works with aggregated flights. This new research line allows near-optimal individual Air Traffic Flow Management (ATFM) measures to be obtained in a short computational time. Queue synchronized outputs in each constraint area (airspace/elementary volumes and airports) are computed by the flow optimization algorithm. Using the appropriate conversion algorithms, the input and output of the Hybrid model are Lagrangian. This new model is flexible enough to include new air traffic concepts. Delays can be computed in each elementary volume and airport. The air traffic measures will be given to airspace users as a set of space-time constraints on the overloaded airspace/airport area. The new model allows user preferences to be taken into account at two different levels: inter-flow and in-flow preferences. A set of Key Performance Indicators (KPIs) in line with the future air traffic system Operational Concept (SESAR ConOps in Europe, NextGen in EEUU) are defined. KPIs are demonstrated to be easily obtained from the model. Finally, a set of simulations of actual air traffic data show the performance of the proposed method.

Paper № 134 -- Equitable Allocation of Enroute Airspace Resources
Mike Ball (University of Maryland)

Ration-by-schedule (RBS) has provided a widely accepted resource-rationing principle for ground delay program (GDP) planning in the U.S. Rationing of airspace resources poses significant new challenges not well-addressed by RBS. In this paper, we describe new resource rationing principles and a new methodology for use in rationing access to constrained enroute airspace. While RBS implicity assumes that all flights requesting a slot must receive one, our new methods explicitly allow some flights to be refused access, since flight operators have the option of rerouting around the constrained airspace. Unlike RBS our methodology requires and makes use of flight operator preference information and it employs randomization. Our methods have potential usefulness both in airspace flow program (AFP) planning and in the emerging System Enhancements for Versatile Electronic Negotiation (SEVEN).

Track 3 – Innovative Methods for Safety Assessment (Room C)

Paper № 19 -- A systems-engineering approach to assessing the safety of the SESAR Operational Concept
Eric Perrin (EUROCONTROL)

The paper explains why a new approach, both broader and more rigorous than that traditionally followed in ATM, is needed for the safety assessment of the major operational and technology changes that are planned for introduction into European ATM over the period up to 2020 and beyond. It presents the theoretical ba-

sis for what is a "systems-engineering approach" and describes how that is being applied to the preliminary work on the safety assessment of the SESAR Operational Concept.

Paper № 130 -- Risk-Benefit Analysis of Advanced Air Transportation System Technologies Using Logic Gate Models

Terry Bott (Logic Evolved Technologies)

Risk-benefit analysis of new systems for use in the Next Generation Air Transportation System (NextGen) is complicated by the large number of alternatives that must be analyzed. The alternatives are generated by combinations of system design options, CONOPS variations and changing assumptions about the evolving state of the NextGen environment. We present here a demonstration of the use of Logic Gate Models (LGMs) to represent and perform a risk-benefit analysis for an advanced ATS technology in NextGen. An LGM is a generalization of a class of hierarchical models that includes event, fault and decision trees. Solution of the LGM yields a set of scenarios; each one is a unique combination of initial conditions, system specifications and ATS environment. An important aspect of our LGM implementation is the ability to perform path wise calculation of risk-benefit metrics for each scenario. Path wise metric calculation allows for a consistent and practical treatment of solution dependencies that are difficult or cumbersome to treat with less general LGMs. A systems model for Airborne Precision Spacing (APS).was developed to demonstrate the application of LGMs to aviation systems analysis. APS is a NASA-developed technology for Flight Deck Merging and Spacing. Models for risk and benefit metrics are presented. The risk model combines accident scenarios obtained from the LGM with historical data for operational incidents and human error rate estimates. The benefit model uses reduction in arrival bank delay time and the increase in airport arrival rate to evaluate changes in system performance. Risk-benefit calculations for each scenario are performed during solution of the LGM. The analysis showed that APS-based merging and spacing operations exhibit significantly lower risk and improved benefit relative to current practice over a range of demand states and system design variations. The interaction of APS with a second, advanced technology and the extension of the approach to larger systems models are discussed.

Paper № 72 -- Monitoring of TCAS Resolution Advisories in Core European Airspace

Stanislaw Drozdowski (EUROCONTROL)

Downlink of Resolution Advisories (RAs) – which are issued by the airborne Traffic Alert and Collision Avoidance System (TCAS) – has been proposed as a more reliable means of informing the air traffic controller that an RA has been posted onboard the aircraft. Previous research has pointed to a number of operational benefits of RA downlink. These pertain to an improved situational awareness and a smaller likelihood that contradictory clearances will be issued to an aircraft involved in an RA event. However, some RAs issued by TCAS will not cause a deviation from the Air Traffic Control (ATC) clearance and, thus, do not affect the controller's responsibility for aircraft separation. Since these types of RA are operationally less relevant for the controller, their being displayed on the controller screen could be regarded as unnecessary. In order to determine to what extent operationally less relevant RAs could limit the potential benefits of RA downlink, comprehensive data on the number and type of RA occurrences in core European airspace are needed. As part of EUROCONTROL's PASS study, RA downlink data from six Mode-S radars covering a large part of the core European airspace were collected from September 2007 to March 2008. The results of the monitoring indicate that approximately a fourth of the RAs issued are likely to cause a deviation from the ATC clearance. Because of the low overall number of RA encounters (i.e. 1 RA per 2160 flight hours), however, the displaying of all RAs – including those that do not involve a change in controller responsibility – is not likely to cause problems related to screen clutter or controller desensitisation. On the basis of the results of the RA monitoring, further refinements to the operational concept for RA downlink are proposed.

Paper № 12 -- Airspace Encounter Models for Conventional and Unconventional Aircraft

Matt Edwards (MIT Lincoln Laboratory)

Collision avoidance systems play an important role in the future of aviation safety. Before new technologies on board manned or unmanned aircraft are deployed, rigorous analysis using encounter simulations is required to prove system robustness. These simulations rely on models that accurately reflect the geometries and dynamics of aircraft encounters at close range. These types of encounter models have been developed by several organizations since the early 1980s. Lincoln Laboratory's newer encounter models, however, provide a higher-fidelity representation of encounters, are based on substantially more data, leverage a theoretical framework for finding optimal model structures, and reflect recent changes in the airspace. Three categories of encounter model were developed by Lincoln Laboratory. Two of these categories are used for modeling conventional aircraft; one involving encounters with prior air traffic control intervention and one without. The third category of encounter model is for encounters with unconventional aircraft—such as gliders, skydivers, balloons, and airships—that typically do not carry transponders. Together, these encounter models are being used to examine the safety and effectiveness of aircraft collision avoidance systems and as a foundation for algorithms for future manned and unmanned systems.

Track 3 – Human Factors (Room C)

Paper № 21 – Developing a Safety Culture Measurement Toolkit (SCMT) For European ANSPS

Richard Kennedy (Boeing)

This paper describes the approach used to develop a Safety Culture Measurement Toolkit (SCMT) for European Air Navigation Service Providers (ANSPs). The concept of safety culture has achieved increasing currency over the past twenty years and is now applied extensively in a number of high reliability industries including nuclear, oil and gas, manufacturing and rail, as well as the medical sector. Following a review of the safety culture literature from 2001-2005, a thematic model of safety culture was developed and items were generated from interviews with ATM personnel to reflect these themes. A questionnaire was developed, validated by ATM safety managers and deployed in eight geographically dispersed ANSPs across Europe. The questionnaire provided a 'snapshot' of the state of safety culture within the ANSP and the second phase of the SCMT involved feedback of results in workshops with ANSP personnel to reflect on the responses and determine 'why' the state of safety was perceived the way it was and how safety could be improved within the organization. Such approaches are now being applied across Europe in an effort to raise the level of safety culture in European ANSPs prior to the next 'generation' of ATM called SESAR, whose implementation phase begins 2013. This toolkit development is therefore also being strongly coordinated with FAA, who have similar safety culture ambitions for the US ATM system and its transformation via NextGen, and CANSO whose ambitions are for global improvement of safety culture in its ANSP members.

Paper № 126 -- Bet on both sides of the coin to improve the organizational climate: The impact of congruent task and role clarity between leaders and staff

Johan Jonsson (Lund University)

Four organizations at Stockholm-Arlanda airport are going through various organizational changes. They are preparing for present and future demands through structural changes, implementation of new technology, training, and other efficiency and capacity improving measures. The change processes will be followed during two years of which this paper presents the baseline measurement. The key factors in focus were situational leadership, work-oriented relationships by means of skills and psychological ability to handle social interactions (i.e., medarbetarskap), and congruent behavior between leaders and staff in work situations. Congruent behavior was believed to facilitate task- and role clarity and situational awareness. The final key factor was organizational climate due to its impact on for example productivity, job satisfaction, and

profit. The results showed that leadership, medarbetarskap, and congruent behavior all had positive influence on organizational climate. The congruent behavior in collaborative settings between leaders and staff showed to have the strongest relationship to organizational climate. Thus, one of the conclusions concerning practical implication, was that collaborate training with both leaders and staff members participating, are preferred in order to obtain a positive development of the organizational climate.

Paper № 28 -- Methodology for Estimation of Benefits of Human Factors Engineering in NextGen/Sesar Development

Lance Sherry (CATSR/GMU)

This paper describes a methodology for estimating the revenue-service cost savings that can be derived from HCI Engineering in the development of NextGen/SESAR flightdeck automation. An example of the cost savings benefits accrued by a hypothetical large U.S. domestic carrier due to the redesign of FMS error messages ($45M per year) is provided along with a discussion of the implications and limitations of the cost savings model.

Paper № 114 -- Human Factors Assessment of Runway Status Lights and Final Approach Runway Occupancy Signal FAA Operational Evaluations at Dallas Ft. Worth and San Diego International Airports

Maria P. Kuffner (MIT Lincoln Laboratory)

Runway incursions have been a persistent problem in airport operations for decades, both in the National Airspace System (NAS) and worldwide. The deadliest accident in the history of commercial aviation occurred at Tenerife Airport in the Canary Islands. As commercial airliners become larger and airports more congested the potential for major accidents on the airport surface is expected to increase. Runway Status Lights (RWSL) and Final Approach Runway Occupancy Signal (FAROS) have shown promise in precluding this potentiality through demonstrated operational suitability and, for RWSL, measured reductions in runway incursions as cited independently in an audit by the US Inspector General. RWSL will be deployed to 22 airports in the near future. MIT Lincoln Laboratory has recently completed human factors assessments in support of the Federal Aviation Administration's (FAA) ongoing operational evaluations of RWSL and FAROS at Dallas/Ft. Worth International Airport (DFW) and RWSL at San Diego International Airport (SAN). The assessments were developed to evaluate the effectiveness and operational suitability of RWSL and FAROS in reducing runway incursions and preventing accidents. The human factors assessments conducted to measure and record operational suitability are presented here. The process established to include human factors research, development, and testing is specifically described.

Tuesday, June 30, 2009

Track 1 – Continous Descent Approaches (Room A)

Paper № 132 -- Analysis of Continuous Descent Benefits and Impacts During Daytime Operations

Sanjiv Shresta (MITRE/CAASD)

This paper presents a case study of modeled arrival operations which utilize descent trajectories optimized for reduced fuel burn and pollutant emissions. Arrival flights descending along optimized vertical profiles are modeled by transforming the descent trajectories of a set of baseline arrival flights, taken from observed radar track data, into descent trajectories at idle throttle. The trajectories of the baseline and modeled arrival flights are described in depth, along with the transformation that connects them. Two implementation scenarios (unconstrained and constrained) of optimized descent procedures during daytime operations are analyzed. In the case of unconstrained optimized descent both the potential benefits and conflicts that result from such operations are quantified. In the case of constrained optimized descent, mitigation strategies are applied which remove the potential conflicts, but also reduce the level of potential benefit. The constrained optimized descent scenario demonstrates that by carefully choosing which level-offs are removed, both benefits can be obtained and conflicts avoided simultaneously. The major conclusion that may be drawn from this study is that procedures for optimized descent arrival operations can be implemented with fuel and emissions savings benefits while avoiding conflicts with other traffic.

Paper № 14 -- Time-Based Arrival Management for Dual Threshold Operation and Continuous Descent Approaches

Hartmut Helmke (DLR, German Aerospace Center)

The paper deals with the successive applica¬tion of time-based arrival management and automatic arrival-departure-coordination. DLR'sarrival manager 4D-CARMA supports approach controllers with sequence and advisory information during two time-based human-in-the-loop experi¬ments: First 4D-CARMA was used for dual thres¬hold operation on a parallel runway system operated in mixed mode for arrivals and departures. The dual threshold operation was performed within the context of the OPTIMAL project of the European commission. Particular consideration is given in this paper to the validation exercises performed with three different European controller teams. An increase of the inbound flow of 3 to 4 arrivals per hour without negative impact on the outbound flow and on controller workload is possible if automatic arrival-departure-coordination together with advisory information is provided to the controllers. In an additional human-in-the loop experiment 4D-CARMA supports the controllers to integrate unequipped aircraft into a stream of 4D equipped ones performing a user-preferred CDA approach.

Paper № 64 -- Controlled Time of Arrival Flight Trials Results and Analysis

Joel Klooster (GE Aviation Systems)

The CASSIS project has been tasked with developing a Concept of Operations for use of Time-of-Arrival Control in the terminal area. Reducing or replacing low level vectors and holding with enroute delay through the use of time constraints is a key component in both NextGen and SESAR. A set of revenue service flights using airborne time control to the Initial Approach Fix and the runway threshold was conducted in September 2008 as part of the CASSIS project. These flight trials facilitated an examination of the factors affecting time control behavior and the potential for use of airborne time control in the terminal area in near- and mid-term time frames. The impact of airborne control to a single time constraint on separation between aircraft is also examined. This analysis shows that the use of current generation avionics to meet a time constraint at a point in the approach is possible with accuracies of less than 5 seconds, and can achieve 2 minute landing spacing at the runway threshold with no loss of intermediate separations. Recommendations for future developments and considerations for larger scale implementation are also discussed.

Paper № 92 -- Evaluation of an Airborne Spacing Concept to Support Continuous Descent Arrival Operations

Bryan Barmore (NASA Langley Research Center)

This paper describes a human-in-the-loop experiment of an airborne spacing concept designed to support Continuous Descent Arrival (CDA) operations. The use of CDAs with traditional air traffic control (ATC) techniques may actually reduce an airport's arrival throughput since ATC must provide more airspace around aircraft on CDAs due to the variances in the aircraft trajectories. The intent of airborne self-spacing, where ATC delegates the speed control to the aircraft, is to maintain or even enhance an airport's landing rate during CDA operations by precisely achieving the desired time interval between aircraft at the runway threshold. This paper describes the operational concept along with the supporting airborne spacing tool and the results of a piloted evaluation of this concept, with the focus of the evaluation on pilot acceptability of the concept during off-nominal events. The results of this evaluation show a pilot acceptance of this airborne spacing concept with little negative performance impact over conventional CDAs.

Paper № 61 -- Feasibility and Benefits of Cockpit Traffic Display-Based Separation Procedure for Single Runway Arrivals and Departures: Implications of a Pilot Survey and Laboratory Simulations

Anand Mundra (MITRE Corporation)

This paper reviews the potential benefits of and the need for implementing a procedure for providing Visual-like Separation in Instrument Meteorological Conditions (IMC) through the use of a Cockpit display of traffic information (CDTI), for single runway arrivals and departures. This procedure is referred to as an "IMC CAVS" procedure in this paper. This paper reviews existing research and status of the current "VMC CAVS" procedure (a CDTI Assisted Visual Separation procedure authorized for use in visual meteorological conditions), discusses the potential for benefit in the NAS of an IMC CAVS procedure, highlights issues surrounding such extension of a CAVS procedure into IMC, shows results of an on-line pilot survey aimed at understanding these issues, provides a description of a CDTI capability aimed at addressing the primary issues, and analyzes results of real-time simulations of conducting such operations. Finally, the paper recommends next steps that should be taken in order to develop an operational IMC CAVS capability.

Paper № 37 -- Flight Deck-Based Merging and Spacing during En Route Descent: Findings from an Air Traffic Controller Simulation

Randy Bone (MITRE CAASD)

In an effort to achieve consistent, low variance spacing between aircraft pairs during arrival operations and to reduce aircraft maneuvering, noise, fuel burn, and controller workload, the Federal Aviation Administration (FAA) is developing, and UPS has implemented an Automatic Dependent Surveillance-Broadcast (ADS-B) concept termed Merging and Spacing (M&S). M&S has two phases: a strategic set-up by a ground operator followed by tactical Flight Deck-Based Merging and Spacing (FDMS). In the initial implementation, both phases, involve pilots being requested to fly speeds from sources other than Air Traffic Control (ATC). In FDMS, the speeds are generated and displayed on-board the aircraft via a Cockpit Display of Traffic Information (CDTI) or other displays. The flight crew follows those speeds to achieve and maintain a desired time interval from a lead aircraft. This paper focuses on FDMS and presents the subjective and objective results of a human-in-the-loop simulation that examined the concept from the en route controller perspective during an in-trail operation, from aircraft top-of-descent through entry into terminal airspace in a Continuous Descent Arrival (CDA). Termed FDMS 4, the simulation was conducted in May and June of 2007 and is part of a development and maturation process that is underway for FDMS. The impact of FDMS on controller operations during entry to a CDA, as well as human performance, operational impact, and communications issues were examined. Concept acceptability and the handling of non-normal situa-

tions were also evaluated. Controllers reported on average that FDMS during en route descent operations was acceptable, desirable and an improvement in operational efficiency. FDMS allowed for acceptable workload and traffic awareness – even in the event of spacing disruptions. Controllers had no issues intervening with FDMS traffic when necessary; however, controller responses were varied on whether it was acceptable to give FDMS aircraft priority. FDMS helped reduce overall controller interventions in an arrival stream under normal conditions, but did not increase or decrease total interventions for overall sector traffic sets under normal conditions or when spacing disruptions were introduced.

Track 2 – Weather (Room B)

Paper № 8 -- Weather Forecast Accuracy: Study of Impact on Airport Capacity and Estimation of Avoidable Costs

Alexander Klein (Air Traffic Analysis, Inc)

It is well known that inclement weather is the single biggest factor causing air traffic delays in the U.S. What is less well understood is what share in this overall adverse impact belongs to weather forecast accuracy. While several en-route convective forecast analyses have been conducted, the role of terminal/surface weather forecast accuracy has not been sufficiently well quantified. The objective of this research is therefore to estimate avoidable delays and costs that can be attributed to terminal weather forecast accuracy. We initially focus on arrival delays and cancellations. The well-established Weather-Impacted Traffic Index (WITI) metric based on actual weather is used as a delay proxy alongside its counterpart, WITI-FA ("Forecast Accuracy") metric based on forecast weather. A nomenclature of various relationships between actual and model-estimated arrival rates is built and arrival rate deficit (difference between scheduled and actually achieved rates) attributable to terminal weather forecast accuracy is computed for each case. This allows us to estimate the avoidable portion of arrival delays and cancellations due to terminal weather forecast inaccuracy, both overall and by specific weather factor. We show that our model is reasonably realistic and apply it to estimating the benefit pool for improving terminal forecast accuracy for OEP35 airports. Total benefits are shown to be at least $330M per year for arrival delays due to terminal weather forecast inaccuracy alone.

Paper № 75 -- The Impact of Severe Weather on Sector Capacity

Lixia Song (MITRE/CAASD)

It is well-accepted that sector capacity is reduced when severe weather is present in the sector. However, no accepted algorithms for calculating the capacity under severe weather impact have been developed. We have proposed methods to estimate the impact of severe weather on sector capacity. These methods introduced three types of weather impact index: 2D weather coverage, 3D weather avoidance field coverage, and flow-based sector capacity reduction ratio. This paper discusses the correlations between the sector throughput and these three sector weather impact indexes with statistical analysis of the historical data. The statistical correlation between the actual sector throughput and the sector weather impact indexes reveals the current operation of the Air Traffic Management system and suggests the acceptable algorithm for calculating the capacity under severe weather impact.

Paper № 99 -- The Route Availability Planning Tool (RAPT): Evaluation of Departure Management Decision Support in New York during the 2008 Convective Weather Season

Michael Robinson (MIT Lincoln Laboratory)

A field study of the operational usage and performance of the Route Availability Planning Tool (RAPT) was conducted during the 2008 storm season. Key to the success of the study were the real-time observations of operations, which were made during the same weather events at 11 traffic different management facilities that service NY departure traffic (10 FAA sites and one airline). Based on an evaluation of these observations and analysis of the supporting traffic and weather data, the annual estimate of RAPT benefits in

2008 totaled 2,600 hours of departure delay saved, with a cost savings of $8.7 M. The observations of the decision-making environment during convective weather revealed several ATM-related elements that were relevant to understanding the operational effectiveness of RAPT. These ATM factors included route status uncertainty, risk management differences between decision-makers, arrival traffic operations dictating departure route usage, and inefficient pathfinder procedures to reopen closed departure routes. Each of these ATM factors contributed to missed opportunities to use RAPT to proactively increase NY departure capacity. A post-event analysis was performed to quantify the frequency and duration of missed opportunities to use RAPT to reopen closed departure routes earlier. It is conservatively estimated that RAPT delay reduction benefits would increase six-fold if traffic managers used RAPT to eliminate these missed opportunities. Efforts to apply the results of this study towards improved RAPT user training, enhanced RAPT guidance, and more efficient departure flow management decision-making are discussed.

Paper № 124 -- Identification of Robust Routes using Convective Weather Forecasts
Diana Michalek (Massachusetts Institute of Technology)

Convective weather is responsible for large delays and widespread disruptions in the U.S. National Airspace System (NAS), especially during summer months when travel demand is high. This has been the motivation for Air Traffic Flow Management (ATFM) algorithms that optimize flight routes in the presence of reduced airspace and airport capacities. These models assume either the availability of reliable probabilistic weather forecasts or accurate predictions of robust routes; unfortunately, such forecasts do not currently exist. This paper adopts a data-driven approach that identifies robust routes and derives stochastic capacity forecasts from deterministic convective weather forecasts. Using techniques from machine learning and extensive data sets of forecast and observed convective weather, the proposed approach classifies routes that are likely to be viable in reality. The resultant model for route robustness can also be mapped into probabilistic airspace capacity forecasts.

Paper № 125 -- A Model for Determining Ground Delay Program Parameters Using a Probabilistic Forecast of Stratus Clearing
Lara Cook (Mosaic ATM, Inc.)

An approach is presented for using the probabilistic forecast of stratus clearing time at San Francisco (SFO) to achieve more efficient Ground Delay Programs (GDPs) by better determining GDP end time and scope. Given a probabilistic forecast, we use a Monte-Carlo simulation approach to generate many stratus clearing times for each discrete GDP end time and scope under consideration. Various key measures are evaluated such as unnecessary ground delay if the GDP ends later than stratus clearing and the risk of airborne holding at the end of the GDP if the GDP ends earlier than stratus clearing. An objective function that includes each of the key metrics captures the cost of each scenario under consideration, and the optimal GDP parameters can then be selected. Results show reductions of 29% for unnecessary issued ground delay and reductions of 39% for unnecessarily delayed flights over the SFO GDPs during the severe weather seasons in 2006 and 2007.

Paper № 91 -- Improvement of thunderstorm hazard information for pilots through a ground based weather information and management system
Arnold Tafferner (DLR - Institut für Physik der Atmosphäre)

The development and outcome from first evaluations of the thunderstorm weather information management system 'CB WIMS' in the EU project FLYSAFE is described. Preliminary results from a flight test campaign carried out in summer 2008 involving two aircraft are presented. They lead to the conclusion that information about thunderstorm hazards delivered from ground based CB WIMS through a ground weather processor and satellite communication to an aircraft could help to improve the pilot's awareness of the weather situation and assist in flight planning particularly in complex thunderstorm situations where the on-board radar cannot provide the pilot with the full situation due to scanning geometry and radar beam attenuation.

Tuesday, June 30, 2009

Track 3 – Human Factors (Room C)

Paper № 27 -- Carbon Copy: The Benefits of Autonomous Cognitive Models of Air Traffic Controllers in Large-Scale Simulations

Steven Estes (MITRE/CAASD)

NextGen proposes a suite of new technologies and procedures to be employed by the en route air traffic controller. Typically, the benefits of NextGen concepts are evaluated using fast-time simulation systems. However, these systems often ignore the human component of the National Airspace System (NAS) or represent it with little fidelity. Providing better estimates of NextGen productivity and efficiency benefits requires, in part, better models of human performance. In this paper we describe the construction and use of a cognitive model, Edgar, designed to address this problem.

Paper № 16 -- Impact of future time-based operations on Situation Awareness of air traffic controllers

Koen van de Merwe (National Aerospace Laboratory Amsterdam)

A time-based operation, as planned in the ATM future, is assumed to affect the controllers' Situation Awareness (SA) due to a higher priority of meeting a time objective and increasing automation. This paper provides SA requirements on the design of controller support tools in time-based operations, based on a short literature review and an empirical study executed at Air Traffic Control the Netherlands (LVNL). LVNL´s future ATM system requires an improved punctuality at the Initial Approach Fix (IAF) to enable Continuous Descent Approaches (CDAs) in the Schiphol TMA. A ground-based Speed and Route Advisor (SARA) tool has been designed to help Area Control (ACC) controllers with achieving a higher punctuality. A future follow-up for SARA could be an air-ground agreed Controlled Time of Arrival (CTA). The SARA real-time experiment results showed that this tool definitely decreases the controllers' workload (R/T load, inputs), while the target of a higher accuracy at IAF was met. The findings have also pointed at two major impacts on the controllers' SA as expected from the literature. First, controllers are currently more focusing on distance than on time in forming a mental picture of the traffic situation. This changes their working strategies in sequencing traffic and solving conflicts. Second, increasing automation (cf. SARA advisories) could be in conflict with the controllers' own plan of traffic handling. They could loose a certain 'feeling of control' and ultimately their SA. This refers to the 'out-of-the-loop' problem of automation. However, there was a strong learning effect already after a few experimental sessions. This suggests that a gradual implementation and training will certainly help supporting a smooth introduction. Moreover, the impact on SA appears to depend on the specific design (e.g. Human Machine Interface (HMI), separation responsibility, quality of advisories). The resulting set of SA requirements on the design of such controller support tools should be addressed in future developments of time-based operations in ATM.

Paper № 41 -- Evaluation of ATC working practice from a safety and human factor Perpective

Karim Mehadhebi (DSNA/DTI/R&D)

In this paper we consider the implications of the SESAR Concept of operations on the working practice of ATC. After introducing the expected changes in the ATC working practice, and the necessity for the regulatory authority to address them, we survey the available approaches. Then, we introduce a methodology, based on existing material, which combines safety and human factor expertise in order to allow a high level assessment of ATC performance.

Tuesday, June 30, 2009

Track 3 – ATM Performance Measurement and Management (Room C)

Paper № 73 – Measurement of the quality of traffic orientation schemes regarding flight plan efficiency

Hartmut Fricke (Chair of Air Transport Technology and Logistics)

Due to growing traffic volumes in aviation there is a need to distribute the daily traffic demand onto the available capacity to make the airspace system as efficient as possible. These measures are known as load balancing within the framework of Strategic Air Traffic Flow Management. Therefore ICAO recommends introducing Traffic Orientation Schemes (TOS) where the demand exceeds the capacity. These TOS are mostly oriented on the ratio of demand and capacity on the one hand and safety on the other hand. Additionally any TOS should take into consideration, that every single flight needs to be as cost or fuel efficient as possible to guarantee the most economic and environmental suitable use of airspace. In this paper a methodology is shown and applied on the European Route Availability Document which enables to monitor the economic and environmental efficiency of a Traffic Orientation Scheme.

Paper № 17 -- Modeling Flight Delays and Cancellations at the National, Regional and Airport Levels in the United States

Banavar Sridhar (NASA Ames Research Center)

Weather is a major influence on the performance of the aviation system in the United States. This paper describes models for predicting weather-related aircraft delays and cancellations at the national, regional and airport levels. Federal Aviation Administration (FAA) uses the delay estimates for system status briefings, long-term post-season reviews and future system-wide analyses. The models estimate delay based on the number of aircraft affected by the expected weather in the en-route environment as well as the terminal areas. The estimation and prediction models are developed using both regression methods and neural networks, using two different operational databases maintained by the FAA. The paper compares the performance of traditional linear regression models with several neural network models in the estimation of key airspace metrics such as total aggregate delay, arrival delay, and airborne delay as well as flight cancellations. The performance metrics are predicted at the national, regional and airport levels. The results are based on using the traffic, weather and delay data for the period 2005-2008. Some of the conclusions based on the results of the study are: (a) the metric based on the number of aircraft expected to be impacted by weather and the extent of the impact is a good proxy for delay of various types at all levels, (b) different delay models are preferable for different seasons and the delay estimation accuracy is higher in the convective weather season (April-September) than the non-convective weather season (October-March), (c) the delay estimation accuracy at all levels and for different metrics is about the same, (d) models resulting from the use of either of the FAA databases are complementary and provide similar level of accuracy and (e) the neural network delay models perform slightly better in the sense that they have a higher correlation between model output and airspace metrics than linear regression methods.

Paper № 115 -- US/ Europe comparison of ATM-related operational performance

John Gulding (FAA)

Air Navigation Service Providers (ANSPs) are continually seeking to improve operations. Measures derived from operational databases are a key component to assessing performance and recommending improvements. This paper examines several key performance indicators derived from comparable operations databases for both EUROCONTROL and the Federal Aviation Administration. This research effort developed a comparable population of operations data and harmonized assessment techniques for developing reference conditions for assessing performance. In the end, measures that address efficiency, punctuality and predictability are presented that can compare high level performance between the two systems by phase of flight.

Wednesday, July 1, 2009

Track 1 – Separation (Room A)

Paper № 138 -- Initial Evaluation of NextGen Air/Ground Operations with Ground-Based Automated Separation Assurance

Thomas Prevot (San Jose State University/NASA Ames Research Center)

NextGen air/ground operations with ground-based automated separation assurance have been initially evaluated with controllers and pilots in the loop at NASA Ames Research Center. Nominal and off-nominal situations were investigated in a highly automated environment, under 2x and 3x traffic densities. The paper starts with a review of previous simulations on nominal operations, followed by a description of the underlying concept and the roles and responsibilities of controller, pilots and automation. The core of this paper discusses a simulation of air/ground operations, in which controllers and pilots were confronted with a challenging situation: Ground-based separation automation was managing the trajectories for all aircraft at 2x and 3x traffic density without controller involvement. Routine and off-nominal events were carefully scripted that caused short-term conflicts, simulated emergency situations or required trajectory negotiations. It was found that the concept shows great promise to enabling the en route capacity increases targeted for NextGen. The medium-term conflict detection and resolution automation coupled with data link was able to solve over 98% of all conflicts during nominal operations, with a significantly higher success rate at 2x (>99 %) than at 3x. More than 95% of uplinked trajectories were acceptable to the flight crews. While controller workload was low in general and they were able to resolve over 75% of scripted off-nominal short-term conflicts, many issues were identified that need to be further addressed in the area of short-term conflict detection and resolution.

Paper № 148 -- Estimation of Separation Buffers for Wind-Prediction Error in an Airborne Separation Assistance System

Maria Consiglio (NASA Langley Research Center)

Wind prediction errors are known to affect the performance of automated air traffic management tools that rely on aircraft trajectory predictions. In particular, automated separation assistance tools, planned as part of the NextGen concept of operations, must be designed to account and compensate for the impact of wind prediction errors and other system uncertainties. In this paper we describe a high fidelity batch simulation study designed to estimate the separation distance required to compensate for the effects of wind-prediction errors throughout increasing traffic density on an airborne separation assistance system. The goal of the study was to measure the impact of wind-prediction errors in order to estimate the additional separation buffers necessary to preserve separation and to provide a baseline for future analyses. Buffer estimations from this study will be used and verified in upcoming safety evaluation experiments under similar simulation conditions. Results suggest that the strategic airborne separation functions exercised in this experiment can sustain wind prediction errors up to 40 kts at current day air traffic density with no additional separation distance buffer and at eight times the current day with no more than a 60% increase in separation distance buffer.

Paper № 94 -- Separation Minima Model: How Changes in Contributing Factors Could Affect Current Standards

Daniel Mosquera-Benitez (ISDEFE)
Lars Fucke, (AENA)

In 1919, the International Commission for Air Navigation (ICAN) was created to develop "General Rules for Air Traffic". In 1926, the US Air Commerce Act was passed calling for implementation of air traffic. Its first basic Separation Minima (SM) was "Do not take off until there is no risk of collision with landing aircraft and until preceding aircraft are clear of the airfield."[1] Since then, many SM standards have been written based upon the technology available at the time and/or expert judgment. Leaps in technology since then require that the SM standards be updated. However, many SM have not been modified to reflect modern technological

capabilities. In addition, many regions around the world have set different values for the same operational case or have used different criteria and context descriptions. As current traffic demand is expected to double by 2020, one of the ATM system challenges is to safely manage the expected increase of movements. Reducing SM becomes a potential part of achieving this challenge, always keeping in mind that SM reductions increase airspace capacity but should never reduce safety levels. A useful tool would allow quick comparative analysis to understand what affect changes in contributing factors would have on SM before investing in a Safety Case. To develop this model RESET, a SESAR aligned project which includes the FAA as a partner, has extracted information from several international regulations (ICAO, FAA, British, Australian, Canadian and Eurocontrol) classifying the descriptions of SM values by phase of flight, operational context, conditions, etc. also identifying aerodynamic factors, human factors, hazards/risks and equipment precision. The valuable results of this research are unprecedented in their contents and for the way in which they are presented. The identified contributing factors were then grouped into budgets and used as variables in the Separation Minima Model.

Paper № 158 -- Progress on Joint FAA/Eurocontrol Effort to Develop an ICAO Wake Turbulence Re-Categorization

Jeffrey Tittsworth (Federal Aviation Administration)
Catalin Lepatadu (Eurocontrol)
Don Delis (NorthWest Research Associates)

Planned improvements in Air Traffic Management, as described by NextGen in the US and SESAR in Europe, have a common goal of enhancing capacity and harmonizing separation standards. Wake vortices are a product of lift for all aircraft and are one of the major constraints in the reduction of separation standards that are one of the solution avenues that NextGen and SESAR are pursuing in the goal for increased capacity. The existing separation standards based on wake turbulence are significantly different between the US and ICAO. Furthermore, both the ICAO and US categories, and associated separation minima among the categories, represent two very safe systems but are optimized for fleet mixes that existed 15 or more years ago. As an example, the last re-categorization effort in the US was performed in 1994. Better knowledge of wake behavior obtained through research and improved sensors that measure wake turbulence provide an opportunity to develop a new set of common categories that provide the same or increased safety over the existing US and ICAO categories while optimizing for current and future traffic demands in the US and Europe. This paper describes a joint FAA/EUROCONTROL methodology for developing and evaluating new candidate wake turbulence categories. The paper provides examples and rough estimates of capacity gains that some examples show over today's US and ICAO categories. Finally, the paper highlights the key steps yet to be completed in achieving a joint recommendation to ICAO in 2010.

Track 1 – Trajectory and Queue Management (Room A)

Paper № 38 -- Use of Linear Aircraft Intent Response for Tactical Trajectory-Based Operations

Stephane Mondoloni (MITRE Corporation)

A method is proposed for exchanging information that allows a ground system to estimate the aircraft intent response to a ground instruction. This method approximates the intent response as a linear function of ground instruction parameters. The approach is described and applied to the case of an aircraft in climb subject to a controlled time-of-arrival. When subject to either lateral maneuvers or altitude constraints, the provision of the aircraft intent response allows for significant improvements in prediction accuracy. Over a 150 nautical mile look-ahead horizon, accuracy is improved between 34% to 81% in the lateral maneuver case and 71% to 93% in the altitude maneuver case. Improved knowledge of the expected intent response allows ground systems to develop more accurate trajectories for application to tactical functions such as separation and trajectory management in higher density environments.

Wednesday, July 1, 2009

Paper № 141 -- Lateral Intent Error's Impact on Aircraft Prediction

Mike Paglione (Federal Aviation Administration)
Ibrahim Bayraktutar (EUROCONTROL)
Greg McDonald (Airservices Australia)

Unprecedented global initiatives have begun to redesign the aviation systems that provide for the efficient and safe transport of civilian aircraft. Success of these initiatives is only possible through global collaborations that allow broader analyses and data to be shared. The paper reports on just such a study that examines the lateral deviations from the automation's known horizontal route of flight to the actual aircraft position. These errors are due to the typical navigation and surveillance errors, as well as the larger atypical errors that are mainly caused by purposeful changes in the route of flight that are not updated. Large data analyses within the ground automation systems of the United States and Europe indicated errors from 20 to 30 nautical miles are common, while airborne Australian and more samples in the United States had errors from 100 to 800 times smaller. Further analysis illustrated the direct impact these errors have on safety critical separation management functions. It was concluded that airborne derived data via Automatic Dependent Surveillance Contract reports offer a major opportunity to improve the ground-based automation functions.

Paper № 30 -- Departure Scheduling in a Multi-airport System

Yanjun Wang (Nanjing University China)

In this paper, we consider a scheduling problem for multi-airport departure flights. A mathematical model is presented for sequencing departure flights in different airports within one terminal area. Due to the traffic influences between airports, both airport runways and departure routes are considered in the model. Moreover, practical issues that affect the implementation of the schedule are also carried out by the Constraint Position Shifting (CPS). Then a tabu search algorithm is developed and implemented to obtain reasonable solutions within acceptable computation times. Finally, we apply the proposed model and algorithm to a real case study of Shanghai Terminal Area with departure flights from Shanghai HongQiao International Airport and Shanghai PuDong International Airport. The computational results validate the proposed model and show the advantage of the algorithm. Efficient scheduling flights for takeoff can fully utilize critical resources and reduce the impact of traffic interaction between airports.

Paper № 101 -- Distributed Trajectory Flexibility Preservation for Traffic Complexity Mitigation

Husni Idris (L-3 Communications)

The growing demand for air travel is increasing the need for mitigation of air traffic congestion and complexity problems, which are already at high levels. At the same time new information and automation technologies are enabling the distribution of tasks and decisions from the service providers to the users of the air traffic system, with potential capacity and cost benefits. This distribution of tasks and decisions raises the concern that independent user actions will decrease the predictability and increase the complexity of the traffic system, hence inhibiting and possibly reversing any potential benefits. In answer to this concern, the authors propose the introduction of decision-making metrics for preserving user trajectory flexibility. The hypothesis is that such metrics will make user actions naturally mitigate traffic complexity. In this paper, the impact of using these metrics on traffic complexity is investigated. The scenarios analyzed include aircraft in en route airspace with each aircraft meeting a required time of arrival in a one-hour time horizon while mitigating the risk of loss of separation with the other aircraft, thus preserving its trajectory flexibility. The experiments showed promising results in that the individual trajectory flexibility preservation induced self-separation and self-organization effects in the overall traffic situation. The effects were quantified using traffic complexity metrics based on Lyapunov exponents and traffic proximity.

Wednesday, July 1, 2009

Paper № 151 -- Use of Queuing Models to Estimate Delay Savings from 4D Trajectory Precision

Tasos Nikoleris (University of California)

The potential benefit from introducing trajectory based operations into the NAS is estimated in this paper. Delay predictions of a stochastic and a deterministic queuing model, which represent high and low levels of trajectory uncertainty, are compared. It is found that delay savings are on the order of 35% in the average case, Delay predictions from the various models are found to be strongly collinear over a wide range of congestion levels.

Track 2 – Innovative ATM Concepts (Room B)

Paper № 67 -- SmartNodes - Towards supporting time-critical decision-making in Aviation Security

Rainer Koelle (EUROCONTROL)

This paper considers decision support for incident management in aviation security. One of the key issues in Aviation Security is that despite the catastrophic magnitude, incidents are rare and their precursors are hard to identify. There is a limited time window available to the decision-makers to identify an incident situation and select the respective tailored response to this incident. The success of avoiding unwanted outcomes can diminish with delays in taking the appropriate decision within the finite time window. In this paper the authors address the challenges of establishing timely situation awareness to support 'course of action' selection. In order to efficiently manage an aviation security incident, smart systems can provide the required technological capability in highly dynamic and complex environments. The goal of the research is to develop a decision support system for incident management. This research-in-progress paper presents our approach to develop and design SmartNodes. We describe our experiments and modeling work. We tested the performance of a network of SmartNodes in comparison to two recent European live trial scenarios to emulate real-time constraints and requirements. The results obtained indicate that automation support for time-critical decision-making in aviation security enhances the early identification of incidents and increases the situational awareness during the management of an incident. This allows decision-makers to select from a wider range of options, as the timewindow for the deployment of responses increases.

Paper № 15 -- Regional GDP -- Extending Ground Delay Programs To Regional Aviation Security

Yu Zhang (University of South Florida)

Following the authors' previous research on real-time intermodalism, this study proposes a Regional Ground Delay Program (Regional GDP) concept into the Collaborative Decision Making (CDM) system when a hub airport located in a regional airport system encounters a severe airside capacity reduction. It suggests that air traffic flow managers evaluate not only the imbalance of traffic demand and terminal capacity at the hub airport but also excess capacity at other airports in the same region, assuming that airlines could incorporate ground modes into their disruption management and use ground vehicles to transport passengers and crew members between original scheduled and diverted airports. A mathematical programming model is established to help air traffic flow managers make decisions on initiating a Regional GDP advisory. A case study at San Francisco International Airport (SFO) was conducted. Results show that the initiation of a Regional GDP is suggested on a day with severe weather conditions.

Paper № 59 -- Near-Term Terminal Area Automation for Arrival Coordination

Jeffrey Shepley (MITRE Corporation)

As the Federal Aviation Administration (FAA) increasingly implements Area Navigation (RNAV) and Required Navigation Performance (RNP) procedures during the transition to the Next Generation Air Transportation System (NextGen), facilities expect to improve the predictability of arrival operations. Sponsored by the FAA, The MITRE Corporation's Center for Advanced Aviation System Development (CAASD) explored methods for retaining this predictability for merging traffic. This paper focuses on near-term solutions which leverage RNAV and RNP procedures to improve predictability of merging arrival operations in the terminal area. CAASD, in coordination with air traffic control (ATC) specialists from FAA operational facilities, has developed the concept for a near-term automation capability which calculates the distance of aircraft to a merge point along an RNAV or RNP procedure and conveys this information via an indicator on the terminal controller workstation. The relative position information facilitates early decision making by controllers, which reduces reliance on vectors, thereby maintaining the predictability of the operation. To further develop the concept and define its functional and interface requirements, CAASD developed a research prototype. Using this prototype, CAASD has conducted human-in-the-loop simulations with ATC specialists. These simulations led to a version of the prototype for which the FAA has requested and CAASD has developed a plan for a field evaluation.

Paper № 110 -- Evaluation of Triple Closely Spaced Parallel Runway Procedures for Off-nominal Cases

Savita Verma (NASA Ames Research Center)
Tom Kozon (Perot System/NASA)

This study investigated the procedures on three closely spaced parallel runways using a high fidelity flight simulator. The operational concept under study aimed to achieve visual meteorological capacities under instrument meteorological conditions when landing aircraft on runways as close as 750 ft apart. The purpose of the study was to investigate procedures related to breakout maneuvers for triple parallel runways flying in an echelon formation. Two-thirds of the data collection runs had an off-nominal situation, which was manipulated as an independent variable. The off-nominal situation was either the wake of the lead aircraft drifting too close to the center or trailing aircraft or the lead aircraft deviating from its course and blundering towards the center and trailing aircraft. The location of the off-nominal situation (high/low altitude) and the position of the ownship (center or right runway) were also manipulated as independent variables. Results showed that the workload and situational demands experienced by pilots were higher in the off-nominal as compared to the nominal scenario. Neither cause of breakout, location of breakout, nor position of ownship had a significant impact on workload or situation awareness. Analysis of the objective flight data indicated that the pilots flew the breakout maneuvers across all conditions and scenarios accurately and safely, similar to the previous two runway study. The results also provide an assessment of the procedures for breakout maneuvers during off-nominal conditions.

Paper № 52 -- Ant Colony Optimization for Air Traffic Conflict Resolution

Nicolas Durand (DSNA)

The n aircraft conflict resolution problem is highly combinatorial and can be optimally solved using classical mathematical optimisation techniques only for small problems involving less than 5 aircraft. This article applies an Ant Colony Optimization (ACO) algorithm in order to solve large problems involving up to 30 aircraft. In order to limit the number of pheromone trails to update, a n aircraft conflict resolution problem is not modeled by a single ant but by a bunch of n ants choosing their trajectories independantly. A relaxation process is also used in order to be able to handle difficult conflicts for which partial solutions can help finding a path toward the optimal solution. Two different sizes of a toy problem are solved and presented.

Wednesday, July 1, 2009

Paper № 146 -- ERASMUS Strategic Deconfliction to Benefit SESAR
Rosa Weber (Honeywell International)

This paper summarizes the methods and results from our analyses of the ERASMUS autonomous strategic deconfliction concept. An international team of researchers from R&D labs and universities across Europe and the US generated conclusive performance results via real-time and fast time simulations and human-in-the-loop experiments during a 30-month study of the impact that machine-generated, subliminal speed modifications of an aircraft trajectory have on controllers and pilots. A new means of separation assurance was investigated using autonomous strategic conflict management and tactical separation via RTA speed adjustments. Our main findings are organized according to the research questions raised in the ERASMUS validation strategy [1]. The ERASMUS solver described in this paper provides a potential "quick win" for insertion into the Single European Sky ATM Research (SESAR) deployment program, starting in mid 2009.

Track 2 – Finance and Policy (Room B)

Paper № 86 -- A Market Mechanism to Assign Air Traffic Flow Management Slots
Andrea Ranieri (University of Trieste)

We propose a market mechanism based on auctions, which could constitute an efficient tool to assign Air Traffic Flow Management delays to flights at a tactical level, when a mismatch between demand and capacity is detected for a specific system resource. Such a mechanism constitutes an improvement to the monolithic central allocation employed today, because the current First Planned First Served solution is taken as the baseline from which a more efficient one is iteratively searched in the solution space. We prove that each actor is better-off when the mechanism converges to an optimal solution. This mechanism actively involves users in the decision making process while respecting at the same time the concepts of transparency, equity, efficiency and non disclosure of airlines private information, as advocated by the User Driven Prioritization Process in the SESAR Target Concept.

Paper № 155 -- Assessing the Role of Operator, Passenger, and Infrastructure Costs in Fleet Planning under Fuel Price Uncertainty
Megan Smirti (University of California, Berkeley)

Aviation system planning is challenged by the rapid increase in fuel prices and uncertainty in air traffic management (ATM) charges. As airlines decrease capacity and decommission older aircraft and aviation navigation service providers ponder new ATM charging schemes, a critical question is which aircraft provide air transportation service for the lowest cost. This study evaluates the introduction of a minimally utilized aircraft type in the United States, a 72-seat turboprop, compared with the currently operated narrow body and regional jet aircraft. Homogenous fleets of these vehicles are compared for operating, passenger preference, and ATM costs over a range of fuel prices and the minimum cost fleet mix is determined. Findings include that when operating costs are considered alone, the regional jet exhibits a higher cost per passenger than the turboprop for the entire fuel price and stage length space; when passenger costs are considered there exists an equal cost per passenger curve between these two aircraft for fuel prices below $4.00/gallon. When infrastructure costs are considered, the fuel price and stage length space where the turboprop offers a lower cost increases. The comparison of the turboprop with the narrow body shows that an equal cost curve exists under all cost combinations considered. With the introduction of ATM charging, the flat landing fee favors the narrow body as providing the lower cost for a large region, while variable ATM charges increase the space where the turboprop offers the lower cost. This analysis shows that aircraft fleet selection is highly sensitive to fuel prices, passenger costs, and ATM charging schemes.

Paper № 82 -- Effects of Fuel Prices and Slot Controls on Air Transportation Performance at New York Airports

John R. Ferguson (George Mason University)

Industry strategists and government regulators have focused on addressing concerns over the performance of the air transportation system with respect to delays. Emphasis has been placed on managing the problems at New York slot controlled airports, since 12% of flight delays have been attributed to flights passing through New York. This paper examines the effect of increased fuel prices on the performance of the air transportation system. Analysis identified that the number of markets served and the flights operated have remained constant in the presence of increased operational costs (+59%). Revenue has increased 29% through changes in airfares and the use of smaller aircraft (down 3%), while keeping service to all markets. With aircraft size changes and scheduling adjustments, flight delays have been reduced by 14% in 2008. The effects of seasonality are also discussed.

Track 3 – ATM Performance Measurement and Management (Room C)

Paper № 121 -- Validation of Runway Capacity Models

Amy King (University of California, Berkeley)

There are many runway capacity estimation models currently available today, and developers usually claim that their models have been validated. However, information about the validation process is often limited, and different models are validated at different levels of complexity. As a result, this paper proposes two validation methodologies that can be used to test model predictions against reality. We demonstrate the methods on two model--the Airfield Capacity Model (ACM) and Runway Simulator (rS)--and two airports—SFO and LAX. The results indicate that both models tend to over-predict capacities under good visibility conditions, and predict wider ranges of capacities than are seen empirically. Overall, capacity estimates from rS are typically more accurate than those from ACM.

Paper № 102 -- Management of ATM performance in operational concept development and validation: a case study

Jelmer J. Scholte (National Aerospace Laboratory NLR)

The NextGen and SESAR programs plan fundamental changes in air traffic operations in the US and Europe to reach ambitious performance objectives. A specific challenge in the development and validation process of advanced air traffic operations is to satisfy multiple and by nature almost contradictory objectives in key performance areas. The aim of this paper is to illustrate and analyze how this worked in a specific example development of an air traffic operation at Amsterdam airport by the Air Navigation Service Provider LVNL, where standard ICAO operations often do not suffice to satisfy ambitious performance objectives in multiple dimensions. In order to learn from this example, first a factual description is given of the cycles of operational concept development and validation performed, with a focus on validation with respect to safety. Subsequently, the factual example development and validation process is compared versus literature and versus FAA/ Eurocontrol overall validation guidance.

Wednesday, July 1, 2009

Track 3 – Airport Operations (Room C)

Paper № 81 -- Airport surface management and runways scheduling
Jean-Baptiste Gotteland (DSNA/DTI/R&D/POM)

This article focuses on the interactions that have to be developed between the runways scheduling (AMAN-DMAN) systems and the surface management (SMAN) system, in order to reduce the ground delay at Roissy Charles de Gaulle airport. The departures delay resulting from the optimised runways scheduling is compared to the total ground delay that can be measured by simulation, when all the taxiing constraints of aircraft are introduced. During traffic peaks, the runways capacity appears to be twice less penalizing than the whole airport traffic management process. As a consequence, some optimisation methods are defined and tested to perform the conflicts resolution between taxiing aircraft and make it more consistent with the runways scheduling. The new ground traffic simulations carried out confirm the significant delay reduction that could be obtained.

Paper № 116 -- Scheduling Aircraft Landings to Closely Spaced Parallel Runways
Michael Kupfer (University of California, Santa Cruz)

An optimization model for a scheduling problem for Closely Spaced Parallel Approaches has been formulated. It takes temporal, pairing, sequencing, separation route and grouping constraints into account. Simulations have been carried out investigating the influence of different scheduling methods as well as varying sizes of the pairing time window and ETA time window. Results indicate that Closely Spaced Parallel Approaches would greatly enhance arrival throughput. Furthermore, the results show that advanced scheduling methods can improve arrival throughput over FCFS if the traffic is sufficiently varied. Schedules computed by an improved genetic algorithm are of similar quality as optimal solutions.

Paper № 79 -- Application of Reinforcement Learning Algorithms for Predicting Taxi-out Times
Poornima Balakrishna (George Mason University)

Accurate estimation of taxi-out time in the presence of uncertainties in the National Airspace System (NAS) is essential for the development of a more efficient air traffic management system. The dynamic nature of operations in the NAS indicates that traditional regression methods characterized by constant parameters would be inadequate to capture variations in taxi-out time across a day. In this paper, we describe how to build a taxi-out time estimation model using Reinforcement Learning, and identify factors that influence taxi-out time through the day. Taxi-out time predictions for a flight are made 15 minutes in advance of scheduled gate pushback time. Results from a case study of Detroit International Airport (DTW), Tampa International Airport (TPA), and John F. Kennedy International Airport (JFK) are presented and analyzed.

Paper № 145 -- Linking Traffic Management to the Airport Surface: Departure Flow Management and Beyond
Nathan Doble (Metron Aviation)

Airport surface operations are largely managed tactically today, and there is little linkage between surface operations and traffic flow management (TFM) decision-making for other National Airspace System resources. The Next Generation Air Transportation System (NextGen) envisions airport operations that are more strategically planned, and which are better aligned with traffic management initiatives for terminal area and en route airspace. This paper describes the Departure Flow Management (DFM) capability, which translates TFM constraints to departure timing decisions and is an interim step in the evolution to NextGen. Results from DFM prototype field trials are presented. In addition, the Tower Flight Data Manager capability is introduced, which will further integrate TFM constraints with airport surface processes, including taxi planning and pre-pushback gate operations.

Paper № 153 -- Delay Impacts onto Turnaround Performance
Hartmut Fricke (Technische Universität Dresden)

During 2007, 19% of all European flights were more than 15 min late. One contributor to this delay is the insufficient ground operation performance inducing excessive process durations. Whenever these processes are part of the critical Turnaround (TA) path, such as de-boarding, fuelling, cleaning, catering and boarding, the effects immediately propagate an accumulating delay through the ATM network. Recent studies have investigated into the effects of technical aircraft deficiencies onto TA reliability, and could show that significant potential is given for improvement. Field analyses at German airlines showed that pre-set quality standards for punctuality can actually not be met. This paper extends that analysis by considering the individual inbound delay measured at the gate, revealing the correlation between TA process duration and stability versus a given delay with an analytical model. The concept of dynamically scheduling buffer times to compensate for potential delays into the ground time of aircraft turnaround operations is introduced into our model. It can be shown that dynamic buffering may overcome deficiencies of the currently applied buffer strategies for ground processes. The paper closes with a strategy on how to scale gate time to cope with demanding punctuality requirements from the customer's side. With regards to Airport CDM concepts, the dependencies found may be used in decision support tools to trigger ground handling resource (personnel and tools) planner and motivate for strategies specifically for Ground Handling Companies.

Paper № 7 -- Airport Service Vehicle Scheduling
Kenneth Kuhn (NASA DLR Moffett Field)

Airport service vehicles, such as luggage trailers and passenger buses, service an aircraft after the aircraft arrives and before it departs. The timely arrivals of these vehicles help ensure efficient use of airport resources. This research investigates algorithms for scheduling airport service vehicles. A mixed integer linear program is proposed, minimizing service provider fuel costs and air carrier delays. The formulation of the integer programming problem is modified to aid solution search strategies. A genetic algorithm heuristic borrowed from aircraft arrival scheduling is introduced for finding approximate solutions relatively quickly, in addition to an exact solution method making use of branch and bound techniques specially designed for this problem. The various algorithms are tested using simulations of service provider dispatch problems at Hamburg and Dallas-Fort Worth Airports. Results show that plan based service vehicle scheduling reduces both delay and fuel costs over passive strategies, often 20% or more. The genetic algorithm based heuristic also reduced delay and fuel costs while incurring computational burdens significantly below those of the optimal search strategy.

Paper № 44 -- Integrating optimization and simulation to gain more efficient airport logistics
Tobias Andersson Granberg (Linköping University Norrköping, Sweden)

In this paper we present airport logistics, which is a framework of resource management in the air transportation system. Focus is on the processes supporting turn-around. A detailed simulation model of various processes involved in turn-around is developed, by which the interaction between these processes are analyzed. We show that integrating optimization and simulation is a powerful tool to demonstrate efficiency improvements in airport logistics, using scheduling de-icing trucks as an example. An optimization algorithm for scheduling de-icing trucks is developed and simulations are performed comparing different schedules. The schedule obtained when considering total airport performance in the optimization algorithm gives minimum flight delay and waiting times in the simulations.

Wednesday, July 1, 2009