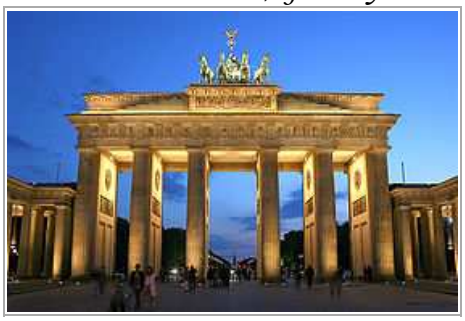
9th USA/EUROPE
Air Traffic Management R&D Seminar

June 14th – 17th 2011

Hilton Berlin, Germany



Jointly sponsored by EUROCONTROL and Federal Aviation Administration

Programme booklet

Contents:

ATM2011 Seminar *AT-A-GLANCE*

Mon 13th

17:30	**Early Registration**
18:30	**Welcome Reception: Room Corinth**

Tuesday 14th June

7:30 **Registration**

Opening Session: Ballsaal A-C

8:30 **Welcome and Logistics** - Sabrina Saunders-Hodge (US Chair) & Vu Duong (Europe Chair)

8:45 **Welcome Message** from the German Minister of Transport (MDir Gerold Reichle, Div. Aeronautics and Astronautics)

8:55 **Greetings from the US** - Karlin Toner (JPDO)

9:05 **Greetings from EUROPE** - Bernard Miaillier (EUROCONTROL)

9:15 COFFEE

	I Room: Ballsaal A	II Room: Ballsaal B-C	III Room: Corinth
	Performance Chair: M. Ball	**Human Factors** Chair: J. Hoekstra	**Separation** Chair: P. Krois
9:45	116 Knorr, Chen et al	34 Hoang, Jung, Holbrook	28 Mayer, Zondervan et al
10:30	112 Odoni, Morisset, Drotleff, Zock	151 Wu, Duong, Koteskey, Johnson	137 Prevot, Homola, Martin, Mercer
11:15	36 Bhadra, Knorr, Levy	135 Kupfer, Callantine, Martin, Mercer	76 Granger, Allignol, Durand
12:00	143 Kotegawa, DeLaurentis et al	133 Moehlenbrink, Papenfuss, Jakobi	103 Lauderdale, Cone, Bowe
12:45	LUNCH		
	Chair: B. Josefsson	Chair: P. Krois	Chair: J. Hoekstra
14:00	65 Gilbo, Smith	144 Clarke, Durand, Feron, Vela	64 Weibel, Edwards, Fernandes
14:45	15 Bloem, Huang	56 Wang, Hu, Vormer, Duong	39 Kochenderfer, Weibel
15:30	COFFEE		
	Chair: B. Josefsson	Chair: P. Krois	Chair: J. Hoekstra
16:00	109 Pozzi, Valbonesi et.al.	150 Lachter, Johnson et al.	68 Holzäpfel, Gerz, Schwarz
16:45	130 Olszta, Olson	131 Chong, Smith	27 Schaad et al. (**Deployment**)
17:30	FREE EVENING		

Wednesday 15th June

	I Room: Ballsaal A	II Room: Ballsaal B-C	III Room: Corinth
	Airports Chair: M. Tanino	**Safety** Chair: D. Zellweger	**Airspace Management** Chair: G. Andreatta
8:30	92 Jung, Hoang et al	44 Netjasov, Vido, Tosic, Blom	153 Lee, Prevot et al.
9:15	132 Foyle, Hooey et al.	152 Meyer, Schultz, Fricke	49 Yifei, Rentian, De
10:00	127 Lohr, Brown et al	14 Stroeve, Blom, Bakker	141 Sawhill, Herriot et al
10:45	Coffee		
	Chair: M. Weber	**Network** Chair: N. Durand	**SurNav** Chair: D. Kuegler
11:15	136 Brinton, Prevost, Passmore	157 Barnier, Allignol	78 Levitt, Weitz
12:00	66 Loth	45 Vaze, Barnhart	120 Penhallegon, Mendolia et al
12:45	122 Schultz, Fricke	123 Ball, Lovell, Glover	94 Moertl
13:30	LUNCH		
	AFTERNOON AVAILABLE FOR NETWORKING		

Thursday 16th June

	I Room: Ballsaal A	II Room: Ballsaal B-C	III Room: Corinth
	Weather Chair: C. Wanke	**Finance** Chair: D. Zellweger	**Environment** Chair: M. Gupta
8:30	9 Klein, Cook	43 Post, Wells, Bonn, Ramsey	30 Burbidge, Melrose, Watt
9:15	33 Cho, Welch, Underhill	126 Churchill, Ball, Donaldson, Hansma	20 Sridhar, Chen, Ng, Linke
10:00	COFFEE		
	Chair: C.Wanke	**Traj & Q** Chair C. Meckiff	Chair: T. Edwards
10:30	71 Hesselink, Nibourg	90 Soler, Olivares, Staffetti, Bonami	62 Cao, Kotegawa et al
11:15	146 Buxi, Hansen	47 Popescu, Clarke, Feigh, Feron	38 Stell
12:00	LUNCH		
	A-G Integration Chair: J. Hoekstra	Chair: J. Merkle	Chair: M. Piera
13:30	21 Verma, Lozito, et al.	119 Taylor, Wanke	25 Bronsvoort, McDonald et al
14:15	32 Hakkeling, Mulder, et al.	40 Swenson, Sullivan, Martin	73 Yaworski, Dinges, Iovinelli
15:00	COFFEE		
	Chair: S. Lozito	Chair: J. Merkle	Chair: M. Gupta
15:30	16 Mueller et al.	41 Gwiggner, Nagaoka, Nikoleris	72 Ryerson, Hansen
16:15	142 Uebbing-Rumke, Temme	19 Klooster, de Smedt	83 Prats, Hansen
17:00	42 Alam, Zhao, Tang, Abbass	138 Smith, Prevot, Mercer	48 Simaiakis, Balakrishnan et al.
18:30	GALA DINNER - assemble in reception		

Friday 17th June

8:00 **Break-out workshops: What are optimum research portfolios for ...**

Capacity	Environment	Safety
Moderators: J. Schroeder, P. Hecker	Moderators: M. Hansen, M. Gupta	Moderators: A. Haraldsdottir, H. Blom

10:00 COFFEE

10:30 **Plenary Panel: How do we develop a robust R&D portfolio?** - Moderators: T. Edwards, C. Meckiff
Panelists: Karlin Toner (JPDO), Bo Redeborn (EUROCONTROL), John Hansman (MIT), Jacco Hoekstra (TU Delft)

12:00 **Plenary Talk: NextGen Research Partnerships** - Karlin Toner (JPDO)

12:30 **Plenary Talk: Looking to the Future** - Bernard Miaillier (EUROCONTROL)

13:00 **Best Paper Awards & Closing** - Sabrina Saunders-Hodge & Vu Duong

13:15 LUNCH

Full programme

Tuesday 14th June – Opening Session

08:30	Opening and logistics	**Sabrina Saunders-Hodge** (FAA); **Vu Duong** (EUROCONTROL)
08:45	Welcome message	**MDir Gerold Reichle**, German Minister of Air transport, Division Aeronautics and Astronautics
08:55	Greetings from the US	**Karlin Toner**
09:05	Greetings from EUROPE	**Bernard Miaillier**

Tuesday 14th June - Track 1: Performance

Rapporteur: Wim Post

Session Chair: Mike Ball

Time	Paper	Title	Authors (presenter in **bold**)
09:45	116	Estimating ATM Efficiency Pools in the Descent Phase of Flight	**Dave Knorr**, Xing Chen, Marc Rose, John Gulding (FAA); Philippe Enaud, Holger Hegendoerfer (EUROCONTROL)
10:30	112	Benchmarking Airport Airside Performance: FRA vs EWR	**Amedeo Odoni**, Thomas Morisset (MIT); Wilhelm Drotleff, Alexander Zock (ECAD)
11:15	36	Benefits of Virtual Queuing at Congested Airports Using ASDE-X: A Case Study of JFK Airport	Dipasis Bhadra, Dave Knorr (FAA); **Benjamin Levy** (Sensis)
12:00	143	Impact of Commercial Airline Network Evolution on the U.S. Air Transportation System	Tatsuya Kotegawa, **Daniel DeLaurentis** (Purdue University); Kimberly Noonan, Joseph Post (FAA)

Session Chair: Billy Josefsson

Time	Paper	Title	Authors (presenter in **bold**)
14:00	65	New Method for Probabilistic Traffic Demand Predictions for En Route Sectors Based on Uncertain Predictions of Individual Flight Events	**Eugene P. Gilbo**, Scott B. Smith (Volpe Center)
14:45	15	Evaluating Delay Cost Functions with Airline Actions in Airspace Flow Programs	**Michael Bloem** (NASA Ames); Haiyun Huang (Delft University of Technology)

Session Chair: Billy Josefsson

Time	Paper	Title	Authors (presenter in **bold**)
16:00	109	Safety Monitoring in the Age of Big Data	**Simone Pozzi**, Carlo Valbonesi, Valentina Beato (Deep Blue); Rodolfo Volpini, Francesco Maria Giustizieri (ENAV); Frederic Lieutaud, Antonio Licu (EUROCONTROL)
16:45	130	Characterization and Analysis of Traffic Alert and Collision Avoidance Resolution Advisories Resulting from 500' and 1,000' Vertical Separation	**Jessica E. Olszta**, Wesley A. Olson (MIT Lincoln Laboratory)

Tuesday 14th June - Track 2: Human Factors

Rapporteur: Sandy Lozito

Session Chair: Jacco Hoekstra

Time	Paper	Title	Authors (presenter in **bold**)
09:45	34	Tower Controllers' Assessment of the Spot and Runway Departure Advisor (SARDA) Concept	**Ty Hoang**, Yoon C. Jung (NASA Ames); Jon B. Holbrook (San Jose State University)
10:30	151	Designing a Flight Deck Predictive Weather Forecast Interface Supporting Trajectory-Based Operations	**Shu-Chieh Wu** (NASA Ames); Constance G. Duong (Stanford University); Robert W. Koteskey, Walter W. Johnson (NASA Ames)
11:15	135	Controller Support Tools for Schedule-Based Terminal-Area Operations	**Michael Kupfer**, Todd Callantine, Lynne Martin, Joey Mercer (San Jose State University/NASA Ames); Everett Palmer (NASA Ames)
12:00	133	The Role of Workload for Work Organisation in a Remote Tower Control Center	**Christoph Moehlenbrink**, Anne Papenfuß, Jörn Jakobi (DLR)

Session Chair: Paul Krois

Time	Paper	Title	Authors (presenter in **bold**)
14:00	144	Determining the Value of Information for Minimizing Controller Taskload: A Graph-Based Approach	John-Paul Clarke (Georgia Tech); Nicolas Durand (DSNA); Eric Feron, William Singhose, **Adan Vela** (Georgia Tech)
14:45	56	Spatial, Temporal, and Grouping Behaviors in Controller Communication Activities	**Yanjun Wang**, Minghua Hu (Nanjing University of Aeronautics & Astronautics); Frizo Vormer, Vu Duong (Eurocontrol)

Session Chair: Paul Krois

Time	Paper	Title	Authors (presenter in **bold**)
16:00	150	Issues for Near-Term Implementation of Trajectory Based Operations	**Joel Lacher**, Vernol Battise, Rob Koteskey, Arik-Quang V. Dao, Summer L. Brandt, Sarah V. Ligda, Shu-Chieh Wu (San Jose State University); Walter W. Johnson (NASA Ames)
16:45	131	Using Data Communications to Manage Tailored Arrivals in the Terminal Domain: A Feasibility Study	**Ronald S. Chong**, Elida C. Smith (MITRE CAASD)

Tuesday 14th June - Track 3: Separation

Rapporteur: Jeff Schroeder

Session Chair: Paul Krois

Time	Paper	Title	Authors (presenter in **bold**)
09:45	28	A Standard for Equivalent Lateral Spacing Operations - Parallel and Reduced Divergence Departures	**Ralf H. Mayer**, Dennis J. Zondervan, Albert A. Herndon, Tyler Smith (MITRE)
10:30	137	Automated Air Traffic Control Operations with Weather and Time-Constraints	**Thomas Prevot** (NASA Ames); Jeffrey R. Homola, Lynne H. Martin, Joey S. Mercer, Christopher C. Cabrall (San Jose State University)
11:15	76	The Influence of Uncertainties on Traffic Control using Speed Adjustments	Geraud Granger (STERIA); Cyril Allignol, **Nicolas Durand** (DSNA)
12:00	103	Relative Significance of Trajectory Prediction Errors on an Automated Separation Assurance Algorithm	**Todd A. Lauderdale**, Andrew C. Cone, Aisha R. Bowe (NASA Ames)

Session Chair: Jacco Hoekstra

Time	Paper	Title	Authors (presenter in **bold**)
14:00	64	Establishing a Risk-Based Separation Standard for Unmanned Aircraft Self Separation	**Roland E. Weibel**, Matthew W. M. Edwards, Caroline S. Fernandes (MIT Lincoln Laboratory)
14:45	39	A New Approach for Designing Safer Collision Avoidance Systems	**Mykel J. Kochenderfer**, James P. Chryssanthacopoulos, Roland E. Weibel (MIT Lincoln Laboratory)

Session Chair: Jacco Hoekstra

Time	Paper	Title	Authors (presenter in **bold**)
16:00	68	The Wake Vortex Prediction and Monitoring System WSVBS	Frank Holzäpfel, Thomas Gerz, **Carsten Schwarz** (DLR)

Tuesday 14th June - Track 3: Deployment

Rapporteur: Midori Tanino

Session Chair: Jacco Hoekstra

Time	Paper	Title	Authors (presenter in **bold**)
16:45	27	Arrival Flow Control by Local Cherry Picking	**Daniel Schaad**, A. Reusser, C. Kern, R. Michalke (AustroControl); Ž. Sivcev, R. Credentino (EUROCONTROL)

Wednesday 15th June - Track 1: Airports

Rapporteur: Christoph Meier

Session Chair: Midori Tanino

Time	Paper	Title	Authors (presenter in **bold**)
08:30	92	Performance Evaluation of a Surface Traffic Management Tool for Dallas/Fort Worth International Airport	**Yoon Jung**, Ty Hoang, Justin Montoya (NASA Ames); Gautam Gupta, Waqar Malik, Leonard Tobias (University of California, Santa Cruz); Hua Wang (San Jose State University)
09:15	132	Flight deck surface trajectory-based operations (STBO): Simulation results and ConOps implications	**David C. Foyle** (NASA Ames); Becky L. Hooey, Deborah L. Bakowski, Jennifer L. Williams, Christina L. Kunkle (San Jose State University)
10:00	127	System Oriented Runway Management: A Research Update	**Gary W. Lohr**, Sherilyn Brown, H. Paul Stough (NASA Langley); Steve Eisenhawer (Logic Evolved Technologies); Steve Atkins (Mosaic ATM, Inc); Dou Long (Logistics Management, Inc)

Session Chair: Mark Weber

Time	Paper	Title	Authors (presenter in **bold**)
11:15	136	Collaborative Departure Queue Management: An Example of Airport Collaborative Decision Making in the United States	**Chris Brinton**, Chris Provan, Steve Lent (Mosaic ATM, Inc); Tom Prevost, Susan Passmore (FAA)
12:00	66	Concept and prototype of a ground handling vehicle management system	**Steffen Loth** (DLR)
12:45	122	Managing Passenger Handling at Airport Terminal	**Michael Schultz**, Hartmut Fricke (Technische Universität Dresden)

Wednesday 15th June - Track 2: Safety

Rapporteur: Paul Krois

Session Chair: Dres Zellweger

Time	Paper	Title	Authors (presenter in **bold**)
08:30	44	Systematic Validation of a Mathematical Model of ACAS Operations for Safety Assessment Purposes	**Fedja Netjasov**, Andrija Vidosavljevic, Vojin Tosic (University of Belgrade); Henk Blom (NLR)
09:15	152	Model-based Safety Requirements Engineering for complex ATM Systems	**Lothar Meyer**, Michael Schultz, Hartmut Fricke (Dresden University of Technology)
10:00	14	Contrasting Safety Assessments of a Runway Incursion Scenario by Event Sequence Analysis versus Multi-Agent Dynamic Risk Modelling	**Sybert H. Stroeve**, Henk A.P. Blom, G.J. (Bert) Bakker (NLR)

Wednesday 15th June - Track 2: Network

Rapporteur: Midori Tanino

Session Chair: Nicolas Durand

Time	Paper	Title	Authors (presenter in **bold**)
11:15	157	Combining Flight Level Allocation with Ground Holding to Optimize 4D-Deconfliction	Nicolas Barnier (ENAC); **Cyril Allignol** (DSNA)
12:00	45	A Multi-stakeholder Evaluation of Strategic Slot Allocation Schemes under Airline Frequency Competition	**Vikrant Vaze**, Cynthia Barnhart (MIT)
12:45	123	Collaborative Approaches to the Application of Enroute Traffic Flow Management Optimization Models	Michael O. Ball, **Charles Glover**, David J. Lovell (University of Maryland)

Wednesday 15th June - Track 3: Airspace Management

Rapporteur: Miguel Angel Piera Eroles

Session Chair: Giovanni Andreatta

Time	Paper	Title	Authors (presenter in **bold**)
08:30	153	Benefits and Feasibility of the Flexible Airspace Management Concept: A Human-in-the-loop Evaluation of Roles, Procedures, and Tools	**Paul U. Lee**, Connie Brasil, Jeffrey Homola, Angela Kessell, Hwasoo Lee, Matt Mainini (San Jose State University); Thomas Prevot (NASA Ames)
09:15	49	Method to Analyse Air Traffic Situation Based on Air Traffic Complexity Map	**Zhao Yifei**, Yue Rentian, Zhang De (Civil Aviation University of China)
10:00	141	Airspace Phase Transitions and the Traffic Physics of Interacting 4D Trajectories	**Bruce K. Sawhill**, James W. Herriot, Bruce J. Holmes, Ken Seehart (NextGen AeroSciences, LLC)

Wednesday 15th June - Track 3: Surveillance and Navigation

Rapporteur: Billy Josefsson

Session Chair: Dirk Kuegler

Time	Paper	Title	Authors (presenter in **bold**)
11:15	78	Towards Defining Required Interval Management Performance	Ian Levitt (FAA); **Lesley A. Weitz** (MITRE CAASD)
12:00	120	Flight Deck-Based Interval Management-Spacing During Departures: Flight Crew Human-In-The-Loop Simulation	**William J. Penhallegon**, Andrew S. Mendolia, Randall S. Bone, Gregory L. Orrell, H. Peter Stassen (MITRE CAASD)
12:45	94	Airline Based En Route Sequencing and Spacing Field Test Results: Observations and Lessons Learned for Extended Metering	**Peter M. Moertl** (MITRE CAASD)

Thursday 16th June - Track 1: Weather

Rapporteur: Jeff Schroeder

Session Chair: Craig Wanke

Time	Paper	Title	Authors (presenter in **bold**)
08:30	9	Three Models for Weather Impacted Airspace Capacity Estimation and Forecast	**Alexander Klein** (Air Traffic Analysis Inc); Lara Cook (Mosaic ATM Inc)
09:15	33	Analytical Workload Model for Estimating En Route Sector Capacity in Convective Weather	**John Y. N. Cho**, Jerry D. Welch, Ngaire K. Underhill (MIT Lincoln Laboratory)

Session Chair: Craig Wanke

Time	Paper	Title	Authors (presenter in **bold**)
10:30	71	Probabilistic 2-Day Forecast of Runway Use	**Henk Hesselink**, Joyce Nibourg (NLR)
11:15	146	Generating Probabilistic Capacity Profiles from weather forecast: A design-of-experiment approach	Gurkaran Buxi, **Mark Hansen** (University of California Berkeley)

Thursday 16th June - Track 1: Air-Ground Integration

Rapporteur: Dirk Kuegler

Session Chair: Jacco Hoekstra

Time	Paper	Title	Authors (presenter in **bold**)
13:30	21	Integrated Pilot and Controllers Procedures: Aircraft Pairing for Simultaneous Approaches to Closely Spaced Parallel Runways	**Savita Verma** (NASA Ames); Lynne Martin (San Jose State University); Sandy Lozito, John Kaneshige, Debbi Ballinger (NASA Ames); Thomas Kozon, Lara Cheng (University of California Santa Cruz); Shivangli Sharma (SGT Inc); Shobana Subramanian (NASA Ames)
14:15	32	Evaluation of an Autonomous Taxi Solution for Airport Operations during Low Visibility Conditions	M.Y. Hakkeling-Mesland, B. van Beek, **F.J.L. Bussink** (NLR); M. Mulder, M.M. van Paassen (Delft University of Technology)

Session Chair: Sandy Lozito

Time	Paper	Title	Authors (presenter in **bold**)
15:30	16	Controller and Pilot Evaluation of a Datalink-Enabled Trajectory-Based Operations Concept	**Eric Mueller**, Dave McNally, Tamika Rentas, Arwa Aweiss, David Thipphavong, Chester Gong (NASA Ames); Jinn-Hwei Cheng, Joe Walton, John Walker, Chu-Han Lee, Scott Sahlman (University-Affiliated Research Center); Diane Carpenter (Science Applications International Corporation)
16:15	142	Controller Aids for Integrating Negotiated Continuous Descent Approaches into Conventional Landing Traffic	**M. Uebbing-Rumke**, M.-M. Temme (DLR)
17:00	42	Discovering Delay Patterns in Arrival Traffic with Dynamic Continuous Descent Approaches using Co-Evolutionary Red Teaming	S. Alam, W. Zhao, J. Tang, C. Lokan, **H. Abbass** (University of New South Wales); M. Ellejmi, S. Kirby (EUROCONTROL)

Thursday 16th June - Track 2: Finance

Rapporteur: Christoph Meier

Session Chair: Dres Zellweger

Time	Paper	Title	Authors (presenter in **bold**)
08:30	43	Financial Incentives for NextGen Avionics: ADS-B Case Study	**Joseph Post**, Michael Wells, James Bonn, Patrick Ramsey (FAA)
09:15	126	Integrating best-equipped best-served principles in ground delay programs	**Andrew M. Churchill**, Michael O. Ball (University of Maryland); Alexander David Donaldson, R. John Hansman (MIT)

Thursday 16th June - Track 2: Trajectory and Queue Management

Rapporteur: Dirk Schaefer

Session Chair: Colin Meckiff

Time	Paper	Title	Authors (presenter in **bold**)
10:30	90	En-Route Optimal Flight Planning Constrained to Pass Through Waypoints using MINLP	**Manuel Soler**, Alberto Olivares, Ernesto Staffetti (Universidad Rey Juan Carlos); Pierre Bonami (CNRS)
11:15	47	ATC Taskload Inherent to the Geometry of Stochastic 4-D Trajectory Flows with Flight Technical Errors	**Vlad Popescu**, John-Paul B. Clarke, Karen M. Feigh, Eric Feron (Georgia Institute of Technology)

Session Chair: Jay Merkle

Time	Paper	Title	Authors (presenter in **bold**)
13:30	119	Dynamically Generating Operationally-Acceptable Route Alternatives Using Simulating Annealing	**Christine Taylor**, Craig Wanke (MITRE CAASD)
14:15	40	Design and Evaluation of the Terminal Area Precision Scheduling and Spacing System Trajectory and Queue Management	**Harry N. Swenson**, Jane Thipphavong, Alex Sadovsky (NASA Ames); Liang Chen, Chris Sullivan, Lynne Martin (University of California Santa Cruz)

Session Chair: Jay Merkle

Time	Paper	Title	Authors (presenter in **bold**)
15:30	41	Trade-offs and Issues in Traffic Synchronization	**Claus Gwiggner**, Masato Fujita, Yutaka Fukuda, Sakae Nagaoka (ENRI); Tasos Nikoleris (University of California Berkeley)
16:15	19	Controlled Time-Of-Arrival Spacing Analysis	**Joel K. Klooster** (GE Aviation Systems); David de Smedt (EUROCONTROL)
17:00	138	A Human-in-the-Loop Evaluation of Flow-Based Trajectory Management in Mixed Equipage Airspace	**Nancy Smith**, Tom Prevot (NASA Ames); Connie Brasil, Jeff Homola, Angela Kessell, Hwasoo Lee, Paul Lee, Matt Mainini, Joey Mercer (San Jose State University)

Thursday 16th June - Track 3: Environment

Rapporteur: Mark Hansen

Session Chair: Mohan Gupta

Time	Paper	Title	Authors (presenter in **bold**)
08:30	30	Potential Adaptation to Impacts of Climate Change on Air Traffic Management	Rachel Burbidge, **Alan Melrose**, Andrew Watt (EUROCONTROL)
09:15	20	Design of Aircraft Trajectories based on Trade-offs between Emission Sources	**Banavar Sridhar**, Neil Y. Chen (NASA Ames); Hok K. Ng (University of California Santa Cruz)

Session Chair: Tom Edwards

Time	Paper	Title	Authors (presenter in **bold**)
10:30	62	Evaluation of Continuous Descent Approach as a Standard Terminal Airspace Operation	Yi Cao, Tatsuya Kotegawa, **Dengfeng Sun**, Daniel DeLaurentis (Purdue University); Joseph Post (FAA)
11:15	38	Prediction of Top of Descent Location for Idle-thrust Descents	**Laurel Stell** (NASA Ames)

Session Chair: Miguel Angel Piera Eroles

Time	Paper	Title	Authors (presenter in **bold**)
13:30	25	Enhanced Descent Wind Forecast for Aircraft	**Jesper Bronsvoort** (Airservices Australia); Rodney Potts (Australian Government Bureau of Meteorology); **Greg McDonald** (Airservices Australia); Ekkehard Gutt (Emirates Airlines)
14:15	73	High-Fidelity Weather Data Makes a Difference Calculating Environmental Consequences with FAA's Aviation Environmental Design Tool	**Michael J. Yaworski**, Eric P. Dinges (ATAC Corporation); Ralph J. Iovinelli (FAA)

Session Chair: Mohan Gupta

Time	Paper	Title	Authors (presenter in **bold**)
15:30	72	Fuel Consumption and Operational Performance	**Megan S. Ryerson**, Mark Hansen (University of California, Berkeley); James Bonn (FAA)
16:15	83	Green Delay Programs	**Xavier Prats** (Technical University of Catalonia); Mark Hansen (University of California, Berkeley)
17:00	48	Demonstration of Reduced Airport Congestion through Pushback Rate Control	**I. Simaiakis**, H. Khadilkar, H. Balakrishnan, T. G. Reynolds, R. J. Hansman (MIT); B. Reilly, S. Urlass (FAA)

Friday 17th June – Parallel breakout workshops

These workshops are designed to allow the gathered ATM R&D community to exchange ideas on three specific themes. As well as producing a report of proceedings, output will be gathered and considered in the subsequent open plenary session.

Briefing material will be prepared by the facilitators to be available in advance of the sessions.

08:00	Room Ballsaal A What is the optimum portfolio for **Capacity** R&D?	Facilitators: **Jeff Schroeder** and **Peter Hecker**
08:00	Room Ballsaal B-C What is the optimum portfolio for **Environment** R&D?	Facilitators: **Mark Hansen** and **Mohan Gupta**
08:00	Room Corinth What is the optimum portfolio for **Safety** R&D?	Facilitators: **Auslag Haraldsdottir** and **Henk Blom**

Friday 17th June – Closing plenary

10:30	**- Open session -** **How do we develop and manage a robust ATM R&D portfolio?** Facilitators: **Tom Edwards** and **Colin Meckiff** Panellists: **Karlin Toner** (Director, JPDO) **Bo Redeborn** (EUROCONTROL, Director SESAR and Research) **R. John Hansman** (MIT, T. Wilson Professor of Aeronautics and Astronautics) **Jacco Hoekstra** (TU Delft, Dean Faculty of Aerospace Engineering)
12:00	Plenary talk: **NextGen Research Partnerships** by **Karlin Toner** (JPDO)
12:30	Plenary talk: **Looking to the Future** by **Bernard Miaillier** (EUROCONTROL)
13:00	Best paper awards and closing: **Sabrina Saunders-Hodge**, **Vu Duong**
13:15	Close and lunch

Abstracts

Abstracts: Performance

Estimating ATM Efficiency Pools in the Descent Phase of Flight – Knorr et al

In the descent phase of flight, limited research has focused on the benefits of ATM improvements in an environment where flight times are constrained by capacity. Both NextGen and SESAR have prioritized increasing capacity to reduce congestion and absorb future demand. For the foreseeable future, ATM will always have to manage congestion. This paper focuses on a methodology for estimating the total benefit pools, in terms of time and fuel that ATM can potentially influence in the descent phase of flight. Best practices from existing research on efficiency pools are incorporated and refined to provide estimates with data commonly available in today's ATC system. The analysis shows that at busy airports, most of the additional fuel used on top of an unconstrained trajectory is directly related to the need to sequence aircraft. How to absorb time in a time constrained environment in the most efficient manner is a key issue. This paper explores the benefits of reducing speed in cruise to absorb delays currently managed in the terminal area. The findings estimate the unimpeded benefit pool, actionable by ATC in the terminal area, averages 3 minutes for the top 34 airports in both US and Europe, or approximately 100 kg. of additional fuel per arrival. The potential benefit of reducing speed in cruise (i.e. with no change in capacity) is estimated to be around 30 percent of the unconstrained benefit pool in a conservative scenario. These findings provide incentive for further research complementing the numerous studies related to optimal descent profiles, which are mainly associated with non-congested periods. The estimated benefit pool associated with speed control in this paper applies directly to optimizing congested periods.

Benchmarking Airport Airside Performance: FRA vs EWR - Odoni et al

A benchmarking study of the Newark International (EWR) and Frankfurt/Main International (FRA) airports has been carried out, focusing on 2007, a year when airport congestion reached a peak. This paper summarizes some of its main findings. The two airports were selected because of the similarities in their runway layouts, regional importance, and air traffic characteristics. The analysis relied on the ASPM database of the FAA and on internal and METAR data of DFS. The maximum throughput capacities of the two airports, under a full range of weather conditions, were estimated from empirical data. They vary significantly with weather conditions at both airports, with FRA achieving higher throughput values, largely because of how the third runway there can be utilized. The two airports display different demand-to-capacity relationships. This is due to the fact that FRA is a "coordinated" airport where EU airport scheduling regulations are applied strictly. The result is a "flat" daily demand profile whose peak values do not exceed the capacity of the airport, even in Instrument Meteorological Conditions (IMC). In contrast, no scheduling limits were in effect at EWR in 2007, with peak-period demand often exceeding the capacity of the airport, even in Visual Meteorological Conditions (VMC). Consequently, delays, airline punctuality, and schedule reliability at the two airports were also vastly different, with arrival and departure delays at FRA significantly lower and punctuality higher. Moreover, punctuality and schedule reliability deteriorated sharply at EWR in the afternoon and evening, suggesting over-scheduling. A detailed analysis of gate delays versus taxi-out delays on departure also demonstrated the effect of differences in the way the two airports are operated. In summary, the study highlights the impact of different operational regimes and of demand management policies on the performance of congested airports.

Benefits of Virtual Queuing at Congested Airports Using ASDE-X: A Case Study of JFK Airport – Bhadra et al

ASDE-X, a runway safety system data, may also be used to manage arrival and departure delay at congested airports. This paper demonstrates the potential for delay management by using departure data recorded by the ASDE-X system at JFK Airport before runway reconstruction in 2010 began. The paper lays out concepts, data, metrics, and a framework to estimate benefits from virtual queuing, a departure management system that allows the aircraft to maintain their rolling spots in the queue without physically joining the queue. While virtual queuing is relatively more common in Europe, its use in the US is limited. This analysis demonstrates that there may be significant benefit, even with most conservative assumptions, of using virtual queuing for departure management at congested airports. Environmental benefits of virtual queuing at JFK Airport are significant as well.

Impact of Commercial Airline Network Evolution on the U.S. Air Transportation System – Kotegawa et al

The air traffic forecast method for future schedules used by the United States Federal Aviation Administration (FAA) assumes a static route network operated by airlines; that is, new routes will not be added nor existing ones removed. However, the competitive nature of the airline industry is such that routes are routinely added or dropped between cities depending on passenger demand and airline business choices. This represents a significant gap between the forecasted and likely actual state of the US National Airspace System (NAS) in the long term, thus hampering stakeholders and decision-makers in their consideration of major policy, technology and infrastructure changes. To address this gap, a series of algorithms which forecast restructuring of the US commercial airline network were developed and tested. One restructuring algorithm produces discernible differences in the NAS of 2020 as compared to the FAA's primary forecast. The impact of these network structure differences on NAS-wide delay are assessed via the National Airspace Performance Analysis Capability (NASPAC) simulation. Both average flight delay and total delay is reduced in the modified schedule versus the FAA's original.

New Method for Probabilistic Traffic Demand Predictions for En Route Sectors Based on Uncertain Predictions of Individual Flight Events - Gilbo et al

Federal Aviation Administration (FAA) Air Traffic Flow Management (TFM) decision-making is based primarily on a comparison of deterministic demand and capacity threshold predictions (usually called Monitor/Alert Parameter, or MAP) at various elements of National Airspace System (NAS) such as airports, fixes and sectors to identify potential congestion. The current FAA Traffic Flow Management System (TFMS) and its decision-support tools do not take into account the stochastic nature of the predictions. Sector demand predictions appear to be less accurate and stable than predictions for airports and fixes. The major reason is that, unlike airports and fixes where flights are aggregated in 15-minute intervals, TFMS predicts sector demand by aggregating flights for each minute and using the one-minute peak demand as a measure for sector demand for entire 15-minute interval. This paper presents a novel analytical approach to and techniques for translating characteristics of uncertainty in predicting sector entry times and times in sector for individual flights into characteristics of uncertainty in predicting one-minute sector demand counts. The paper shows that expected one-minute sector demand predictions are determined by a probabilistically weighted average of one-minute sector entry demand predictions for several consecutive one-minute intervals within a sliding time window. The width of the window is determined depending on probability distributions of errors in flights' sector entry time predictions. Expected one-minute sector demands along with standard deviations of demand counts are expressed via probabilistic averaging of series of one-

minute deterministic predictions of number of flights entering a sector. The results of the paper contribute to probabilistic predictions of congestion in airspace. These results can also be used to evaluate the impact of improved accuracy in flight timing predictions on reducing uncertainty in traffic demand predictions, hence leading to better identification of congestion in airspace.

Evaluating Delay Cost Functions with Airline Actions in Airspace Flow Programs – Bloem et al
Air traffic management research and simulation use delay cost functions that attempt to quantify the cost of delay to airlines. Seventeen delay cost functions from previous research are evaluated with airline actions in Airspace Flow Programs. Airline actions from 34 days in the summer of 2006 were used to compute four metrics designed to quantify the consistency of the airline actions with each of the cost functions. Two of these metrics compare the cost of airline actions to the cost of the default first-scheduled-first-served actions. The other two metrics compare the cost of the airline actions to the minimum costs. Two classes of delay cost functions were most consistent with airline actions. One class consists of delay cost functions in which costs increase in discrete steps as delay increases. In the other class, costs are proportional to the length of delay but with larger proportionality constants for flights bound for hub airports.

Safety Monitoring in the Age of Big Data – Pozzi et al
The paper discusses how the increasing availability of large amount of digital data in ATM addresses the need for an approach that combines operational expertise, data analysis skills and information design. Big data pose both opportunities and challenges: by describing the big picture, they can provide fruitful insights into the ATM system that would be otherwise impossible to get, but they may as well remain opaque and merely overwhelming if a proper sense-making process is not put in place. Other industries have been taking advantage of big data for a long time with results that are hardly questionable. ATM is still exploring the methods and tools for the best exploitation of large data sets; the case of ASMT (Automatic Safety Monitoring Tool) well exemplifies the efforts in progress. The results from three previous studies based on ASMT are discussed in order to highlight the gap that exists when trying to transform ASMT-informed analysis into operationally relevant recommendations. A tentative solution proposed in the conclusive section focuses on the role of information design.

Characterization and Analysis of Traffic Alert and Collision Avoidance Resolution Advisories Resulting from 500' and 1,000' Vertical Separation – Olszta et al
Some U.S. and international aviation organizations have expressed a desire to reduce the existing Traffic alert and Collision Avoidance (TCAS) Resolution Advisory (RA) rate, especially in those cases where the alerts are perceived unnecessary, such as where TCAS alerting criteria is incompatible with normal and safe ATC vertical separation. The first step in pursuing this goal is a comprehensive examination of data to quantify and characterize actual TCAS RA experiences and identify: 1) if nuisance RAs exist, and 2) the impact on airspace efficiency and workload. In this study, data on 36,689 TCAS RAs from five terminal areas collected under the Federal Aviation Administration's (FAA) TCAS Operational Performance Assessment (TOPA) program were analyzed to determine the relationship between vertical separation and TCAS RA experiences. The results show that most RAs are likely due to interactions between TCAS aircraft operating under Instrument Flight Rules (IFR) and other aircraft operating under Visual Flight Rules (VFR). Normal, legal, 500' foot vertical separation between IFR and VFR traffic in Visual Meteorological Conditions (VMC) contributed to ~65% of the RAs observed in terminal airspace. Additionally, RA encounters occurring when IFR aircraft intentionally level-off in close horizontal proximity to other aircraft 1,000' above or below contributed to approximately 7% of all the terminal RAs studied. In order to better understand the impact of these RAs on pilot workload and airspace efficiency, this study also examined other facets of TCAS performance including: the types of RAs issued, relevant encounter features such as the vertical geometry, operating rules of the aircraft involved, and locations relative to navigational fixes. These analyses found that TCAS is operating as intended in most cases by providing alerts that enhance situational awareness on the flight deck but should not increase pilot workload or cause disturbances in the National Airspace System (NAS).

Abstracts: Human Factors

Tower Controllers' Assessment of the Spot and Runway Departure Advisor (SARDA) Concept – Hoang et al
Airports are often a capacity-limiting constraint for the rest of the National Airspace System (NAS). A recent effort investigated methods to improve surface operations by supplying optimized scheduling and sequencing advisories for the Ground and Local controllers working at Air Traffic Control Towers. The tool is collectively known as the Spot and Runway Departure Advisor (SARDA). A series of high fidelity human-in-the-loop simulations was conducted to assess scheduling performance and their effects on the human operators. This paper documents the impact of the advisories on controllers' workload, situation awareness (SA), and usability. Fifty-six high fidelity human-in the- loop simulations were conducted using a matrix of traffic level (normal and high) and advisory display formats (data tag and timeline). Results revealed that the high traffic level increased perceived workload for both Ground and Local controllers. Local and Ground controllers also reported a decrease in subjective SA in the high traffic condition. There was no significant effect of traffic level or advisory usage on the objective SA measure, although their interaction was statistically significant. For Ground, objective SA decreased in the high traffic but not during the normal traffic level. Ground controllers showed a preference for using the timeline format by reducing scans for information and aiding with future planning. Feedback also revealed that future work should focus on harmonization between the optimization model and the human planning model, thus providing a transparent planning and execution strategy.

Designing a Flight Deck Predictive Weather Forecast Interface Supporting Trajectory-Based Operations – Wu et al
It is envisioned in NextGen that predictive weather forecasts will be available and assimilated into decision making processes. There however has been limited discussion on how weather avoidance decisions based on predictive forecasts are to be made and executed on the flight deck under Trajectory-Based Operations (TBO). The present study examined three prototype methods by which predictive weather forecasts can be viewed in conjunction with tools to modify flight trajectories. Eighteen transport pilots participated in a part-task experiment where they were asked to modify flight trajectories when necessary using one of the three methods. Subjective evaluations by the pilots showed overall acceptance of the concepts behind all of the methods, with room for improvement in the implementation of each. Performance results showed that different methods were preferable under different weather encounter scenarios. Implications on designing interfaces to support weather decisions in Air Traffic Management (ATM) environments will be discussed.

Controller Support Tools for Schedule-Based Terminal-Area Operations – Kupfer et al
A human-in-the-loop simulation was conducted to evaluate advanced controller support tools and display enhancements in terminal airspace. Terminal-area air traffic controllers managed aircraft arriving on optimized profile descents along Area Navigation/Required Navigation Performance routes following runway arrival schedules using only speed clearances in the presence of forecast wind errors and other disturbances. Three toolsets, designed to reflect tools that could be implemented in notional near-, mid-, and far-term timeframes, as well as three wind forecast errors comprised the experimental conditions. The results demonstrated that arrival schedule timelines (near-term), timelines plus 'slot marker' circles (mid-term), and timelines/slot markers plus speed advisories (far-term) all enabled controllers to manage arrivals according to the runway schedules and maintain safe separation while keeping aircraft on their assigned routes. Participants preferred the mid-term toolset, in which the slot markers provided a spatial target useful for achieving schedule compliance. Speed advisories were the least usable. The paper discusses possible reasons behind this and suggests potential improvements.

The Role of Workload for Work Organisation in a Remote Tower Control Center – Moehlenbrink et al
This paper focuses on the role which workload can play for work organisation in a future remote control tower center. Nowadays you can find a control tower next to each airport. A tower is equipped with a team of controllers which maintain the declared surface movement rate under all weather conditions within the aerodrome visibility operational level (AVOL) while maintaining the required level of safety. Novel concepts for air traffic control (ATC) consider remotely controlling regional airports from a control center that includes working positions for the control of multiple airports. When evaluating such controller working positions, workload is a crucial concept. A thorough analysis of workload in a remote tower domain is used in the paper at hand to draw conclusions for the work design of a remote control center. In a simulator study at the Institute of Flight Guidance of the German Aerospace Center a remote center working environment was realized for controlling two regional airports. In a 3-factor experimental design it was investigated empirically how workload ratings differed when (1) one controller was responsible for two airports; or when two controllers were responsible for two airports with (2) each controller responsible for one airport or rather (3) working in a team responsible for both airports. Workload ratings were gathered online using the Instantaneous Self-Assessment scale and after each simulation run using the NASA-Task Load Index. In addition, expert participants judged specific traffic situations in the single operator condition for two airports in respect to its operational feasibility. The data are analysed and discussed in respect to what can be learned for work organisation and future ATC concepts. This paper, thus, contributes to better understanding the basic conditions a controller needs to meet his obligations as an air traffic controller. Such knowledge is indispensable when developing novel concepts for remote control of regional airports.

Determining the Value of Information for Minimizing Controller Taskload: A Graph-Based Approach – Clarke et al
In the future, air traffic controllers will most likely come to rely on decision-support tools and increased levels of automation to help manage and separate aircraft. Conflict detection and conflict resolution are examples of two key areas where increased automation and improved accuracy are considered imperatives to the future efficiency of airspace systems. The inclusion of decision-support tools for conflict-detection and resolution is expected to reduce controller workload by decreasing the mental stress associated with identifying potential conflicts and maintaining aircraft separation. Despite the benefits of such systems, there has been little study into the best methods to implement conflict-detection and resolution algorithms in practice, and what is the resulting controller taskload. In this paper, we examine how the capabilities and implementation strategy of conflict-detection and resolution tools affect controller taskload. Our goal is to understand how conflict-detection and resolution decision-support tools can best be designed and implemented to support human-based control of aircraft.

Spatial, Temporal, and Grouping Behaviors in Controller Communication Activities - Wang et al
Recent reports on human dynamics have uncovered regular patterns of human communication and other interactive activities that exhibit characteristics of heavy-tailed, power-law distributions instead of ever-belief Poisson-like random distributions. Motivated by these findings, we adopt a similar data-driven approach to investigate controller's communication activities. On three different datasets, we examined the intercommunication events to characterize temporal behavior of controller communications. The results showed that controller communications also exhibit a heavy-tailed feature with power-law exponent lying between 2~3. When using a network dynamics approach to characterize spatial behavior of controller communications, we found out that the degree of the node (or the number of neighbor flights in the communication process) can be used to quantify the grouping behavior in structure-based abstraction for mitigating cognitive complexity. We finally identified a general Poisson distribution that transforms to a power-law distribution when increasing the strength of link connectivity. Also, the analysis of fluctuation scaling phenomena showed that the relationship between the average number of communications and its standard deviation could be well described with a Taylor's series. These exciting results confirm the hypothesis that traditional metrics of controller workload could be replaced by quantifiable measures of controller availability against airspace or sector activities, which is crucial to complex systems modeling approach for ATM.

Issues for Near-Term Implementation of Trajectory Based Operations - Lacher et al
A primary feature of the NextGen is trajectory based operations (TBO). Under TBO aircraft flight plans are known to computer systems on the ground which aid in scheduling and separation. FANS is presently the primary flight deck system in the US supporting TBO, but relatively few aircraft are FANS-equipped. Thus any near-term implementation must provide TBO procedures for non-FANS aircraft. Previous research has looked at controller clearances, but any implementation must also provide procedures for aircraft requests. The research presented here aims to surface issues surrounding TBO communication procedures for non-FANS aircraft and for aircraft requesting deviations around weather. Procedures were developed to stringently follow TBO principles, in particular minimizing the discrepancy between flight plans stored in a ground based system and the flight plans actually flown. Three types of communication were explored: Voice, FANS, and ACARS. The latter is a digital communication system widely used in the United States for communication between aircraft and their Airline Operation Centers (AOC); it differs primarily from FANS in that FANS allows the uplinked flight plans to be automatically loaded into the FMS, while ACARS delivers the flight plans in a text format that must then be entered manually into the FMS via the CDU. These procedures were used in a medium fidelity simulation. Sixteen pilots (eight two-person flight decks) and four retired controllers participated in 20-minute scenarios that required the flight decks to navigate through convective weather as they approached their top of descents (TODs). In this context, the rate of non-conformance across all conditions was higher than anticipated, with aircraft off path in excess of 20% of the time. Controllers did not differentiate between the ACARS and FANS datacom, and were mixed in

their preference for Voice vs datacom (ACARS and FANS). Pilots uniformly preferred Voice to FANS, liking ACARS least.

Using Data Communications to Manage Tailored Arrivals in the Terminal Domain: A Feasibility Study – Chong et al
The Tailored Arrivals (TAs) concept proposes routes that are generated by automation on a per-flight basis and communicated to the aircraft via Data Communications (Data Comm). A human factors concern with this concept is whether approach controllers would be able to maintain "the picture" in an operational environment with many types of arrival operations. Another concern is how the presence of Data Comm might affect controller performance in such an environment. To address these concerns, we performed a human in the loop (HITL) simulation study that examined the effect of Operational Condition, Data Comm Equipage Level, and Traffic Load on controller performance metrics that fall into three broad classes: traffic management strategies and decisions, efficiency of service, and safety. We also collected the opinions of Subject Matter Experts (SMEs) regarding the operational feasibility of using Data Comm to manage Tailored Arrivals.

Abstracts: Separation

A Standard for Equivalent Lateral Spacing Operations - Parallel and Reduced Divergence Departures – Mayer et al
For the better part of half a century, a single 15-degree divergence requirement of the radar separation standard applies when conducting independent parallel departure operations. The origins and analytic basis of the 15-degree requirement are shrouded in history. Recent implementations of Area Navigation (RNAV) Standard Instrument Departure (SID) procedures that result in improved navigational precision and the need for more efficient operations in increasingly constrained airspace give cause to re-evaluate the divergence standard. In this paper, the current standard is reviewed, a divergence concept is presented that capitalizes on advantageous runway layout geometries as well as observed RNAV navigational precision, and an analysis of operational data is described that serves as an analytic basis for an advanced divergence concept. Depending upon runway layout geometry, the concept enables reduced divergence angles of 5 to 10 degrees in the majority of cases. Finally, the concept is applied to a RNAV departure procedure design recently proposed for The Hartsfield-Jackson Atlanta International Airport. The discussion is concerned with a key characteristic of the proposed concept: reducing divergence angles while maintaining the lateral spacing between departure paths in a manner that is defined to be equivalent to the spacing observed in diverging departure operations that meet minimum requirements of the current standard. With this characteristic, the proposed Equivalent Lateral Spacing Operation (ELSO) concept is well-suited to support the near- and mid-term development, further testing, and implementation of performance-based air traffic spacing applications that enable Next Generation Air Transportation System (NextGen) operational improvements and benefits.

Automated Air Traffic Control Operations with Weather and Time-Constraints - Prevot et al
In this paper we discuss results from a recent high fidelity simulation of air traffic control operations with automated separation assurance in the presence of weather and time-constraints. We report findings from a human-in-the-loop study conducted in the Airspace Operations Laboratory (AOL) at the NASA Ames Research Center. During four afternoons in early 2010, fifteen active and recently retired air traffic controllers and supervisors controlled high levels of traffic in a highly automated environment during three-hour long scenarios. For each scenario, twelve air traffic controllers operated eight sector positions in two air traffic control areas and were supervised by three front line managers. Controllers worked one-hour shifts, were relieved by other controllers, took a 30-minute break, and worked another one-hour shift. On average, twice today's traffic density was simulated with more than 2200 aircraft per traffic scenario. The scenarios were designed to create peaks and valleys in traffic density, growing and decaying convective weather areas, and expose controllers to heavy and light metering conditions. This design enabled an initial look at a broad spectrum of workload, challenge, boredom, and fatigue in an otherwise uncharted territory of future operations. In this paper we report human/system integration aspects, safety and efficiency results as well as airspace throughput, workload, and operational acceptability. We conclude that, with further refinements, air traffic control operations with ground-based automated separation assurance can be an effective and acceptable means to routinely provide very high traffic throughput in the en route airspace.

The Influence of Uncertainties on Traffic Control using Speed Adjustments - Granger et al
The RTA (Required Time Arrival) capabilities of aircraft FMS (Flight Management Systems) offer new opportunities to solve mid-term horizon conflicts (20 minutes in advance) with small speed adjustments. The ERASMUS project has shown promising results of up to 80% conflict resolution using small speed adjustments in the [????6%; +3%] range with 20 minutes advance notice. The hypotheses were based on very accurate trajectory predictions (TPs). In this article we show how the quality of these results decreases as the uncertainties on the trajectory prediction increase. Therefore we used the CATS (Complete Air Traffic Simulator) developed in the late 90s at CENA (Centre d'Etudes de la Navigation A´erienne) and constrained the solver to use only speed maneuvers for leveled or descending aircraft with different hypotheses on speed ranges and speed uncertainties. Results show that Traffic Control using Speed Adjustments (TCSA) can solve most of the conflicts even when we consider uncertainty on the TP. However, the number of maneuvers that need to be given to aircraft is highly influenced by the uncertainties used in the TP.

Relative Significance of Trajectory Prediction Errors on an Automated Separation Assurance Algorithm – Lauderdale et al
Trajectory prediction is fundamental to automated separation assurance. Every missed alert, false alert and loss of separation can be traced to one or more errors in trajectory prediction. These errors are a product of many different sources including wind prediction errors, inferred pilot intent errors, surveillance errors, navigation errors and aircraft weight estimation errors. This study analyzes the impact of six different types of errors on the performance of an automated separation assurance system composed of a geometric conflict detection algorithm and the Advanced Airspace Concept Autoresolver resolution algorithm. Results show that, of the error sources considered in this study, top-of-descent errors were the leading contributor to missed alerts and failed resolution maneuvers. Descent-speed errors were another significant contributor, as were cruise-speed errors in certain situations. The results further suggest that increasing horizontal detection and resolution standards are not effective strategies for mitigating these types of error sources.

Establishing a Risk-Based Separation Standard for Unmanned Aircraft Self Separation – Weibel et al
Unmanned Aircraft Systems require an ability to sense and avoid other air traffic to gain access to civil airspace and meet requirements in civil aviation regulations. One sense and avoid function is self separation, which requires that aircraft remain "well clear." An approach is proposed in this paper to treat well clear as a separation standard, thus posing it as a relative state between aircraft where the risk of collision first reaches an unacceptable level. By this approach, an analytically-derived boundary for well clear can be derived that supports rigorous safety assessment. A preliminary boundary is proposed in both time and distance for the well clear separation standard, and recommendations for future work are made.

A New Approach for Designing Safer Collision Avoidance Systems - Kochenderfer et al
The Traffic Alert and Collision Avoidance System (TCAS) has been shown to significantly reduce the risk of mid-air collision and is currently mandated worldwide on all large transport aircraft. Engineering the collision avoidance logic was a very costly undertaking that spanned several decades. The development followed an iterative process where the logic was specified using pseudocode, evaluated on encounters in simulation, and revised based on performance against a set of metrics. Modifying the logic to get the desired behavior is difficult because the pseudocode contains many heuristic rules that interact with each other in complex ways. Over the years, the TCAS logic has become challenging to maintain. With the anticipated introduction of next-generation air traffic control procedures and surveillance systems, the logic will require significant revision to prevent unnecessary alerts. Recent work has explored a new approach for designing collision avoidance systems that has the potential to shorten the development cycle, improve maintainability, and enhance safety with fewer false alerts. The approach involves leveraging recent advances in computation to automatically derive optimized collision avoidance logic directly from encounter models and performance metrics. This paper outlines the general approach and discusses the anticipated impact on development, safety, and operation.

The Wake Vortex Prediction and Monitoring System WSVBS - Holzäpfel et al
Design and performance of the Wake Vortex Prediction and Monitoring System WSVBS are described. The WSVBS has been developed to tactically increase airport capacity for approach and landing on single runways as well as closely-spaced parallel runways. It is thought to dynamically adjust aircraft separations dependent on weather conditions and the resulting wake vortex behaviour without compromising safety. Dedicated meteorological instrumentation and short-term numerical terminal weather prediction provide the input to the prediction of wake-vortex behaviour and respective safety areas. LIDAR monitors the correctness of WSVBS predictions in the most critical gates at low altitude. The WSVBS is integrated in the arrival manager AMAN of DLR. Within 66 days of performance test at Frankfurt airport it was found that the system ran stable and the predicted minimum separation times were correct. The capacity improving concepts of operation could have been used in 75% of the time. From fast-time simulations the eventual capacity gain for Frankfurt was estimated to be 3% taking into account the real traffic mix and operational constraints in the period of one month. Aircraft separations for landings on single runways have been compared employing the concepts of either heavy - medium weight class combinations or dynamic pairwise separations where individual aircraft type pairings are considered. The consideration of individual aircraft types and their respective wake characteristics may almost double the fraction of time when radar separation could be applied.

Abstract: Deployment

Arrival Flow Control by Local Cherry Picking – Schaad et al
In the past arrival regulations have been used at Vienna airport almost on a daily basis to resolve short term congestion. With the aim to reduce arrival delays and improve management of traffic flows, Austro Control and Eurocontrol's Central Flow Management Unit (CFMU) have performed a trial in close cooperation with two airlines home-based in Vienna. The trial was supported by a number of Flow Management Positions (FMP) in the region and took place between the 4th and 30th October, 2010. The trial implied the application of a newly developed Air Traffic Flow and Capacity Management (ATFCM) technique called "local cherry picking" to manage short period congestion (in arrival peaks of up to 40 min). Instead of applying an arrival regulation systematically, Vienna FMP and CFMU tried to spread the traffic in a Collaborative Decision Making (CDM) manner through direct contacts with FMPs, Tower (TWR) units and flight operations departments of the airlines concerned. The trial was highly successful as delay was reduced considerably compared to the normal flow management process and overall workload was not increased for the participants (specifically the air traffic controllers). The successful conclusions drawn from the trial have led Austro Control to implement the concept as a normal operating procedure for Vienna starting January 17, 2011. The Vienna trial has demonstrated that the method of "local cherry picking" may be used to reduce arrival delays and resolve short term congestion at other European airports that have similar structural problems.

Abstracts: Airports

Performance Evaluation of a Surface Traffic Management Tool for Dallas/Fort Worth International Airport – Jung et al
This paper presents detailed results from a high-fidelity human-in-the-loop evaluation of an airport surface decision support tool. The Spot And Runway Departure Advisor is designed to aid controllers in managing aircraft surface operations and is based on two optimization algorithms: the Spot Release Planner and the Runway Scheduler. The Spot Release Planner provides sequence and timing advisories to the Ground controller for releasing departure aircraft into the aircraft movement area to reduce taxi delay while achieving maximum throughput. The Runway Scheduler provides take-off and arrival runway crossing sequences to the Local controller to maximize runway usage. Performance metrics from the simulation include delay, number of aircraft stops, fuel consumption, and aircraft engine emissions. The results were not consistent among the different traffic scenarios. Results from high traffic scenarios show the average departure delay and number of aircraft stops in the movement area were reduced by 64 and 68 percent, respectively. Fuel consumption and engine emissions were reduced by as much as 38 percent. There was a slight reduction in taxi time of arrival aircraft even if the emphasis of the tool was on departure traffic. However, for normal traffic scenarios there was little change in any of performance metrics mainly due to low traffic volume.

Flight deck surface trajectory-based operations (STBO): Simulation results and ConOps implications - Foyle et al
The results of four piloted medium-fidelity simulations investigating flight deck surface trajectory-based operations (STBO) will be reviewed. In these flight deck STBO simulations, commercial transport pilots were given taxi clearances with time and/or speed components and required to taxi to the departing runway or an intermediate traffic intersection. Under a variety of concept of operations (ConOps) and flight deck information conditions, pilots' ability to taxi in compliance with the required time of arrival (RTA) at the designated airport location was measured. ConOps and flight deck information conditions explored included: Availability of taxi clearance speed and elapsed time information; Intermediate RTAs at intermediate time constraint points (e.g., intersection traffic flow points); STBO taxi clearances via ATC voice speed commands or datalink; and, Availability of flight deck display algorithms to reduce STBO RTA error. The results of these simulations show that when pilots are provided with STBO speed-only taxi clearances by ATC, pilots either have poor RTA compliance with acceptable workload and safety estimates, or have good RTA compliance with unacceptable workload and safety estimates. The presence of a flight deck error-nulling algorithm display allows pilots to comply accurately with STBO taxi RTA clearances while maintaining safety under acceptable workload. The need for flight deck capabilities (integrated avionics or an electronic flight bag, EFB, at a minimum) to conduct effective STBO taxi clearance operations and implications for the development of surface traffic management (STM) systems are discussed.

System Oriented Runway Management: A Research Update - Lohr et al
The runway configuration used by an airport has significant implications with respect to its capacity and ability to effectively manage surface and airborne traffic. Aircraft operators rely on runway configuration information, as it can significantly affect an airline's operations. Current practices in runway management are limited by a relatively short time horizon for reliable weather information and little assistance from automation. Wind velocity is the primary consideration when selecting a runway configuration, however when winds are below a defined threshold, discretion may be used to determine the configuration. Other considerations relevant to runway configuration selection include airport operator constraints, weather conditions (other than winds) traffic demand, user preferences, surface congestion, and navigational system outages. The future offers an increasingly complex landscape for the runway management process. Concepts and technologies that hold the potential for capacity and efficiency increases for both operations on the airport surface and in terminal and enroute airspace are currently under investigation. Complementary advances in runway management are required if capacity and efficiency increases in those areas are to be realized. The System Oriented Runway Management (SORM) concept has been developed to address this critical part of the traffic flow process. The SORM concept was developed to address all aspects of runway management for airports of varying sizes and which accommodates a myriad of traffic mixes. SORM, to date addresses the single airport environment; however, the longer term vision is to incorporate capabilities for multiple airport (Metroplex) operations as well as accommodating advances in capabilities resulting from ongoing research.

Collaborative Departure Queue Management: An Example of Airport Collaborative Decision Making in the United States - Brinton et al
The management of airport surface operations to provide shared situational awareness and to control taxi times through the use of 'virtual queues' has become an important component of Air Traffic Management (ATM) research and development in both Europe and the United States. Airport Collaborative Decision Making (CDM) has been implemented at a number of airports in Europe, and multiple departure metering concepts have now been tested in the US National Airspace System (NAS). This paper provides a review and comparison of the different airport surface departure management concepts, and describes one such concept in detail that has been evaluated operationally in the field in the US, the Collaborative Departure Queue Management (CDQM) concept. CDQM has been developed and evaluated by the Federal Aviation Administration (FAA) under the Surface Trajectory Based Operations (STBO) project. This paper provides a description of the operational field evaluation of CDQM that was conducted in Memphis, Tennessee, during 2009 and 2010. An analysis of the effectiveness, accuracy and benefit of CDQM in managing departure operations during the field evaluation is presented. CDQM was found to provide reduced taxi times, and resultant reduced fuel usage and emissions, while maintaining full use of departure capacity. Additional operational findings regarding the use of CDQM by the Air Traffic Control Tower (ATCT) and by the flight operators are also included.

Concept and prototype of a ground handling vehicle management system - Loth
As airports are being identified as the bottleneck of the future ATM system, optimized airport processes have a significant influence on the overall ATM system. Comprehensive research in the field of the surface movement and scheduling of aircraft has led to technology and support systems that are in place at various airports worldwide. In contrast the coordination and optimization of service vehicles on the aprons were investigated only insignificantly. Within two projects at the Airport Research Facility Hamburg a concept for managing the process of the luggage transport to and from the aircraft was developed. The concept is based on experiences from A-SMGCS research and implements a complete data link process as a replacement of the actual voice solution. Furthermore a first prototype of a support system was developed, implemented and technically tested at Hamburg Airport. Live connection to operational systems like A-SMGCS and airport database enabled the use of real data and first shadow mode trials.

Managing Passenger Handling at Airport Terminal - Schultz et al
An efficient handling of passengers is essential for reliable terminal processes. Since the entire progress of terminal handling depends on the individual behavior of the passengers, a valid and calibrated agent-based model allows for a detailed evaluation of handling and for identifying system optimization capabilities. Our model is based on a stochastic approach for passenger movements including the capability of individual tactical decision making and route choice, and moreover, on a stochastic approach of the handling processes. Each component of the model was calibrated with a comprehensive, scientifically reliable empirical data set; a virtual terminal environment was developed and real airport conditions were evaluated. Our detailed stochastic modeling approach points out the need for a significant change of the common flow-oriented design methods to illuminate the still undiscovered terminal black box.

Abstracts: Safety

Systematic Validation of a Mathematical Model of ACAS Operations for Safety Assessment Purposes - Netjasov et al
Current international regulations and policies do not consider the effect of airborne safety nets in the analysis of safety risks. This widely accepted practice tends to create significant tension between the realization of the ambitious safety improvement targets of SESAR and NextGEN, and standing regulations. In order to close this gap, there is a need for systematic development of safety risk analyses of airborne safety nets within an Air Traffic Management context. The aim of the research described in this paper is to address the systematic validation of an unambiguous mathematical model of Airborne Collision Avoidance System (ACAS) operations, together with its interactions with own and other pilots and with air traffic controllers. The specific modelling formalism used for this is Stochastically and Dynamically Coloured Petri Nets (SDCPN); which supports both mathematical analysis as well as Monte Carlo simulation. In order to build confidence, the focus of this paper is on the performance of a systematic validation of the developed model. This validation includes both comparisons against ”real data” and comparison with the results of Eurocontrol’s ACAS simulation model. Initial application of this validation process to the novel model shows that it is at least as good as the existing ACAS simulation model. However, the added value is that the novel model defines both an unambiguous mathematical model as well as an unambiguous simulation model.

Model-based Safety Requirements Engineering for complex ATM Systems - Meyer et al
Today’s system design development and certification of air navigation systems becomes more complex due to the contribution of many stakeholders to the development process. With increasing complexity, assuring safety operation within ATM domain by determining safety requirements is harder to achieve and higher process integrity of all stakeholders is demanded. The proposed methodology and implementation into software shall support the mandatory safety assessment for certification issues by assuring a safe operation according to a certain target level of safety. The methodology augments the Eurocontrol safety assessment methodology by using model-based approach, logic networks and linear algebra. Beside safety requirements, general system requirements can change during development phases and have to comply with numerous constraints and with economic criteria. The presented tool enables the user to evaluate the safety requirements by given criteria in short evaluation cycles to assure cost-optimized safety requirements for the system design. A cost function is presented that quantifies the achieved safety while also considering the economy of the chosen safety requirements. The methodology is finally applied to a safety assessment for the design of innovative virtual control tower ATC applications, which is performed with German ANSP Deutsche Flugsicherung. We could significantly improve the apportionment method for determining safety requirements.

Contrasting Safety Assessments of a Runway Incursion Scenario by Event Sequence Analysis versus Multi-Agent Dynamic Risk Modelling - Stroeve et al
Recently we compared safety analyses for a runway incursion scenario based on an event sequence analysis, as a key exponent of a traditional risk assessment technique, versus one based on an agent-based dynamic risk model (DRM), as an exponent of new techniques based on system complexity and variability-based accident models. We found that lower accident risk levels were assessed in the event sequence analysis and we compared various factors contributing to these differences. As the reasons of these differences were not completely understood, this paper sets forth additional analyses towards a better understanding of the relations between conflict recognition and resolution events that may occur in the runway incursion scenario and their relation to accident risk. To this end, such events were recorded in additional Monte Carlo simulations of the DRM and a broader set of conditions was considered with agents being in or out of monitoring/control loops. The results show that the accident risk can be very elastic for changes in the operation. The level of this risk elasticity is not manifest from the performance of individual human operators and technical systems, nor from the sole relations between human operators and/or technical systems, but only from the totality of the performance and interactions of all human operators and technical systems in the operational context considered. Implications for real-time simulations, expert judgment and feedback to design are discussed.

Abstracts: Network

Combining Flight Level Allocation with Ground Holding to Optimize 4D-Deconfliction - Barnier et al
As acknowledged by the SESAR program, 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. Building on a preliminary ground holding algorithm aimed at directly solving all conflicts (instead of satisfying sector capacity constraints), a prior flight level allocation program is used to reduce the complexity of the traffic input, dramatically improving the quality of the solutions. We present Constraint Programming (CP) models of these large scale combinatorial optimization problems and the encouraging results obtained with the FaCiLe constraint library. However, our approach does not yet address uncertainties and we plan to overcome this issue by improving the robustness of our conflict model and iteratively solving the problem over a sliding time window.

A Multi-stakeholder Evaluation of Strategic Slot Allocation Schemes under Airline Frequency Competition – Vaze et al
In addition to the increasing passenger demand, airline frequency competition is another reason for the growing demand for airport resources. By providing more flight frequency, an airline attracts more passengers. As a result, demand for flight operations often exceeds capacity at congested airports, resulting in delays and disruptions. At some congested airports, the limited airport capacity is allocated between different airlines using administrative slot controls. At a slot controlled airport, (a) the total number of allocated slots, and (b) the distribution of slots across different airlines, together determine the effectiveness of any slot control strategy. We propose a game-theoretic model of airline frequency competition under administrative slot controls. The model is based on the popular S-shaped relationship between market share and frequency share of an airline. The model is solved for a Nash equilibrium and the model predictions are validated against actual frequency data, with the results indicating a good fit. We describe two different schemes for distributing the available slots among different airlines. We evaluate the impact of varying the total number of allocated slots on the airlines and the passengers. The results from a case-study at the New York LaGuardia (LGA) airport suggest that a small reduction in the total number of allocated slots translates into a substantial reduction in flight and passenger delays, and a considerable improvement in airlines’ profits.

Collaborative Approaches to the Application of Enroute Traffic Flow Management Optimization Models - Ball et al
Recent research has produced stochastic optimization models for adjusting traffic flows in response to predicted congestion in the enroute airspace. These models simultaneously consider a set of options for each flight that includes both the possibility of ground delay and reroutes. They take into account a distribution of possible weather scenarios and their outputs include alternate courses of action based on weather outcomes. The direct application of such models has been challenging because they do not provide the decision making flexibility to flight operators that has now become standard for collaborative air traffic management. In this paper we propose two different recipes for incorporating collaborative features into a meta-framework for the application of one such model. This paradigm for the combined use of optimization and collaboration is specifically geared for use within airspace flow programs, which are now in widespread use within the U.S. We provide computational results that demonstrate the effectiveness of this approach.

Abstracts: Airspace Management

Benefits and Feasibility of the Flexible Airspace Management Concept: A Human-in-the-loop Evaluation of Roles, Procedures, and Tools - Lee et al
A human-in-the-loop simulation was conducted to assess potential user and system benefits of the Flexible Airspace Management (FAM) concept, as well as designing role definitions, procedures, and tools to support the FAM operations in the mid-term en route environment. The study evaluated the benefits and feasibility of flexible airspace reconfiguration in response to traffic overload caused by weather deviations versus a baseline condition with no airspace reconfiguration. The test airspace consisted of either four sectors in one Area of Specialization or seven sectors across two Areas. The test airspace was assumed to be at or above FL340 and required all aircraft to be fully equipped with data communications, automated transfer-of-communication, and advanced conflict detection and resolution capabilities on the controller stations. Overall, results showed that FAM operations with multiple Traffic Management Coordinators, Area Supervisors, and radar controllers worked remarkably well. The results showed both user and system benefits, including decreased flight distance, fewer reroutes, and increased airspace utilization. Also, the roles, procedures, airspace designs, and tools were well received by the participants. Airspace configuration options that resulted from a combination of algorithm-generated airspace configurations with manual modifications were well accepted during the airspace reconfiguration process. The results suggest a positive impact of the FAM operations in an en route environment with low traffic complexities and when aircraft are fully equipped with data communications. Further investigation needs to evaluate whether the benefits and feasibility of FAM extend to other environments such as those with mixed equipage and/or higher traffic complexities.

Method to Analyse Air Traffic Situation Based on Air Traffic Complexity Map - Yifei et al
The matching rate between traffic flow and capacity has been the key metric for evaluation on air traffic situation for long. When facing the more flexible traffic flow planned by NextGen and SESAR, the traditional capacity assessment methods based on controller workload have shown its big limitation. On the contrary, the complexity assessment methods with a microscopic characteristic have begun to prove its advantage. The re-definition of air traffic complexity and traffic complexity parameter are given through the deep discussion of its connotations and characters. Based on the idea of traffic flow turbulence analysis, the sector-aircraft model is established and the mapping analyses method to air traffic complexity is designed, followed with a further analysis on time revolution of complexity map. Results show that the method can accurately describe the microscopic behavior of multi-aircraft, visually display the sector traffic situation, and provide effective strategy to controllers in a more complex airspace and a more flexible flight condition.

Airspace Phase Transitions and the Traffic Physics of Interacting 4D Trajectories – Sawhill et al
This paper presents early progress in the development of a modeling and simulation capability derived from advancements in complexity science coupled with advancements in computational platforms for the simulation and analysis of emergent phenomena in the airspace. We present a research effort to test concepts of collective dynamics of large numbers of heterogeneous aircraft (thousands to tens of thousands) in the NAS undergoing continuous 4D trajectory replanning in the presence of noise and uncertainty while optimizing performance measures and deconflicting trajectories. We use a combination of modified genetic algorithms and pseudopotential methods acting on extended objects (trajectories) rather than on aircraft themselves to implement this capability. This is a natural way to preserve intent while deconflicting aircraft. Subjects under investigation include measures of fullness of the airspace, emergent structures arising from interacting trajectory optimization, tradeoffs between centralized and distributed optimization, and phase transitions in collective behavior ("traffic physics"). Our work is concentrated in the enroute airspace, but can in principle be extended to the terminal airspace. We describe the combined software and hardware platform we have built to realize a rapid-prototyping environment capable of investigating these questions at a realistic level of fidelity and in much greater than real time speed. Our simulation platform is built on the principle of minimum assumption and maximum emergence. There are no sectors, no flight level constraints, and control actions can be arbitrarily subtle and continuous in all four dimensions. Constraints up to and including the current NAS configuration can be "switched on" for comparison purposes. With this software simulation system, we can address implications for centralized versus decentralized control in a real-world system and explore alternative TBO concepts of operation, including applications such as game theory for economic considerations, bulk management of airspace phase state for capacity considerations, and well as policy and technology strategy evaluations.

Abstracts: Surveillance and Navigation

Towards Defining Required Interval Management Performance - Levitt et al
Interval Management (IM) is an airborne spacing concept that provides precise inter-aircraft spacing relative to another aircraft. The IM concept is currently being developed by the FAA and in Europe under SESAR through standards and local implementation plans. The IM system is comprised of a ground-based component (GIM) and a flight-deck-based component (FIM). The FIM component involves the use of avionics, called the FIM equipment, which provides speeds to the IM aircraft that will achieve

and/or maintain a desired spacing interval relative to a target aircraft. IM operations are expected to provide benefit in a variety of environments with a wide-range of operational objectives, where the performance characteristics of the FIM equipment needed for each IM operation may vary. This paper presents the concept of Required Interval Management Performance (RIMP) to be used in the design, management, and certification of IM operations. RIMP is a categorization scheme, comprised of four required components-the longitudinal spacing precision, the accuracy of the IM and target aircraft state data, the performance of the speed control algorithm in the environment, and unique functional capabilities. The combination of these components uniquely identifies the performance required for a given IM operation. Initial analysis and standards development has shown that a few discrete performance levels for each of these components is possible and may sufficiently span the performance needed to support both near-term and longer-term IM operations. The analytical methodology used to determine the RIMP category for an IM operation developed thus far is presented, and further development is proposed. The analysis developed to date is applied to two example IM operations, and direction for future work is provided. Coordination within the user community to further develop and analyze the RIMP concept, in the context of a robust set of IM operations, is the next step.

Flight Deck-Based Interval Management-Spacing During Departures: Flight Crew Human-In-The-Loop Simulation - Penhallegon et al

An Automatic Dependent Surveillance-Broadcast (ADS-B) concept termed Interval Management-Spacing (IM-S) was evaluated in a human-in-the-loop (HITL) simulation. IM-S is a set of capabilities and procedures supported by ground and Flight deck (FIM) components for controllers and flight crews to use in combination to manage inter-aircraft spacing. Air traffic control (ATC) issues an IM Clearance and flight crews manage spacing through speed adjustments generated by onboard FIM equipment until reaching a planned termination point. Past research on IM-S operational applications applied the concept to the arrival and approach phases of flight using a precise spacing goal. The purpose of this study was to determine if IM-S could support the departure phase of flight when departing aircraft are merging with other aircraft into an en route stream. The environment selected was above 10,000 feet to an en route cruise altitude. Scenarios consisted of a baseline (i.e., no FIM-S), nominal FIM-S, and off-nominal FIM-S. Sixteen airline pilots with advanced Boeing cockpit experience participated, and two pilots participated per day and acted as a flight crew. The results of the study generally suggest that FIM-S during departure is a manageable and suitable operation for pilots. Pilots reported their workload, situation awareness, and head-down time as acceptable. Procedures and phraseology were also generally acceptable, although there was some confusion with the appropriate speed to fly after termination. Results also indicate that the necessary display features were available to the flight crews. Pilots reported overall trust in the spacing algorithm, which accurately delivered the assigned spacing goal, when given sufficient time to do so with the implemented algorithm. The findings from this study provide an initial framework for the application of FIM-S during departure operations. A FIM-S departure operation may be feasible and manageable from a flight deck perspective with promise of crew acceptability and compatibility with current operations. However, in addition to specifically evaluating the benefits of this operation, areas such as the appropriate engagement altitude (or conditions beyond that studied in this simulation), termination procedures, information display, and algorithm design require additional research.

Airline Based En Route Sequencing and Spacing Field Test Results: Observations and Lessons Learned for Extended Metering - Moertl

Airline Based En Route Sequencing and Spacing (ABESS) is a concept of operations that allows airlines to precondition flights during their en route phase of flight for spacing prior to entry into the terminal domain. This preconditioning process is intended to prepare flights for advanced descent procedures including Optimized Profile Descents (OPDs) and Flight-deck based Interval Management (IM). This paper describes the ABESS concept and a series of four field-tests with the United Parcel Service (UPS) Airline Operations Center (AOC) where an ABESS software prototype had been fielded and tested between 2006 and 2010 during regular UPS operations. The results of the field tests indicate improvements over the four year test period, and demonstrated flight trajectory predictions of up to 100 minutes (min) that allowed the detection of up to 90 percent of spacing conflicts and lead to additional work areas to make long distance spacing preparations operationally feasible for airlines. This paper discusses the contributors to, and limits of stability for long-term trajectory predictions in the context of the flight tests. These findings are expected to be useful for the Next Generation Air Transportation System (NextGen) and Single European Sky ATM Research (SESAR) projects that require longer-term predictions of flight trajectories and fix crossing times during the en route phase of flight.

Abstracts: Weather

Three Models for Weather Impacted Airspace Capacity Estimation and Forecast – Klein et al

Following NASA's request to develop and test airspace capacity estimation models of different fidelity (for use in the agency's air traffic simulation toolsets), we have developed three different models - simple, mid-level, and complex - and have evaluated them on airspace units of different size, from large (Centers), to medium (Areas-of-Specialization) to small (Sectors). The simple model computes capacity degradation of an airspace unit as the area of convective weather coverage within its boundary divided by the unit's total area. The mid-level Scanning model utilizes our multi-directional scanning algorithm developed in the course of prior research. The most complex model, Probe Reroutes, extends the directional scanning idea by "flying" groups of aircraft on parallel tracks through weather-impacted airspace, rerouting them if needed and finding the viable number of safe-passage "air lanes"; airspace capacity estimate is derived from that. A range of convective weather-impacted days were studied and model capacity estimates were compared to actual occupancy counts in airspace units. Initial validation results are encouraging and they also demonstrate the trade-off between model complexity and accuracy. It appears that capacity estimates become more accurate as we "zoom in" from Centers to Sectors; and the accuracy improves somewhat (but not dramatically) when a finer weather grid resolution is used. Reasonably good airspace capacity predictions can also be made if a forecast product is used as input instead of convective weather diagnostic.

Analytical Workload Model for Estimating En Route Sector Capacity in Convective Weather – Cho et al

We have extended an analytical workload model for estimating en route sector capacity to include the impact of convective weather. We use historical weather avoidance data to characterize weather blockage, which affects the sector workload in three ways: (1) Increase in the conflict resolution task rate via reduction in available airspace, (2) increase in the recurring task load

through the rerouting of aircraft around weather, and (3) increase in the inter-sector coordination rate via reduction in the mean sector transit time. Application of the extended model to observed and forecast data shows promise for future use in network flow models.

Probabilistic 2-Day Forecast of Runway Use - Hesselink et al
In this paper, we present a method to predict runway use at airports for the period of one hour to two days in the future. Based on actual, nowcast, and forecast meteo data, probabilistic runway use can be an aid to air traffic controllers in choosing runway combinations for a period of time as long as possible. A stable runway system is necessary; first as runway changes are costly operations, moreover, ATC developments in Collaborative Decision Making (CDM) and Continuous Descent Operations (CDO) require an efficient traffic flow and predictable runway allocation for aircraft in order to create lasting plans. The proposed system has been evaluated at Amsterdam Airport Schiphol, with its complex noise preferential runway system, and unstable weather conditions, where we demonstrate a quality of 60 to 70% in predicting runway use on a meteo and traffic sample for the year 2009. The work has been performed by the National Aerospace Laboratory NLR in cooperation with the Royal Netherlands Meteorological Institute (KNMI). The system we propose will assist air traffic controllers to anticipate upcoming weather changes and will enable more lasting runway use. Other benefits from our system are that airlines will be given the opportunity to look further ahead, based on the runways that will be in use for the following 3 to 10 hours, to improve operational planning. Inhabitants of the local communities around the airport will get insight into the traffic that will fly over their houses. Being informed is the first step in understanding and will reduce the number of noise complaints.

Generating Probabilistic Capacity Profiles from weather forecast: A design-of-experiment approach – Buxi et al
It is common understanding that weather plays an important role in determining the capacity of an airport. Severe weather causes capacity reductions, creating a capacity demand imbalance, leading to delays. The role of air traffic flow management (ATFM) measures is to reduce these delay costs by aligning the demand with the capacity. Ground delay program (GDP) is one such measure. Though the GDP is initiated in poor weather conditions, and weather forecasts are subject to errors, present GDP planning procedures are essentially deterministic in nature. Forecast weather is translated into deterministic capacity predictions on which GDP planning is based. Models which employ probabilistic capacity profiles for planning GDPs have been developed, but their application has been limited by the inability to create such profiles from weather forecasts. This paper develops probabilistic profiles for three airports, BOS, LAX and SFO using the Terminal Aerodrome Forecast and San Francisco Marine Initiative. The profiles are inputs to a static stochastic GDP model to simulate ATFM strategies. A design of experiments approach has been employed to determine optimal profiles which minimize the total average costs. The average cost of the methodologies is evaluated against realized capacities to determine the benefit of the forecast. It is also shown that inclusion of weather forecasts reduces the cost of delays. It is shown for SFO that on average TAF offers similar benefit in controlling cost of delay when compared to STRATUS. Careful use of the TAF indicates that other airports would also benefit from using TAF in planning of operations.

Abstracts: Air-Ground Integration

Integrated Pilot and Controllers Procedures: Aircraft Pairing for Simultaneous Approaches to Closely Spaced Parallel Runways - Verma et al
Parallel runway operations have been found to increase capacity within the National Airspace but poor visibility conditions reduce the use of these operations [1]. Previous research examined the concepts and procedures related to parallel runways; however, there has been no investigation of the procedures associated with the strategic and tactical pairing of aircraft for these operations. This study developed and examined the pilot and controller procedures and information requirements for creating aircraft pairs for parallel runway operations. The goal was to achieve aircraft pairing with a temporal separation of 15s (+/- 10s error) at a "coupling" point that was about 12 nmi from the runway threshold. Two variables were explored for the pilot participants: two levels of flight deck automation (current-day flight deck automation and auto speed control future automation) as well as two flight deck displays that assisted in pilot conformance monitoring. The controllers were also provided with automation to help create and maintain aircraft pairs. Results show the operations in this study were acceptable and safe. Subjective workload, when using the pairing procedures and tools, was generally low for both controllers and pilots, and situation awareness was typically moderate to high. Pilot workload was influenced by display type and automation condition.

Evaluation of an Autonomous Taxi Solution for Airport Operations during Low Visibility Conditions - Hakkeling-Mesland et al
The growth in air transport creates the need for weather independent airport operations. Currently, Low Visibility Conditions have a strong negative effect on the airport capacity. One of the reasons is the reduced capacity of Air Traffic Control. Due to the limited outside view of Ground Controllers from the control tower, additional workload is generated, which limits the number of taxiing aircraft a controller can control. Transferring some of the tasks of the controller to the flight crew is therefore seen as a potential means to increase capacity. Enhanced taxi display systems in the cockpit may enable this. In the ultimate case, the flight crew can operate independent of Air Traffic Control; hence autonomous taxiing. This paper discusses the potential of autonomous taxiing with a focus on taxi separation. An experiment was conducted with different taxi display systems and Alert Levels to evaluate the concept with respect to safety, efficiency and acceptability. The results indicate that improved taxi displays increase the safety by providing more Situational Awareness and may enable taxiing without Air Traffic Control support. A considerable number of inefficient situations occurred though, mainly due to the uncertainty about intentions of other aircraft. Furthermore navigation errors occurred that may be prevented by route deviation alerting. Both indicate areas for improvement.

Controller and Pilot Evaluation of a Datalink-Enabled Trajectory-Based Operations Concept - Mueller et al
Results are presented for a pilot- and controller-in-the-loop evaluation of a 2016 timeframe datalink-enabled Trajectory- Based Operations concept with mixed voice and datalink operations. Eleven recently retired Fort Worth Center controllers and twelve current commercial pilots evaluated the concept over 28 hours of simulation time, providing quantitative metrics on controller workload and trajectory efficiency benefits and qualitative feedback on the feasibility of the concept. Eight experimental conditions were tested: four fleet-wide datalink equipage levels ranging from 0% (voice only) to 80%, along with two levels of traffic density.

Feedback on the feasibility of the concept was positive from both pilots and controllers, though off-nominal conditions were not tested. The key objective finding of the evaluation was that controllers issued significantly more timesaving flight plan amendments under the datalink conditions than under the voice-only conditions, amounting to between five and twelve minutes of flying time savings per hour in the six-sector area tested. Statistically significant decreases in controller workload were also measured with increasing datalink equipage level, but this decrease was far smaller than the variation in workload across sectors and traffic density levels. The frequency with which aircraft requests for lateral trajectory changes were approved did not change with datalink equipage level for voice requests, but did increase for datalink requests; however, under all conditions, voice requests were significantly more likely to be approved than datalink requests.

Controller Aids for Integrating Negotiated Continuous Descent Approaches into Conventional Landing Traffic - Uebbing-Rumke et al

This paper deals with the challenges that appear if Continuous Descent Approaches (CDA) with landing times negotiated in an air ground protocol have to be integrated into approaching traffic on heavily loaded airports using standard arrival profiles like Low Drag Low Power. The controller is not able to guide those flights and standard approaches simultaneously in an efficient and safe way because of unpredictable flight levels and speeds of CDAs over the timely progress of the landing procedure. Therefore controllers will need assistance by a ground system that is calculating suitable landing sequences and landing times. The support system will have to take into account data about the CDA flights it has got by the negotiation process and the results of its own trajectory prediction engine. This engine calculates possible profiles for the standard approaches. These profiles can be translated to timely precise controller commands to be displayed on a controller human-machine interface (HMI). As result of intensive human-in-the-loop investigations during the DLR project Future Air Ground Integration (FAGI) further controller aids were developed to support controllers to implement time-based arrival management by having the possibility to use their distance based procedures.

Discovering Delay Patterns in Arrival Traffic with Dynamic Continuous Descent Approaches using Co-Evolutionary Red Teaming - Alam et al

The gradual introduction of advanced ATM procedures such as Continuous Descent Approaches (CDA) creates a challenge when balancing the capacity-demand of arrival traffic in the presence of constrained ground (runway, taxiway, gate) resources. Part of the challenge is to understand the interdependency between spatial-temporal distribution of arrival traffic (traffic distribution) and the dynamics of ground resources to better manage, sustain and improve the airport throughput capacity and to minimize delays. In this paper, we use the Computational Red Teaming (CRT) Framework to identify patterns in arrival traffic and ground events that lead to delays in dynamic CDA scenarios. The scenarios represent the interaction of ground events with traffic distributions. The search engine in CRT relies on co-evolutionary search, with the reciprocal interaction of traffic distributions and ground events evolving to identify bottlenecks in the system. With each interaction a variety of metrics are recorded which are then data mined to identify patterns that lead to delays. Results identified scenarios whereby delays become seriously significant. For example, for a model of the Sydney domestic terminal area in a dynamic CDA scenario, flights arriving from the South- East direction with an average inter-arrival time of 53 sec can cause significant delays if runway 16L is impacted by a ground event. Another example identified taxiway C as a critical ground resource for arrival throughput capacity.

Abstracts: Finance

Financial Incentives for NextGen Avionics: ADS-B Case Study – Post et al

A policy framework for evaluating avionics financial assistance proposals is presented. This framework, based on traditional public policy theory, can be used to determine whether or not financial incentives are justified, and if so, how much assistance should be provided. The framework is applied to a case study involving Automatic Dependent Surveillance – Broadcast (ADS-B) surveillance for Gulf of Mexico high-altitude airspace.

Integrating best-equipped best-served principles in ground delay programs – Churchill et al

Future air traffic management systems will consist not only of enhanced ground equipment, but also upgrades and new systems on board aircraft. To this end, an important tenet of future systems will be rewarding properly equipped aircraft. One method for doing so is through explicit prioritization of flights operated by equipped aircraft in traffic management initiatives. In this paper, the principle of Best Equipped, Best Served is examined as to its potential role in incentivizing equipage and enhancing the efficiency of Ground Delay Programs. To this end, several important policy questions pertaining to the direction of these benefits are examined. Then, three alternate allocation methods are described, incorporating aircraft equipage level as a criteria superseding scheduled arrival time. Then, a case study examining Newark Liberty International Airport, a critical and delay-prone node in the airspace system of the United States, is described. Several equipage scenarios are described, with particular attention paid to both the magnitude and distribution of the benefits realized from integrating Best Equipped, Best Served principles into Ground Delay Programs.

Abstracts: Trajectory and Queue Management

En-Route Optimal Flight Planning Constrained to Pass Through Waypoints using MINLP - Soler et al

In this paper we study the en-route strategic flight planning of a commercial aircraft constrained to pass through a set of waypoints whose sequence is not predefined. This problem has been solved as an hybrid optimal control problem in which, given the dynamic model of the aircraft, the initial and final states, the path constraints constituting the envelope of flight, and a set of waypoints in the European air space, one has to find the control inputs, the switching times, the optimal sequence of waypoints and the corresponding trajectory of the aircraft that minimize the direct operating cost during the flight. The complete layout of waypoints in the European airspace is reduced and waypoints are gathered into a small number of clusters. The aircraft is constrained to pass through one waypoint inside every cluster of waypoints. The presence of multi point constraints makes the optimal control problem particularly difficult to solve. The hybrid optimal control problem is converted into a mixed integer non-

linear programming problem first making the unknown switching times part of the state, then introducing binary variable to enforce the constraint of passing through one waypoint inside every cluster, and finally applying a direct collocation method. The resulting mixed integer non linear programming problem has been solved using a branch and bound algorithm. The cases studied and the numerical results show the effectiveness, efficiency and applicability of this method for enroute strategic flight plans definition.

ATC Taskload Inherent to the Geometry of Stochastic 4-D Trajectory Flows with Flight Technical Errors – Popescu et al
A method to quantify the probabilistic controller taskload inherent to maintaining aircraft adherence to 4-D trajectories within flow corridors is presented. An Ornstein-Uhlenbeck model of the aircraft motion and a Poisson model of the flow scheduling are introduced along with reasonable numerical values of the model parameters. Analytic expressions are derived for the taskload probability density functions for basic functional elements of the flow structure. Monte Carlo simulations are performed for these basic functional elements and the controller taskload probabilities are exhibited.

Dynamically Generating Operationally-Acceptable Route Alternatives Using Simulating Annealing – Taylor et al
This paper presents a Simulated Annealing methodology for defining operationally-acceptable route alternatives for flights impacted by weather. By dynamically generating route alternatives that inherently possess traits amenable to traffic managers and users, more efficient use of the airspace can be realized. This paper explores the use of Simulated Annealing to provide quality solutions quickly, and to capture additional route alternative options, such as ground delay. For comparison, a k-shortest path approach and an ad-hoc heuristic search approach have also been employed to generate reroutes and the results show that Simulated Annealing indeed provides competitive alternatives to the k-shortest path approach and improved alternatives over the heuristic search procedure. Furthermore, Simulated Annealing can potentially generate these alternatives with less computation effort than the k-shortest path approach and therefore, represents a desirable alternate flight option generation method.

Design and Evaluation of the Terminal Area Precision Scheduling and Spacing System Trajectory and Queue Management - Swenson et al
This paper describes the design, development and results from a high fidelity human-in-the-loop simulation of an integrated set of trajectory-based automation tools providing precision scheduling, sequencing and controller merging and spacing functions. These integrated functions are combined into a system called the Terminal Area Precision Scheduling and Spacing (TAPSS) system. It is a strategic and tactical planning tool that provides Traffic Management Coordinators, En Route and Terminal Radar Approach Control air traffic controllers the ability to efficiently optimize the arrival capacity of a demand-impacted airport while simultaneously enabling fuel-efficient descent procedures. The TAPSS system consists of four-dimensional trajectory prediction, arrival runway balancing, aircraft separation constraint-based scheduling, traffic flow visualization and trajectory-based advisories to assist controllers in efficient metering, sequencing and spacing. The TAPSS system was evaluated and compared to today's ATC operation through extensive series of human-in-the loop simulations for arrival flows into the Los Angeles International Airport. The test conditions included the variation of aircraft demand from a baseline of today's capacity constrained periods through 5%, 10% and 20% increases. Performance data were collected for engineering and human factor analysis and compared with similar operations both with and without the TAPSS system. The engineering data indicate operations with the TAPSS show up to a 10% increase in airport throughput during capacity constrained periods while maintaining fuel-efficient aircraft descent profiles from cruise to landing.

Trade-offs and Issues in Traffic Synchronization - Gwiggner et al
In traffic synchronization, aircraft will receive traffic windows along their trajectories, such that the resulting traffic flows are guaranteed to be smooth and efficient. While the concept is currently being investigated worldwide, its feasibility is still unclear. In this paper we formulate traffic synchronization as a queueing problem and summarize intuitive results based on analytical and simulation studies. These include insight into the delay propagation in arrival flows, trade-offs between ground and en-route delays, and limitations of speed control due to airspace constraints. All in all, the study clarifies the elementary delay generating mechanisms and opens the door to more transparent decision making in tactical air traffic management.

Controlled Time-Of-Arrival Spacing Analysis – Klooster et al
Controlled Time of Arrival and Required Time of Arrival are two key concepts in the United States' NextGen and Europe's SESAR programs, supporting initial Trajectory Based Operations. One concern with using airborne Time of Arrival Control has been the potential spacing loss between aircraft when maneuvering to meet a time constraint. Within the scope of EUROCAE Working Group 85, EUROCONTROL and GE have performed simulations examining the likelihood of achieving a time constraint at a metering fix in descent, as well as the probability that a spacing infringement would occur while maneuvering to meet that time constraint. A large number of conditions were used, giving over 30,000 aircraft pairs in the comparison. For a target spacing at the metering fix of 90 seconds, approximately 82% of aircraft can meet their assigned RTA, and 5% of those cases would encounter some loss of separation if no active control were exerted to ensure separation. Heavy aircraft following Medium aircraft have the highest probability of a separation infringement, and increasing the target spacing at the metering fix to 120 seconds for those aircraft pairs decreases the probability of an infringement by over 50%. A trend-based alerting criterion using the rate of change of longitudinal and vertical separation over a 3 minute look-ahead was also simulated, to represent the more realistic case when the controller would undertake action well before separation is lost.

A Human-in-the-Loop Evaluation of Flow-Based Trajectory Management in Mixed Equipage Airspace - Smith et al
The feasibility and benefits of a concept for flow-based trajectory management was tested in a mixed equipage en route environment. Aircraft were designated equipped or unequipped based on the presence or absence of a data communications (Data Comm) capability for receiving auto-loadable clearances and transfer of communication messages from the air navigation service provider. Feasibility issues addressed in this simulation included: (1) whether these operations were feasible for unequipped aircraft, and (2) whether they worked in a mixed equipage context. Two categories of benefits were also explored: (1) system performance improvements (throughput, workload) at different equipage levels, and (2) how well flow-based trajectory management could support a "best-equipped, best-served" policy of air traffic management. FAA facility personnel staffed six traffic management, supervisor and radar controller positions for four high altitude sectors and the surrounding airspace within a simulated facility in the central United States. Eight test scenarios presented variations of a combined convective weather and traffic load problem with either 10%, 50% or 90% equipped aircraft. Traffic management coordinators used decision support tools to identify and assess the situation, and to manage it by modifying the trajectories of one or several aircraft. Solutions were

coordinated as needed with the area supervisors. Trajectory clearance requests were then sent to the controllers for review and delivery to the aircraft. Results found trajectory clearance coordination for unequipped aircraft to be feasible and useful in a variety of contexts. Flow management operations were also effective, with traffic management coordinators achieving a good balance between demand (traffic load) and capacity (controller workload) at all three equipage levels. These operations also proved an effective means for providing priority service to the Data Comm equipped aircraft, supporting the proposed NextGen "best-equipped, best-served" policy of air traffic management.

Abstracts: Environment

Potential Adaptation to Impacts of Climate Change on Air Traffic Management - Burbidge et al

The need for all sectors of society to adapt to climate change is now gaining prominence in the scientific and political arena, for the financial and insurance institutions, and for many industries. Aviation has historically focussed on reducing its carbon dioxide emissions, placing less emphasis on adapting to the effects of climate change itself. However, with increasing certainty that climate change-related impacts will occur, and given aviation's sensitivity to climate and weather, the need to take pre-emptive action becomes more pressing. New research commissioned by EUROCONTROL, the European Organisation for the Safety of Air Navigation, identifies three areas where climate change impacts may have adaptation issues for air traffic management (ATM): shifts in passenger demand due to changes in local temperature, loss of airport capacity through sea-level rise, and impacts to en-route operations due to increases in extreme weather events storminess). This paper considers how each issue may affect ATM and whether current ATM planning and research can adequately meet any new challenges which may need to be faced. The paper concludes that although some impacts will not be experienced in the short-term, it would be prudent to begin to consider adaptation in current medium to long-term planning.

Design of Aircraft Trajectories based on Trade-offs between Emission Sources – Sridhar et al

Aviation operations affect the climate in several ways. Carbon dioxide, water vapor and other greenhouse gasses are unavoidable by-product of the combustion of fossil fuel. There are indications that persistent contrails can lead to adverse climate change, although the complete effect on climate forcing is still uncertain. A flight trajectory optimization algorithm with fuel and contrails models, which develops alternative flight paths, provides policy makers the necessary data to make trade-offs between persistent contrails mitigation and aircraft fuel consumption. This study develops an algorithm that calculates wind-optimal trajectories for cruising aircraft while reducing the amount of time spent in regions of airspace prone to persistent contrails formation. The optimal trajectories are developed by solving a non-linear optimal control problem with path constraints. The regions of airspace favorable to persistent contrails formation are modeled as penalty areas that aircraft should avoid. The trade-off between persistent contrails formation and additional fuel consumption is investigated for 12 city-pairs in the continental United States. The avoidance of contrails using only horizontal maneuvers results in a small reduction of contrails with increasing fuel consumption. When both horizontal maneuvers and altitude are optimized, a 2% increase in total fuel consumption can reduce the total travel times through contrail regions by more than 70%. Allowing further increase in fuel consumption does not seem to result in proportionate reduction in contrail travel times. This trend is maintained even in the presence of uncertainties in the contrail formation regions such as uncertainties in relative humidity values computed by weather forecast models.

Evaluation of Continuous Descent Approach as a Standard Terminal Airspace Operation – Cao et al

This paper presents a simulation-based evaluation of Continuous Descent Approach (CDA) which is used as a standard terminal airspace operation at New York Metroplex airports. Initial simulations reveal that granting the freedom to arriving flights to plan the user-preferred continuous descent trajectories incurs conflicts. A scheduling method is proposed to strategically solve the conflict based on the 4-D trajectory concept. Initially, arriving flights plan their times of arrival and preferred descent trajectories without considering mutual interferences. Estimations of such 4-D trajectories are used to sequence the arrival flows. A Mixed Integer Linear Program is established to produce a conflict-free CDA while minimizing the total delay under separation constraints. Four scenarios, namely unconstrained step-down, constrained step-down, unconstrained CDA and constrained CDA, are simulated and statistically analyzed. The overarching goal of the research is to examine the feasibility of CDAs at the national level, in particular to provide a better estimate of the benefits and trade-off of the conflict-free CDAs.

Prediction of Top of Descent Location for Idle-thrust Descents – Stell et al

To enable arriving aircraft to fly optimized descents computed by the flight management system (FMS) in congested airspace, ground automation must accurately predict descent trajectories. Development and assessment of the trajectory predictor and the concept of operations requires models of the prediction error due to various error sources. Polynomial approximations of the along-track distance of the top of descent (TOD) from the meter fix are given in terms of the inputs to the equations of motion. Polynomials with three different levels of complexity are presented, with the simplest being linear. These approximations were obtained by analyzing output from one predictor. While this predictor's thrust and drag models do not seem to agree well with those used by the FMS, both laboratory and operational data using commercial FMSs support the conclusion that, for given models of thrust and drag, the TOD location is roughly a linear combination of cruise altitude, descent CAS, aircraft weight, wind, and altitude and speed at the meter fix. The laboratory data include 14 descents each in a Boeing 737-700 simulator and a Boeing 777-200 simulator, using a test matrix that varied aircraft weight and descent speed. The operational data include approximately 70 descents each in commercial Boeing 757 and Airbus 319/320 aircraft.

Enhanced Descent Wind Forecast for Aircraft – Bronsvoort et al

In order to perform an efficient and predictable Continuous Descent Arrival (CDA), it is critical to accurately determine the geometric descent path that can be flown with idle thrust for the selected Cost Index. To build the geometric descent path, the aircraft's Flight Management System (FMS) needs to be aware of the forecast winds during the descent. Inaccuracies in these forecast winds can lead to a geometric path that cannot be flown as an idle-thrust CDA; (manual) energy management is required to maintain the path at the cost of loss in efficiency (fuel burn). Secondly, inaccurate forecast winds impact on predictability as they reduce the accuracy of trajectory predictions made by the FMS. This inaccuracy is caused by both the error in the forecast wind, and the deviations from the target descent speed as result of maintaining the inaccurately built geometric path at idle thrust (either too steep or too shallow). Design constraints of current FMSs restrict the number of flight levels at which forecast data can

be entered. This limits the definition of the wind profile for the complete descent path. Airservices Australia has developed a tool that tailors the wind forecast for a specific arrival using an improved resolution forecast provided by the Australian Bureau of Meteorology. Flight trial results indicate that the tailored descent forecasts can provide the FMS with a better representation of the wind profile on descent leading to improved predictability. However, no benefits to aircraft operating efficiency were observed. The research found consistent large deviations from the target speed while performing a path managed descent (10kts slow on average); these deviations could however not be correlated to the error in the forecast. As non-idle thrust settings were often required because of these large deviations, it is believed any efficiency benefits of the tailored descent forecasts are obscured. The large deviations from the target performance revealed in this research have major consequences for trajectory prediction initiatives which assume the aircraft will hold the target speed.

High-Fidelity Weather Data Makes a Difference Calculating Environmental Consequences with FAA's Aviation Environmental Design Tool - Yaworski et al

High-fidelity atmospheric weather conditions used in FAA's Aviation Environmental Design Tool (AEDT) directly affect aircraft speed, location and engine thrust during flight, which drives the fuel burn, emissions, and noise consequences. Current environmental models use static, geographically invariant atmospheric data. Modifying current modeling methods to be capable of using varying weather inputs, and also implementing methods for obtaining and utilizing high fidelity weather has the potential to make the outputs of environmental models much more realistic. Such improvements can directly enhance the utility of simulation-based air traffic planning and management tools, whether driven by measured aircraft position data or by standard flight procedures. This paper presents an examination of using a high-fidelity weather data to model aircraft performance for the purpose of quantifying environmental consequences in FAA's Aviation Environmental Design Tool.

Fuel Consumption and Operational Performance – Ryerson et al

Reducing fuel consumption is a major goal for the aviation community due to environmental concern and fuel price uncertainty. The Federal Aviation Administration (FAA) is currently developing and implementing Air Traffic Management (ATM) technologies to ensure reliable operational performance that is robust to delays caused by congestion and weather. These technologies will reduce planned and unexpected airborne delays; as such they will reduce the airline practice of schedule padding, or contingency planning for excess fuel and time consumption on a give route, as well as airborne and departure delay. In this study, we seek to quantify the fuel consumption impact of these technologies on the three operational performance measures: schedule padding, airborne delay, and departure delay. We do so by modeling airline fuel consumption using econometric techniques to isolate the contribution of operational performance. We use fuel consumption reported by a major US-based airline to capture revealed, and not simulated, airspace inefficiencies. For two aircraft types we find that a minute spent in airborne delay burns 50-60 lbs of fuel, compared with 4.5-12 lbs for a minute of schedule padding and 2.3-4.6 lbs for a minute of departure delay. We find additionally that fixed fuel consumed due to congested and complicated airport terminal areas is can be up to 16% greater. When considering specific origin-destination pairs, we find the elimination of the three delay metrics due to technology could reduce airborne fuel consumption up to 10% percent per operation.

Green Delay Programs - Prats et al

Delaying aircraft on ground is one of the most used strategies when an imbalance between planned demand and actual capacity arises, either at an airport or in an airspace sector. This paper focuses on a new strategy consisting in delaying aircraft from their nominal cruise speed to the minimum fuel consumption speed. Therefore, trip times are increased and air traffic management delay can be partially performed in the air. For these flights, fuel consumption is reduced and consequently, their environmental impact. Based on data from ground delay programs at San Francisco International airport during 2006, this paper quantifies the impact that such a strategy would have had if applied to all delayed flights. Results show that for the majority of flights, the 5% to 15% of the initially assigned delay could have been absorbed in the air, leading to fuel savings in the order of 4% to 7% for each individual flight, if compared with the nominal situation.

Demonstration of Reduced Airport Congestion through Pushback Rate Control - Simaiakis et al

Airport surface congestion results in significant increases in taxi times, fuel burn and emissions at major airports. This paper presents the field tests of a control strategy to airport congestion control at Boston Logan International Airport. The approach determines a suggested rate to meter pushbacks from the gate, in order to prevent the airport surface from entering congested states and reduce the time that flights spend with engines on while taxiing to the runway. The field trials demonstrated that significant benefits were achievable through such a strategy: during eight four-hour tests conducted during August and September 2010, fuel use was reduced by an estimated 12,000-15,000 kg (3,900-4,900 US gallons), while aircraft gate pushback times were increased by an average of only 4.3 minutes.

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