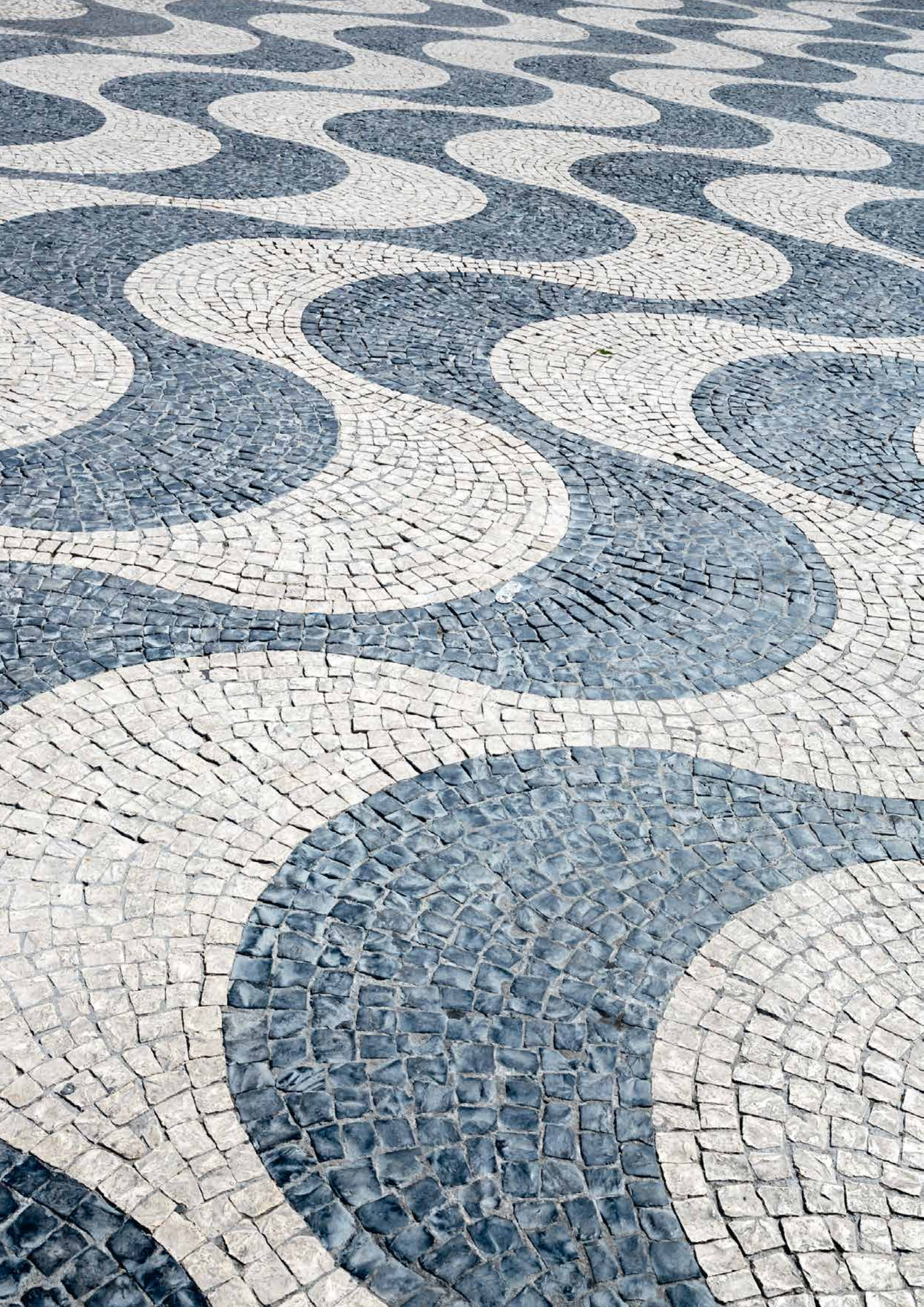
11th USA/EUROPE
Air Traffic Management R&D Seminar

23 - 26 June 2015

Lisbon, Portugal

Contents



Seminar at-a-glance

Monday 22 June 2015

18:30 **Early Registration, welcome cocktail - *Main hotel river deck***

Tuesday 23 June 2015

07:00 **Registration - *Conference centre entrance foyer***

Plenary opening session - *Astaire*

08:00 **Welcome to Lisbon: Luís Coimbra (President, NAV Portugal)**

08:15 **Welcome to ATM2015, introduction, programme & logistics: seminar co-chairs**

08:30 **Keynote US: John-Paul Clarke (Georgia Institute of Technology) - The three M's of ATM**

09:15 **Keynote Europe: Bernard Miaillier (Eurocontrol) - 30 years of ATM strategies and concepts**

10:00 **Coffee - *Conference centre 1st floor***

	Track 1: Astaire	Track 2: Fellini	Track 3: Rodin
	SAFETY *Session Chair: Jacco Hoekstra*	**ENVIRONMENT** *Session Chair: Midori Tanino*	**SURVEILLANCE AND NAVIGATION** *Session Chair: Peter Hecker*
10:30	425 De Visscher, Winckelmans et al	433 Yamashita, Grewe et al	376 Dautermann & Geister
11:15	414 Chang	481 Jensen, Tran & Hansman	411 Pelchen-Medwed et al
12:00	366 Stroeve, van Doorn et al	355 Sridhar, Chen et al	424 Groskreutz & Dominguez

12:45 **Lunch - *Leonidas main hotel mezzanine***

	SAFETY *Session Chair: Sandy Lozito*	**ENVIRONMENT** *Session Chair: Mark Hansen*	**ATM PERFORMANCE** *Session Chair: Dirk Schaefer*
14:00	525 Mehadhebi	501 McConnachie, Bonnefoy & Belle	370 Bronsvoort, Zisserman et al
14:45	522 Fleming & Leveson	395 Fricke, Seiß & Herrmann	400 McEnteggert & Whidborne

15:30 **Coffee - *Conference centre 1st floor***

	SAFETY *Session Chair: Sandy Lozito*	**ENVIRONMENT** *Session Chair: Hartmut Fricke*	**ATM PERFORMANCE** *Session Chair: Anthony Smoker*
16:00	441 Luchkova, Vujasinovic et al	418 Belle, McConnachie & Bonnefoy	460 Calvo, Cordero et al
16:45	473 Mahboubi & Kochenderfer	532 Hao, Kang et al	479 Dray, Marzouli et al

Wednesday 24 June 2015

05:30 **5K 'fun' run - *start point boardwalk 500m north of hotel***

	Track 1: Astaire	Track 2: Fellini	Track 3: Rodin
	NETWORK AND STRATEGIC FLOW *Session Chair: Jose Miguel de Pablo*	**AIRPORT/AIRSIDE OPERATIONS** *Session Chair: Dirk Kuegler*	**SEPARATION** *Session Chair: Eric Neiderman*
07:45	539 Irvine	509 Avery & Balakrishnan	470 Parke, Chevally et al
08:30	512 Jones, Lovell & Ball	538 Vela, Reynolds & Sanderg	472 Lehouillier, Omer et al
09:15	384 Mondoloni, Liu & Kirk	466 van Baren, Chalon-Morgan et al	408 Durand & Barnier
10:00	386 Taylor, Masek et al	535 Lee, Smith, Homola et al	537 Alam, Hossain et al

10:45 **Coffee - *Conference centre 1st floor***

	NETWORK AND STRATEGIC FLOW *Session Chair: Mike Ball*	**AIRPORT/AIRSIDE OPERATIONS** *Session Chair: Midori Tanino*	**WEATHER** *Session Chair: Craig Wanke*
11:15	454 Lau, Berling et al	403 Hayashi, Hoang et al	385 McNally, Sheth et al
12:00	457 Rebollo & Brinton	374 Gerdes & Schaper	391 Sheth, McNally et al
12:45	428 Belkoura & Zanin	398 Bosson, Xue & Zelinski	471 Reynolds, McPartland et al

13:30 **Light lunch - *Leonidas main hotel mezzanine or deck***

Thursday 25 June 2015

	Track 1: Astaire	Track 2: Fellini	Track 3: Rodin
	UAS *Session Chair: Michael Standar*	**HUMAN FACTORS** *Session Chair: Billy Josefsson*	**TRAJECTORY AND QUEUE MGT.** *Session Chair: Guglielmo Lulli*
08:00	388 Johnson, Mueller & Santiago	359 Ohneiser, Temme & Rataj	401 Robinson, Thipphavong et al
08:45	427 Londner	453 Wang, Cong et al	415 Zelinski & Jung
09:30	356 Upchurch, Muñoz et al	420 Ijtsma, Hoekstra et al	390 Jung, Verma, Zelinski et al
10:15	**Coffee - *Conference centre 1st floor***		
	UAS *Session Chair: Parimal Kopardekar*	**HUMAN FACTORS** *Session Chair: Billy Josefsson*	**TRAJECTORY AND QUEUE MGT.** *Session Chair: Guglielmo Lulli*
10:45	387 Santiago & Mueller	363 Helmke, Rataj et al	407 Alligier, Gianazza & Durand
11:30	498 Sunil, Hoekstra et al	429 Chen & Kopald	369 Bronsvoort, McDonald et al
12:15	**Lunch - *Leonidas main hotel mezzanine***		
	FINANCE AND POLICY *Session Chair: Joe Post*	**COMPLEXITY** *Session Chair: Miguel Angel Piera*	**TRAJECTORY AND QUEUE MGT.** *Session Chair: Eric Hoffman*
13:30	487 Delgado	440 Bongiorno, Micciche et al	373 De Smedt, Bronsvoort et al
14:15	536 Jovanović, Babić & Tošić	358 Wang, Wen & Zhao	516 Tielrooij, Borst et al
15:00	**Coffee - *Conference centre 1st floor***		
	FINANCE AND POLICY *Session Chair: Joe Post*	**COMPLEXITY** *Session Chair: Dres Zellweger*	**TRAJECTORY AND QUEUE MGT.** *Session Chair: Eric Hoffman*
15:30	357 Adler, Hanany & Proost	477 Ciruelos, Arranz et al	434 Miyazawa, Matsuda et al
16:15	436 Proost, Glazer & Blondiau	511 Cook, Tanner et al	483 Ruiz & Soler
19:30	**Seminar dinner**		

Friday 26 June 2015

Plenary opening session - *Astaire*

08:30 **Special session: RPAS research, moderated by James L. Grimsley, University of Oklahoma**

Special guest speakers from USA and Europe

Panel and discussion

10:30 **Coffee - *Conference centre 1st floor***

11:00 **Perspectives from SESAR and NextGen:**

Michael Standar, Chief Strategy and External Affairs, SJU

Ed Bolton, Assistant Administrator for NextGen, FAA

12:00 **Best Paper awards & closing – Colin Meckiff & Eric Neiderman**

12:45 **Lunch - *Leonidas main hotel mezzanine***

13:00 **Committee meeting (working lunch) - *Quartz room 1st floor conference centre***

Full programme

Monday 22 June - Welcome Cocktail

18:30 **Early registration and welcome cocktail**
Main hotel river deck

Tuesday 23 June - Opening Session

08:00 **Welcome to Lisbon**
Luís Coimbra *President, NAV Portugal*

08:15 **Welcome to ATM2015, introduction, programme and logistics**
Colin Meckiff *(Eurocontrol) &* ***Eric Neiderman*** *(FAA), ATM2015 co-chairs*

08:30 **Opening keynote: The three M's of ATM**
John-Paul Clarke *(Georgia Institute of Technology)*

09:15 **Opening keynote: 30 years of ATM strategies and concepts**
Bernard Miaillier *(Eurocontrol)*

10:00 **Coffee - *Conference centre, 1st floor***

Tuesday 23 June - Track 1: Safety - *Room: Astaire*

Session Chair: *Jacco Hoekstra (TU Delft)*

Time	Paper	Title	Authors (presenter in ***bold***)
10:30	425	A Simple Wake Vortex Encounter Severity Metric	***Ivan De Visscher*** *& Grégoire Winckelmans (WaPT),* ***Vincent Treve*** *(EUROCONTROL)*
11:15	414	Risk Analysis Process Tool for Surface Loss of Separation Events	***Eric B. Chang*** *(MITRE)*
12:00	366	A risk-based framework for assessment of runway incursion events	***Sybert Stroeve****, Bas van Doorn & Bert Bakker (NLR), Pradip Som (FAA)*

12:45 **Lunch - *Leonidas main hotel mezzanine***

Session Chair: *Sandy Lozito (NASA Ames)*

Time	Paper	Title	Authors (presenter in ***bold***)
14:00	525	Identification of critical scenarios of risk: An operational approach	***Karim Mehadhebi*** *(DSNA)*
14:45	522	Including Safety during Early Development Phases of Future Air Traffic Management Concepts	***Cody H. Fleming*** *& Nancy G. Leveson (MIT)*

15:30 **Coffee - *Conference centre, 1st floor***

Session Chair: *Sandy Lozito (NASA Ames)*

Time	Paper	Title	Authors (presenter in ***bold***)
16:00	441	Analysis of Impacts an Eruption of Volcano Stromboli could have on European Air Traffic	***Tanja Luchkova,*** *Ruzica Vujasinovic, Alexander Lau & Michael Schultz (DLR)*
16:45	473	Autonomous Air Traffic Control for Non-Towered Airports	***Zouhair Mahboubi*** *& Mykel J. Kochenderfer (Stanford University)*

Tuesday 23 June - Track 2: Environment - *Room: Fellini*

Session Chair: *Midori Tanino (FAA)*

Time	Paper	Title	Authors (presenter in ***bold***)
10:30	433	Towards Climate Optimized Flight Trajectories in a Climate Model: AirTraf	***Hiroshi Yamashita**, Volker Grewe, Patrick Jöckel, Florian Linke & Martin Schaefer (DLR), Daisuke Sasaki (Kanazawa Institute of Technology)*
11:15	481	Cruise Fuel Reduction Potential from Altitude and Speed Optimization in Global Airline Operations	***Luke L. Jensen**, Henry Tran & R. John Hansman (MIT)*
12:00	355	Strategic Planning of Efficient Oceanic Flights	***Banavar Sridhar** & Neil Y. Chen (NASA Ames), Hok K. Ng (UC Santa Cruz), Olga Rodionova & Daniel Delahaye (ENAC), Florian Linke (DLR)*

12:45 **Lunch - *Leonidas main hotel mezzanine***

Session Chair: *Mark Hansen (UC Berkeley)*

Time	Paper	Title	Authors (presenter in ***bold***)
14:00	501	Investigating Benefits from Continuous Climb Operating Concepts in the National Airspace System	***Dominic McConnachie**, Philippe Bonnefoy & Akshay Belle (Booz Allen Hamilton)*
14:45	395	Fuel and Energy Benchmark Analysis of Continuous Descent Operations	***Hartmut Fricke** (TU Dresden), Christian Seiß & Robert Herrmann (GfL)*

15:30 **Coffee - *Conference centre, 1st floor***

Session Chair: *Hartmut Fricke (TU Dresden)*

Time	Paper	Title	Authors (presenter in ***bold***)
16:00	418	A Methodology for Environmental and Energy Assessment of Operational Improvements	***Akshay Belle,** Dominic McConnachie & Philippe Bonnefoy (Booz Allen Hamilton)*
16:45	532	Fuel Burn Impacts of Taxi-out Delay and their Implications for Gate-hold Benefits	*Lu Hao, Lei Kang & Mark Hansen (UC Berkeley), **Megan S. Ryerson** (University of Pennsylvania)*

Tuesday 23 June - Track 3: Surveillance and navigation - *Room: Rodin*

Session Chair: *Peter Hecker (TU Braunschweig)*

Time	Paper	Title	Authors (presenter in ***bold***)
10:30	376	Combining Advanced-RNP with SBAS Guided Precision Terminal Area Paths and Final Approach Guidance	***Thomas Dautermann*** *& Robert Geister (DLR)*
11:15	411	Validation of the use of GBAS precision approaches for improved runway throughput in poor weather conditions	***Renée Pelchen-Medwed, Lendina Smaja*** *& Anna Wennerberg (EUROCONTROL)*
12:00	424	Required Surveillance Performance for reduced minimal-pair arrival separations	***Alan R. Groskreutz*** *(CRIDA) & Pablo Muñoz Dominguez (Technical University of Madrid)*

12:45 **Lunch - *Leonidas main hotel mezzanine***

Tuesday 23 June - Track 3: ATM performance - *Room: Rodin*

Session Chair: *Dirk Schaefer (EUROCONTROL)*

Time	Paper	Title	Authors (presenter in ***bold***)
14:00	370	A Framework for Assessing and Managing the Impact of ANSP Actions on Flight Efficiency	***Jesper Bronsvoort,*** *Paul Zissermann, Steven Barry & Greg McDonald (Airservices Australia)*
14:45	400	Trajectory Optimization Based Analysis of the 3Di Flight Efficiency Metric	*Quintain McEnteggart &* ***James Whidborne*** *(Cranfield University)*

15:30 **Coffee - *Conference centre, 1st floor***

Session Chair: *Anthony Smoker (IFATCA)*

Time	Paper	Title	Authors (presenter in ***bold***)
16:00	460	A New Method to Validate the Route Extension Metric against Fuel Efficiency	***Esther Calvo,*** *José Manuel Cordero (CRIDA), Luis D'Alto, Javier López-Leonés, Miguel Vilaplana & Marco La Civita (Boeing Research and Technology Europe)*
16:45	479	Air Transportation and Multimodal, Collaborative Decision Making during Adverse Events	*Lynnette Dray (Cambridge University), Aude Marzuoli &* ***Eric Feron*** *(Georgia Institute of Technology), Isabelle Laplace (ENAC), Antony Evans (University College London)*

Wednesday 24 June

Wednesday 24 June - Track 1: Network and strategic flow optimisation - *Room: Astaire*

Session Chair: *Jose Miguel de Pablo (CRIDA)*

Time	Paper	Title	Authors (presenter in ***bold***)
07:45	539	Assessing the capacity benefit of airborne speed adjustment	***Richard Irvine*** *(EUROCONTROL)*
08:30	512	Combining Control by CTA and Dynamic Enroute Speed Adjustment to Improve Ground Delay Program Performance	***James C. Jones****, David J. Lovell & Michael O. Ball (University of Maryland)*
09:15	384	Performance Improvements Through Trajectory Feedback in the Future Collaborative Flight Planning Environment	*Stéphane Mondoloni,* ***Sheng Liu*** *& Daniel Kirk (MITRE)*
10:00	386	Designing Traffic Flow Management Strategies Under Uncertainty	***Christine Taylor****, Tudor Masek & Craig Wanke (MITRE), Sandip Roy (Washington State University)*

10:45 **Coffee - *Conference centre, 1st floor***

Session Chair: *Mike Ball (University of Maryland)*

Time	Paper	Title	Authors (presenter in ***bold***)
11:15	454	Large-Scale Network Slot Allocation with Dynamic Time Horizons	***Alexander Lau****, Jan Berling, Florian Linke, Volker Gollnick & Karl Nachtigall (DLR)*
12:00	457	Brownian Motion Delay Model for the Integration of Multiple Traffic Management Initiatives	***Juan Rebollo*** *& Chris Brinton (Mosaic ATM Inc.)*
12:45	428	A micro view to en-route delays	***Seddik Belkoura*** *& Massimiliano Zanin (INNAXIS Foundation)*

13:30 **Light lunch - *Leonidas main hotel mezzanine or conference centre deck***

Free afternoon

Wednesday 24 June - Track 2: Airport/airside operations - *Room: Fellini*

Session Chair: *Dirk Kuegler (DLR)*

Time	Paper	Title	Authors (presenter in ***bold***)
07:45	509	Predicting Airport Runway Configuration: A Discrete-Choice Modeling Approach	*Jacob Avery &* ***Hamsa Balakrishnan*** *(MIT)*
08:30	538	Evaluation of Dynamic Departure-Demand Allocation and Runway Balancing	***Adan E. Vela****, Tom Reynolds & Lanie Sanderg (MIT Lincoln Laboratory)*
09:15	466	The current practice of separation delivery at major European airports	***Gerben van Baren*** *(NLR), Catherine Chalon-Morgan &* ***Vincent Treve*** *(EUROCONTROL)*
10:00	535	Reducing Departure Delays in LaGuardia Airport with Departure-Sensitive Arrival Spacing (DSAS) Operations	***Paul U. Lee*** *& Nancy M. Smith (NASA Ames), Jeffrey Homola, Connie Brasil, Nathan Buckley, Chris Cabrall, Eric Chevalley, Bonny Parke & Hyo-Sang Yoo (San Jose State University)*

10:45 **Coffee - *Conference centre, 1st floor***

Session Chair: *Midori Tanino (FAA)*

Time	Paper	Title	Authors (presenter in ***bold***)
11:15	403	Evaluation of Pushback Decision-Support Tool Concept for Charlotte Douglas International Airport Ramp Operations	***Miwa Hayashi****, Ty Hoang & Yoon C. Jung (NASA Ames), Waqar Malik & Hanbong Lee (UC Santa Cruz), Victoria L. Dulchinos (San Jose State University)*
12:00	374	Management of Time Based Taxi Trajectories coupling Departure and Surface Management Systems	***I. Gerdes*** *& M. Schaper (DLR)*
12:45	398	Optimizing Integrated Arrival, Departure and Surface Operations Under Uncertainty	***Christabelle Bosson*** *(Purdue University), Min Xue (UC Santa Cruz), Shannon Zelinski (NASA Ames)*

13:30 **Light lunch - *Leonidas main hotel mezzanine or conference centre deck***

Free afternoon

Wednesday 24 June - Track 3: Separation - *Room: Rodin*

Session Chair: *Eric Neiderman (FAA)*

Time	Paper	Title	Authors (presenter in ***bold***)
07:45	470	The Effectiveness of a Route Crossing Tool in a Simulated New York Airspace	***Bonny Parke***, *Eric Chevalley, Nancy Bienert, Paul Lee, Kari Gonter, Faisal Omar, Joshua Kraut, Hyo-Sang Yoo, Abhay Borade & Conrad Gabriel (San Jose State University), Daphne Rein-Weston (Delft University of Technology), Everett Palmer (NASA Ames)*
08:30	472	A Flexible Framework for Solving the Air Conflict Detection and Resolution Problem using Maximum Cliques in a Graph	***Thibault Lehouillier***, *Jeremy Omer, Francois Soumis & Guy Desaulniers (Polytechnique Montreal)*
09:15	408	Does ATM Need Centralized Coordination? Autonomous Conflict Resolution Analysis in a Constrained Speed Environment.	***Nicolas Durand*** *& Nicolas Barnier (ENAC)*
10:00	537	Shift for Safety - An Differential Evolution Approach to Optimize Lateral Airway Offset for Collision Risk Mitigation	***Sameer Alam*** *& Md. Murad Hossain (University of New South Wales), Fareed Al-Alawi & Fathi Al-Thawadi (ICAO)*

10:45 **Coffee - *Conference centre, 1st floor***

Wednesday 24 June - Track 3: Weather - *Room: Rodin*

Session Chair: Craig Wanke (MITRE)

Time	Paper	Title	Authors (presenter in ***bold***)
11:15	385	Dynamic Weather Routes: Two Years of Operational Testing at American Airlines	***David McNally***, *Kapil Sheth & Chester Gong (NASA Ames), Scott Sahlman, Susan Hinton & Chuhan Lee (University Affiliated Research Center), Mike Sterenchuk (American Airlines), Fu-Tai Shih (SGT Inc.)*
12:00	391	Assessment of a National Airspace System Airborne Rerouting Tool	***Kapil Sheth*** *& Dave McNally (NASA Ames), Patrick Somersall (FAA), Alex Morando & Alexis Clymer (UC Santa Cruz), Fu-Tai Shih (SGT Inc.)*
12:45	471	Exploring Wind Information Requirements for Four Dimensional Trajectory-Based Operations	***Tom G. Reynolds***, *Michael McPartland, Tom Teller & Seth Troxel (MIT Lincoln Laboratory)*

13:30 **Light lunch - *Leonidas main hotel mezzanine or conference centre deck***

Free afternoon

Thursday 25 June

Thursday 25 June - Track 1: UAS - *Room: Astaire*

Session Chair: *Michael Standar (SJU)*

Time	Paper	Title	Authors (presenter in ***bold***)
08:00	388	Characteristics of a Well Clear Definition and Alerting Criteria for Encounters between UAS and Manned Aircraft in Class E Airspace	***Marcus Johnson**, Eric R. Mueller & Confesor Santiago (NASA Ames)*
08:45	427	Interoperability of Horizontal and Vertical Resolution Advisories	***Edward H. Londner** (MIT Lincoln Laboratory)*
09:30	356	Characterizing the Effects of a Vertical Time Threshold for a Class of Well-Clear Definitions	***Jason M. Upchurch**, Cesar A. Munoz, Anthony J. Narkawicz, Maria C. Consiglio, James P. Chamberlain (NASA Langley)*

10:15 **Coffee - *Conference centre, 1st floor***

Session Chair: *Parimal Kopardekar (NASA Ames)*

Time	Paper	Title	Authors (presenter in ***bold***)
10:45	387	Pilot Evaluation of a UAS Detect-and-Avoid System's Effectiveness in Remaining Well Clear	***Confesor Santiago** & Eric R. Mueller (NASA Ames)*
11:30	498	Metropolis: Relating Airspace Structure and Capacity for Extreme Traffic Densities	***Emmanuel Sunil, Jacco Hoekstra** & Joost Ellerbroek (TU Delft) Frank Bussink & Dennis Nieuwenhuisen (NLR), Andrija Vidosavljevic (ENAC), Stefan Kern (DLR)*

12:15 **Lunch - *Leonidas main hotel mezzanine***

Thursday 25 June - Track 1: Finance and policy - *Room: Astaire*

Session Chair: *Joe Post (FAA)*

Time	Paper	Title	Authors (presenter in ***bold***)
13:30	487	European route choice determinants	***Luis Delgado** (University of Westminster)*
14:15	536	Pricing to reconcile predictability, efficiency and equity in ATM	***Radosav Jovanović**, Obrad Babić & Vojin Tošić (University of Belgrade)*

15:00 **Coffee - *Conference centre, 1st floor***

Session Chair: *Joe Post (FAA)*

Time	Paper	Title	Authors (presenter in ***bold***)
15:30	357	Managing European Air Traffic Control Provision	***Nicole Adler** (Hebrew University of Jerusalem), Eran Hanany (Tel Aviv University), Stef Proost (KU Leuven)*
16:15	436	Air Traffic Control Regulation in a Union Bargaining Model Setting	***Stef Proost** (KU Leuven), Amihai Glazer (UC Irvine), Thomas Blondiau (TML)*

Thursday 25 June - Track 2: Human factors - *Room: Fellini*

Session Chair: *Billy Josefsson (LFV)*

Time	Paper	Title	Authors (presenter in ***bold***)
08:00	359	Trawl-Net Technology for Timely Precise Air Traffic Controller Turn-To-Base Commands	***Oliver Ohneiser***, *Marco-Michael Temme, Jürgen Rataj (DLR)*
08:45	453	Statistical analysis of air traffic controllers eye movements	***Yanjun Wang***, *Wei Cong, Bin Dong, Fan Wu & Minghua Hu (Nanjing University)*
09:30	420	Computational assessement of different air-ground function allocations	*Martijn IJtsma & Jacco Hoekstra (Delft University of Technology), Raunak P. Bhattacharyya &* ***Amy Pritchett*** *(Georgia Institute of Technology)*

10:15 **Coffee - *Conference centre, 1st floor***

Session Chair: *Billy Josefsson (LFV)*

Time	Paper	Title	Authors (presenter in ***bold***)
10:45	363	Assistant-Based Speech Recognition for ATM Applications	***Hartmut Helmke***, *Jürgen Rataj, Thorsten Mühlhausen, Oliver Ohneiser, Heiko Ehr & Matthias Kleinert (DLR), Youssef Oualil & Marc Schulder (Saarland University)*
11:30	429	The Closed Runway Operation Prevention Device: Applying Automatic Speech Recognition Technology for Aviation Safety	***Shuo Chen*** *& Hunter Kopald (MITRE)*

12:15 **Lunch - *Leonidas main hotel mezzanine***

Thursday 25 June - Track 2: Complexity - *Room: Fellini*

Session Chair: *Miquel Angel Piera (Universitat Autònoma de Barcelona)*

Time	Paper	Title	Authors (presenter in ***bold***)
13:30	440	Adaptative air traffic network: statistical regularities in air traffic management	*C. Bongiorno, S. Micciche and R. N. Mantegna (Universita di Palermo),* ***G. Gurtner*** *& F. Lillo (Scuola Normale Superiore di Pisa), Simone Pozzi (Deep Blue)*
14:15	358	Topological characteristics of air traffic situation	***Hongyong Wang***, *Ruiying Wen & Yifei Zhao (Civil Aviation University of China)*

15:00 **Coffee - *Conference centre, 1st floor***

Session Chair: *Dres Zellweger (ATCA Institute)*

Time	Paper	Title	Authors (presenter in ***bold***)
15:30	477	Modelling Delay Propagation Trees for Scheduled Flights	*C. Ciruelos, A. Arranz, I. Etxebarria & S. Peces (ISDEFE),* ***B. Campanelli***, *P. Fleurquin, V.M. Eguiluz & J. J. Ramasco (IFISC)*
16:15	511	Delay propagation - new metrics, new insights	*A. Cook & G. Tanner (University of Westminster), S. Cristóbal &* ***M. Zanin*** *(Innaxis)*

Thursday 25 June - Track 3: Trajectory and queue management - *Room: Rodin*

Session Chair: *Guglielmo Lulli (University Bicocca Milan)*

Time	Paper	Title	Authors (presenter in ***bold***)
08:00	401	Enabling Performance-Based Navigation Arrivals: Development and Simulation Testing of the Terminal Sequencing and Spacing System	***John E. Robinson III*** *& Jane Thipphavong (NASA Ames) William C. Johnson (NASA Langley)*
08:45	415	Arrival Scheduling with Shortcut Path Options and Mixed Aircraft Performance	***Shannon J. Zelinski*** *& Jaewoo Jung (NASA Ames)*
09:30	390	Assessing Resilience of Scheduled Performance-Based Navigation Arrival Operations	***Jaewoo Jung****, Savita A. Verma & Shannon J. Zelinski (NASA Ames),Thomas E. Kozon & Lindsay Sturre (UC Santa Cruz)*

10:15 **Coffee - *Conference centre, 1st floor***

Session Chair: *Guglielmo Lulli (University Bicocca Milan)*

Time	Paper	Title	Authors (presenter in ***bold***)
10:45	407	Machine Learning Applied to Airspeed Prediction During Climb	***R. Alligier****, D. Gianazza & N. Durand (ENAC)*
11:30	369	Real-Time Trajectory Predictor Calibration through Extended Projected Profile Down-Link	***Jesper Bronsvoort*** *& Greg McDonald (Airservices Australia), Mike Paglione & Christina M. Young (FAA), Jean Boucquey (Eurocontrol), Joachim K. Hochwarth (GE Aviation Systems), Eduardo Gallo (Boeing Research & Technology Europe)*

12:15 **Lunch - *Leonidas main hotel mezzanine***

Session Chair: *Eric Hoffman (EUROCONTROL)*

Time	Paper	Title	Authors (presenter in ***bold***)
13:30	373	Model for Longitudinal Uncertainty during Controlled Time of Arrival Operations	***David De Smedt*** *(Eurocontrol), Jesper Bronsvoort & Greg McDonald (Airservices Australia)*
14:15	516	Predicting Arrival Time Uncertainty from Actual Flight Information	***M. Tielrooij****, C. Borst, M. M. van Paassen & M. Mulder (Delft University of Technology)*

15:00 **Coffee - *Conference centre, 1st floor***

Session Chair: *Eric Hoffman (EUROCONTROL)*

Time	Paper	Title	Authors (presenter in ***bold***)
15:30	434	Potential Benefits of Arrival Time Assignment, Dynamic Programming Trajectory Optimization applied to the Tokyo International Airport	***Yoshikazu Miyazawa****, Haruki Matsuda, Sadanari Shigetomi, Akinori Harada & Tomoyuki Kozuka (Kyushu University), Navinda Kithmal Wickramasinghe, Mark Brown & Yutaka Fukuda (ENRI)*
16:15	483	Conflict pattern analysis under the consideration of optimal trajectories in the European ATM	*Sergio Ruiz (Universidad Autonoma de Barcelona),* ***Manuel Soler*** *(Universidad Carlos III de Madrid)*

Friday 26 June – Closing plenaries

08:30 **Special session on RPAS research**

Moderator: ***James L. Grimsley*** *(University of Oklahoma)*

Speakers and panellists: ***Denis Koehl*** *(SJU)*
Henk Hesselink *(NLR)*
Parimal Kopardekar *(NASA Ames)*
Raja Sengupta *(UC Berkeley)*

Each panellist will give a short presentation on a different aspect of RPAS. This will be followed by an interactive session.

10:30 **Coffee - *Conference centre, 1st floor***

11:00 **Perspectives from SESAR**
Michael Standar *(Chief Strategy & External Affairs, SJU)*

11:30 **Perspectives from NextGen**
Ed Bolton *(Assistant Administrator for NextGen, FAA)*

12:00 **Best paper awards and closing**
Colin Meckiff & Eric Neiderman

12:45 **Lunch - *Leonidas main hotel mezzanine***

Abstracts

Abstracts: Safety

A Simple Wake Vortex Encounter Severity Metric - De Visscher et al

This paper presents a severity metric supporting the characterization of the effect of a wake vortex encounter on a follower aircraft. The proposed metric is the Rolling Moment Coefficient computed using various simplified assumptions that lead to a simple and usable metric. The metric can indeed be computed using available aircraft data. The paper also presents the assessment of the metric based on the results of a wake vortex encounter flight test campaign performed by Airbus. The use of the proposed metric yields good agreement with the experimental data. Because it is simple, yet realistic compared to experimental data, the metric can be used in a relative safety analysis permitting a reduction of the wake turbulence separations compared to today's ICAO standard, as was done in the framework of the RECAT-EU project.

Risk Analysis Process Tool for Surface Loss of Separation Events - Chang

The MITRE Corporation's Center for Advanced Aviation System Development (MITRE/CAASD) made improvements to the Risk Analysis Process (RAP) Tool scoring methods used in quantifying the risk level for loss of separation events. These enhancements are designed to evolve the present scoring methods by using operational data for trend analysis and promoting increased safety through risk mitigation and management. The new changes aim to simplify the tool's use and eliminate any potential biases associated with it. A newly modified RAP Tool has been developed for future evaluation of events and it closely aligns with the current Federal Aviation Administration (FAA) Safety Management System (SMS) Risk Matrix. The tool will be used by the FAA to closer examine the risk involved in loss of separation events in order to better prioritize their mitigations.

A risk-based framework for assessment of runway incursion events - Stroeve et al

Current safety management of aerodrome operations uses a severity-based categorization of runway incursion events. This severity assessment is mainly based upon the outcome of a runway incursion event, in particular on the closest distance attained. As such the severity depends to a considerable extent on uncontrolled random circumstances and we argue that it is not suitable as prime indicator for safety management of aerodrome operations. In this paper we present a new framework for the evaluation of runway incursion events, which is based on the risk of scenarios associated with the initiation of runway incursion events, rather than on the outcomes of the events. In support of this framework an inventory of scenarios is provided, which can represent most runway incursion events involving a conflict with an aircraft. A main step in the framework is the assessment of the conditional probability of a collision given a runway incursion scenario. This can be effectively achieved for large sets of scenarios by agent-based dynamic risk modelling. The results provide detailed feedback on risks of runway incursion scenarios, thus enabling effective safety management for the most safety-critical situations.

Identification of critical scenarios of risk: An operational approach - Mehadhebi

This paper introduces an innovative approach for identifying critical scenarios of risk, which are scenarios likely to cause an accident. This approach was designed in the course of an ambitious DSNA program called 4-Flight, with a massive operational change (switch to electronic stripping, new Flight Data Processing Server, DataLink, new HMI for air traffic controllers). The purpose of this innovative approach is to guarantee that, although emerging risk could appear when implementing the new system, all critical scenarios of risk have been identified and mitigated. We present the approach and provide applications both in SESAR and in one 4-Flight large scale experimentation.

Including Safety during Early Development Phases of Future Air Traffic Management Concepts - Fleming & Leveson

Safety should be designed into future air traffic management systems from their very conception, which can be achieved by integrating powerful hazard analysis techniques into the general systems engineering process. The primary barrier to achieving this objective is the lack of effectiveness of the existing analytical tools during early concept development.

This paper introduces a new technique, which is based on a more powerful model of accident causality—called systems-theoretic accident model and process (STAMP)—that can capture behaviors that are prevalent in these complex, software-intensive systems. The goals are to (1) develop rigorous, systematic tools for the analysis of future ATM concepts in order to identify potentially hazardous scenarios and undocumented assumptions, and (2) extend these tools to assist stakeholders in the development of concepts using a safety-driven approach.

Analysis of Impacts an Eruption of Volcano Stromboli could have on European Air Traffic - Luchkova et al

The current regulatory situation in Europe is that flying in forecasted, differently contaminated volcanic ash zones is allowed as long as airline's specific Safety Risk Assessment for volcanic ash events (SRA) is approved. This regulation has the goal to reduce adverse impact of volcanic ash on air traffic management (ATM). There are three different types of SRAs and it is, however, not yet clear what effects on air traffic operations each type eventually has. In this contribution, we concentrate on analysis of those effects: posed number of encounters with volcanic ash cloud as well as the generation of optimized flight trajectories around the cloud. More importantly, we introduce an airspace re-opening scheme during ash crisis situation and investigate its effect. The accent is here put on capacity analysis of the air traffic control (ATC) sectors estimated to be more affected by the necessity of re-routing around the areas of contamination. The analysis of the work-load of the controllers responsible for providing services in those sectors is due to the complexity planned for the future work. Important to mention is that European states do not implement this approach and that it therefore presents the novelty in the field. Moreover, European states do not have a unique understanding of SRA approach meaning that, in a few cases, states still decide to close their airspace in case of ash presence. We do not concentrate on that problem in this investigation and treat the European airspace as airspace with harmonized, unique regulatory set up. Volcanic ash data from the International Civil Aviation Organization's (ICAO's) volcanic ash exercise (VOLCEX14/01) and Eurocontrol's daily traffic data are used as input data for simulations.

Shift for Safety - A Differential Evolution Approach to Optimize Lateral Airway Offset for Collision Risk Mitigation - Alam et al

A majority of aircraft are now using Global Navigation Satellite System (GNSS) for navigation. This has led to an effect of reducing the magnitude of lateral deviations from the route center line and, consequently, increasing the probability of a collision, should a loss of vertical separation between aircraft on the same route occur. ICAO has introduced Strategic Lateral Offset Procedures (SLOP) which allows suitably equipped aircrafts to fly with 1nm or 2nm lateral offset to the right of airway centerline in oceanic airspace. However, very few aircrafts are using the SLOP procedure due to lack of understanding of its safety benefits and implementation issues in identifying correct lateral offset that can reduce the collision risk. This paper proposes an Evolutionary Computation framework using Differential Evolution process to identify optimal lateral offsets for each airway in a given airspace such that it reduces the overall collision risk. Airway specific lateral offsets are then correlated with airway-traffic features using Multiple Regression models to identify which features can explain the optimal lateral offset. The proposed approach establishes a generic mapping that can suggest optimal lateral offsets for a given airspace based on airway-traffic features to mitigate collision risk. The proposed methodology is applied for Collision Risk assessment of one day traffic data (710 flights) in Bahrain Upper Airspace (FL290-FL410) to estimate optimal lateral offset which resulted in significant reduction of collision risk. Further, number of flights and crossings on an airway were identified as key features affecting optimal lateral offset.

Abstracts: Environment

Towards Climate Optimized Flight Trajectories in a Climate Model: AirTraf - Yamashita et al

Aviation contributes to the anthropogenic climate impact through emissions. Mobility becomes more and more important to society and hence air transportation is expected to grow further over the next decades.

Mitigating the climate impact from aviation emissions is needed and a climate compatible air transportation system is required for a sustainable development of commercial aviation. A number of studies suggest avoiding climate sensitive regions by re-routing horizontally and vertically: climate optimized routing. This includes several routing strategies (mitigation options) and shows a great potential for a climate impact reduction, since most of the climate impact arises from non-CO2 emissions, which are short-lived and vary regionally. This study introduces a new assessment platform AirTraf, which is a simplified model to perform long-term global air traffic simulation in a climate-chemistry model, enabling the assessment of routing strategies. A demonstration of a one-day AirTraf simulation was performed using 103 flight plans for transatlantic flights of Airbus A330 aircraft. The results confirmed that AirTraf simulates the air traffic properly both for flights along the great circle and wind-optimal strategies.

Cruise Fuel Reduction Potential from Altitude and Speed Optimization in Global Airline Operations - Jensen et al

This paper examines the potential fuel efficiency benefits of cruise altitude and speed optimization using historical fight path records. Results are presented for a subset of domestic US flights in 2012 as well as for long haul flights tracked by the European IAGOS atmospheric research program between 2010 and 2013. For a given lateral flight route, there exists an optimal combination of altitude and speed. Analysis of 217,000 flights domestic US airspace has shown average potential savings of up to 1.96% for altitude optimization or 1.93% for speed optimization. International flights may be subject to different airline and/or air traffic management procedures and constraints. Examination of 3,478 long-haul flights, representing three airlines and a single aircraft type over a four-year period, indicates average potential savings of up to 0.87% for altitude optimization or 1.81% for speed optimization. This is equivalent to a mean fuel savings of 905 pounds and 1981 pounds per flight, respectively. Due to the limited sample set for long haul flight records, conclusions from this stage of the international study are currently limited to the specific airlines and aircraft types included in the IAGOS measurement program.

Strategic Planning of Efficient Oceanic Flights - Sridhar et al

The efficiency of oceanic flights is low due to limited navigational and communication equipment, congestion and airspace restrictions. The availability of Automated Dependent Surveillance-Broadcast (ADS-B) and other improvements provides opportunity for better strategic planning of trajectories. Transatlantic flights between US and Europe constitute one of the busiest oceanic airspace regions in the world. This paper examines the benefits of a wind-optimal trajectory concept with a strategic de-confliction component compared to the current flight planning using the North Atlantic Tracks. The methodology generates a wind-optimal route for each aircraft and a strategic reduction in the potential conflicts between aircraft by a combination of small adjustments to departure times and rerouting. The de-confliction is achieved by optimization techniques involving simulated annealing with local gradient searching. The fuel burn for the tracks in today's Organized Track System are compared with the corresponding quantities for the wind-optimized routes to evaluate the potential benefits of flying wind-optimal routes in North Atlantic Airspace. The analysis is based on air traffic between US and Europe during July 2012. The potential fuel savings depend on existing inefficiencies in current flight plans, atmospheric conditions and location of the city-pairs. The paper provides both aggregate results and detailed examination of some of the most popular city-pairs. Results show that strategic planning can improve the efficiency of flight trajectories by 3 to 5% depending on citypairs and aircraft type. This translates into a potential fuel savings in the range of (420-970) kg per flight for a Boeing 767- 300, the most widely used aircraft between the city-pairs in this study.

Investigating Benefits from Continuous Climb Operating Concepts in the National Airspace System - McConnachie et al

Operational improvements have the potential for near term environmental and energy benefits in the National Airspace System. Research into terminal area operational improvements has predominantly focused on the descent phase of flight and improvements of operational performance using continuous descent approaches, optimized profile descents. This paper primarily focuses on the climb phase of flight and investigates the need for continuous climb operations. The paper presents the results of an analysis which quantifies the prevalence of inefficiencies in the departure phase across the National Airspace System and the magnitude of operational and environmental performance change if continuous climb operations are implemented at certain airports. Results show that climb inefficiencies occur on average for 30% of departures in the National Airspace System. A detailed operational and energy analysis at Boston Logan International Airport, Denver International Airport and Los Angeles International

Airport found that the average potential fuel savings from continuous climb operations range between 6 and 19kg per departure, with annual carbon dioxide savings of 6,970 tons, 3,380 tons and 7,360 tons respectively. The distribution in fuel savings is skewed, with a few operations having greater than average fuel savings. Implementing continuous climb operations for 18% of operations could result in the capture of 59% of total fuel savings from continuous climb operations. Each airport has signature concentrations of level-offs where level offs tend to concentrate at certain altitudes. This provides evidence of the role of airspace design and constraints in climb inefficiencies. Based on results to date, change in noise impact is inconclusive, but limited by the choice of typical noise metrics. Although, alternative noise metrics showed significant potential noise benefits from continuous climb operations.

Fuel and Energy Benchmark Analysis of Continuous Descent Operations - Fricke et al

In this paper the existing CDO procedures at three relevant German airports are analyzed with respect to both the achievable (maximum specific range) and the effectively achieved fuel savings in comparison to conventionally flown arrivals. To do so, we applied our highly precise flight performance model EJPM [1] to several thousand flown trajectories before and after CDO implementation, the data of which was provided to us as radar track data. A technique was developed to estimate the individual aircraft gross mass for calculating the optimum rate of descent starting from the computed flight-specific Top of Descent (ToD). Furthermore, we considered 3D weather and wind data to determine the CDO trajectory. When locating the trajectories within typical ICAO CDO procedure corridors, we found that the current, generic design criteria does not allow the fuel saving potential of CDO to be utilized. Often because of poor CDO execution from the ground and flight deck, only selected aircraft types managed to maintain the defined boundaries. To gain insight on how much detailed procedure guidance is required, a comprehensive weather and aircraft mass sensitivity analysis is also presented. We found analytic models to improve CDO procedures based on local traffic and meteorological conditions, which should supplement current guidance material.

A Methodology for Environmental and Energy Assessment of Operational Improvements - Belle et al

NextGen Operational Improvements (OIs) have the potential for delivering Environmental and Energy (E&E) benefits in the near term. To foster improved aviation environmental performance, it is important to assess the E&E impacts of NextGen OIs. This paper presents a methodology that uses the advanced aviation modeling tool i.e., FAA Aviation Environmental Design Tool (AEDT) to assess the E&E benefits and tradeoffs of OIs that can potentially improve terminal airspace operations and can affect noise exposure in areas surrounding the airport. The methodology is demonstrated in performing an E&E assessment of the Enhanced Visual Approach (EVA) concept across operational performance (i.e., track distance and time), energy (i.e., fuel savings), emissions and noise. The E&E assessment of EVA is performed at three airports: Denver International Airport (DEN), General Edward Lawrence Logan International Airport (BOS) and Los Angeles International Airport (LAX). The results indicate that at 100% equipage (i.e., all aircraft are equipped with EVA-CAVS capability) and traffic levels of year 2012-2013, EVA-CAVS can result in on average 0.4%, 0.3% and 1.2% improvement annually in terms of operational performance (distance) at DEN, BOS and LAX, respectively. This corresponds to 0.1%, 0.6% and 1.1% reduction in terms of fuel and CO2 emissions. In addition, the potential reduction in trombones (i.e., stretched flight paths in the downwind leg of final approach) from use of EVA-CAVS can reduce noise exposure as well. The applicability of the methodology to assess the E&E benefits and tradeoffs of other NextGen Operational Improvement Con-Ops is also discussed.

Fuel Burn Impacts of Taxi-out Delay and their Implications for Gate-hold Benefits - Hao et al

Reducing fuel consumption is a unifying goal across the aviation industry. As such the aviation community is considering many initiatives in the form of policy, operational changes and technology deployment. One fuel-saving initiative for the air transportation system is the possibility of holding aircraft at the gate, or the spot, until the point at which they can taxi unimpeded to the departure runway. The extent to which gate holding strategies have financial and environmental benefits hinges on the quantity of fuel that is consumed during surface operations. Aircraft may execute the taxi procedure on a single engine or utilize different engine thrust rates; in addition an aircraft might change their fuel consumption rate during the taxi phase because of a delay. In the following study, we utilize airline fuel consumption data to distill the taxi fuel consumption rate both in nominal taxi time and in delayed taxi time for different aircraft types towards understanding the fuel consumption rate in taxi, both during nominal and delayed times. We find that the fuel consumption attributed to a minute of taxi out delay is less than the impact of a minute of nominal taxi time; for some aircraft types, the fuel consumption rate for a minute of taxi delay is half of that for nominal taxi. It is therefore not appropriate, even for rough calculations, to apply the nominal rates to convert delayed taxi out time into fuel burn. On average we find that eliminating taxi delay would reduce overall flight fuel consumption by about 1%. When we consider the savings on an airport-by-airport basis, we find that some airports could help the flights that operate at their airport reduce up to 2% of fuel consumption if delay were eliminated on their airfields.

Abstracts:
Surveillance and navigation

Combining Advanced-RNP with SBAS Guided Precision Terminal Area Paths and Final Approach Guidance - Dautermann & Geister

Satellite Based Augmentation Systems (SBAS) for Global Navigation Satellite Systems (GNSS) currently enable precise vertical and lateral guidance for aircraft during the final approach. The newly established advanced-Required Navigation Performance (RNP) concept allows all aircraft to follow repeata-ble ground tracks even during curved segments in the approach. This was previously only possible with special aircraft and air-crew authorization. Terminal Area Paths (TAPs) allow the path definition and vertical guidance during the arrival and initial through intermediate approach segment. Here, we report on the design and flight test results of advanced procedures that employ combinations of the three aforementioned possibilities. We in-clude TAPs, originally a concept from the Ground Based Aug-mentation System (GBAS), into the onboard Flight Management System (FMS) database in order to use them with an SBAS based navigation solution. The TAPs transition to a localizer perfor-mance with vertical guidance final approach segment, thus ena-bling vertically guided continuous descent approaches from cruise level at selectable descent angles down to 200ft. During the flight trials, an A320 research aircraft was able to follow the desired trajectory with vertical and lateral total system accuracy of less than 20 meters. Secondly, we show that combinations of advanced RNP with SBAS final approach segments can effective-ly decouple runways in dense traffic environments where these runways previously were procedurally dependent. Sufficient obstacle clearance can also be achieved despite power lines with a height of ~300ft passing just south of the airport. While perform-ing the flight trials, we recorded a lateral precision better than 44.5 m during a curved missed approach using automatic flight control in a Hawker 750XP business aircraft.

Validation of the use of GBAS precision approaches for improved runway throughput in poor weather conditions - Pelchen-Medwed et al

In current low visibility operations at an airport while normally using Instrument Landing System (ILS), extra spacing margins between aircraft have to be provided in order to protect the ILS critical and sensitive areas. This results in a decrease of runway throughput during low visibility conditions. The benefit of the use of Ground-Based Augmentation System (GBAS) instead of ILS in low visibility conditions is that there is no sensitive or critical area that has to be protected. The GBAS Local Object Consideration Areas (LOCA) are also much smaller and usually located outside aircraft movement areas. This leads to an immediate improvement in runway throughput in adverse weather conditions. To validate this anticipated benefit a real-time simulation was conducted in the frame of the SESAR 06.08.05 GBAS operational implementation project. The results of this real-time simulation show that when using GBAS precision approach in LVP operations for segregated runways, the expected runway throughput benefit is materialised without negatively impacting safety and human performance. However, GBAS in LVP operations for mixed mode runway operations might not bring any significant gain in runway throughput since the results indicate that the spacing cannot be reduced as much as expected.

Required Surveillance Performance for reduced minimal-pair arrival separations - Groskreutz & Dominguez

This paper will investigate and propose preliminary Required Surveillance Performance (RSP) requirements associated to a longitudinal arrival separation of 2.0 NM. Just as new regulations regarding navigation are using Required Navigation Performance (RNP) to disassociate the regulation from a particular type of technology and substitute general performance requirements for any current or future navigation technology, an effort in needed to assign RSP requirements to separation minima. RSP requirements have already been set in Europe for 5NM and 3NM horizontal separations in en-route flight. Currently referred to as the minimal-pair radar separation, non wake turbulence longitudinal arrival separations are set by ICAO at 3 NM (or 2.5 NM if conditions permit). Part of the effort in the SESAR 6.8.1 project is to propose a new, non wake turbulence longitudinal arrival separation of 2.0 NM enabled through Required Surveillance Performance (RSP).

The proposed preliminary requirements for a 2NM minimal-pair arrival separation were achieved through the use of the separation model developed within the RESET project. This model uses the current separation minima and their influencing factors to create a separation assurance budget software tool, identifying the various budget components and influencing factors that contribute to the establishment of separation minima. Although several approaches are possible, this formalization takes into account the uncertainties in the position, velocity, and aircraft intent as well as all the factors needed for perception, comprehension and projection of the status of aircraft. This formalization provides the homogeneous means for the technological and procedural assessments in term of contribution to separation minima.In order to ensure the required TLS, a safety assessment needs to be done to analyze the other factors in order to present a complete safety case. However, the preliminary results of this study show that a RSP associated with ADS-B seems to be sufficient for a 2NM minimal-pair arrival separation with current TLS.

Abstracts: ATM performance

A Framework for Assessing and Managing the Impact of ANSP Actions on Flight Efficiency - Bronsvoort et al

This paper presents a framework for the assessment of Air Traffic Management (ATM) performance in relation to flight efficiency. The main philosophy behind the approach presented in this paper is to quantify the quality of the service delivered by an Air Navigation Service Provider (ANSP) to an airline in terms of meeting commonly agreed objectives. The definition is therefore aligned with the future paradigm of Trajectory Based Operations, where achieving the trajectory agreed between the ANSP and the airspace user becomes the focus. A staged approach to flight efficiency assessment is proposed to quantify the quality of the ANSP's service in terms of both "facilitating what has been agreed" and "improving what can be agreed". The framework promotes the development of more consistent efficiency performance metrics between ANSPs, as clear definitions exist for assessment references. Application of the framework was illustrated with several examples using the Airservices Dalí trajectory modeller.

Trajectory Optimization Based Analysis of the 3Di Flight Efficiency Metric - McEnteggart & Whidborne

As a means of measuring progress towards fuel and emissions reduction targets, the United Kingdom Air Navigation Service Provider NATS developed the 3Di flight efficiency metric. In principle the 3Di score of a flight is calculated by comparing a flown trajectory to a theoretical fuel/CO2 optimum trajectory. In response to a Eurocontrol review of the metric, the 3Di score has been analysed using a trajectory optimization method based on optimal control. The results suggest that further development of the metric is required to make it sensitive to vertical flight inefficiencies not related to periods of level flight. The results also show that the BADA trajectories used in the 3Di score to define the optimum fuel efficient operation of the aircraft are not optimal fuel efficient trajectories. Additionally, the results show that fuel inefficiencies introduced by flight planning restrictions need to be accounted for in any vertical flight inefficiency metric.

A New Method to Validate the Route Extension Metric against Fuel Efficiency - Calvo et al

The Flight Efficiency indicator is used to measure how closely the actual (and eventually the planned) trajectory flown by an aircraft approaches the optimum (or more efficient) trajectory between the departure and arrival airports. While this is a clear definition from a purely conceptual point of view, is not trivial to determine that so-called optimum trajectory, and thereby its practical calculation.

Considering this perspective, the most common implementation of the Flight Efficiency indicator (for instance, in the SES Performance Scheme) limits the calculation to the horizontal component of the flight and considers the optimum or reference trajectory as the Great Circle one, introducing the concept of "achieved distance", what is in fact an apportion of the first. This direct, geodesic route, (only taking into account the horizontal component) is considered in this algorithm as the cheapest and thereby most efficient option (with the additional benefit of being a constant benchmark, independent of individual strategies). In reality, some objections can be put to this methodology, as aircrafts often do not follow this direct route since airlines have to make tradeoffs between several factors, such as meteorological conditions, which may lead to definitions of optimum which differ from Great Circle distance. In particular, many of the considerations on the limits of the Horizontal Flight Efficiency indicator lead to the inclusion of the vertical component in the Flight Efficiency computation, what is in fact is a major improvement in the ATM Performance Monitoring field that hasn't been deployed yet, and that may lead to confirm if these Great Circle trajectories are really efficient in terms of fuel consumption.

This paper explores this innovative direction in a practical way by using real operation data to validate, addressing first the study of the correlation between the Horizontal Efficiency metric proposed by Eurocontrol and used in the SES Performance Scheme and the estimated real fuel efficiency, and secondly it proposes a new methodology that constructs an Enhanced Flight Efficiency indicator that captures better this fuel efficiency by considering also the vertical component of flight. In addition, there is a preliminary study on the relationship of this new metric with the cost efficiency, taking as a reference the published initial flight plan from the airline.

Air Transportation and Multimodal, Collaborative Decision Making during Adverse Events - Dray et al

This paper makes the case for multimodal Collaborative Decision Making (CDM) during adverse events. Two case studies, the Asiana Crash in the US, and an hypothetical closure of London Heathrow airport in Europe, demonstrate that multimodal alternatives to reaccommodate passengers impacted by diversions and cancellations, have the potential to significantly decrease passenger delay at effective costs. Based upon additional evidence and interviews conducted a preliminary study sponsored by the EU, a multimodal CDM concept is elaborated, defining milestones and information flows to support harmonized decision-making and passenger treatment, and ensure a faster recovery process from a passenger standpoint.

Abstracts: Network and strategic flow optimisation

Assessing the capacity benefit of airborne speed adjustment - Irvine

In European air traffic flow management, regulation is the assignment of take-off times to prevent the over-delivery of flights to sectors and airports. This paper reports on a validation exercise to quantify the increases in the capacity of regulated sectors to be expected from a SESAR step 1 concept element: airborne speed adjustment to reduce sector entry time errors. Increases in the capacity of regulated sectors are related to reductions in sector occupancy count variance. Fast-time simulations relate sector occupancy count variance (during regulation) to entry time accuracy. Reductions in entry-time standard deviation are calculated. Estimated capacity gains from the use of airborne speed adjustment are reported.

Combining Control by CTA and Dynamic Enroute Speed Adjustment to Improve Ground Delay Program Performance - Jones et al

Over the past several years there have been proposals and discussions regarding a move from the use of controlled times of departure (CTDs) to controlled times of arrival (CTAs) for ground delay programs (GDPs) in the U.S. In this paper we show that, by combining control by CTA with the judicious use of en route speed control, significant improvements to GDP performance can be achieved. Our analysis of this problem includes both new GDP control procedures and also new flight operator GDP planning models. While the ability to achieve all the benefits we describe will require NextGen capabilities, substantial performance improvements could be obtained even with a near-term implementation.

Performance Improvements through Trajectory Feedback in the Future Collaborative Flight Planning Environment - Mondoloni et al

Pre-departure feedback on trajectory constraints will be enabled through future flight planning provisions under development by ICAO. Select operational benefits of such feedback were investigated. Two benefit mechanism are described and quantified through the use of operational data to drive Monte Carlo simulations. One mechanism involves the use of pre-departure feedback to enable an airspace user to select the route that is lowest cost when considering ATC constraints. This mechanism yields an average 0.2% improvement in time and fuel costs. Individual flights may gain up to 2% improvements. The benefit is highly dependent on the flight's origin and destination. A second benefit mechanism allows an airspace user to pre-emptively take ground delay to reduce the likely airborne delay on arrival. This is accomplished through feedback on the estimated delay distribution based upon shared information on all relevant flights. A simulation of arrivals into London Heathrow as an example of the benefit mechanism revealed the potential to shift an average of 2.3 minutes of airborne holding to the ground for 138 flights per day. This represent an annual gain on the order of 10 million kilograms of fuel for that one airport alone.

Designing Traffic Flow Management Strategies Under Uncertainty - Taylor et al

This paper proposes a framework for designing and adapting strategic traffic management under uncertainty. A primary function of strategic traffic management is the development of traffic management initiatives to mitigate potential large-scale congestion. However, the associated longer planning horizon - 2-24 hours in advance of anticipated problems - means that congestion forecasts are highly uncertain. Furthermore, complex interactions exist between management initiatives and traffic propagation, producing a non-intuitive planning environment. The proposed adaptive planning framework captures these features, enabling quantitative design of traffic management initiatives that balance uncertainty with performance. Specifically, a decision tree is constructed to represent critical deviations in the forecast over the planning horizon. Corresponding decision points provide opportunities for management initiatives to be defined, and a genetic algorithm is employed to optimize the expected performance of the initiatives over the entire decision tree. Thus, this method identifies optimal strategies under forecast uncertainty, capturing the tradeoff between employing initiatives that may not be required and lost opportunities due to inaction. Performance of the adaptive design framework is compared with alternate design approaches, verifying the potential value of this new approach for real time decision making.

Large-Scale Network Slot Allocation with Dynamic Time Horizons - Lau et al

The purpose of this paper is to introduce an approach, which serves as initial step for the integration of adverse network impact information, like e.g. weather, to tactical European Air Traffic Flow Management (ATFM). A binary optimization methodology for large-scale linear problem decomposition with column-generation and structured variable pricing is combined with time-based problem segmentation to be able to dynamically integrate information on network impact states. The dynamic character of the approach is in line with SESAR 2020 objectives to improve the NM function in gathering benefits of short-term variations in network system states. A large-scale network scenario with a traffic sample of more than 25.000 flight plan data sets within European airspace is evaluated. Depending on the model time iteration, the Rolling Time Horizon concept adapts the ATFM optimization problem according to actual flight- and system-states. This segmentation approach shows improvements regarding the number of delayed flights, total delay sum and computation time and is suitable for future tactical ATFM optimization with dynamic network impact scenarios.

Brownian Motion Delay Model for the Integration of Multiple Traffic Management Initiatives - Rebollo & Brinton

There is no technology that provides effective support for procedural consideration of the effect of strategic programs on tactical Traffic Management Initiatives (TMIs) and vice versa. A key challenge in the design and use of Air Traffic Management (ATM) decision support tools is to determine how much control should be applied to the flow of traffic and at what point in the flow should it be applied. This challenge has significant impact on the resulting effectiveness of any ATM control program that is applied, because inefficiencies can be caused by either under or over-control of the flow. This paper presents a new analytical approach based on a Brownian Motion (BM) formulation, which quantifies the interactions between TMIs. The proposed General Brownian Motion (GBM) model takes as input uncertain and dynamic demand and capacity and provides an estimate of the delay distribution associated with the TMI controlling the demand. The obtained delay distribution can be used to estimate the probability of over-controlling or under-controlling the flow for the selected TMI parameters. Interactions between TMIs can be characterized by evaluating the probability that one TMI over-/under-controls the flow seen by a down-stream TMI. The delay prediction performance of the model is evaluated using actual Time-Based Flow Management (TBFM) data for PHL, and three case studies including multiple days of data are presented to demonstrate operational uses of the GBM model over two different TMIs and three airports.

A micro view to en-route delays - Belkoura & Zanin

The analysis and characterization of delays is one of the most important research topics in ATM, mainly due to their implications in the cost-efficiency and safety of the system. In spite of this, little attention has been devoted to the assessment and study of non-ATFM delays, and specifically of en-route delays. In this contribution, we present a methodology for comparing the planned and real trajectories of a flight, aimed at identifying those events generating both positive and negative delays. This methodology is then applied to an historical data set representing flights crossing the European airspace during several key days of 2011. Among the results obtained, of special relevance are the characterization of the resilience of the European ATM system, measured by the amount of delays generated and absorbed in en-route segments; and the geographical distribution of events, which is characterized by a high heterogeneity. From a more general perspective, this methodology would allow shedding light on the mechanisms involved in the appearance of en-route delays, thus enabling a better systemic performance.

Abstracts:
Airport/airside operations

Predicting Airport Runway Configuration: A Discrete-Choice Modeling Approach - Avery & Balakrishnan

The runway configuration is a key driver of airport capacity at any time. Several factors, such as weather conditions (wind and visibility), traffic demand, air traffic controller workload, and the coordination of flows with neighboring airports influence the selection of runway configuration.

This paper identifies a discrete-choice model of the configuration selection process from empirical data. The model reflects the importance of various factors in terms of a utility function. Given the weather, traffic demand and the current runway configuration, the model provides a probabilistic forecast of the runway configuration at the next 15-minute interval. This prediction is then extended to obtain the 3-hour probabilistic forecast of runway configuration. The proposed approach is illustrated using case studies based on data from LaGuardia (LGA) and San Francisco (SFO) airports, first by assuming perfect knowledge of weather and demand 3-hours in advance, and then using the Terminal Aerodrome Forecasts (TAFs). The results show that given the actual traffic demand and weather conditions 3 hours in advance, the model predicts the correct runway configuration at LGA with an accuracy of 82%, and at SFO with an accuracy of 81%. Given the forecast weather and scheduled demand, the accuracy of correct prediction of the runway configuration 3 hours in advance is 79% for LGA and 80% for SFO.

Evaluation of Dynamic Departure-Demand Allocation and Runway Balancing - Vela et al

Under the Terminal Flight Data Manager program new functionalities are envisioned at a number of large airports. One function is the Airport Resource Management Tool, which seeks to balance departure demand at runways. Another related functionality is runway balancing, which is expected to provide greater flexibility in tactical runway assignments. Both functions are expected to reduce surface delays for departing aircraft. This paper provides a study into the potential delay-reduction benefits of both capabilities at three case-study airports (DFW, LAX, and MCO). Through a series of simulation studies, it is found that the benefits associated with each function are closely linked to departure demand and imbalances in demand across filed aircraft departure procedures. So while large benefits are expected at LAX -- which exhibit both large demand and departure imbalances -- the benefits observed at DFW smaller, while at MCO there is no perceived benefit directly related to reductions in surface delays.

The current practice of separation delivery at major European airports - van Baren et al

Separation minima are or can become a key bottleneck for the runway throughput at major airports. Therefore, in the context of SESAR Project 6.8.1, Eurocontrol is investigating concepts for flexible and dynamic use of wake turbulence separations. In order to successfully develop such concepts and optimize the benefits, it is important that current practices and lessons learnt from today's operations are understood and taken into account. The aim of the study presented in this paper is therefore to baseline the current practices for separation delivery on final approach at major European airports. For this, site visits to European ATC units in combination with analysis of radar data have been conducted. Statistical characteristics on speed, distance and time spacing as observed in today's operations depending on e.g., airport, headwind, and distance to threshold are determined. Distance spacing close to the threshold as observed in the data satisfies the minimum radar or wake turbulence separation minima with a buffer that is on average in between 0.5 and 1.0 NM and has a standard deviation of about 0.5 NM. The mean compression of distance spacing on the last 10 NM of the final approach is approximately 1 NM. About half of this compression occurs when the leader aircraft is beyond 4 DME when aircraft adapt to their final approach speed. It is shown that there are considerable differences per airport, and this illustrates that it is important to take into account local conditions in the assessment of benefits for a certain airport. Furthermore, the observed mean and variation of spacing buffers may suggest that for optimized runway throughput, new concepts should not only focus on reduction of minima but also on the management of distance spacing compression variation, e.g. better understanding and predicting aircraft speed performance, such that buffers can be optimized. The results of this study are used by SESAR and EUROCONTROL in the development of a new ATC tool to predict aircraft speed performance. This Leading Optimised Runway Delivery (LORD) tool will support Air Traffic Controllers to optimize the separation buffer and more efficiently and easily deal with the compression effect on the last part of the final approach.

Reducing Departure Delays in LaGuardia Airport with Departure-Sensitive Arrival Spacing (DSAS) Operations - Lee et al

Air traffic management in the New York (NY) metropolitan area presents significant challenges including excess demand, chronic delays, and inefficient routes. At NASA, a new research effort has been initiated to explore Next Generation Air Transportation System (NextGen) Trajectory Based Operations (TBO) solutions to address lingering problems in the NY metroplex area. One of the larger problems in this area is departure delays at LaGuardia airport (LGA). Constant traffic demand and physical limitations in the number of taxiways and runways causes LGA to often end up with excessive departure queues that can persist throughout the day.

At the Airspace Operations Laboratory (AOL) at NASA Ames Research Center, a TBO solution for "Departure-Sensitive Arrival Spacing" (DSAS) was developed. DSAS allows for maximum departure throughput without adversely impacting the arrival traffic during the peak demand period. The concept uses Terminal Sequencing and Spacing (TSS) operations to manage the actual runway threshold times for arrivals. An interface enhancement to the traffic manager's timeline was also added, providing the ability to manually adjust inter-arrival spacing to build precise gaps for two or even three departures between arrivals. With this set of capabilities, inter-arrival spacing could be controlled for optimal departure throughput.

The concept was prototyped in a human-in-the-loop (HITL) simulation environment so that operational requirements such as coordination procedures, timing and magnitude of TSS schedule adjustments, and display features (for Tower, TRACON and TMU) could be determined. A HITL simulation was conducted in August 2014 to evaluate the concept in terms of feasibility, controller workload impact, and potential benefits. Three conditions were compared: (1) a baseline condition using the new RNAV/RNP procedures (no TSS); (2) new procedures + TSS; and (3) new procedures + TSS + DSAS schedule adjustments. Results showed that with maximum arrival demand (40-41
arrivals per hour), departure throughput could be increased from 38 / hour (baseline condition), to 44 / hour (TSS condition) to 47 / hour (TSS + DSAS). The results suggest that DSAS operations have the potential to increase departure throughput at LGA by up to 9 a/c per hour with little or no impact on arrivals during peak traffic demand period.

Evaluation of Pushback Decision-Support Tool Concept for Charlotte Douglas International Airport Ramp Operations - Hayashi et al

This paper proposes a new departure pushback decision-support tool (DST) for airport ramp-tower controllers. It is based on NASA's Spot and Runway Departure Advisor (SARDA) collaborative decision-making concept, except with the modification that the gate releases now are controlled by tactical pushback (or gate-hold) advisories instead of strategic pre-assignments of target pushback times to individual departure flights. The proposed ramp DST relies on data exchange with the airport traffic control tower (ATCT) to coordinate pushbacks with the ATCT's flow-management intentions under current operational constraints, such as Traffic Management Initiative constraints. Airlines would benefit in reduced taxi delay and fuel burn. The concept was evaluated in a human-in-the-loop simulation experiment with current ramp-tower controllers at the Charlotte Douglas International Airport as participants. The results showed that the tool helped reduce taxi time by one minute per flight and overall departure flight fuel consumption by 10-12% without reducing runway throughput. Expect Departure Clearance Time (EDCT) conformance also was improved when advisories were provided. These benefits were attained without increasing the ramp-tower controllers' workload. Additionally, the advisories reduced the ATCT controllers' workload.

Management of Time Based Taxi Trajectories coupling Departure and Surface Management Systems - Gerdes & Schaper

This paper presents concept and results of coupling the surface management system research prototype "TRACC: Taxi Routing for Aircraft: Creation and Controlling" with the departure management system "CADEO: Controller Assistance for Departure Optimisation". TRACC supports Air Traffic Controllers in creating optimized conflict-free taxi trajectories as well as with conflict detection and resolution. TRACC features speed control as new element of surface management and extends the concept of time-based trajectories to the ground. With up-to-date trajectories and therewith accurate taxi time prediction, the cooperation with the runway sequence optimizer prototype CADEO is enhanced. Within this paper both tools are introduced briefly and necessary adaptions of CADEO and TRACC for a combined application are described like push-back management and management of target start-up times. Results of first simulation runs are presented.

Optimizing Integrated Arrival, Departure and Surface Operations Under Uncertainty - Bosson et al

In airports and surrounding terminal airspaces, The integration of arrival, departure and surface scheduling and routing have the potential to improve operations efficiency. Recent research developed a mixed-integer-linear-programming algorithm-based scheduler for integrated arrival and departure operations in the presence of uncertainty. This paper extends previous research to the surface to integrate taxiway and runway operations. The developed algorithm is capable of computing optimal aircraft schedules and routings that reflect the integration of air and ground operations. A preliminary study case is conducted for a set of thirteen aircraft evolving in a model of the Los Angeles International Airport surface and terminal areas. Using historical data, a representative traffic scenario is constructed and probabilistic distributions of pushback delay and arrival gate delay are obtained. To assess the benefits of optimization, a First-Come-First-Served algorithm approach comparison is realized. Evaluation results demonstrate that the optimization can help identify runway sequences and schedules that reduce gate waiting time without increasing average taxi times.

Abstracts: Separation

The Effectiveness of a Route Crossing Tool in a Simulated New York Airspace - Parke et al

Congested airspace is the cause of many delays in the terminal area and these delays can have a ripple effect on the rest of a nation's airspace. The New York terminal area is an example of where this happens in the U. S. An important goal, therefore, is to increase the efficiency of operations in congested terminal airspace where possible. Modeling studies of arrival and departure flows have shown that sharing of arrival and departure airspace increases efficiency in terminal operations. One source of inefficiency in terminal operations is that departure aircraft are frequently held level under arrival flows when it would be more efficient to climb the departure aircraft earlier. A Route Crossing Tool was developed to help controllers climb Newark (EWR) departures to the south earlier by temporarily sharing airspace with arrivals coming into LaGuardia (LGA) from the south. Instead of flying under the arrivals, a departure to the south could climb earlier by flying through the arrival airspace if there was a suitable gap between arrivals. A Human-in-the-Loop (HITL) simulation was conducted in this environment which compared three tool conditions: Baseline (no tool), a Single Route Crossing tool in which one route through the arrival flow was evaluated for crossing, and a Multi-Route Crossing tool in which five parallel routes were evaluated. In all conditions, the departures could be held level under the arrival flow. The results showed that controllers climbed a higher proportion of departures in the Multi-Route tool condition than in the other two conditions, with a higher proportion of departures climbed in smaller gaps and in front of trailing arrivals. The controllers indicated that the Multi-Route and Single Route tools helped them estimate distances more accurately and rated safety, workload, and coordination in the simulation as acceptable.

A Flexible Framework for Solving the Air Conflict Detection and Resolution Problem using Maximum Cliques in a Graph - Lehouillier et al

In this article, we present a new formulation for the air conflict detection and resolution problem. Given the current position, speed and acceleration of a set of aircraft, we identify the maneuvers required to avoid all possible conflicts and such that the fuel costs are minimized. To this end, we design a graph whose vertices correspond to discretized values of maneuvers and whose edges link conflict-free maneuvers. Finding a solution to the problem is equivalent to searching a clique of minimum weight and maximum cardinality in the graph. We formulate this search as a mixed integer linear program, since the weights of the vertices depend on the vertices in the clique. The significance of the presented algorithm relies on its flexibility, as changing hypotheses like the objective function, aircraft dynamics or the maneuvers considered do not change the method presented. Computational results highlight short solution times, where situations involving up to 20 aircraft in a complex situation are solved to optimality in less than 20 seconds.

Does ATM Need Centralized Coordination? Autonomous Conflict Resolution Analysis in a Constrained Speed Environment - Durand & Barnier

The concept of Free-Flight, introduced in the 90s, opened a debate on the efficiency of letting aircraft deal with conflicts without any centralized control. Many models have been proposed for autonomous aircraft solvers but their efficiency is not well-known. In this paper, we experiment powerful algorithm derived from robotics which is able to deal with thousands of robots in very small spaces, and show how its performance plummets when speeds are constrained. We also compare this autonomous algorithm with a centralized approach using evolutionary computation on a complex example to point out their relative performance in a speed constrained environment. This comparison provides scientific arguments for the necessity of centralized air traffic control.

Autonomous Air Traffic Control for Non-Towered Airports - Mahboubi & Kochenderfer

Half of all reported near mid-air collisions involve at least one general aviation aircraft. More than half of NTSB reports of mid-air collisions occur in the vicinity or in the traffic pattern of an airport, and a majority of them occur at non-towered airports. This paper proposes a concept for traffic collision prevention targeted for general aviation aircraft operating in the vicinity of non-towered airports. We envision an autonomous air traffic control system as a non-intrusive, ground based system with no additional requirements to participating aircraft except for radio communication. We outline how such a system can be modeled and solved as a Markov decision process and present simulation results for aircraft in the traffic pattern.

Abstracts: Weather

Dynamic Weather Routes: Two Years of Operational Testing at American Airlines - McNally et al

The Dynamic Weather Routes (DWR) tool continuously analyzes active flights in en route airspace and finds simple route corrections to achieve more time- and fuel-efficient routes around convective weather. A strong partnership between NASA, American Airlines (AA), and the Federal Aviation Administration has enabled testing of DWR in real-world air traffic operations. NASA and AA have been conducting a trial of DWR at AA's Integrated Operations Center in Fort Worth, Texas since July 2012. This paper describes test results based on AA's use of DWR for their flights in and around Fort Worth Center (ZFW). Results indicate an actual savings of 3,290 flying minutes for 526 AA revenue flights from January 2013 through September 2014. Of these, 48 flights each indicate a savings of 15 min or more. Potential savings for all flights in ZFW airspace,

corrected for savings flights achieve today through normal pilot requests and controller clearances, is about 100,000 flying minutes for 15,000 flights in 2013. Results indicate that AA flights with DWR in use realize about 20% more savings than non-AA flights. A weather forecast analysis examines the extent to which DWR routes rated acceptable by AA users remain clear of downstream weather. A sector congestion analysis indicates congestion could be reduced 19-38% if all flights fly DWR routes rather than nominal weather-avoidance routes.

Assessment of a National Airspace System Airborne Rerouting Tool - Sheth et al

This paper presents the assessment of a National Airspace System airborne rerouting tool. The tool implements NASA's Dynamic Weather Routes concept for wind-corrected flying-time savings during convective weather activity. A description of the system, as applicable to the entire United States airspace is provided, and results are presented demonstrating benefits of such a system from various Centers and airlines' perspectives. Three cases for selection of reroute-return capture fix, which prevent unrealistically large controller clearances are presented. Results are shown for potential time- and fuel-savings (over 134,000 minutes and 4.2 million lbs. of fuel for over 35,000 proposed reroutes) and sector congestion reduction (over 121 hours in congested sectors) for all 20 Centers. The data used were for 30 days with highest delays attributable to convective weather from April to October of 2014. Other results show the evaluation of the maneuver or reroute start point (a parameter representing the amount of coordination time needed), which highlight the need for a controller-pilot data link. A data link would help achieve higher savings. The results for persistence time, beyond which the time-savings dwindle quickly, help determine the maximum coordination time required for each Center. Finally, an assessment from a current National Operations Manager at the Air Traffic Control System Command Center of the FAA is documented. Those suggestions could improve the efficiency of the air transportation system, especially with the expected improvements in the traffic flow management infrastructure. Currently, one industry partner and one airline are assessing this technology for commercial operational use.

Exploring Wind Information Requirements for Four Dimensional Trajectory-Based Operations - Reynolds et al

Many future air traffic control concepts depend on access to high accuracy wind data due to time-based control elements, such as required time of arrival at a meter fix under 4D-Trajectory-Based Operations. Errors in the wind information relative to the truth winds could significantly degrade the performance of the procedure. Unacceptable performance could be mitigated by improving wind information accuracy by using higher accuracy forecast models, updating wind information more frequently, or upgrading the way winds are handled in the avionics systems. This paper: (1) establishes the relationship of wind information accuracy to 4D-TBO performance for a selection of operationally relevant scenarios to identify wind needs to support them, and (2) presents examples of how this information can be used to determine what wind information content and update rate to the aircraft will deliver a given target performance level to help inform concept of operations development and supporting technology needs.

Abstracts: UAS

Characteristics of a Well Clear Definition and Alerting Criteria for Encounters between UAS and Manned Aircraft in Class E Airspace - Johnson et al

Unmanned aircraft systems will be required to equip with a detect-and-avoid (DAA) system in order to satisfy the federal aviation regulations to remain well clear of other aircraft. For a DAA system to satisfy the requirement to stay well clear of other airborne traffic, a quantitative definition of well clear needs to be defined and evaluated. This study investigates the implications of UAS using proposed well clear definitions as a separation standard for conducting operations in the national airspace system. The first analysis considers three well clear definitions and presents the relative state conditions of intruder aircraft as they encroach upon the well clear boundary. The second analysis focuses on the definition of the alerting criteria needed to inform the UAS operator of a potential loss of well clear. All analyses are conducted in a NAS-wide fast-time simulation environment using UAS aircraft models, proposed UAS missions, and historical air defense radar data to populate the background traffic operating under visual flight rules. The results presented in this study inform the safety case, requirements development, and the operational environment for DAA minimum operational performance standards.

Interoperability of Horizontal and Vertical Resolution Advisories - Londner

To operate in civil airspace, unmanned aircraft systems (UAS) are expected to maintain safe separation from other aircraft. Self-separation and Collision Avoidance Systems (CAS) designed for unmanned aircraft are under development to meet this requirement. To maintain airspace safety, these systems must interoperate safely with CAS onboard manned aircraft. Whereas manned aircraft CAS such as TCAS and ACAS Xa issue vertical resolution advisories (RA) that may direct aircraft to climb or descend, new UAS systems may issue horizontal RAs that direct aircraft to turn left or right, potentially leaving UAS free to maneuver vertically during the collision avoidance timeframe. These vertical maneuvers may negatively interact with manned aircraft employing a vertical CAS, representing a potential safety risk. This paper summarizes a study conducted to determine the extent of this safety risk and whether the vertical dynamics of UAS should be constrained to ensure interoperability. Fast time simulations were conducted to determine the collision risk of encounters between an aircraft equipped with TCAS or ACAS Xa and a UAS equipped with ACAS Xu: a CAS developed for unmanned aircraft. A worst-case-scenario approach was taken in which the UAS altered its vertical rate towards the intended path of the manned aircraft during the collision avoidance timeframe. The results show that ACAS Xa was safer and more robust to the UAS's vertical maneuvers than TCAS. A vertical coordination scheme was also evaluated and was shown to reduce collision risk. These results will contribute to the drafting of interoperability recommendations for UAS collision avoidance and self-separation system behavior in encounters with manned aircraft.

Characterizing the Effects of a Vertical Time Threshold for a Class of Well-Clear Definitions - Upchurch et al

A fundamental requirement for the integration of unmanned aircraft into civil airspace is the capability of aircraft to remain well clear of each other and avoid collisions. This requirement has led to a broad recognition of the need for an unambiguous, formal definition of well clear. It is further recognized that any such definition must be interoperable with existing airborne collision avoidance systems (ACAS). A particular class of well-clear definitions uses logic checks of independent distance thresholds as well as independent time thresholds in the vertical and horizontal dimensions to determine if a well-clear violation is predicted to occur within a given time interval. Existing ACAS systems also use independent distance thresholds, however a common time threshold is used for the vertical and horizontal logic checks. The main contribution of this paper is the characterization of the effects of the decoupled vertical time threshold on a well-clear definition in terms of (1) time to well-clear violation, and (2) interoperability with existing ACAS. The paper provides governing equations for both metrics and includes simulation results to illustrate the relationships. In this paper, interoperability implies that the time of well-clear violation is strictly less than the time a resolution advisory is issued by ACAS. The encounter geometries under consideration in this paper are initially well clear and consist of constant-velocity trajectories resulting in near-mid-air collisions.

Pilot Evaluation of a UAS Detect-and-Avoid System's Effectiveness in Remaining Well Clear - Santiago & Mueller

Unmanned aircraft will equip with a detect-and-avoid (DAA) system that enables them to comply with the requirement to "see and avoid" other aircraft, an important layer in the overall set of procedural, strategic and tactical separation methods designed to prevent mid-air collisions. Regulators will establish minimum operating standards for DAA effectiveness, but different combinations of algorithms, displays and procedures could be used to meet those standards. The research presented in this paper indicates the effectiveness of the combined pilot-DAA system as a function of the DAA design requirements and provides data that may be used to model the behavior of pilots when employing such systems. Two simulations involving 21 professional unmanned aircraft system (UAS) pilots evaluated eight different DAA system designs in order to assess their ability to maintain the "well clear" separation standard, i.e., the state of maintaining a safe distance from other aircraft that would not normally cause the initiation of a collision avoidance maneuver on either aircraft. When the traffic display was integrated with the primary mission map directly in front of the pilot, there were fewer losses of well clear. Greater warning time provided to the pilot was strongly correlated with success in remaining well clear. Pilots' ability to separate from aircraft with cooperative and non-cooperative surveillance systems was nearly the same after accounting for the amount of alert time provided in each encounter, although the limited surveillance volume for the airborne-equipped aircraft meant alerts tended to occur later and therefore were more difficult to resolve.

Metropolis: Relating Airspace Structure and Capacity for Extreme Traffic Densities - Sunil et al

Personal and unmanned aerial vehicles have received increasing media attention over the last decade. As a result of the growing excitement for these two aircraft types, many within and outside the aerospace industry envision a future in which large numbers of small aircraft fly over urban areas. With this vision for the future, the question arises what would be required, in terms of airspace organization, to make this feasible, or indeed, if it will be possible at all. In this context, the Metropolis project aims to investigate the influence of airspace structure on capacity, complexity, safety, and efficiency for high-density airspace. To this end, four airspace concepts, ranging from a decentralized direct routing concept, to a highly structured tube network using 4D trajectory-based operations, have been considered. The four concepts were compared by means of large-scale simulation experiments, for multiple scenarios that are extreme when compared to current air traffic densities. This paper presents an overview of the Metropolis project with a focus on the project objectives, design and implementation of airspace concepts, and preliminary simulation results.

Abstracts: Finance and policy

European route choice determinants - Delgado

Different charging zones are found within European airspace. This allows airlines to select different routes between origin and destination that have different lengths and en-route charges. There is a trade-off between the shortest available route and other routes that might have different charges. This paper analyses the routes submitted by airlines to be operated on a given day and compares the associated costs of operating those routes with the shortest available at the time, in terms of en-route charges and fuel consumption. The flights are characterised by different variables with the idea of identifying a behaviour or pattern based on the airline or flight characteristics. Results show that in some areas of the European airspace there might be an incentive to select a longer route, leading to both a lower charge and a lower total cost. However, more variables need to be considered and other techniques used, such as factor analysis, to be able to identify the behaviour within an airline category.

Pricing to reconcile predictability, efficiency and equity in ATM - Jovanovic et al

Driven by a number of uncertainties a considerable share of airspace users (AU) look for "last-minute" 4D route choice gains, and thus exercise a fairly late submission of flight plans. While orders of magnitude of such gains, from AUs' perspective, are in the range of tens or hundreds of euros per flight, such AUs' behaviour creates uncertainty which is difficult to manage cost-efficiently from the air navigation service providers' and network manager's perspective. Due to low traffic load predictability, ANS providers tend to declare more conservative sector capacities, which effectively means that additional sectors need to be open sooner (at lower traffic loads) than if predictability was better. Against such a background, the distinguishing idea of the proposed approach is to design a pricing scheme which incentivises AUs to reduce such uncertainties by filing their flight intentions earlier and sticking with them as much as possible, aiming at improved network performance. In a centralised environment a coordinated network pricing approach is employed. This paper exposes a conceptual "Rewarding Predictability" (RP) model. The obtained results are contrasted against the outcomes of both current flow management practice ("F scenario") as well as against those of Ad-hoc modulations (AHM) method, proposed in [1] and [2]. The three methods involve notably different approaches to dealing with intrinsic efficiency vs. equity trade-offs.

Managing Change in European Air Traffic Control Provision - Adler et al

We develop a network congestion game to test a series of scenarios in order to analyse potential paths for change in air traffic management in Europe. The two stage game models en-route and terminal air traffic control (ATC) providers that set peak and off-peak charges and in the second stage airlines that choose flight paths given an airline schedule and the charges from the first stage. The scenarios analysed in the model include (i) the impact of privatization and deregulation; (ii) defragmentation of the set of current providers; (iii) introduction of technology via the common projects and SESAR step 1; and (iv) the regional forerunner approach in which ATC providers and a specific airline co-operate. The results show that horizontal integration across ATC providers, known as functional airspace blocks, would appear to be problematic with respect to incentives hence regional forerunners in a bottom-up institutional process would appear to be a preferable approach. Vertical integration between companies may succeed in accelerating change as long as the ATC companies are permitted to charge for improved quality, such as reduced congestion. Institutionally, a clear separation of the ATC providers from the Member States and subsequent franchising of the support services and ATC services could further encourage efficiency, consolidation and technology adoption.

Air Traffic Control Regulation in a Union Bargaining Model Setting - Proost et al

This paper studies the behaviour of the air traffic control (ATC) centres in the EU. We investigate the functioning of the European ATC sector with a union bargaining model. In this model, working conditions are the outcome of a bargaining game between the public air traffic agency and the unions of air traffic controllers. This framework is used to understand the behaviour of the ATC center for wage formation, their reactions to a price-cap, adoption of new technologies, congestion pricing, effect of vertical disintegration, competition and the possible success of mergers between different national ATC centres. We also conduct an empirical analysis to test the theoretical model and to estimate its parameters. The empirical analysis is based on actual ATC performance data that we obtain from ATM cost-effectiveness reports.

Abstracts: Human factors

Trawl-Net Technology for Timely Precise Air Traffic Controller Turn-To-Base Commands - Ohneiser et al

With a transition to a time-based flight guidance approach, timely precise flight guidance of aircraft will become more important in the future than today. Amongst others, air traffic controllers will have to integrate several arrival streams of aircraft with different equipage. On the one hand there are conventional equipped aircraft which are common today. On the other hand more and more aircraft will have advanced four-dimensional flight management system (A-FMS) available onboard. To stagger conventional aircraft against equipped ones which have negotiated overflight times at significant waypoints, time critical maneuvers exist. This is particularly applicable to downwind, centerline, and final. One example is the aircraft's turn from downwind onto the centerline where each second delay in the first direction is doubled in the other one on the centerline.

This paper describes our trawl-net technology that supports air traffic controllers in giving timely precise turn-to-base commands to pilots. The trawl-net technology provides for every aircraft in the vicinity of the downwind a line of optimal turn points displayed on the human machine interface (HMI). Thus the mechanism also works for aircraft flying parallel to the downwind and complement controller assistance systems like AMAN advisories or visual aircraft spacing tools.

Statistical analysis of air traffic controllers eye movements - Wang et al

Eye movements are important indicators of information seeking behavior, and provide an insight into information about interests, goals, plans and cognitive strategies. The understanding of eye movements is thus of great importance to study the behaviors of human who are responsible for the safety and efficiency of a complex system. In air traffic management, much previous research has focused on the investigations on pilots' eye movements. Little has been done on the study of controller's eye movements. Here, we present statistical analysis of controller's eye movements data that are recorded during real-time simulations. Specifically, we examine two commonly investigated oculomotor behaviors, fixation and saccades, to study effect of working experience on eye movements. By comparing the statistical properties of defined metrics and by applying Multifractal Detrended Fluctuation Analysis method to the time series data, we show that working experience do have notable effects on eye movements patterns. Both fixation and saccades are different between qualified controllers and novices. Qualified controllers can use more efficient searching strategies than novices. These findings may help to enhance the quality of controller training. More importantly, they may shed lights on understanding of mechanisms of information seeking of human when execute complex tasks.

Computational assessment of different air-ground function allocations - Ijtsma et al

NextGen and SESAR are re-defining each agent's role in the airspace in terms of autonomy, authority and responsibility. Function allocation is the process of defining authority, i.e., which functions are executed by which agents. This is an essential design decision in creating transformative ATM concepts of operation. This paper presents a computational simulation methodology to assess function allocations in early design phases, before functional prototypes and HITL experiments can be developed. Thus, this method applies the same models of the functions regardless of which agent executes them, so that any observed effects can be isolated to the function allocation without confounds. A case study is presented in which ten potential function allocations within a new concept of operation were evaluated. A distinction is made between coherent and incoherent function allocations. The key metrics of the function allocations include the time history of each agent's task load and required information exchange with other agents. The results show that the coherency of a function allocation can have a pronounced effect on the amount of information requirements. The paper concludes with a discussion of how this method can be applied to other concepts of operation, and how this method can be used, after the early-in-design analysis described here, as an evolving computational analysis tool for more detailed evaluations using higher fidelity models.

Assistant-Based Speech Recognition for ATM Applications – Helmke et al

Situation awareness of today's automation relies so far on sensor information, data bases and the information delivered by the operator using an appropriate user interface. Listening to the conversation of people is not addressed until today, but an asset in many working situations of teams. This paper shows that automatic speech recognition (ASR) integrating into air traffic management applications is an upcoming technology and is ready for use now.
Apple's Siri® or Google's Voice Search® are based on hundreds of thousands of hours of training data. This paper presents an assistant based speech recognition system (ABSR), based on only 40 hours of training data. ABSR uses speech recognition embedded in a controller assistant system, which provides a dynamic minimized world model to the speech recognizer. ASR and assistant system improve each other. On the one hand, the latter significantly reduces the search space of the first one, resulting in low command recognition error rates. On the other hand, the assistant system gains benefits from ASR, if the controllers' mental model and the model of the system deviate from each other. Then the controller cannot rely on the output of the system anymore, i.e. the assistant system is useless during these time intervals. By using ABSR the duration of these time intervals is reduced by a factor of two.

The Closed Runway Operation Prevention Device: Applying Automatic Speech Recognition Technology for Aviation Safety - Chen & Kopald

The MITRE Corporation's Center for Advanced Aviation System Development (MITRE CAASD) recently completed a field demonstration at Washington/Dulles International Airport (KIAD) of a proof-of-concept system called the Closed Runway Operation Prevention Device (CROPD) to validate the operational feasibility of employing an emerging technology—automatic speech recognition—in the Air Traffic Control (ATC) domain during live operations for safety improvement. Completed on behalf of the Federal Aviation Administration (FAA), the demonstration and subsequent analysis assessed the accuracy of speech recognition in detecting clearances to closed runways in local controller (LC) transmissions and the overall performance of an alerting mechanism dependent on speech recognition. The success of applying speech recognition technology in a live ATC environment depends on overcoming domain-specific challenges, such as rapid and/or slurred speech, poor field audio quality, and language ambiguity (e.g., the number sequence one-two can appear in a call sign, speed, wind advisory, or runway identifier), and stringent requirements on system accuracy. To address these challenges, MITRE CAASD employed a combination of tuning and configuration techniques to create the speech recognition component of the CROPD: dictionary customization, statistical language modeling, acoustic model adaptation, and robust parsing. Further, MITRE CAASD developed an application-specific analysis methodology, including performance metrics beyond the standard Word Error Rate (WER) measure of speech recognition performance, to better fit the application and provide a meaningful measure of the overall system performance. This paper briefly outlines the challenges and considerations for applying speech recognition in the ATC domain and describes the CROPD as a particular application to exemplify how the challenges and considerations are addressed via tuning techniques used to adapt the speech recognition system. Performance results from the field test demonstration are presented to illustrate the value of these tuning techniques and identify where future research can target further improvement.

Abstracts: Complexity

Adaptative air traffic network: statistical regularities in air traffic management - Bongiorno et al

Starting from traffic data on flights trajectories – planned and actual ones – in Europe, we build a navigation point network. We study this network which exhibits different features for different European countries. In particular, some countries uses a high number of navpoints, facilitating the planning of the flight plan by air companies at the cost of higher concentrations of traffic in few nodes. Making use of the deviations from the planned trajectories, we find that once again different countries have different control procedures with respect to traffic management. Interestingly, we find that some countries tend to make more deviations when the traffic conditions are low. Moreover, they tend to concentrate the deviations in a few number of nodes, especially during daytime. Finally, the position of these key navigation points are sometimes stable over the days, which shows a consistent use of some navpoint for the same kind of rerouting operations.

Topological characteristics of air traffic situation - Wang et al

A method for description of structural characteristics of air traffic situation based on the theory of complex network was proposed. This method characterizes the air traffic situation from three dimensions, including single aircraft, local sector, and overall sector. This work provides a ne−w clue for precise description of air traffic situation complexity. We selected the routinely-recorded flight data in an air traffic control sector within China's airspace in 2013. With the aircraft in the sector regarded as node, and with the between-aircraft proximity relations as edge, we constructed an undirected and unweighted aircraft network. The air traffic situation network under three thresholds were statistically analyzed using network topology indices including degree, edge, connection rate, clustering coefficient, and network structure entropy. The results show that network node degree can distinguish the key aircraft in the sector; the network connection rate reflects the proximity of aircraft; the clustering coefficient identifies the presence of high-density aircraft group; the network structure entropy reflects the homogeneity of aircraft node degrees.

Modelling Delay Propagation Trees for Scheduled Flights - Ciruelos et al

Reactionary delays have a large impact in the air transportation system both at operational and economical point of view. However, research efforts to understand their origin and propagation patterns in Europe have been limited. The TREE project (data-driven modeling of network-wide extension of the tree of reactionary delays in ECAC area) is focused on characterizing and forecasting the propagation of reactionary delays through the European Network. The best approach to tackle this problem passes through the use of Complex Systems theory. This theory analyzes systems formed by a large number of components interacting between them by means of networks and attempts at predicting their meso-scale and global behaviors. In this model, airports are taken as nodes and links between them are created by direct flights, with delays appearing as malfunctions in the daily planned schedule that can and do propagate over an important fraction of the network. An agent-based, data-driven approach is introduced, able to simulate the delay propagation process. The first results show a promising similarity with the real delay propagation patterns, being able to describe the cluster of congested airports and its evolution along the day.

Delay propagation - new metrics, new insights - Cook et al

Network delay propagation is intimately linked with the challenges of managing passenger itineraries and corresponding connections. Airline decision-making governing these processes is driven by operational and regulatory factors. Using the first European network simulation model with explicit passenger itineraries and full delay cost estimations, we explore these factors through various flight and passenger prioritisation rules, assessing the performance impacts. Delay propagation is further characterised under the different prioritisation rules using complexity science techniques such as percolation theory and network attack. The relative effects of randomised and targeted disruption are compared.

Abstracts: : Trajectory and queue management

Enabling Performance-Based Navigation Arrivals: Development and Simulation Testing of the Terminal Sequencing and Spacing System - Robinson et al

NASA has developed an advanced arrival management capability for terminal controllers, known as Terminal Sequencing and Spacing (TSS). TSS increases use of performance-based navigation (PBN) arrival procedures during periods of high traffic demand. It enhances two Federal Aviation Administration operational systems with terminal metering and controller spacing tools. Sixteen high-fidelity human-in-the-loop simulations, involving more than five hundred hours of evaluation time, were conducted to mature TSS from proof-of-concept design to fully functional prototype. These simulations modeled arrival procedures at several U.S. airports, incorporated a broad range of traffic demand profiles and wind conditions, and used controllers with extensive operational experience. Two metrics are evaluated for these simulations: PBN Success Rate and Inter-Arrival Spacing Error. The PBN Success Rate shows a definitive trend when TSS is used. It increases from 42% for today's operations to 68% for terminal metering only and 92% for terminal metering with controller-managed spacing tools. Meanwhile, the Inter-Arrival Spacing Error improves 25–35% when TSS is used compared to not used. The TSS technology was transferred to the FAA and, and it is targeted for deployment to several busy airports in the United States starting in 2018.

Arrival Scheduling with Shortcut Path Options and Mixed Aircraft Performance - Zelinski et al

Previous work introduced the concept of using tactical shortcut options to improve schedule conformance in terminal airspace. When a scheduling point is congested, aircraft are scheduled to longer nominal paths, holding shortcut path options in reserve for tactical use if an aircraft is late, thereby improving the schedule conformance, reducing the required scheduling buffer, and increasing throughput. When the scheduling point is less congested, aircraft may be scheduled to the shorter path with original larger scheduling buffers. Previous work focused on a single generic merge point serving aircraft with uniform arrival precision. This paper extends the previous concept to enhance the performance of time-based arrival management and consider mixed aircraft performance. Aircraft equipped to achieve a high degree of schedule conformance may be scheduled to the shorter path under the same conditions that a less equipped aircraft would be scheduled to the longer path, giving the equipped aircraft an advantage that can be seamlessly integrated into the scheduler. The arrival scheduler with shortcut path options for mixed aircraft performance is applied to a model of first-come first-served terminal metering at Los Angeles International Airport. Whereas clear system benefits were found for tactical shortcut routing and higher percentages of equipped aircraft, very little advantage could be seen for equipped over unequipped aircraft that could be used to incentivize early equipage.

Assessing Resilience of Scheduled Performance-Based Navigation Arrival Operations - Jung et al

This paper assesses the resilience of scheduled Performance-Based Navigation (PBN) arrival operations. Resilience is defined as an ability to return to nominal operations following a schedule perturbation. Results from a Human-in-the-Loop (HITL) experiment that included off-nominal events to perturb the schedule are described. The schedule comes from a precision trajectory-based arrival manager. The experiment collected data regarding the response to perturbed schedules in three conditions, where: 1) a disturbance rejection algorithm made schedule adjustments automatically, 2) a Traffic Management Coordinator (TMC) participant made schedule adjustments manually, or 3) no schedule adjustments were made. Analyses showed that the simulation's scheduled PBN operations have inherent resilience, recovering from more than half of the perturbed schedules even with no schedule adjustments. Resilience to the same off-nominal events improved with schedule adjustments; an increased proportion of perturbed schedules recovered within the length of operation run, and the average duration of the schedule's perturbed state decreased. Compared to the manual schedule adjustments condition, a greater number of schedule adjustments occurred for the same off-nominal events in the automated condition. However, perturbed schedules were recovered more frequently and perturbations were less severe in the automated condition. Subjective and objective workload in the manual and the automated schedule adjustment conditions were similar to the no schedule adjustment condition.

Machine Learning Applied to Airspeed Prediction During Climb - Alligier et al

In this paper, we apply Machine Learning methods to improve the aircraft climb prediction in the context of ground based applications. Mass and speed intent are key parameters for climb prediction. As they are considered as competitive parameters by many airlines, they are currently not available to ground based trajectory predictors. Consequently, most predictors today use reference parameters that may be quite different from the actual ones.
In our most recent paper ([1]), we have demonstrated that Machine Learning techniques provide a mass estimation significantly more precise than two state-of-the-art mass estimation methods.

In this paper, we apply similar techniques to the speed intent. We first build a set of examples by adjusting CAS/Mach speed profile to each climb trajectory in our database. Then, using the adjusted values (ccas; cM) in this database, we learn a model able to predict the (cas;M) values of a new trajectory, using its past points as input.
We apply this technique to actual Mode-C radar data and we consider 9 different aircraft types. When compared with the reference speed profiles provided by BADA, the reduction of the speed RMSE ranges from 36 % to 79 %, depending on the aircraft type. Using the predicted mass and speed profile, BADA is used to compute the predicted future trajectory with a 10 minute horizon. When compared with BADA used with the reference parameters, the reduction of the future altitude RMSE ranges from 45 % to 87 %.

Real-Time Trajectory Predictor Calibration through Extended Projected Profile Down-Link - Bronsvoort et al

This paper investigates the capability of the Extended Projected Profile (EPP) trajectory down-link definition to facilitate air-ground trajectory synchronisation. It will be demonstrated that the EPP allows for practically unambiguous description of the aircraft intent, but that unknown aircraft performance characteristics such as climb thrust derate, anti-ice and tail-specific drag adjustments still can lead to significant errors. These errors especially impact the 'what-if' functionality of ground-based trajectory predictors essential to effective trajectory negotiation and management. A method is proposed that uses the EPP down-link trajectory to determine an aircraft performance calibration function accounting for any variables not specifically recorded in the EPP, ensuring high accuracy 'what-if' trajectories. Where EPP on its own synchronises the current trajectory, in combination with the calibration proposed in this paper, it can synchronise the ground trajectory prediction process with that of the FMS. EPP therefore enables the ground to properly synchronise with the aircraft and creates value based on airborne and ground-based trajectory prediction capabilities.

Model for Longitudinal Uncertainty during Controlled Time of Arrival Operations - De Smedt et al

This paper presents a model to estimate the longitudinal uncertainty of an aircraft's future trajectory while flying towards a Controlled Time of Arrival (CTA). Uncertainties during such operations are mostly caused by meteorological forecast errors and the associated speed corrections applied by the guidance system to meet the CTA, which pose challenges to Air Traffic Control (ATC). Firstly, the model in this paper can be used to estimate the probability of spacing reductions between two in-trail aircraft performing a CTA operation. Secondly, the model allows for predicting the upper and lower bound of the possible speed corrections to meet a CTA. Thirdly, the model can be used to predict the effect of meteorological uncertainty on the range of achievable times an aircraft can reliably meet at the CTA fix. Finally, as this range of achievable times depends on the time or distance to go to the CTA fix, the model can be used to assess when or where this window will be maximal which is relevant to arrival management systems. For a popular range of aircraft types and flight conditions, 1 hour was found to be an appropriate average horizon for CTA allocation. The model was applied to a recorded set of arrival track data from Melbourne airport upon which several operational considerations were made with respect to the anticipated use of CTA.

Predicting Arrival Time Uncertainty from Actual Flight Information - Tielrooij et al

Air traffic control uses Arrival Managers (AMANs) to schedule an inbound stream of aircraft. These systems use predicted arrival times to optimize the planning for capacity and flight efficiency. The accuracy of these predictions is therefore one of the factors in the performance of arrival planning operation. While prediction capabilities have improved, and are likely to improve more, it is unlikely that prediction error will disappear altogether. Especially in future scenarios with longer planning horizons, techniques will have to be found to support planning in the presence of prediction uncertainty. To enable working with uncertainty on a predicted arrival time, that uncertainty needs to be predicted itself. This paper proposes, and tests a method to predict arrival time uncertainty based on historic prediction accuracy using currently available arrival time estimates.

Potential Benefits of Arrival Time Assignment, Dynamic Programming Trajectory Optimization applied to the Tokyo International Airport - Miyazawa et al

Increasing the efficiency and capacity of flights arriving at a congested airport is one of the most challenging problems in air traffic management research. The efficiency of commercial jet airliner flights arriving at the Tokyo International Airport, the busiest airport in Japan, is analyzed using integrated Air Route Surveillance Radar (ARSR) information. Fuel consumption is estimated for each flight from the surveillance data using meteorological and aircraft performance data. The actual flight is compared with the optimized trajectory in terms of fuel consumption and flight time, which introduces the potential benefits of optimizing the flight. A total performance index, which comprises

the fuel consumption and flight times of each flight, is proposed to optimize all flights arriving at the airport under the constraint of safe time separation at the terminal point. Dynamic programming is used to optimize not only each trajectory but also the arrival time assignment, where arrival times are assigned to each flight to minimize the total performance index. The results show that a rational arrival sequence and time assignment are generated by the optimization method, and the potential benefit deterioration due to imposing the arrival time separation constraint is limited.

Conflict pattern analysis under the consideration of optimal trajectories in the European ATM - Ruiz et al

In the future Air Traffic Management (ATM) system, the trajectory becomes the fundamental element of a new set of operating procedures collectively referred to as Trajectory- Based Operations (TBO). This has encouraged a renewed interest for the application of trajectory optimization techniques in commercial aviation, resulting in the so-called continuous operations that have shown significant benefits in terms of fuel savings and CO2 emissions. Unfortunately, the real implementation of continuous operations is in turn still far to be possible. Its implementation must be also tested and compared against other key performance indicators such as safety and capacity. Therefore, the main contribution of this paper is to provide a preliminary analysis on how continuous operations might impact the traffic and subsequent conflict patterns (i.e, number and distribution of potential interactions among trajectories) at the European ATM network level. Based on simulations using realistic traffic scenarios and flight performances, this paper provides insight on the conflict patterns as an indicator of the safety and capacity ATM performances under the consideration of continuous operations. The problem analysis has two scales, i.e., the mircroscale and the mesoscale. The microscale refers to single trajectories, whereas the mesoscale refers to a number of trajectories that may interact among them within a given volume of airspace (in this case, a big single sector representing the entire European airspace).

Full papers available at www.atmseminar.org

Keynote speakers and panellists

Edward L. Bolton Jr. is the Assistant Administrator for NextGen at the Federal Aviation Administration. The Office of NextGen (ANG) is responsible for leading the transformation of the National Airspace System. Bolton leads a federal workforce of more than 900 employees, and manages the $1 billion annual budget of the Next Generation Air Transportation System. Bolton joined the FAA in September 2013 after a career with the U.S. Air Force, most recently with the rank of Major General and the position of Deputy Assistant Secretary for Budget in the Office of the Assistant Secretary for Financial Management and Comptroller. He led a team of financial managers responsible for the Air Force's $110 billion annual budget.

John-Paul Clarke is a Professor at the Georgia Institute of Technology (Georgia Tech), where he has appointments in Aerospace Engineering and Industrial and Systems Engineering, and serves as Director of the Air Transportation Laboratory. He is an expert in aircraft trajectory prediction and optimization, especially as it pertains to the development of flight procedures that reduce the environmental impact of aviation. He is also an expert in the development and use of stochastic models and optimization algorithms to improve the efficiency and robustness of airline, airport, and air traffic operations. In addition to conducting research, teaching and consulting, Dr. Clarke often chairs or serves on advisory and technical committees chartered by the AIAA, EU, FAA, ICAO, NASA, US National Academies, and the US DOT. Most recently, he was co-Chair of the National Academies Committee that developed the US National Agenda for Autonomy Research related to Civil Aviation, and a Member of the National Academies Committee that reviewed the Next Generation Air Transportation System. Professor Clarke received the S.B., S.M., and Sc.D. degrees from MIT in 1991, 1992, and 1997, respectively. His many prior honors include the 1999 AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award, the 2003 FAA Excellence in Aviation Award, the 2006 National Academy of Engineering Gilbreth Lectureship, and the 2012 AIAA/SAE William Littlewood Lectureship.

James L Grimsley is an Associate Vice President for Research at the University of Oklahoma – Norman Campus (OU). Mr. Grimsley was also the founding director of the OU Center for Applied Research and Development (CARD). Mr. Grimsley is also President and CEO of Design Intelligence Incorporated, LLC (DII). DII is a leading edge advanced research and development company based in Oklahoma that focuses on innovative technology for long endurance unmanned aerial systems (UAS) also called unmanned air vehicles (UAVs) or "drones". Mr. Grimsley is a graduate of the University of Oklahoma with a B.S. in Aerospace Engineering and an M.S. in Mechanical Engineering. Prior to starting DII, Mr. Grimsley was a Division Chief Engineer and later an Assistant Vice President with Science Applications International Corporation (SAIC). Mr. Grimsley has been active in a variety of state organizations and initiatives. Mr. Grimsley organized the Unmanned Systems Alliance of Oklahoma (USA-OK) that is now a state chapter of the Association for Unmanned Vehicle Systems International (AUVSI) and served as founding president. Mr. Grimsley currently serves as vice president of the USA-OK chapter. Mr. Grimsley also organized and led Oklahoma's first five UAS Summits beginning in 2009. In 2011 Mr. Grimsley was appointed by Oklahoma Governor Mary Fallin to the Governor's UAS Advisory Council. AUVSI named Mr. Grimsley the "AUVSI Member of the Year" for 2014 in recognition of the state and national leadership for the UAS industry and for important advocacy work on behalf of the industry. Mr. Grimsley is one of the leading recognizable Oklahoma figures in the UAS industry and is frequently interviewed in the international media (The Economist, The Guardian Newspaper, CNBC, etc.). Mr. Grimsley was recognized as a 2014 Oklahoma Innovator of the Year for 2014 by the Journal Record newspaper.

Henk Hesselink is employed at NLR for over 20 years now. He has been working as analyst and project manager on decision support systems for fighter pilots and air traffic controllers, before joining the ATM and Airports department. He is involved in innovative studies and roadmap developments bringing in airport and air traffic management related aspects and has amongst others participated to the ERSG Roadmap development. He is project manager for RPAS airspace integration projects, where he participated to real time simulations with air traffic controllers and to projects in which MALE flights have been performed.

Denis Koehl joined the French Air Force as fighter pilot in 1976. In 1987, he is detached to serve within the Navy and obtained all Navy fighter pilot wings on board aircraft carriers. He was given command of a Fighter squadron than later Fighter Wing level and performed several oversea operational detachments. He was posted as Commander of Orange Air base in 2002. In 2004, Denis receives an assignment as Chief of Staff to the Air Forces Command and was nominated to Flag Officer in Oct. 2005. Promoted to Major General in 2009, Denis ended this military career and joined SESAR Joint Undertaking in Brussels in May 2010, as Senior Advisor to the Executive Director. He is responsible in particular for Military Affairs, RPAS and Cyber-Security.

Parimal Kopardekar (PK) serves as the Manager of the NASA's Safe Autonomous System Operations (SASO) Project. The goal of the project is to develop autonomy related concepts, technologies, and architectures that will increase efficiency, safety, and capacity of airspace operations. Prior to that he managed NextGen Concepts and Technology Development Project. He has published more than 40 articles. He enjoys initiating new concepts and technology ideas that increase airspace capacity and throughput, reduce delays, and reduce the total cost of air transportation. At NASA, he has initiated many innovative research initiatives including reduced crew operations, net-enabled air traffic management, autonomy for airspace operations, Shadow-Mode Assessment using Realistic Technologies for the National Airspace System (SMART NAS), and low-altitude airspace management system focused on UAS operations. He is recipient of numerous NASA awards including Outstanding Leadership Medal and Engineer of the Year. He holds Ph.D. and M.S. degrees in Industrial Engineering and Bachelor's degree in Production Engineering. He also serves as the Co-Editor-in-Chief of the Journal of Aerospace Operations.

Colin Meckiff is head of long-term research activities at the Eurocontrol Experimental Centre, Brétigny sur Orge, France. He joined EUROCONTROL in 1990 and has since worked on ATM research as project and programme manager for many Europe-wide activities. Prior to this he spent 10 years in industry in the UK. He has a bachelor's degree in electrical engineering and a PhD in computer-aided design.

Bernard Miaillier graduated engineer from Ecole Polytechnique in Paris (1976) and the French National Civil Aviation School in Toulouse (1978). After 1 year air traffic control experience as deputy to Director of the Paris Air Traffic Control Centre, spent 8 years as R&D project engineer and manager in the French Air Navigation Directorate. Bernard joined EUROCONTROL in 1987 and was since then involved in future ATM/CNS concept definition and implementation planning, and in management and co-ordination of R&D programmes. He was the Project Manager of the SESAR Definition Phase, and until end of 2010 managed the contribution of EUROCONTROL to the SESAR Joint Undertaking work programme. Current position: Head of Division "ATM Strategies" in the Directorate ATM, EUROCONTROL.

Eric Neiderman is the Manager of the Federal Aviation Administration's Aviation Research Division at the William J. Hughes Technical Center in Atlantic City, NJ. The division develops scientific solutions to current and future air transportation challenges by conducting applied research and development in collaboration with industry, academia, and government. Research areas include: fire safety, human factors, airport technology, software and systems, and structures and propulsion. He has more than 19 years of government experience, beginning with the FAA as an engineering research psychologist working in aviation security. Dr. Neiderman holds a bachelor's degree in industrial psychology from La Salle University, and a master's degree and Ph.D. in human factors from George Mason University. He also holds a master's degree in public administration from the University of Pennsylvania and is a certified project management professional.

Raja Sengupta is currently Professor and Program Leader of the Systems program in Civil & Environmental Engineering at the University of California, Berkeley. He received his Ph.D. from the EECS department of the University of Michigan, at Ann Arbor. His current research interests are in aviation, smart cities, robotics, and human behavior measurement. He is current Chair of the IEEE Technical Committee on Smart Cities. He was recognized by USDOT in 2012 with the Connected Vehicle Technology Award.

Michael Standar is the Chief Strategy & External Affairs at the SESAR Joint Undertaking based in Brussels, Belgium since January 2015. Michael started at the SESAR Joint Undertaking 2008 as Chief Operational Concept & Validation and was promoted to Chief ATM 2011 and to Chief Strategies and International Relations 2012. He is responsible for the SJU Strategic direction, Communication and External Relations, including international collaborations notably with the FAA and ICAO. He holds the chair of the EU-US MoC SESAR/NextGen Coordination Committee and leads the SJU collaboration with ICAO under the EU umbrella. Michael has more than 35 years' experience in ATM and started his career as an Air Traffic Controller in the Swedish Air Force and the Swedish CAA and in LFV whilst maintaining his officer status in the Swedish Air Force Reserve. Michael did during his operational ATCO career hold a PPL and validated a full book of ratings for all ATC operational areas including supervision and training. His operational background includes work in Sweden, the UAE and Bahrain. Michael´s comprehensive background also includes active membership in ICAO Air Traffic Management Operational Concepts Panel, ATMCP - which developed the ICAO Global ATM Operational Concept Document and later in the in the ICAO Air Traffic Management Requirements and Performance Panel, ATMRPP.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