ICRAT '16

International Conference on Research in Air Transportation

June 20-24, 2016 Drexel University, Philadelphia, PA, USA

Conference Guide

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FEDERAL AVIATION ADMINISTRATION

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ICRAT 2016 Conference Schedule - at a glance -

Monday, June 20, 2016

6:30 PM — Welcome reception - Drexel Main Building
Shelly Yak, Director, William J. Hughes Technical Center, FAA
Brian Blake, PhD, Provost, Drexel University

Tuesday, June 21, 2016

8:00 AM — Sign-in and Breakfast - Conference Hall # 1 - Behrakis Grand Hall

8:45 AM — Introduction to the conference:
Eric Neiderman (U.S. Federal Aviation Administration)
Marc Bourgois (Eurocontrol)
Kurtulus Izzetoglu (Drexel University)

8:55 AM — Welcome address - Drexel University

9:00 AM — Keynote address: C. J. Taylor University of Pennsylvania *Autonomous UAS Research*

9:45 AM — Coffee break

Tutorial Sessions 10:00 - 12:00

Conference Hall # 1 - Behrakis Grand Hall	Conference Hall #2 - MacAlister 2019/2020
10:00 AM — Brian Hilburn (CHPR) *Human Performance Measurement*	Dale Richards (Coventry University, UK) *Drone Human Factors*
10:45 AM — Michael Schultz (DLR) *Human-in-the-Loop Simulation*	
11:30 AM — Jacco Hoekstra (TU Delft) *Aircraft Performance Models in ATM Simulation*	

12:00 PM — Lunch

Paper Sessions 1:00 - 3:00

Conference Hall # 1 - Behrakis Grand Hall	Conference Hall #2- MacAlister 2019/2020	Conference Hall #3 - MacAlister Skyview Room
Session RP1: Track 1 - Trajectory Optimization 1 Session Chair: Daniel Delahaye	Session RP2: Track 2 - Advanced Modeling 1 Session Chair: Megan Ryerson	Session RP3: Track 3 - System Performance 1 Session Chair: Hamsa Balakrishnan
1:00 PM — Ramon Dalmau and Xavier Prats *Assessment of the feasible CTA windows for efficient spacing with energy-neutral CDO*	Angela Campbell and Andrew Cheng *Uncertainty Limits for an Aircraft Based Runway Friction Assessment Method*	Karthik Gopalakrishnan, Hamsa Balakrishnan and Richard Jordan Deconstructing Delay Dynamics: An air traffic network example
1:40 PM — Yan Xu, Ramon Dalmau and Xavier Prats *Effects of speed reduction in climb, cruise and descent phases to generate linear holding at no extra fuel cost*	Junzi Sun, Joost Ellerbroek and Jacco Hoekstra *Large-Scale Flight Phase Identification from ADS-B Data Using Machine Learning Methods*	Leonardo Camargo Forero, Ramon Dalmau, Sergio Ruiz and Xavier Prats *High performance computing simulator for the performance assessment of trajectory based operations*
2:20 PM — Man Liang, Daniel Delahaye and Pierre Marechal *Potential Operational Benefits of Multi-layer Point Merge System on Dense TMA Operation*	Max Li and Megan Ryerson *Modeling and Estimating Airspace Movements Using Air Traffic Control Transcription Data: A Data-Driven Approach*	Stefan Reitmann, Alexander Gillissen and Michael Schultz *Performance Benchmarking in Interdependent ATM Systems: Integration of Analytical and Process Oriented Performance Benchmarking Schemes in Complex ATM Systems*

3:00 PM — Tea break

Paper Sessions 3:30 - 5:30

Conference Hall # 1 - Behrakis Grand Hall	Conference Hall #2 - MacAlister 2019/2020	Conference Hall #3 - MacAlister Skyview Room
Session RP4: Track 1 Trajectory Optimization 2 Session Chair: Xavier Prats	Session RP5: Track 2 - Advanced Modeling 2 Session Chair: Norbert Fuerstenau	Session RP6: Track 3/4 System Performance 2 Complexity & Information 1 Session Chair: Seth Young
3:30 PM — Ismael Matamoros, Xavier Prats, Javier López Leonés, Enrique Casado, Miguel Vilaplana, Vincent Mouillet, Angela Nuic, Laurent Cavadini *Modelling Flexible Thrust Performance for Trajectory Prediction Applications in ATM*	Seddik Belkoura and Massimiliano Zanin *Phase changes in delay propagation networks*	Lei Yang, Honghai Zhang and Chengpeng Jiang *Identification Method for Terminal Air Traffic Congestion Status*
4:10 PM — Valentin Polishchuk *Generating Arrival Routes with Radius-to-Fix Functionalities*	Norbert Fürstenau, Monika Mittendorf and Shumpei Kamo *Nonlinear Dynamics Approach for Modeling of Air Traffic Performance Disruption and Recovery*	Charles Johnson, Adrian Rusu, Anthony Breitzman, John Bucknam and Nicholas Laposta *Phase of Flight and Rule of Flight Calculator*
4:50 PM — Guillermo Orenga and Manuel Soler *ATM Performance analysis in Madrid ACC sectors considering optimal aircraft trajectories*	Nikola Ivanov, Fedja Netjasov and Radosav Jovanovic *Utilizing schedule buffers to reduce propagated delay: A new approach for tactical Air Traffic Flow Management slot allocation*	Josh Schimmel, Shawn Pruchnicki, Phil Smith and Seth Young *SAGA: Safety Analysis in General Aviation - Leveraging Digital Flight Data towards the Development of a Flight Performance Database Tool to improve General Aviation Safety*

5:30 PM — Break

6:30 PM — ICRAT dinner - The National Constitution Center

Wednesday, June 22, 2016

8:00 AM Sign-in and Breakfast - Conference Hall # 1 - Behrakis Grand Hall

Keynote address

8:45 AM Eric Silverman, Manager ATC/Airfield Operations:PHL/NY & NE Region Airport Operations at PHL
American Airlines ATC In The Present/Future'

9:45 AM Coffee break

Tutorial Session 10:00 - 12:00

	Conference Hall # 1 - Behrakis Grand Hall	Conference Hall #2 - MacAlister 2019/2020
10:00 AM	Mike Paglione, Albert Schwartz, Christina Young, Jessica Young, Marie Kee (FAA) *Application of Fast-time Computer Modeling for ATM Systems*	Kurtulus Izzetoglu (Drexel) *Quantitative Performance Assessment Studies in Air Transportation: Portable Brain Activity Monitoring Technology*

12:00 PM Lunch

Paper Sessions 1:00 - 3:40

	Conference Hall # 1 - Behrakis Grand Hall	Conference Hall #2 - MacAlister 2019/2020	Conference Hall #3 - MacAlister Skyview Room
	Session RP7: Track 5 - Decision Support Session Chair: Nicolas Durand	Session RP8: Track 6 - Economics and Policy Session Chair: Gokhan Inalhan	Session RP9: Track 4/7 - Complexity & Information 2 / Safety & Human Performance 1 Session Chair: John Shortle
1:00 PM	Oliver Ohneiser *Transition Steps to Orthogonal Unidirectional Air Traffic Controller Monitoring Display*	Yulin Liu, Mogeng Yin and Mark Hansen *Estimating Costs of Flight Delay to Air Cargo Carriers*	Jacco Hoekstra and Joost Ellerbroek *BlueSky ATC Simulator Project: an Open Data and Open Source Approach*
1:40 PM	Cyril Allignol, Nicolas Barnier, Nicolas Durand and Éric Blond *Detect and Avoid, UAV Integration in the Lower Airspace Traffic*	Kleoniki Vlachou and David Lovell *Estimating the Long-Run Effects of Resource Allocation Mechanisms*	Seungwon Noh and John Shortle *Application of Common Cause Failure Methodology to Aviation Safety Assessment Model*
2:20 PM	Antonio Alonso-Ayuso, Laureano F. Escudero, F. Javier Martin-Campo and Nenad Mladenovic *A Variable Neighborhood Search approach for the aircraft conflict resolution problem*	Lennert Bentrup and Max Hoffmann *Free Routing Airspace in Europe - Implementation concepts and benefits for airspace users*	Zhenming Wang, Lance Sherry and John Shortle *Improving the Nowcast of Unstable Approaches*
3:00 PM	Alexander Estes and David Lovell *Representative Traffic Management Initiatives*	Emre Koyuncu, Baris Baspinar, Guney Guner, N. Kemal Üre, Massimiliano Zanin, Vaishali Mirchandani, Emilio Alvarez Pereira and Gokhan Inalhan *Implementing Dynamic Air Transport Slot Trading Through Secure Auction Mechanism*	Zoltan Koppanyi, Charles K. Toth and Seth Young *Runway Centerline Deviation Estimation from Point Clouds using LiDAR Imagery*

3:40 PM Tea break

Doctoral Paper Sessions 4:10 - 5:30

	Conference Hall # 1 - Behrakis Grand Hall	Conference Hall #2 - MacAlister 2019/2020	Conference Hall #3 - MacAlister Skyview Room
	Session DS1 Session Chair: Eric Neiderman	Session DS2 Session Chair: Hartmut Fricke	Session DS3 Session Chair: Dirk Schaeffer
4:10 PM	Floris Herrema, Richard Curran, Vincent Treve and Dries Visser *Evaluation of feasible machine learning techniques for predicting the time to fly and aircraft speed profile on final approach*	Paula Rachel Mark *The Role of Delays in the Efficiency Analysis of Air Traffic Management Systems*	Emmanuel Sunil, Jerom Maas, Joost Ellerbroek, Jacco Hoekstra and Martijn Tra *The Relationship Between Traffic Stability and Capacity for Decentralized Airspace*
4:50 PM	René Verbeek *Why aircraft will fly more fuel-efficiently on FRIDAY - The FRIDAY route charges method*	Junzi Sun, Joost Ellerbroek and Jacco Hoekstra *Modeling and Inferring Aircraft Takeoff Mass from Runway ADS-B Data*	Åsa Svensson *Attention Distribution and Trust in Higher Levels of Automation within Air Traffic Control*

5:30 PM Break

6:30 PM Committee dinner - Paul Peck Alumni Center

Thursday, June 23, 2016

Conference Hall # 1 Behrakis Grand Hall

8:00 AM — Sign-in and Breakfast

8:45 AM — Welcome address - John A. Fry, President, Drexel University

8:50 AM — Keynote address - Captain Manfred Müller, Deutsche Lufthansa AG, Flight Safety Department FRA CF/J
Quantitative Risk Management

9:45 AM — Coffee break

Tutorial Session 10:00 - 12:00

Conference Hall # 1 - Behrakis Grand Hall
10:00 AM — Daniel Delahaye (ENAC) Mathematical Optimization with Applications to ATM

12:00 PM — Lunch

Paper Sessions 1:00 - 3:00

	Conference Hall # 1 - Behrakis Grand Hall	Conference Hall #2 - MacAlister 2019/2020	Conference Hall #3 - MacAlister Skyview Room
	Session RP10: Track 8 - Network Management Session Chair: Eric Neiderman	Session RP11: Track 9 - Environment Session Chair: Hartmut Fricke	Session RP12: Track 7 - Safety & Human Performance 2 Session Chair: David Lovell
1:00 PM	Karim Legrand, Daniel Delahaye and Christophe Rabut *Wind and Temperature Networking Applied to Aircraft Trajectory Prediction*	Sabrina Groth, Judith Rosenow and Hartmut Fricke *Aviation-induced nitrogen oxide emissions and their effect on the energy budget of the Earth-atmosphere system*	Brandon Lundeen, Shawn Pruchnicki and Seth Young *Weather Technology in the Cockpit: Analysis of Pilot Decision Making*
1:40 PM	Emmanuel Sunil, Jacco Hoekstra, Joost Ellerbroek, Frank Bussink, Andrija Vidosavljevic, Daniel Delahaye and Dennis Nieuwenhuisen *The Influence of Traffic Structure on Airspace Capacity*	Damian Rivas, Rafael Vazquez and Antonio Franco *Probabilistic Analysis of Aircraft Fuel Consumption Using Ensemble Weather Forecasts*	Jacco Hoekstra, Jerom Maas, Martijn Tra and Emmanuel Sunil *How Do Layered Airspace Design Parameters Affect Airspace Capacity and Safety?*
2:20 PM	Ji Ma, Daniel Delahaye, Mohammed Sbihi and Marcel Mongeau *Merging Flows in Terminal Maneuvering Area using Time Decomposition Approach*		

3:00 PM — Tea break

Doctoral Paper Sessions 3:30 - 4:50

	Conference Hall # 1 - Behrakis Grand Hall	Conference Hall #2 - MacAlister 2019/2020
	Session DS4 Session Chair: Jacco Hoekstra	Session DS5 Session Chair: Seth Young
3:30 PM	Yanjun Wang *On the correlations between air traffic and controller's eye movements*	Stefan Kern and Michael Schultz *Analysis of runway capacity to derive a normalized capacity model*
4:10 PM	Emrah Durmaz and Ünal Battal *A Case Study: With Public & Private Sector Perceptions, New İstanbul Airport Through PPP*	Eunsun Ryu and Seth Young *General Aviation Runway Design Evaluation based on Aircraft Deviations from Runway Centerline*

4:50 PM — Break

6:30 PM — Conference Dinner - Bachelors Barge Club #6 Boathouse Row

Friday, June 24, 2016

8:00 AM Sign-in and Breakfast Conference Hall #1 - Behrakis Grand Hall

Doctoral Paper Sessions 8:50 - 10:10	
Conference Hall # 1 - Behrakis Grand Hall	**Conference Hall #2 - MacAlister 2019/2020**
Session DS6 Session Chair: Mark Hansen	Session DS7 Session Chair: David Lovell
8:50 AM Giuseppe Sirigu, Manuela Battipede, John-Paul Clarke and Piero Gili *A Fleet Management Algorithm for Automatic Taxi Operations*	Erol Duymaz, Abdullah Ersan Oguz and Hakan Temeltas *Airborne-SLAM Approaches as Automation Techniques of Air Transportation*
9:30 AM Jiseon Lee and Yoonjin Yoon *Impact of the Mt.Baekdu explosion to South Korea's Air Transportation with hypothetical scenario*	

10:10 AM Coffee break

Paper Sessions 10:40 - 12:00	
Conference Hall # 1 - Behrakis Grand Hall	**Conference Hall #2 - MacAlister 2019/2020**
Session RP13: Track 10 - Airport Design 1 Session Chair: Yu Zhang	Session RP14: Track 11 - Automation 1 Session Chair: Raja Sengupta
10:40 AM Nicolas Bontikous, Franziska Dieke-Meier and Hartmut Fricke *The potential of modern mobile technologies to improve airport operations - A concept for controlling passengers flows*	Romaric Breil, Daniel Delahaye, Laurent Lapasset and Eric Feron *Multi-agent Systems for Air Traffic Conflicts Resolution by Local Speed Regulation*
11:20 AM Yu Zhang and Yuan Wang *Implications of Autonomous Vehicles to Airport Terminal Planning and Design*	Vishwanath Bulusu, Raja Sengupta and Zhilong Liu *Unmanned Aviation: To Be Free or Not To Be Free?*

12:00 PM Lunch

Paper Sessions 1:00 - 2:20	
Conference Hall # 1 - Behrakis Grand Hall	**Conference Hall #2 - MacAlister 2019/2020**
Session RP15: Track 10 - Airport Design 2 Session Chair: Marc Bourgois	Session RP16: Track 11 - Automation 2 Session Chair: David Lovell
1:00 PM Una Blanusa, Seth Young, Shawn Pruchnicki and Brian Strzempkowski *An Evaluation of Linear Length LED Centerline Taxiway Exit Light Systems*	Richard Alligier, David Gianazza and Nicolas Durand *Predicting Aircraft Descent Length with Machine Learning*
1:40 PM Tobias Andersson, Peter Axelsson, Jonas Petersson, Tatiana Polishchuk, Valentin Polishchuk and Christiane Schmidt *Configuration and Planning of the Remote Tower Modules in a Remote Tower Center*	Jerom Maas, Emmanuel Sunil, Joost Ellerbroek and Jacco Hoekstra *The Effect of Swarming on a Voltage Potential-Based Conflict Resolution Algorithm*

2:20 PM Awards and Closing Remarks - Conference Hall #1 - Behrakis Grand Hall

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Condensed technical program

	Tuesday June 21	Wednesday June 22	Thursday June 23	Friday June 24
8:00 AM	Breakfast, Keynotes, Coffee	Breakfast, Keynotes, Coffee	Breakfast, Keynotes, Coffee	Breakfast
				DS6, DS7
10:00 AM	Tutorials	Tutorials	Tutorials	Coffee
				RP13, RP14
12:00 PM	Lunch	Lunch	Lunch	Lunch
1:00 PM	RP1, RP2, RP3	RP7, RP8, RP9	RP10, RP11, RP12	RP15, RP16
				Closing
3:00 PM	Tea	Tea	Tea	
	RP4, RP5, RP6		DS4, DS5	
5:00 PM		DS1, DS2, DS3		

RP = Regular paper sessions

DS = Doctoral symposium sessions

Times are approximate - check the detailed schedule for exact session start and end times

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Chairs & Committees

General chairs:
Marc Bourgois Eurocontrol BE
Eric Niederman FAA US

Program chairs:
David Lovell Univ of Maryland US
Hartmut Fricke TU Dresden DE

Tutorial chair
Jacco Hoekstra TU Delft NL

Doctoral Symposium chair
Mark Hansen UC Berkeley US

Local Arrangement chair
Kurtulus Izzetoglu Drexel Univ US

Program Committee

Kenneth Allendoerfer	FAA	US	Colin Meckiff	Eurocontrol	FR
Hamsa Balakrishnan	MIT	US	Max Mulder	TU Delft	NL
Michael Ball	Univ of Maryland	US	Alberto Pasquini	Deep Blue	IT
Steve Bradford	FAA	US	Xavier Prats	UPC Barcelona	ES
Lorenzo Castelli	Univ of Trieste	IT	Amy Pritchett	Georgia Tech	US
Michael Cooke	Trinity College	IE	Jasenka Rakas	UC Berkeley	US
Tom Davis	NASA	US	Jose Ramasco	IFISC	ES
Daniel Delahaye	ENAC	FR	Damian Rivas	Univ. Sevilla	ES
Luis Delgado	Univ Westminster	UK	Alvaro Rodriguez	UPM	ES
Nicolas Durand	DSNA	FR	Megan Ryerson	Univ. Penn.	US
Miguel Angel Eroles	UAB	ES	Dirk Schaefer	Eurocontrol	FR
Peter Hecker	TU Braunschweig	DE	Michael Schultz	DLR	DE
Robert Hoffmann	Metron Aviation	US	Lance Sherry	GMU	US
Gokhan Inalhan	ITU	TR	Lara Shisler	Mosaic ATM	US
Kurtulus Izzetoglu	Drexel Univ	US	John Shortle	GMU	US
Christopher Johnson	Univ. Glasgow	UK	Senay Solak	U. Massachusetts	US
Radoslav Jovanovic	Univ of Belgrade	RS	Banavar Sridhar	NASA	US
Yoon Jung	NASA	US	Sybert Stroeve	NLR	NL
Amy Kim	Univ. Alberta	CA	Dengfeng Sun	Purdue Univ.	US
Paul Krois	FAA	US	Pernilla Ulfvengren	KTH	SE
Sandra Lozito	NASA	US	Miguel Vilaplana	Boeing	ES
Guglielmo Lulli	Univ de Milano	IT	Thomas Vossen	Univ. Colorado	US
Jonas Lundberg	Linköping Univ	SE	Seth Young	Ohio State	US
Natesh Manikoth	FAA	US	Yu Zhang	U. South Florida	US
Etienne Marcotte	ULB	BE			

We thank American Airlines for supporting the ICRAT '16 Conference

Keynote Speaker
Eric Silverman

Keynote Talk: American Airlines ATC In The Present/Future

Eric Silverman is American Airlines' Air Traffic Control (ATC)/Airfield Operations Manager covering some of the busiest airspace in the country – the Northeast. He is currently based at one of American's 9 hubs, Philadelphia International Airport (PHL) and covers NY/BOS as well.

Silverman started his delve into aviation at Philadelphia International Airport working for the Division of Aviation (DOA) as an intern in its Operations unit in 1997. After graduating from The Ohio State University in 2000 with a Bachelor's degree in aviation management, Silverman was employed full time as an airport administrative trainee and has been promoted through the ranks to airport operations manager until his departure.

In 2013, Eric was the winner of Airport Business' "Top 40 under 40" award. The award highlights some of the outstanding and up-in-coming individuals in the business of aviation.

While working for the Airport, on his own initiative, Silverman began compiling an in-house operational weather forecast, provided daily to airport management, to keep management personnel informed of weather events that may impact the airport along with surrounding airports. Recognizing a need for close coordination and effective communication, Silverman initiated conference calls with the FAA, Air Traffic Control, tenant airlines, and operations staff during snow storms, thunderstorms, and other events that impact airline operations. In the 10 years since, participation has grown to include airline operations centers, the FAA Command Center, and all airport tenants – and the practice still exits even after his exit from the DOA.

Recognizing the need for the best possible information during adverse conditions, Silverman also spearheaded the effort to gain access to the FAA's Command Center IntraNet and Enhanced Traffic Management System (ETMS), an effort he considers to be one of his proudest achievements to date. These systems help PHL manage airfield operations during irregular operations, and effectively plan for aircraft diverted to Philadelphia and arrange recovery of those diverted away.

Since September 2014, Silverman has many responsibilities at American including; serving as a primary point of contact between the company and ATC system facilities, acting as a company liaison with all FAA Air Traffic Facilities and surrounding Airport Authorities and administering departmental efforts.

Eric is a proud certified member (CM) of the American Association of Airport Executives (AAAE) since 2013.

Keynote Speaker
Camillo J. Taylor

Keynote Talk: Autonomous UAS Research

Dr. Taylor received his A.B. degree in Electrical Computer and Systems Engineering from Harvard College in 1988 and his M.S. and Ph.D. degrees from Yale University in 1990 and 1994 respectively. Dr. Taylor was the Jamaica Scholar in 1984, a member of the Harvard chapter of Phi Beta Kappa and held a Harvard College Scholarship from 1986-1988. From 1994 to 1997 Dr. Taylor was a postdoctoral researcher and lecturer with the Department of Electrical Engineering and Computer Science at the University of California, Berkeley. He joined the faculty of the Computer and Information Science Department at the University of Pennsylvania in September 1997. He received an NSF CAREER award in 1998 and the Lindback Minority Junior Faculty Award in 2001. In 2012 he received a best paper award at the IEEE Workshop on the Applications of Computer Vision. Dr Taylor's research interests lie primarily in the fields of Computer Vision and Robotics and include: reconstruction of 3D models from images, vision-guided robot navigation and smart camera networks. Dr. Taylor has served as an Associate Editor of the IEEE Transactions of Pattern Analysis and Machine Intelligence. He has also served on numerous conference organizing committees and was a Program Chair of the 2006 edition of the IEEE Conference on Computer Vision and Pattern Recognition and of the 2013 edition of 3DV. In 2012 he was awarded the Christian R. and Mary F. Lindback Foundation Award for Distinguished Teaching at the University of Pennsylvania.

Keynote Speaker
Manfred Müller

Keynote Talk: Quantitative Risk Management

Born 11th of August 1955 in Munich

Manfred Müller is Training- and Check-Captain on Airbus A330 and A340 and General Manager Flight Safety Research for the Lufthansa Group. After studying five semester physics and mathematics he started his commercial flying career in 1979 at the Lufthansa Flight Training School in Bremen and Phoenix, Az. He had been working as first officer on B737, B747-400 and A340 before receiving his captain upgrade in 1998. In 1991 he passed his accident investigator training at the University of Southern California in Los Angeles. Captain Müller leads a research project, partly financed by the German Government, to improve evidence based risk management in aviation. He his member of the OPTICS steering committee, controlling European financed Flight Safety Research and works as Lecturer on Risk Management at the University of Bremen.

TUTORIAL SESSIONS
and the Biographies of the Speakers

A1: Human Performance Measurement in ATM Simulation – Dr. Brian Hilburn (CHPR)

Abstract: The content will include methods for measuring such constructs as situation awareness, workload, and error in real-time simulations, along with guidance on their application, including collecting, processing and analysing data.

Biography: **Dr. Brian Hilburn**
Brian Hilburn is Senior Consultant at CHPR. He earned his PhD in Applied Experimental Psychology from the Catholic University of America. He is former head of Human Factors at the Netherlands Aerospace Lab (NLR), and ATM Human Factors lead for Northrop Grumman. His research interests are ATM, automation, and psycho-physiology. He is also an active and instrument-rated general aviation pilot, who gets to test the patience of US air traffic controllers on a regular basis.

A2: Human-in the-Loop Simulation in ATM - Michael Schultz (DLR)

Abstract: The tutorial will give guidance on the planning of Human-in-the-loop simulator studies. While the European Operational Concept Validation Methodology (E-OCVM) focuses on detailed descriptions for the programme management level, it may lack to give guidance on a project level or even on the exercise level - especially for newcomers in the field of validation. E-OCVM gives a lot - and maybe too much - freedom how to plan a validation exercise. Lessons learnt from successful ATM validation trials (e.g. Advanced Surface Movement Guidance and Control Systems (A-SMGCS); EU-project EMMA2) will illustrate how to apply the E-OCVM successfully. It will be shown how to validate concepts in early stages of maturity, by starting to validate the operational feasibility in the first place (e.g. fulfilment of operational requirements, acceptance, usability). Concepts with higher levels of maturity will be validated then with the focus on operational improvements (e.g. effect on KPAs like capacity, safety, plus human factors as workload and situation awareness). If possible, a cycle of validation runs should be constructed which will act as confidence-building measure between the operators concerned (e.g. ATCOs, pilots) and the system developers. It should start with the aforementioned feasibility trials and later focus on comparisons between the nowadays concepts and the new solutions. The tutorial will focus on how to facilitate the dialogue between operators and developers by highlighting the need of tailor-made questionnaires and extensive debriefing sessions with all participants.

Biography: **Michael Schultz**
Michael Schultz is the head of the Air Transportation Department at the DLR Institute of Flight Guidance. He focuses on model-/data-based performance assessments, performance-based airport management and advanced air traffic management concepts. Besides scientific research, methodical development and implementation of operational concepts as well as applied validations, his department also pursues ways to improve system modelling, analysis and assessment.

Dr. Michael Schultz received his PhD in Aviation Technologies (2010) and Diploma degree in Economics and Engineering (2002) from Technische Universität Dresden. Dr. Schultz's research interests are with efficient airport operation considering a cooperative competition environment, modelling complex system dynamics and efficient air traffic management under immanent uncertain operational/environmental conditions.

A3: Aircraft Performance Models in ATM simulation – Prof.dr.ir. Jacco Hoekstra

Abstract: Aircraft performance simulation is an important aspect in Air Traffic Management. As ATM concepts and systems are evaluated in terms of performance, using the correct the fuels costs, emissions and flight envelope limits are essential in ATM research. Eurocontrol has made a dataset with aircraft performance parameters called BADA. Today we see a reference to BADA in may research publications as it is widely used and accepted. for this. What is BADA exaclty? How should you use it? What are the limitations and which version, 3.x or 4.x, should you use when? This will be discussed in this tutorial, which has been compiled with the help of Eurocontrol.

Biography: **Jacco Hoekstra**
From the TU Delft Jacco Hoekstra obtained an MSc in Aerospace Engineering, a doctoral degree and a private pilot's license. At the Dutch National Aerospace laboratory NLR he started at the flight simulation and handling qualities department. His research topics were handling qualities, avionics, data link, 4D trajectories, Air Traffic Management concepts and navigation. He then became head of several departments, head of the air transport research division and later was asked by the TU Delft to serve two terms as dean of the faculty of Aerospace Engineering. Currently, he is full professor at this faculty and the chair holder CNS/ATM at the Control & Simulation section. He is a founding board member of ASDA, active in SESAR and associate editor of the AIAA Journal of Air Transport.

A11: Drone Human Factors – Dr. Dale Richards (Coventry University)

Abstract: Unmanned systems have seen an unprecedented growth in demand and potential application. While this presents a challenge to the regulators in terms of policy and airspace integration, there are other significant issues that range from technological to operational requirements. It is easy to focus on these areas and , by its very nature, forget that somewhere within the unmanned system is a human that is responsible for controlling the aircraft.

The nature of the different platforms and control concepts presents a number of Human Factors issues that can impact the safe use of the system; from different input controls, display requirements, and the level of training a user must possess. In order to address these issues a Human-Systems Integration (HSI) approach not only allows us to examine the different aspects in this area, but also stresses the importance of adopting a holistic approach to the whole system. This would include not just the elements concerned with the concept of UAV operation, but the wider infrastructure associated with its use.

This talk will outline the HSI approach to UAV operation, whilst also highlighting the emerging trend in applying autonomy to UAVs and what this means to the operator.

Biography: **Dr. Dale Richards**
Dr Dale Richards is a Chartered Psychologist and an Associate Fellow of the British Psychological Society. After completing his PhD Dale worked for QinetiQ (formerly the Defense Evaluation Research Agency) for over eleven years, before joining Coventry University in 2012. As a Principal Psychologist at QinetiQ Dale providing the Human Factors input to ensure human-systems integration aspects were considered. Some of the early work he was involved with included Future Offensive Air Systems (FOAS) and Airborne Stand-Off Radar (ASTOR), until he was asked to lead the Human Factors element of the UK MoD Autonomy & Control project which over several years led to successful flight trials involving a fast jet controlling multiple UAVs (by using a surrogate air platform). This would also lead Dale to assist in putting together the Autonomous Systems Technology Related Airborne Evaluation and Assessment (ASTRAEA) programme. During this time he designed the QinetiQ Ground Control Station and was part of the Industry team that assisted with putting together the Human Factors Chapter for the regulatory guidance on UAVs for the CAA (CAP722).

At Coventry Dale continues his work in unmanned and autonomous systems, with recent funded research projects examining aspects of human-agent teaming, and also the training requirement for the use of unmanned systems for the UK Royal Navy.

B1: Application of Fast-time Computer Modeling for ATM Systems - Mike Paglione, Albert Schwartz, Dr. Christina Young, Jessica Young, Marie Kee

Abstract: The Federal Aviation Administration (FAA) created the National Airspace System (NAS) to provide a safe and efficient airspace environment for the air transportation in the United States. This includes all commercial, general civilian and military aviation. The NAS is a complex system-of-systems and composed of a network of air navigation facilities, air traffic control facilities, and airports, along with the technologies and the rules and regulations to operate the system. As the air transportation system in the United States has grown, the NAS has evolved by incorporating new procedures and new technologies but is still among the business yet safest in the world. However, with projected increases in traffic demand and emerging technologies like unmanned aircraft systems, most anticipate a greater stress leading to a potential for decreased quality of service for NAS users. In an effort to mitigate the impact of these stresses on the system and an added objective of improving safety and efficiency in the NAS even further, the FAA has implemented a major initiative to redesign, integrate, and deploy advances in guidance, navigation, and control technologies, called the Next Generation Air Transportation System (NextGen).

The Modeling and Simulation Branch of the Federal Aviation Administration (FAA) conducts research to assess the operational and technical feasibility of proposed system changes to NAS operations and in particular to support NextGen initiatives. A key capability that the team utilizes to achieve its mission is the fast-time computer simulation. Fast-time computer simulation involves the use of computer models that simulate how a system functions using rule-based decisions that control the interactions between system components. Typical fast-time studies are conducted to validate a concept's effect on air traffic system capacity, efficiency, and safety. The tutorial shall present the Modeling and Simulation Branch's process of developing and conducting a fast-time computer simulation on the NAS. The team will present the overall steps; describe the key scientific and engineering disciplines employed, while integrating a series of demonstrations of advanced NAS simulation modeling tools using actual studies completed by the team. This includes studies examining emerging technologies like unmanned aircraft systems and space vehicle operations, and NextGen automation that optimizes traffic flows to mitigate the effects of weather.

Biographies: **Mike Paglioni, Albert Schwartz, Jessica Young, Christine M. Young, and Maria Kee**

Mike Paglione is Branch Manager of the Federal Aviation Administration's (FAA) Modeling and Simulation Branch at the W. J. Hughes Technical Center, Atlantic City, New Jersey. Before taking his current management position in 2012, he had served as a FAA engineer and project lead for 13 years. He has extensive experience in air traffic control automation algorithms, simulation problems, analysis of decision support software, applied statistics, and general systems engineering. The Modeling and Simulation Branch he manages conducts research to assess the operational and technical feasibility of proposed system changes to National Aviation System (NAS) operations. This work includes validating new aviation concepts' technologies, investigating system capacity issues, and evaluating the performance of emerging and existing systems within the NAS. The research utilizes a variety of engineering and scientific disciplines such as modeling, rapid prototyping, fast-time computer simulation, applied statistical methods, object oriented programming, and real time human-in-the-loop simulation techniques. Mr. Paglione has supported the development, testing, and evaluation of FAA air traffic management software and also served as a NextGen program manager. He was FAA's Rutgers University Fellow from 1994-1996, Accuracy Test Lead for the FAA's User Request Evaluation Tool, Program Manager for the Joint University Program from 1999 to 2004, Lead for the Automation Metrics Test Working Group (a cross organizational team developing and implementing metrics for the En Route Automation Modernization Program, ERAM), and a program manager supporting a NextGen project investigating improvement to the separation management functions in the en route automation . He holds B.S. and M.S. degrees in Industrial and Systems Engineering from Rutgers University.

Albert Schwartz is a cross cutting project lead and subject matter expert on fast-time simulation models and analysis tools. He earned his Bachelor of Science degree in Information Systems at the Richard Stockton College of New Jersey in Pomona, NJ in 1985. Mr. Schwartz is currently an Operations Research Analyst with the FAA's Modeling and Simulation Branch at the FAA William J. Hughes Technical Center in Atlantic City, NJ.

Mr. Schwartz has over 25 years' experience in the FAA. Mr. Schwartz is directly responsible or involved in all fast-time simulation projects within the organization that are related to concept validation of the Next Generation Air Transportation System (NextGen). As the project, team, or analysis lead he manages simulation and analysis projects in support of aviation concept validation both internal and external to the organization. Mr. Schwartz is responsible for all aspects of project management; scheduling, budgets, risk management, and resource allocation. Previously Mr. Schwartz performed airport analysis on over 20 airport studies.

Christina M. Young received the B.S. degree in Industrial Engineering from Rutgers, The State University of New Jersey. She worked on FAA research projects under a fellowship grant while earning graduate degrees: M.S. in Statistics and Ph.D. in Industrial and Systems Engineering. Since completing her doctorate in 2010, she has worked on NextGen projects at the FAA William J. Hughes Technical Center in Atlantic City, New Jersey. Dr. Young is a member of the FAA's Modeling and Simulation Branch. As key member of this FAA team, she conducts research to validate new aviation concepts technologies and evaluate the performance of both emerging and existing systems within the National Airspace System.

Jessica Young leads and performs fast-time simulation and analysis research to quantify potential effects of future concepts on the National Airspace System. She earned her Bachelor of Science degree in mathematics at The Richard Stockton College of New Jersey in Pomona, NJ in 2006 and completed her Masters of Science degree in mathematical sciences at Rutgers, The State University of New Jersey in Camden, NJ in 2008. Starting her career as a cooperative intern in 2006, Jessica is currently a computer specialist with the FAA's Modeling and Simulation Branch at the FAA William J. Hughes Technical Center in Atlantic City, NJ.

Mrs. Young has participated in NextGen research including dynamic density, flight trajectory accuracy, and Unmanned Aircraft System (UAS) NAS integration; she has also lead studies including a benefits analysis of the NextGen Mid-Term Concept of Operations, impact of convective weather on flight reroutes, Integrated Arrival/Departure Control Services (IADCS), and a fast-time simulation study to evaluate the effects of future space vehicle operations in the National Airspace System.

Marie Kee is an Aerospace Engineer working on NextGen projects in the FAA's Modeling and Simulation Branch. She has been conducting modeling, simulation, and data analytics at the William J Hughes Technical Center for 6 years. Prior to federal civilian service, she attended Virginia Polytechnic Institute & State University (Virginia Tech) where she earned a Bachelor of Science in Aerospace Engineering with emphasis on Astronautics in 2009. Currently, Ms. Kee is looking forward to mastering her craft as an Aerospace Engineer by pursuing her Masters' Degree in Aerospace Engineering with a specialization in Astronautics and Space Operations and a minor in Systems Engineering.

B11: Quantitative Performance Assessment: Portable Brain Activity Monitoring Technology - Dr. Kurtulus Izzetoglu (Drexel) Quantitative Performance Assessment Studies in Air Transportation

Abstract: Military and civilian aviation personnel are required to utilize larger and more complex human-automation networks. Hence, the information-processing load and decision-making demands have been increased on aviation personnel including, pilots, unmanned aircraft systems (UAS) and air traffic controllers.

The emerging objective functional brain activity monitoring technologies can help evaluate expertise development and the cognitive capacities of the crew in cockpit as well as in ground control stations. Such technologies could provide additional performance metrics directly driven from brain based measures, which would be an important asset in maintaining safe and effective performance.

Functional near infrared (fNIR) spectroscopy is a field-deployable non-invasive optical brain monitoring technology that provides a measure of cerebral hemodynamics within the prefrontal cortex in response to sensory, motor, or cognitive activation. The audience will be introduced to the use of fNIR in air transportation including manned and unmanned pilot training, and air traffic controller workload assessment.

Biography: **Kurtulus Izzetoglu, PhD**
Kurtulus Izzetoglu, Associate Research Professor at Drexel University, Philadelphia, U.S.A. His research interests include human performance, learning, training, and portable functional brain imaging, in particular functional near infrared spectroscopy (fNIRS). His research projects mainly focus on development of the performance assessment metrics, wearable sensor, novel algorithms and techniques to deploy the neuro-technology systems for various application areas, such as pilot/operator training, joint systems-human performance assessment in air transportation domain.

Over the last half decade, he has been working with academic partners, federal agencies including DoD, FAA, NIH, and corporate partners including Lockheed Martin Corporation. He is currently leading Drexel University's efforts for the NextGen Research with FAA's William J Hughes Tech Center, and for the FAA Center of Excellence for Unmanned Aircraft Systems (UAS) - Alliance for System Safety of UAS through Research Excellence (ASSURE). Select research projects he has been involved in 1) quantitative assessment of expertise development and cognitive workload of air traffic controllers, pilots, UAS ground controllers, 2) cognitive baselining and index developments, 3) use of neurotechnology to improve pilot training, 4) use of fNIRS for assessment of medical team (pediatric trauma unit) workload and expertise development.

C1: Mathematical Optimization with Applications to ATM – Prof.dr. Daniel Delahaye (ENAC)

Abstract:
Dr. Delahaye will discuss four main topics:
- Overview of optimization algorithms
- Optimization for Airspace sector design
- Optimization for 4D trajectory design
- Optimization for TMA

The first part will discuss he modelling of a problem to make it fit on the optimization algorithm. A range of different existing optimization algorithms will be discussed such as

Linear Programming, Non-Linear Programming, Branch & Bound, Global Optimization, dynamic programming and more. Then a number of applications will be discussed. In Airspace design Dr. Delahaye will look at how to define your models, objective, decision variables and constraints. This can be used 3D design of Airspace, in dynamic Airspace configurations well as the Optimal location for a Military Area. When applied on 4D trajectory design, how the optimization is used depends on whether it is used strategically, pre-tactically or in a tactical way. Finally several application In the terminal area will be discussed such the design of SIDs & STARs, sequencing and merging, PMS optimization, DMAN and AMAN.

Biography: **Daniel Delahaye**
Professor Daniel Delahaye is the head of the optimization group of the Applied Mathematical Laboratory (MAIA) at ENAC (French Civil Aviation University). He obtained his engineer degree from the ENAC school and did a master of science in signal processing from the national polytechnic institute of Toulouse in 1991. His obtained his PH.D in automatic control from the aeronautical and space national school in 1995 and did a post-doc at the Department of Aeronautics and Astronautics at MIT in 1996. He get his tenure in applied mathematics in

2012. He conducts researches on mathematical optimization for airspace design and traffic assignment and works on air traffic complexity for more than 12 years. He is also very active on aircraft trajectory design for strategic, pre-tactical and tactical applications.

REGULAR PAPERS
Track 1
Trajectory Optimization

Assessment of the feasible CTA windows for efficient spacing with energy-neutral CDO

Ramon Dalmau, Xavier Prats; Technical University of Catalonia; Castelldefels, Barcelona (Spain)

Abstract — Continuous descent operations (CDO) with controlled times of arrival (CTA) at one or several metering fixes could enable environmentally friendly procedures at the same time that terminal airspace capacity is not compromised. This paper focuses on CTA updates once the descent has been already initiated, assessing the feasible CTA window (and associated fuel consumption) of CDO requiring neither thrust nor speed-brake usage along the whole descent (i.e. energy modulation through elevator control is used to achieve different times of arrival at the metering fixes). A multiphase optimal control problem is formulated and solved by means of numerical methods. The minimum and maximum times of arrival at the initial approach fix (IAF) and final approach point (FAP) of an hypothetical scenario are computed for an Airbus A320 descent and starting from a wide range of initial conditions. Results show CTA windows up to 4 minutes at the IAF and 70 seconds at the FAP. It has been also found that the feasible CTA window is affected by many factors, such as a previous CTA or the position of the top of descent. Moreover, minimum fuel trajectories almost correspond to those trajectories that minimise the time of arrival at the metering fix for the given initial condition.

Effects of speed reduction in climb, cruise and descent phases to generate linear holding at no extra fuel cost

Yan Xu, Ramon Dalmau, Xavier Prats; Technical University of Catalonia; Castelldefels, Barcelona (Spain)

Abstract — Speed reduction strategies have proved to be useful to recover delay if air traffic flow management regulations are cancelled before initially planned. Considering that for shorthaul flights the climb and descent phases usually account for a considerable percentage of the total trip distance, this paper extends previous works on speed reduction in cruise to the whole flight. A trajectory optimization software is used to compute the maximum airborne delay (or linear holding) that can be performed without extra fuel consumption if compared with the nominal flight. Three cases are studied: speed reduction only in cruise; speed reduction in the whole flight, but keeping the nominal cruise altitude; and speed reduction for the whole flight while also optimizing the cruise altitude to maximize delay. Three representative flights have been simulated, showing that the airborne delay increases significantly in the two last cases with nearly 3-fold time for short-haul flights and 2-fold for midhauls with the first case. Results also show that fuel and time are traded along different phases of flight in such a way the airborne delay is maximized while the total fuel burn is kept constant.

Potential operational benefits of multi-layer point merge system on dense TMA operation Hybrid arrival trajectory optimization applied to Beijing Capital International Airport

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Pierre Marechal, Mathematical Institute of Toulouse, University of Toulouse Paul Sabatier, Toulouse, France
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Abstract — 4D Trajectory optimization in dense terminal control area is one of the most challenging problems in air traffic management research. In order to efficiently and robustly land more aircraft at Beijing Capital International Airport (BCIA), one of the busiest airport in the world, a novel trajectory operation model is proposed, i.e. Multi-layer Point Merge (ML-PM) based Autonomous Arrival Management System. This paper aims at the evaluation of its potential operational benefits in terms of flight efficiency and runway throughput. Horizontal and Vertical profiles of ML-PM route network are introduced, the objective and constraints of this optimizing mathematical model are analyzed, especially the speed change profile and the conflict detection mode for merging zone. Then a case study is made by simulating arrival flows under three different operational modes: baseline, traditional point merge, and the ML-PM. Finally, the results show that rational arrival sequence and conflict-free trajectories are generated in ML-PM system, the benefits gained are very positive. Comparing with baseline and the traditional point merge system, ML-PM system shows good performance on flight time, fuel consumption, CO2 emission. The saving of fuel with ML-PM system is expected around 26838 Yuan per hour at BCIA compared with baseline scenario by numerical simulation. Furthermore, more flexible sequence position shift and continuous descent are possible in ML-PM system, and it is capable to handle the high-density operation environment.

Modelling flexible thrust performance for trajectory prediction applications in ATM

Ismael Matamoros, Xavier Prats, Technical University of Catalonia (UPC); Castelldefels, Spain, Javier López, Leonés Enrique Casado, Miguel Vilaplana, Boeing Research & Technology Europe (BR&TE), Madrid, Spain
Vincent Mouillet, Angela Nuic, Laurent Cavadini, EUROCONTROL Experimental Centre (EEC), Brétigny-sur-Orge, France

Abstract — Reduced thrust operations are of widespread use nowadays due to their inherit benefits for engine conservation. The ability to model reduced thrust operations is a necessary contribution to ATM development in order to ensure fidelity in the simulation of what-if ATM scenarios and environmental assessment tools. This paper proposes a methodology for modelling flexible thrust by combining an assumed temperature (AT) polynomial model identified from manufacturer take-off performance data and public thrust models taken from typical ATM performance databases. The main advantage of the proposed AT model is that it only depends on the take-off conditions —runway length, airport altitude, temperature, wind, etc. The results derived from this methodology were compared to simulation data obtained from manufacturer's take-off performance tools and databases. This comparison revealed that the polynomial model provides AT estimations with sufficient accuracy for their use in ATM simulation. The Base of Aircraft Data (BADA) and the Aircraft Noise and Performance (ANP) database were chosen as representative of aircraft performance models commonly used in ATM simulation. It was observed that there is no significant degradation of the overall accuracy of their thrust models when using AT, while there is a correct capture of the corresponding thrust reduction.

Generating arrival routes with radius-to-fix functionalities

Valentin Polishchuk,ITN, Linköping University, Sweden

Abstract — We investigate Radius-to-Fix (RF) functionality – a future operational concept present in several specifications of Performance-Based Navigation (PBN), including those used for terminal area operations. We show how to generate operationally feasible arrival routes using RF segments, balancing two conflicting objectives: (horizontal) efficiency of the flight paths in the produced STAR tree topology and keeping the overall traffic picture amenable to monitoring. The balance is achieved and controlled by essentially one user-tunable parameter in our model – the minimum required separation distance between route merge points. This makes our approach simple and easy to implement, which we demonstrate by running our algorithm for runways in Stockholm Arlanda airport. At the same time, our general scheme is directly extendable in several ways, allowing one to attach addons relevant in various specific application areas.

ATM performance analysis in Madrid ACC sectors considering optimal aircraft trajectories

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Universidad Carlos III de Madrid (UC3M), Leganés (Madrid), Spain

Abstract — 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. They 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 ATM performance indicators such as safety and capacity. Therefore, the main contribution of this paper is to provide a preliminary analysis on how an operational concept allowing continuous operations might affect the ATM performance at a network level. Different state-of-the art indicators will be used to measure ATM performance in terms of flight efficiency, environment, safety, and capacity. For the sake of illustration, a case study based on Madrid's ACC is considered. Current operational scenario (based on Flight plans) and an envisioned scenario allowing continuous operations (based on 4D optimized trajectories) are compared in three different days (with high, medium, and low traffic).

Track 2
Advanced Modeling

Uncertainty limits for an aircraft-based runway friction assessment method

Angela Campbell and Andrew Cheng, Aviation Research Division, FAA William J. Hughes Technical Center, Atlantic City, USA Angela.Campbell@faa.gov and Andrew.Cheng@faa.gov

Abstract — A category combining runway excursion, abnormal runway contact, and runway undershoot/overshoot was the third leading cause of fatal commercial aviation accidents worldwide between 2005 and 2014, according to a study by Boeing [1]. A lack of timely and accurate information, regarding runway conditions, has been identified as a significant contributing factor. Since aircraft braking capability is not directly recorded in the current setting, a novel approach of using airplane data to identify real-time runway conditions is currently being evaluated. The airplane-based assessment relies on estimating the deceleration forces acting on the aircraft during the landing roll-out to deduce the runway friction coefficient. The accuracy of the airplane-based runway condition reporting is consequently dictated by the uncertainty associated with the calculation of the deceleration forces. This paper presents a methodology for defining acceptable uncertainty limits for the calculated forces based on the granularity of the friction reporting system, force estimation bias, and desired confidence level for the friction estimation. The methodology will then be demonstrated by evaluating the ability of a landing performance model for the Global 5000 aircraft to meet the prescribed uncertainty limits.

Large-scale flight phase identification from ADS-B data using machine learning methods

Junzi Sun, Joost Ellerbroek, Jacco Hoekstra, Control and Simulation, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands

Abstract — With the increasing availability of ADS-B transponders on commercial aircraft, as well as the rapidly growing deployment of ground stations that provide public access to their data, accessing open aircraft flight data is becoming easier for researchers. Given the large number of operational aircraft, significant amounts of flight data can be decoded from ADSB messages daily. These large amounts of traffic data can be of benefit in a broad range of ATM investigations that rely on operational data and statistics. This paper approaches the challenge of identifying and categorizing these large amounts of data, by proposing various machine learning and fuzzy logic methods. The objective of this paper is to derive a set of methods and reusable open source libraries for handling the large quantity of aircraft flight data.

Modeling and Estimating Airspace Movements Using Air Traffic Control Transcription Data A Data-Driven Approach

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Abstract — High-fidelity models of airport and airspace capacity enable researchers to study modernization strategies that optimize capacity. The design and the development of airport and airspace capacity models require volumes of detailed aircraft movement data in the terminal airspace. This data, while it exists in the public realm, is highly challenging and cumbersome to collect in large quantities. In this study, we present a methodology to develop our titled Approach Airspace Characterization (AAC) database, fed by flight data scraping techniques and transcriptions of Air Traffic Control voice commands in the terminal airspace. We illustrate the mathematical mechanisms required to assign aircraft movements to specific arrival fixes to develop high-fidelity models of movements. We then present innovative new ways of measuring delay and refining arrival airspace models based on this fine-grained data.

Phase Changes in Delay Propagation Networks

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Abstract — The analysis of the dynamics of delays propagation is one of the major topics inside Air Transport Management research. Delays are generated by the elements of the system, but their propagation is a global process fostered by relationships inside the network. If the topology of such propagation process has been extensively studied in the literature, little attention has been devoted to the fact that such topology may have a dynamical nature. Here we differentiate between two phases of the system by applying two causality metrics, respectively describing the standard phase (i.e. propagation of normal delays) and a disrupted one (corresponding to abnormal and unexpected delays). We identify the critical point triggering the change of the topology of the system, in terms of delays magnitude, using a historical data set of flights crossing Europe in 2011. We anticipate that the proposed results will open new doors towards the understanding of the delay propagation dynamics and the mitigation of extreme events.

Nonlinear dynamics approach for modeling of air traffic performance disruption and recovery

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Abstract — The inclusion of a priori knowledge on random disturbance into stochastic and robust optimisation of arrival and departure scheduling for controller assistance is a topic of ongoing research. One direction is the development of advanced algorithms utilizing (microscopic) stochastic models of empirical traffic rate and delay time statistics derived from hundreds of flights over limited periods of time. The typically asymmetric delay distributions usually include some extreme disturbances ("Xevents", e.g. low pressure weather situations) which often are disregarded as outliers. In this contribution we focus on the modeling of disruption and recovery dynamics of performance during single Xevents. Based on previous work in the literature on formalizing performance disruption and systems resilience we analyse the potential of a simple logistic dynamics approach for deriving characteristic performance parameters (e.g. disruption / recovery time constants) from empirical data. We continue with initial results obtained with time dependent control parameters dependent e.g., on wind/gust speed variation, for dynamic performance simulation using nonlinear first and second order dynamics. This macroscopic low dimensional order and control parameter approach has the potential for anticipative disruptive events management within the Viability theory framework and complements microscopic (high dimensional) stochastic and robust optimization based scheduling.

Utilizing schedule buffers to reduce propagated delay
A new approach for tactical Air Traffic Flow Management slot allocation

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Abstract — To compensate for anticipated delays and improve on-time performance, Aircraft Operators usually embed a buffer time in their schedules strategically, but also have the flexibility to fine tune their departure times on the day of operations (tactically). In Europe, one of the instruments at the Network Manager's disposal to tackle demand-capacity imbalance is to impose ground, i.e. Air Traffic Flow Management – ATFM, delays to flights. The current practice for assigning ATFM delays does not take into account whether flights have any remaining schedule buffer to absorb ATFM delay and potentially reduce delay propagation to subsequent flights. Furthermore, the policy presently employed is to minimize ATFM delays, an order of magnitude of half a minute per flight on average, while propagated delays are approximately ten times higher. We explore the possibility to use ATFM delay as a tool to minimize delay propagated to subsequent flights, but also to increase flights' adherence to airport slots at coordinated airports.

Track 3
System Performance

Deconstructing delay dynamics
An air traffic network example

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Richard Jordan, Group 43, Air Traffic Control Systems, MIT Lincoln Laboratory, Lexington, MA, USA richard.jordan@ll.mit.edu

Abstract — This paper develops and analyzes a simplified model of the dynamics of delay propagation in air traffic networks. The proposed model considers the redistribution of delays by accounting for aircraft flows between airports, the persistence of delays at an airport, the mitigation of delays due to slacks or buffers in flight schedules, and inputs such as sudden impulsive disruptions or sustained impacts due to longer duration traffic management initiatives. Using inter-airport traffic flows from operational data, different properties of the model are studied, including the resilience of different airports (as measured by the length of time before delays mitigate after a disruption), the amount of delay induced by disruptions at a particular airport, and the number of airports that are impacted when a given airport experiences disruptions. These properties are evaluated for different levels of delay sustainment, and for different values of available slack in schedules..

High performance computing simulator for the performance assessment of trajectory based operations

Leonardo Camargo-Forero, Ramon Dalmau, Xavier Prats, Sergio Ruiz, Technical University of Catalonia, Castelldefels, Barcelona (Spain)

Abstract — High performance computing (HPC), both at hardware and software level, has demonstrated significant improvements in processing large datasets in a timely manner. However, HPC in the field of air traffic management (ATM) can be much more than only a time reducing tool. It could also be used to build an ATM simulator in which distributed scenarios where decentralized elements (airspace users) interact through a centralized manager in order to generate a trajectory-optimized conflict-free scenario. In this work, we introduce an early prototype of an ATM simulator, focusing on air traffic flow management at strategic, pre-tactical and tactical levels, which allows the calculation of safety and efficiency indicators for optimized trajectories, both at individual and network level. The software architecture of the simulator, relying on a HPC cluster of computers, has been preliminary tested with a set of flights whose trajectory vertical profiles have been optimized according to two different concepts of operations: conventional cruise operations (i.e. flying at constant altitudes and according to the flight levels scheme rules) and continuous climb cruise operations (i.e., optimizing the trajectories with no vertical constraints). The novel ATM simulator has been tested to show preliminary benchmarking results between these two concepts of operations. The simulator here presented can contribute as a testbed to evaluate the potential benefits of future Trajectory Based Operations and to understand the complex relationships among the different ATM key performance areas.

Performance benchmarking in interdependent ATM systems
Integration of analytical and process oriented performance benchmarking schemes in complex ATM systems

Stefan Reitmann, Alexander Gillissen, Michael Schultz, German Aerospace Center (DLR), Institute of Flight Guidance, Dept. of Air Transportation, Germany, stefan.reitmann@dlr.de

Abstract — Understanding and quantifying aviation as a whole system of coupled and interdependent sub-systems is a challenging task. To overcome resulting complexities and dynamic effects we approach the problem from an analytical and operational point of view. Both differ in their required data inputs as well as their methods to analyze and identify interdependencies in the system. Interdependencies are central elements for holistic optimizations as they take into account propagation of data and decisions; i.e. how a local system affects other systems and vice-versa. In this paper we discuss our approach to leverage the potential of both measurement methods. We discuss how they solve specific problems and how they differ. Finally we offer a concept on how to integrate both methods which offers the possibility to compare and complement each other. This allows to cross-validate results and the partial mitigation of weaknesses of the other. Also it opens new ways to identify potential for improvements, which will be discussed.

Identification method for terminal air traffic congestion status

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Abstract — For the purpose of supporting the real-time monitoring and management for terminal air traffic, a new congestion status identification method for terminal maneuvering area (TMA) is developed. Firstly, from the objective and subjective perspective, a set of basic status metrics based on air traffic flow characteristics and complexity, and equivalent airspace occupancy based on air traffic controllers' workload are introduced respectively. Then, by combining the basic status metrics and the equivalent airspace occupancy, an integrated congestion status measuring model is proposed, and a congestion status classification method based on fuzzy C-means (FCM) clustering is brought up. In the end, a case study of some large domestic TMA is provided. The relevant coefficients are calibrated by analyzing the actual data of radar tracks and air-ground communications, and then the congestion status is computed and divided into five categories. By means of random sampling analysis and comparison with existing methods, the effectiveness and correctness of proposed method is proved.

Track 4
Complexity and Information

Phase of flight and rule of flight calculator
Using National Offload Program Data

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Abstract — Calculating Phase of Flight is an analysis that could be widely used when determining patterns in air traffic or causes of airline accidents. However, currently there exists no way to determine Phase of Flight without being explicitly sent the data from the aircraft. The problem is that, typically, the FAA only retains access to surveillance data such as primary and secondary radar data from sources such as the National Offload Program (NOP). This paper discusses a preliminary statistics-driven classification system which only classifies basic phases of flight but could be expandable to classify a larger set of phases of flight for different aircraft types. It also discusses an approach to classify flights based on rules of flight (i.e. Visual Flight Rules (VFR) or Instrument Flight Rules (IFR)).

SAGA: Safety Analysis in General Aviation leveraging digital flight data towards the development of a flight performance database tool to improve General Aviation safety

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Abstract — The emerging prevalence of flight data recording technology in general aviation aircraft presents new analytical potential to enhance safety evaluation. In this paper we describe a prototype tool that not only examines individual flight parameters, but also provides information displays to help the user consider the relationships among related flight parameters. In addition, because the flight data for the broader population of general aviation pilots is stored in a single database, users of the tool can not only review performance data on their own flights, but also can compare their own performance with that of pilots in general.

BlueSky ATC simulator project
An open data and open source approach

Jacco M. Hoekstra, Joost Ellerbroek, Control & Simulation section, Faculty of Aerospace Engineering,
TU Delft, Delft, Netherlands

Abstract — To advance ATM research as a science, ATM research results should be made more comparable. A possible way to do this is to share tools and data. This paper presents a project that investigates the feasibility of a fully open-source and open-data approach to air traffic simulation. Here, the first of the two main challenges is to achieve a high fidelity, without using proprietary data, e.g. for aircraft performance. The second challenge is to increase the adoption by the community by keeping the program easy to use, easy to modify, multi-platform, downloadable for free and running stand-alone on relatively simple systems. The approach chosen by the project is to investigate this feasibility by trying to start the development. The paper describes the many hurdles to be overcome when using a fully open-data and open-source policy in this area.

Impacts of flawed flight test data and its repercussions on helicopter flight performance

Juliane Blank and Hartmut Fricke, Institute of Logistics and Aviation, TU Dresden, Chair of Air Transport Technology and Logistics, Dresden, Germany, Juliane.Blank@mailbox.tu-dresden.de

Abstract — In the course of the development of new and modified helicopter models with Airbus Helicopters Deutschland GmbH (Airbus Helicopters), the respective flight performance data can be calculated by using simulations. Additionally, a demonstration of the simulated flight performance through flight tests is required to obtain certification and define operational limits depicted in the Flight Manual. Based on the critical safety aspect, the most accurate data and assessment of flight performance should be pursued. The process however, is not error-free due to its complexity and the unsteady environmental conditions. Therefore, a methodology to determine the impacts of flawed flight test data is developed in the scope of this paper. Based on the flight testing process, the errors of the relevant parameters are initially identified. Subsequently, the impacts on the flight performance are determined using parameter variation and error propagation analysis. Finally, the application of the results, as well as the review of possible problems and limitations allow a detailed quality and usability evaluation.

Track 5
Decision Support

Transition steps to orthogonal unidirectional air traffic controller monitoring display

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Abstract — Current displays of Air Traffic Controllers (ATCO) do hardly support future tasks of a time-, trajectory- and performance-based approach. The "Orthogonal Flight Monitoring with Unidirectional Controller HMI (OFMUCH)" shall assist ATCOs with small consecutive learning steps corresponding to iterative display revisions without broad big bang integrations. Ten different displays succeed each other with only minor changes, but resulting in a broad change comparing the first with the last display. A study with ten controllers showed improved acceptability and usability of new display concepts with a row of changes guiding from the current to a future ATCO display.

Detect & avoid, UAV integration in the lower airspace traffic

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Abstract — In this article, we test a horizontal detect and avoid algorithm for Unmanned Aerial Vehicules (UAVs) flying in the lower airspace (under FL180). We use recorded commercial traffic trajectories and randomly build 3000 conflicts scenarios with UAVs to check the ability of such an algorithm to ensure the separation with commercial aviation. We consider two different types of UAVs, the first type flying at 80 kn and the second type flying at 160 kn with six different missions: flying straight or turning and leveled, climbing or descending. We only focus on horizontal maneuvers in order not to interfere with aircraft Traffic Collision Avoidance System (TCAS). The article investigates the influence of the various parameters on the separation achieved. The analysis of results from over 200 000 simulations provides minimum requirements on the frequency and anticipation time of the resolution process for an efficient detect and avoid strategy and brings up remaining issues in scenarios where the UAV has a low maneuverability and encounters fast airliners with changing speed and heading.

A Variable Neighborhood Search approach for the aircraft conflict resolution problem

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Abstract — A metaheuristic approach based on Variable Neighborhood Search to tackle the enroute aircraft conflict resolution problem is presented. The three maneuvers (velocity, heading angle and altitude level variations) are allowed to be performed. Based on geometric rules, we can determine if a conflict situation occurs between each pair of aircraft under consideration. As three different maneuvers could be performed, they are dealt with in a multiobjective framework, allowing Air Traffic Control officers to make the final decision based on economic and comfort terms.

Identifying representative traffic management initiatives

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Abstract — The Federal Aviation Administration uses traffic management initiatives to prevent excessive congestion of airspace resources. We present a method that would aid in the planning of traffic management initiatives by identifying a representative set of initiatives that have been run in the past. In a more general unsupervised learning context, this method could be used to identify a small set of data points that are representative of the entire data set.

Track 6
Economics and Policy

Estimating costs of flight delay to air cargo carriers

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Abstract — We consider the costs of flight delay, which has received scant attention in previous research. We present two models that are developed to estimate the costs of flight delay. First we estimate a mixed-logit model to investigate the factors that influence late deliveries, with specific emphasis on flight on-time performance. Then we build a linear regression model to monetize the loss of late deliveries, using the hedonic approach to estimate the degradation in product value resulting from less reliable on-time package delivery. Estimates of flight delay cost for four representative US airports range from $600 – $1,200 per aircraft for a five-minute flight delay and $12,000 – $25,000 for an hour.

Estimating the long-run effects of resource allocation mechanisms

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Abstract — A potentially powerful way to improve the planning of en route traffic management initiatives would be to grant carriers some ability to express their preferences for allocation details that the service provider would otherwise be ambivalent to. In this paper we propose an idea of how airlines can express their preferences without revealing too much information about their business models and cost functions and we test this idea for its validity. We also examine if airlines in the long-run will be treated equally by the allocation mechanism chosen, by receiving on average the number of slots close to what would have been considered their fair share.

Free routing airspace in Europe
Implementation concepts and benefits for airspace users

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Abstract — The European aviation industry is exposed to major challenges such as profitability and efficiency, environmental sustainability and capacity constraints, economic difficulties and rising concerns due to non-leveled playing fields. That clearly demonstrates the necessity for further investments into newer, more efficient concepts. One of these concepts is Free Routing Airspace. In a Free Routing Airspace, the airspace user may freely choose a flight path using user-defined segments between published or user-defined points. This option of a flexible flight planning allows an optimization of the flight trajectory best suited to the business requirements of each individual airspace user. However, the general Free Routing Airspace concept offers many different kinds of implementation possibilities. This paper estimates the benefits of Free Routing Airspace in Europe for an airspace user. To that end, extensive representative flight samples have been calculated with the help of the flight planning system Lido/Flight from Lufthansa Systems GmbH & Co. KG. The calculated trajectories have been evaluated primarily in terms of overall costs reductions, but also in terms of fuel saving. The results of the analysis show that the concept has significant saving potential and efficiency benefits when compared to the current traditional Air Traffic Services route network. Both, the total operating costs can be reduced, and the environmental goals such as a reduction of greenhouse gas emissions can be achieved through fuel saving. This highlights that the concept of Free Routing Airspace is an important step for the future of the European aviation industry.

Implementing dynamic air transport slot trading through secure auction mechanism

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Abstract — Future business cases based on air transportation market will need applying secure information sharing and calculation that allows untrusted parties to perform computation over a data set. In this work, we have structured a secure market mechanism that is specific to conceptual airport slot trading based on secure multi-party computation. Considering the needs of a secure information sharing and slot market, we have developed a web-based portal enabling participant to see the open auctions and put their bids. To demonstrate the feasibility of such mechanism, we have utilized historical data to create a realistic market structure and interests. In the simulations, primary and secondary markets including tactical slot trade have been simulated through the Secure Multiparty Computation (SMC). Moreover, we have also performed the cost benefit analysis through the computational effort assessing of such SMC-based auction mechanism for the realistic operational environment, provided results of these analyze, and given a detailed discussion.

Track 7
Safety and Human Performance

Application of common cause failure methodology to aviation safety assessment model

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Abstract — The Federal Aviation Administration (FAA) has been developing the Integrated Safety Assessment Model (ISAM) to provide a baseline risk assessment for the National Airspace System and to evaluate the safety impact of proposed changes to the system. ISAM consists of a set of event sequence diagrams and underlying fault trees for various accident scenarios. In the current model, all basic events in the fault trees are assumed to be independent. However many basic events throughout the model appear with the same descriptive label. Such events might have some dependence, rather than being completely independent as is currently assumed. This paper evaluates the dependency between basic events having the same label in order to see the overall impact on accident risk. A common cause failure (CCF) methodology is applied to the event sequence diagrams (ESDs) in ISAM. A modified beta-factor model is applied, and a binary decision diagram method is implemented to evaluate end-state frequencies of an ESD. Accounting for CCFs, this paper observes a wide range of changes in accident frequency relative to the current assumption of independent events. Results for different ESDs range from a decrease in accident frequency by 50% to an increase by more than a factor of 1,000.

Improving the Nowcast of Unstable Approaches

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Abstract — The approach and landing is a complex phase of flight in which the flight crew needs to conduct a series of procedures in a condensed time frame to safely land the aircraft. Unstable approaches can lead to events with reduced safety margins and additional operating costs. To ensure flights have stable approaches, airlines have established stabilized approach criteria to make sure the landing flight is on track and within an appropriate range of speed and rate of descent. If the criteria are not satisfied at stabilization altitudes, a go-around must be executed. Nowcasting the likelihood of unstable approaches before reaching the stabilization altitudes may assist flight crews in taking actions to correct the flight trajectory to avoid a potential unstable approach. A previous study shows the feasibility of detecting unstable approaches using historical trajectory data and the feasibility of nowcasting unstable approaches using state variables. This paper describes improvements in the nowcast performance through the modification of existing features and the addition of more features. For the nowcast at 6 nm for unstable approaches after reaching 1000' AGL, the accuracy is improved from 71.3% to 74.8%, the recall is improved from 60.8% to 64.7%, and the precision is improved from 74.0% to 78.4%.

Runway centerline deviation estimation from point clouds using LiDAR imagery

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Abstract — Secure airport operations are an important part of the aviation safety, as about 20 percent of collisions between aircrafts and objects as well as about one third of fatal accidents occur on airfields. The older airports need to be modernized to better cope with increasing traffic and larger aircrafts. Determining proper separation distances or safety areas is part of the revision process. In addition, engineering, environmental and economic impacts have to be considered during such revisions. To support the redesign, statistically significant and representative data is needed, including driving patterns and various derived metrics, such as centerline deviations. Remote sensing technologies offer an effective way to collect large volume of data on aircraft movements at airfields. This study describes the initial results of a LiDAR-based multi-sensor system that is deployed around runways and taxiways to remotely observe aircraft movement. The primary objective is to derive the centerline deviation of moving aircrafts from point clouds. Benefits from these derivations may allow for greater understanding of aircraft movements in the runway environment, and provide data for evaluating the operational safety of various runway design specifications.

Weather technology in the cockpit
Analysis of pilot decision making

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Abstract — Weather is a very important concern for pilots, and even more so for pilots of small, general aviation aircraft as they fly at lower altitudes with less weather managing capabilities. Over the last decade, many emerging technologies have allowed the general public to have real-time weather data on their portable devices. Currently there is little to no guidance for design and usage of these devices. The study analyzed records from the Aviation Safety Reporting System and the National Transportation Safety Board from 2003 to 2013. All weather related incidents and accidents were categorized for both weather factors and presence of weather technologies. In addition to the trend of increasing use of all types of weather technology, more complicated relationships between the use of weather information and outcome of incidents have emerged. Commonly found weather accident patterns were discovered and have been used elsewhere to develop and test the effectiveness of weather training tools. This study will allow for the creation of a custom database that will allow government agencies and other researchers to make informed policy decisions regarding the continued use of these new weather technologies in cockpits.

How do layered airspace design parameters affect airspace capacity and safety?

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Abstract — In many ATM studies experiments are performed to determine the capacity. This paper looks at the effect of airspace design on the capacity. Using an algebraic approach a relation is derived between the design parameters of a layered airspace design and the capacity of the airspace. The validity of the assumptions which are used in this derivation are tested experimentally. This airspace lay-out proved to be the airspace design which had the highest capacity for the unstructured, extremely high traffic demand used in an earlier experimental study. The result is both a method to relate an airspace design to the capacity as well as a relation which shows the effect on the airspace capacity for an airspace design where different levels or layers are defined each with their own segment of heading angles.

Track 8
Network Management

Wind and temperature networking applied to aircraft trajectory prediction

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Abstract — Trajectory prediction estimates the future position of aircraft along their planned trajectories in order to detect potential conflicts and to optimize air space occupancy. In the present paper we will try to improve the trajectory prediction by sharing the wind and the temperature information between aircraft. Based on the current performances of Air Traffic Control systems , controllers are able to efficiently detect conflict 20 minutes in advance ; for a larger time horizon (look-ahead time), the induced trajectory prediction uncertainty strongly reduces the reliability of the conflict detection. The goal of this work is to measure the potential benefit produced by sharing wind/temperature measures between aircraft (this concept will be called Wind/Temp Networking (WTN)). To reach this goal, aircraft measure (temperature and pressure) and calculate (wind and density) their local atmospheric data and broadcast them to the other aircraft. Having such distributed weather information, each aircraft is able to compute an enhanced local wind/temperature map as a function of location (3D) and time. These updated wind/temp fields could be shared with other aircraft and/or with ground systems. Using this enhanced weather information, each aircraft is able to improve drastically its own trajectory prediction. This concept has been simulated in the French airspace with 8000 flights. Comparisons have been investigated on trajectory prediction performances with and without wind/temp networking. Statistics have been conducted in order to measure the benefit of such concept in both time and space dimensions showing higher improvement in high traffic areas, as expected.

The influence of traffic structure on airspace capacity

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Abstract — Airspace structure can be used as a procedural mechanism for a priori separation and organization of en-route air traffic. Although many studies have explored novel structuring methods to increase en-route airspace capacity, the relationship between the level of structuring of traffic and airspace capacity is not well established. To better understand the influence of traffic structure on airspace capacity, in this research, four airspace concepts, representing discrete points along the dimension of structure, were compared using large-scale simulation experiments. By subjecting the concepts to multiple traffic demand scenarios, the structure-capacity relationship was inferred from the effect of traffic demand variations on safety, efficiency and stability metrics. These simulations were performed within the context of a future personal aerial transportation system, and considered both nominal and non-nominal conditions. Simulation results suggest that the structuring of traffic must take into account the expected traffic demand pattern to be beneficial in terms of capacity. Furthermore, for the heterogeneous, or uniformly distributed, traffic demand patterns considered in this work, a decentralized layered airspace concept, in which each altitude band limited horizontal travel to within a predefined heading range, led to the best balance of all the metrics considered.

Merging flows in terminal maneuvering area using time decomposition approach

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Abstract — With a continuous growth of air traffic demand, more effort must be made to alleviate the current overloaded airspace charges. This research focuses on the aircraft merging and sequencing problem at Terminal Maneuvering Area. Tactical conflict detection and resolution methods are applied to a predefined route network structure. Speed and time changes are proposed via an optimization methodology to resolve conflicts and maintain separation between aircraft with regard to the wake turbulence constraints and runway occupancy time. A new time decomposition approach is introduced. It consists in partitioning the whole time interval under consideration into several overlapping time windows, and in solving the merging and sequencing problem individually in each such sub-window. Four aircraft status are defined to classify flights according to their temporal position relative to the current sliding window. Moreover, an adapted simulated annealing heuristic is proposed to solve the corresponding sub-problems. Finally, computational experiments of the proposed algorithm, performed on real-world case studies of Paris Charles De-Gaulle airport, show the benefits of this sliding-window time-decomposition approach.

Track 9
Environment

Aviation-induced nitrogen oxide emissions and their effect on the energy budget of the Earth-atmosphere system Identification of climate optimized trajectories

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Abstract — The present paper contains statements about the influence of the aviation-induced nitrogen oxide emissions on the atmosphere and investigates the generation of climate optimized trajectories. First, it presents a general model approach which connects all needed single models for generating optimized trajectories concerning minimization of the nitrogen oxide induced climate impact. Second, it contains the calculation of emitted nitrogen oxides for different generated horizontal trajectories including variable flight distances and altitudes. Subsequently, qualitative statements about the generation of climate optimized trajectories in terms of nitrogen oxide emissions are derived. Furthermore, some potential strategies for reducing the climate impact of nitrogen oxides regarding operative regulatory measures are discussed.

Probabilistic analysis of aircraft fuel consumption using ensemble weather forecasts

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Abstract — The effects of wind uncertainty on aircraft fuel consumption are analyzed using a probabilistic trajectory predictor. The case of cruise flight subject to an average constant wind is considered. The average wind is modeled as a random variable; the wind uncertainty is obtained from ensemble weather forecasts. The probabilistic trajectory predictor is based on the Probability Transformation Method, which is a method that evolves the wind probability density function; the output of the probabilistic trajectory predictor is the probability density function of the fuel consumption. A general analysis is performed for arbitrary winds distributed uniformly, with a twofold objective: 1) present the capabilities of the probabilistic trajectory predictor, and 2) understand how the wind uncertainty affects the fuel consumption.

Track 10
Airport Design

The potential of modern mobile technologies to improve airport operations A concept for controlling passengers flows

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Abstract — In this paper we present an innovative passenger flow handling concept inside airport terminals using state-of-the-art communication capabilities of mobile devices. It mainly relies on well adopted information presented to either all passengers or selected parties in time and space. The advantage of the newly designed processes as part of the concept are improved capacity utilization, on-time services to both passengers and airlines while maintaining typical service levels according to airport operator's, passenger's and airline's expectations. Even temporary capacity bottlenecks decreased or did not show up while the infrastructure remains unchanged. The paper presents useful metrics to measure competing concepts for managing passengers. We finally applied these in a simulation with the setup of Berlin Brandenburg airport (BER). The results of the simulation suggest that already a passenger participation in concept of 25-30% provides remarkable improvements in the level of service (waiting times) and the utilization of capacity or rather resources.

Implications of autonomous vehicles to airport terminal planning and design

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Abstract — Incomes from parking and rental car facilities, for most of commercial airports in the U.S., are significant components in their revenue. Current design of parking capacity and parking fees are based on historical passenger throughput, travel mode splits, and projected future air traffic demand. With the emerging Autonomous Vehicle (or driverless vehicle, self-driving vehicle), the fundamentals could change. This paper describes the potential impacts of AV to airport parking and ground access and designs a simulation platform for quantitative analysis. Statistical methods are used to provide inputs for simulation based on airport historical aggregate level mode split and parking information. The results in this study show the impact of AVs to the private car dependent airport is detrimental. Airport planners and designer need to consider how to accommodate the future needs in dynamic strategic and master planning and flexible terminal design.

An evaluation of linear length LED centerline taxiway exit light systems

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Abstract — Airfield lighting, such as runway and taxi edge and centerline lighting has, traditionally been implemented using incandescent bulbs spaced at set intervals as determined by Federal Aviation Administration (FAA) design standards. The introduction of LED based lights on airfields has allowed for the developments of prototype light systems that have some linear length, rather than be limited to "point" bulb sources. The FAA has been interested in determining if "linear length LED" lights of variable lengths, and laid out in given configurations along a runway or taxiway, may provide greater visibility and thus enhanced airfield orientation to pilots. This study investigated the potential enhancements to airfield visual guidance by deploying an array of Linear Length LED lights to be evaluated by pilots traveling along a runway. Initial results of this investigation validate previous laboratory and simulation studies that reveal that linear length LED lighting configurations do provide statistically significant enhanced visual guidance to pilots, as determined by observed reduced reaction times and greater accuracy of determining airfield orientations by pilot subjects.

Configuration and planning of the remote tower modules in a remote tower center

Tobias Andersson Granberg, Peter Axelsson, Jonas Petersson, Tatiana Polishchuk,
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Abstract — Today, many small aerodromes struggle with financial difficulties, and a large cost is air traffic control. Remote tower centers, which remotely provide air traffic services to aerodromes, can help reduce this cost. Each center may contain a number of remote tower modules, where each module is manned by a controller that can handle one or more aerodromes. In this paper we present the remote tower center concept and develop a model that optimizes the assignment of airports to the remote tower modules. Computational results for a possible scenario based on real data for Swedish airports are presented.

Track 11
Automation

Multi-agent systems for air traffic conflicts resolution by local speed regulation

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Abstract — Air Traffic Flow Management (ATFM) aims at structuring traffic in order to reduce congestion in airspace. Congestion being linked to aircraft located at the same position at the same time, ATFM organizes traffic in the spatial dimension (e.g. route network) and/or in the time dimension (sequencing and merging in TMA, Miles-in-Trail for en-route airspace). The objective of this paper is to develop a methodology that allows the traffic to self-organize in the time dimension when demand is high. This structure disappears when the demand diminishes. In order to reach this goal, a multi-agent system has been developed. This algorithm regulates aircraft speed in order to reduce the number of conflicts, thus decreases overall traffic complexity, which becomes easier to manage by air traffic controllers. This algorithm was applied on realistic examples.

Unmanned aviation: To be free or not to be free? A complexity based approach

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Abstract — This paper assesses the feasibility of organizing unmanned aviation as free flight. We do this by estimating the frequency of occurrence of large de-confliction problems. Statistics of these frequencies are measures of air traffic complexity appropriate for unmanned air traffic management. These complexity measures increase with air traffic density. Data suggests as many as 100,000 unmanned flights per day is realistic at maturity in a region such as the San Francisco Bay Area. We simulate 100 to 1,000,000 flights per day. Results suggest simple free unmanned flight is feasible up to 10,000 flights per day, but needs intelligent management thereafter. We also analyze a hypothetical unmanned airway network. The complexity reductions are large and optimistic.

Predicting aircraft descent length with machine learning

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Abstract — Predicting aircraft trajectories is a key element in the detection and resolution of air traffic conflicts. In this paper, we focus on the ground-based prediction of final descents toward the destination airport. Several Machine Learning methods – ridge regression, neural networks, and gradient-boosting machine – are applied to the prediction of descents toward Toulouse airport (France), and compared with a baseline method relying on the Eurocontrol Base of Aircraft Data (BADA). Using a dataset of 15,802 Mode-S radar trajectories of 11 different aircraft types, we build models which predict the total descent length from the cruise altitude to a given final altitude. Our results show that the Machine Learning methods improve the root mean square error on the predicted descent length of at least 20 % for the ridge regression, and up to 24 % for the gradient-boosting machine, when compared with the baseline BADA method.

The effect of swarming on a voltage potential-based conflict resolution algorithm

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Abstract — Several conflict resolution algorithms for airborne self-separation rely on principles derived from the repulsive forces that exist between similarly charged particles. This research investigates whether the performance of the Modified Voltage Potential algorithm, which is based on this algorithm, can be improved using bio-inspired swarming behavior. To this end, the collision avoidance function of the algorithm is augmented with the velocity alignment and flock centering swarming traits displayed by animals such as birds and fish. The basic and swarm augmented versions of the algorithm were compared using large-scale fast time simulations, for multiple traffic demand scenarios. For ideal conditions, the results show that the process of aligning with neighboring traffic triggered a large number of conflicts. However, when noise was added to scenarios, swarming led to a lower increase in the number of intrusions, which could indicate that it can be used to improve the robustness of the Modified Voltage Potential algorithm. Furthermore, the stability results suggest that both versions of the algorithm could reduce the number of conflict chain reactions with respect to simulations without resolution. Future research will further explore the effect of conflict resolution on airspace stability, as well as whether varying the relative weights of swarming elements can improve the safety of swarm augmentations.

DOCTORAL SYMPOSIUM
Chair: Mark Hansen

On the correlations between air traffic and controllers' eye movements

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Abstract — Air traffic controllers always play an important role in the air transportation system. However, the understanding of the interaction between controllers' cognitive activities and complex traffic activities are less addressed. Many kinds of metrics have been summarized to analyze complex traffic situations. Eye movements are considered to be related to cognitive activities. This paper aims to investigate quantitative correlations between air traffic controller's eye movement activities and traffic activities. Eye-tracking data and flight radar tracks are recorded during real-time simulations. Commonly used eye movement and traffic measures are calculated. Linear or nonlinear correlations between traffic measures and visual measures are profoundly examined based on time series analysis techniques. We assume that there are three types of cognitive activities during the control process, i.e. targets tracking, conflict recognition, and attention allocation. Various combinations between eye movements and traffic activities are identified correspond to the different cognitive behaviors.

The FRIDAY route charges method

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Abstract — The Single European Sky is being introduced to improve the efficiency of flight and traffic operations by reforming the air traffic management system. Despite all of these technical advances, airlines choose detours to avoid high route charges. This mechanism is intensified when fuel prices are low. The single unit rate method has been proposed to counter this behavior, but it will introduce other problems for both air navigation service providers (ANSPs) and airlines. For instance ANSPs have to agree on the redistribution of revenues, and some airlines can be confronted with considerable hikes in the route charges. We propose a novel route charges method called FRIDAY (Fixed Rate Incorporating Dynamic Allocation for optimal Yield) that will i). take away the incentive to airlines for detours, ii). keep ANSPs in control of their unit rates, and iii). keep the new route charges for airlines close to the current route charges when introducing FRIDAY. We will show how the FRIDAY method calculates route charges for flights, and revenues for air navigation service providers. Furthermore, we will introduce a numerical method for setting the unit rates for the FRIDAY method. The expected benefits of introducing the FRIDAY route charges method are i). cost, fuel and time savings for airlines, ii). increased predictability, and reductions in traffic risks for ANSPs, and iii). reductions in emissions and CO2 for society.

Aircraft fleet mix optimization in airline networks under ecological and soft time window constraints

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Abstract — This paper provides an approach to solve an aircraft fleet mix optimization problem under a set of flight legs, aircraft performance limitations and both aircraft specific operational costs and environmental costs due to aircraft specific emissions. It is formulated as an adapted vehicle routing problem with fix and soft time windows representing airport business hours or airline target times in flight scheduling. To achieve a minimization of the ecological impact of aircraft emissions, we account for an aviation specific global warming potential model to calculate external environmental costs. Consequently, we solve a multi criteria cost based optimization aiming at identifying an environmental sustainable aircraft fleet mix for individual departure-origins while granting economic operations for the airline. By applying the model, we demonstrate an emission reducing potential by 8% in comparison to the cost minimum solution with even minor differences in fleet efficiency characteristics. Starting with a linear programming approach, we also present a fast time optimization using a GRASP heuristic to even deal with more complex problems.

The role of delays in the efficiency analysis of air traffic management systems

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Abstract — This study tests the assumption that delays in air traffic management are not necessarily bad by including them in the organizational performance assays of air navigation systems. It also demonstrates that nonparametric approaches can be useful in the efficiency analysis of these systems given the ambiguous nature of the data environment in air traffic control. A partial frontier analysis analyzed the role of delays in the efficiency of air navigation service providers across Europe and Turkey for the period 2010-2011. The dataset is taken from the dashboard of Eurocontrol. Two outputs are used: capacity of the service provider based on airport movements as the good output and delays as the undesirable output. The inputs comprised features of service providers and aircraft characteristics. Efficiencies are estimated using a bootstrapped partial frontier analysis for a pessimistic model of delays and an optimistic model of capacity. Integrated efficiencies are derived from the mean of minimum and maximum efficiencies. A bootstrapped quantile regression validated the integrated efficiencies. The results showed that the omission of delays in this performance measurement resulted in the overestimation of efficiency for service providers and that it is not possible to statistically reduce delays without reducing capacity levels. Also, a feedback effect existed in the production of air navigation services between airlines and these service providers which provided the scope for further studies.

The relationship between traffic stability and capacity for decentralized airspace

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Abstract — The work that is presented in this paper is part of an ongoing study on the relationship between structure and capacity of decentralized airspace concepts. In this paper, the effect of traffic stability, which considers the occurrence of conflict chain reactions as a result of conflict resolution maneuvers, on capacity is examined closely. Using the domino effect parameter as a measure of traffic stability, a model relating stability and capacity is derived. Although the derivation of this model is not complete, its current form shows that traffic stability, and therefore capacity, is also affected by the safety and efficiency characteristics of decentralized concepts. This suggests that the capacity measurement of decentralized concepts must consider the variation of intrinsic system-wide properties with density, using a minimum of safety, efficiency and stability metrics. Future work will continue the development of the model, and its validation using large-scale simulation experiments.

Attention distribution and trust in higher levels of automation within air traffic control

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Abstract — Air traffic control (ATC) is constantly changing and developing to handle more traffic and increase fuel efficiency among aircrafts, but still maintain a highly safe environment. The levels of automation are increasing to respond to the new demands and challenges, but this comes with an uncertainty for the automation behavior. Situation awareness and attention distribution for the operators are important factors to maintaining control and trust within automation. This paper presents findings from one case study including distributed attention and trust in automation within ATC. An approach on how to investigate trust in higher levels of automation is then proposed. Further, this paper will also present an approach on how to proceed with future research in this area, and the importance of investigating trust in automation and levels of automation in all domains of air traffic control.

Evaluation of feasible machine learning techniques for predicting the time to fly and aircraft speed profile on final approach - Predictive dynamic support tool on final approach

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Abstract — Currently, at many airports, the runway throughput is the limiting factor for the overall capacity. Among the most important constraining parameters is the separation minima expressed in distance. On the top of these minima, the difference of the leader and follower aircraft speed profiles imposes to consider buffer to cope with compression effect. Currently, Air Traffic Control Officers (ATCO's) take these buffers on the basis of their training and experience. However, this experience will not be sufficient to safety deploy advanced concepts, like pair-wise separations, that increase variability in the separations to be delivered and therefore in the compression buffer to be considered. Systematic analysis of years of radar tracks has allowed to better predict the buffers to apply by characterising the time to fly (T2F) given a separation distance and True Airspeed (TAS) profile as a function of meteorological parameters. This paper presents how Machine Learning (ML) techniques may be used for predicting the T2F and TAS profile on final approach. Different ML techniques will be assessed on their forecast performance, computational time and amount of data needed for delivering a reliable prediction. The techniques will be applied on 2 different major European airports traffic and will be benchmarked against Optimized Runway Delivery (ORD) study using a Model Based Approach (MBA) for deriving the T2F and TAS. As a result the most efficient ML techniques will be applied on two case studies for predicting the T2F and TAS.

A case study: With public & private sector perceptions, New İstanbul Airport through PPP

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Abstract — Air transportation includes a lot of uncertainty for all shareholders of industry such as airlines, fuel suppliers, air traffic, airport operators. To address this, some research focused on reel option as a right investment evaluation tool by highlighting the importance of flexibility against uncertainty. Reel options as an investment evaluation tool helps decision makers to evaluate investment within the contexts of flexibility. As previous studies indicated, considering airport investments as massive infrastructure projects and including too much uncertainty, it is rational to plan these investments with options those which could conserve project against uncertainties and evaluate through the instrument of real option (RO). Yet public and private sector interests on options in public-private partnership projects (PPP) has never been examined. Motivated by this absence this paper focuses on the public and private sector interests on options in airport infrastructure project. We purpose the investigate; perception and motivation source of private sector involvement in PPPs and importance rate of options for both public and private sector perceptions by taking New Istanbul Airport (NİA) as a case study which planed modularly and has passenger grantee by government those which can be seen as options.

Modeling and inferring aircraft takeoff mass from runway ADS-B data

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Abstract — Aircraft mass is an important parameter in many ways, either to build aircraft performance models, to predict flight trajectories, or to simulate air traffic. Mass data is usually considered as sensitive information for airlines and is, therefore, not disclosed to researchers publicly. In this paper, we use two methods to infer the mass of an aircraft at its takeoff phase. The first is by studying the kinetic model at lift-off moment. The second is to look at the motion of aircraft on the runway at each sample moment to estimate the mass recursively.

General aviation runway design evaluation based on aircraft deviations from runway centerline

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Abstract — Accidents or Incidents where aircraft veer-off or overrun a runway, known as runway excursions, are among the most common abnormal events at general aviation airports. The design of a runway environment has direct effects on whether or not a given aircraft incurs a runway excursion as a result of an abnormal takeoff or landing. As runways continue to accommodate larger and faster aircraft, there is some question as to how current runway design standards protect against runway excursions. To assess this, this FAA supported research analyzes the deviation from centerline of aircraft operating on a general aviation runway. A configuration of LiDAR sensors and point cloud analysis was used to track aircraft using the runway for touch and go operations during calm wind conditions had minimal deviation, an average of less than 2 feet, from centerline. This may imply that the designed runway width specifications may be accurate if not generous. These preliminary results may offer the FAA an opportunity to revisit current design standards. Future research will analyze aircraft operations of various aircraft types under various atmospheric conditions in order to derive results that may benefit the FAA in future runway design considerations.

A fleet management algorithm for automatic taxi operations

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Abstract — The continuous growth of air traffic has resulted in congestion and long queues at airports, causing delays, pollution and loss of money for the airlines. In this paper, we present a new solution to perform just in time taxi operations using autonomous electric towbarless tractors. The purpose of this solution is to eliminate queues and to reduce the environmental and economic impact of ground operations, meeting the requirements for the future air traffic management (ATM). An algorithm for a tool that provides conflict-free schedules for the tractor autopilots will be presented; the generated schedule is meant to minimize the overall cost of the ground operations. The proposed algorithm is based on a hybrid particle swarm optimization (HPSO), hybridized with a hill-climb meta-heuristic, that defines an optimal set of path and speed for each flight in the flight schedule. The effectiveness of the proposed HPSO algorithm compared to the classical particle swarm optimization (PSO) was studied. Results showed that the proposed algorithm is more effective with respect to the classical PSO, even though the required computational time drastically increases.

Impact of the Mt. Baekdu explosion to South Korea's air transportation with hypothetical scenario

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Abstract — This research focuses on the hypothetical case of the possible eruption of Mount Baekdu and the assessment of the level of disruption to South Korea. The focus of the analysis is on the nine routes that are connected with major airports in South Korea. This study analyzes the effects of volcanic ash to air traffic flow at national and worldwide levels.

Analysis of runway capacity to derive a normalized capacity model

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Abstract — Airports are intermodal interfaces between landside and airside traffic. The accompanied infrastructure is planned for target capacity and the expected use inside the (air) transport sector (e.g. intercontinental hub, feeder airport, secondary hub) and cannot easily adapted to react on increasing demand when exceeding its capacity. Additionally, in densely populated areas, land needed for expansion is very rare, which leads to developments of new technologies and optimizations to cope with the increasing demand. This paper presents an approach to evaluate the effect of technologies increasing the airport capacity regarding to the runway capacity. In this context, a normalized airport model is developed and implemented. The normalized model covers several aspects of the runway infrastructure, like length or offset. Furthermore, the traffic structure including arrival/departure rates and traffic mix (heavy, medium, and light aircraft) are analyzed to reflect different characteristics of the operational airport environment. This normalized approach allows a reliable benchmark of different airport capacities and overcome the long lasting argumentation of non-comparability based on specific airport characteristics. Finally, this paper provides a fundamental concept as an essential element of a capacity development roadmap using both current and future technologies/procedures.

Airborne-SLAM approaches as automation techniques of air transportation

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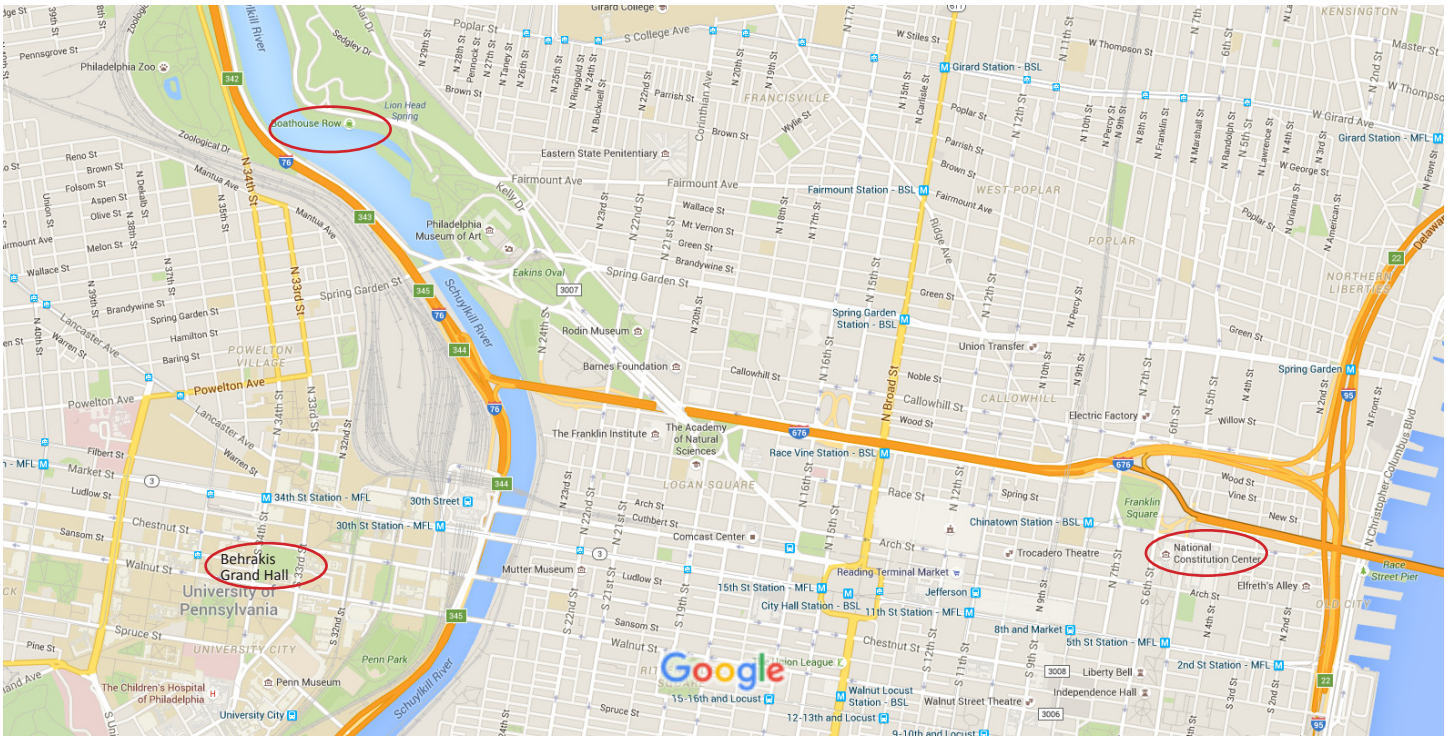
Abstract — Simultaneous localization and mapping (SLAM) of unmanned systems has been proposed in last decade for global navigation satellite systems (GNSS) denied environments. In this reseach it is identified in details by detecting SLAM algorithms particularly in air vehicle platforms as a tool for application of an automation strategies from other domains to air transportation or surveillance and navigation applications of data science in aviation besides particle and particle flow filter based SLAM of aerial systems is first stated as well. Regarding to survey consequences the variety of SLAM applications span from parametric filters such as Unscented Kalman Filter, Extended Kalman Filter to nonparametric such as Particle Filter and concerning diversity of vision based approaches that aims up level control and variety of sensors that unmanned vehicles carry a taxonomy is a requirement of better comprehension SLAM performances. Although it is not aimed to compare performance of all SLAM methods for problem of Airborne-SLAM (A-SLAM) navigation the scan of indexed papers suggests that best SLAM algorithm can only be identified in reference to the scenario which differs in environment, platform, vehicle, sensor, etc. and can be used as an transportation tool by combining path planning and other navigation approaches.



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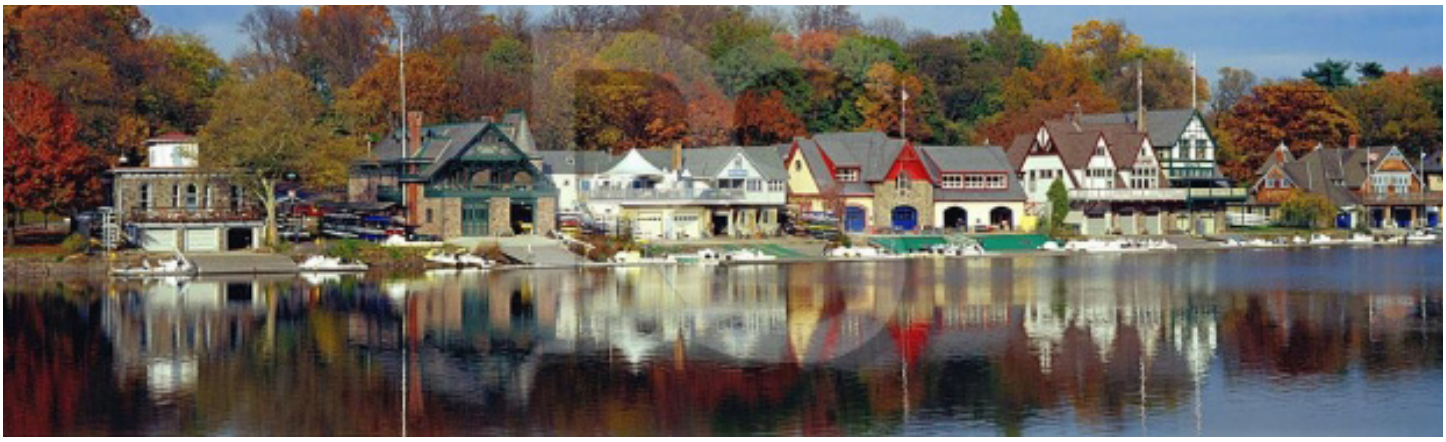

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