AAS NEWSLETTER
Aviation Applications Section of INFORMS

Spring 2019

A Word from the Section Chair

Andrew Churchill
Mosaic ATM
AAS Chair

Welcome to the latest issue of the AAS newsletter, highlighting the section's recent and upcoming activities. It remains an exciting time to be at the intersection of operations research, analytics, and aviation. While there have been many recent advances, challenges continue to arise, but research and development (like that conducted by AAS members) to support data-driven decision-making will continue to improve the safety and efficiency of the global aviation system. While the same generic description may be relevant each year, to me it truly feels as though our data-driven work is beginning to make more significant breakthroughs in the industry, and we're just about to reach an inflection point. It is, and will continue to be, an exciting domain in which to work!

This newsletter includes a number of announcements of upcoming activities, as well as summaries of past activities, and I encourage everyone to review these to identify new opportunities. Many people contribute to this newsletter, but special thanks go to guest editor Farbod Farhadi for his excellent work collecting the materials and prodding everyone to complete their assignments. The other current AAS officers are Vice Chair Alexandre Jacquillat, Secretary/Treasurer Bruno Santos, and webmaster Reed Harder. This team (guided ably by the INFORMS staff!) ensures that the valuable work of AAS continues.

A highlight of this newsletter is the interview with Wouter Kalfsbeek of KLM Royal Dutch Airlines, in which he describes the various analytics activities ongoing at KLM. This continues a trend with AAS newsletters of interviews describing operations research and analytics activities at airlines, providing a useful glimpse into how airlines try to leverage research and development to develop or maintain a competitive advantage. I encourage everyone to review past newsletters to compare the focus of these various airlines, and contrast the approaches described by each interviewee.

INSIDE THIS ISSUE

A Word from the Section Chair

I am looking forward to this year's INFORMS Annual Meeting in just a few short months, from October 20-23 in Seattle. As usual, it will be a busy time for us all, full of technical sessions, keynote speeches, reconnecting with colleagues, and of course, the AAS business meeting. Our cluster chair, Chiwei Yan, has done a great job assembling the presentations germane to our section, and coordinating with other relevant INFORMS groups. We will highlight student presentations during the AAS Best Student Presentation Competition, and I encourage everyone to attend these sessions and provide feedback for these rising stars.

If anyone has any feedback on this newsletter, or would like to become more involved with AAS, please feel free to contact any of the AAS officers.

Thanks for reading!

Andrew Churchill

Interview with Wouter Kalfsbeek at KLM:
Analytics in Aircraft Maintenance

Wouter Kalfsbeek

KLM E&M Big Data Lead
KLM Royal Dutch Airlines

Part I: Wouter Kalfsbeek Carrier's Background

1. Can you describe your educational background and work experiences?

I studied Aerospace Engineering at TU Delft and for my MSc. I chose the Air Traffic & Operations track because I was more interested in how technology could aid the airline business directly. During my studies, I was also introduced to Operations Research techniques and applied this while conducting research on future military airborne supply chain concepts for the Royal Netherlands Army.

After graduating in 2011, I joined KLM E&M's Engineering department as a "generic" Project Engineer and later became a Liaison Engineer between Air France Industries and KLM E&M, which are two branches of the same mother company Air France KLM. During my regular job responsibilities, I also started spotting opportunities for applying more advanced data analytics within our aircraft maintenance business. Starting out with applying the traditional Six Sigma methods, I also found that data-driven solutions for the Improve and Control phases were not really available and that Predictive analytics and Operations Research were relatively unexplored territory within KLM E&M. Here I found my vocation.

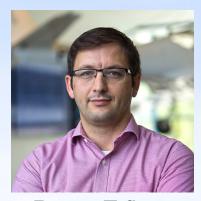**2. Can you describe your current role and job responsibilities at KLM?**

As the E&M Big Data Lead, I am responsible for the Big Data program within KLM E&M. The program concerns all activities with regard to the development of Advanced analytics applications, including the use of "Big Data" technologies and infrastructure. We recently created a new business department to facilitate this development, pulling it out of the project sphere and making it a continuous program because we're here to stay. As the program manager, I report to and consult with the business executive management on the direction of the program, products, priorities, results, etc… and other related/strategic topics. Otherwise, I also manage the product development funnel from ideation to implementation of the products, organizing and supporting the cross-functional product teams that develop the products.

Part II: Interview Questions

1. You are responsible for leading a team working on data analytics to improve aircraft maintenance practices at KLM. Can you tell us more about your work and the goal of this team?

Aircraft maintenance is a tremendously interesting area to develop data analytics. Maintenance is a necessity of course, and safety levels must be guaranteed at all times, but there is still quite a lot that can be done to optimize the availability of the aircraft fleet for our Operator and maintenance customers, by preventing or managing technical disruption. Also, there are still plenty of opportunities in the business and maintenance processes where resource efficiencies can be increased and thus reducing the cost of maintenance as well. A big challenge is, of course, the high level of uncertainty that we have to cope with in maintenance.

Featured Article by Bruno F. Santos & Farbod Farhadi
Interview with Wouter Kalfsbeek at KLM:
Innovations in Air Travel Through Analytics (cont.)

Bruno F. Santos
Assistant Professor
Delft University of Technology
AAS Treasurer/Secretary

Basically, any aircraft maintenance process can benefit from some form of predictive or forecasting, and many maintenance processes concern planning and resourcing aspects which can be. Seeing so much potential, we've started creating in-house capabilities for Data Science and Operations Research development in order to develop these advanced analytic products.

Our Flagship product is "Prognos for Aircraft", which is a Big Data-driven predictive maintenance system that continuously analyses the sensor parameter values of aircraft technical systems (ACMS) for upcoming failures. Since we're collecting thousands of technical parameters, recorded at on average 1Hz frequency over all flights for an entire fleet, we really needed a Big Data solution for data storage and processing of the analytics. We're now also extending our Big Data technology capabilities as developed for Prognos for Aircraft to our other products. This makes a lot of sense, as maintenance is a very connected business. The same data can be used in multiple ways for different processes/products.

Aside from predictive maintenance, which is the holy grail in aircraft maintenance, we also develop planning optimization tools for the Hangar maintenance planning organization. Our tools prescribe which aircraft should come in which hangar maintenance slots, to guarantee optimal use of the fleet maintenance intervals. We're starting to make the connection with KLM operations and the flight network, and want to start optimizing the maintenance planning into the network planning.

2. You are currently working on several projects regarding big data and the application of machine learning techniques. Can you tell us more about some of these projects?

Well, the truth is, machine learning has not been very successful with so far and we have only one Product implemented that is driven by a machine learning (Random forest) model. So far, we've been a lot more successful with translating engineering hypotheses and features to business rules on the normal/abnormal system/process behaviour. Nevertheless, we expect more for machine learning. We're advancing nicely with our "Non-Routine Predictor" which can predict that amount of fault rework that comes out of inspection tasks during hangar letter-checks. The prediction is made on an inspection task level and overall historical tasks data performed in the past on that particular fleet. The model beats the optimized statistically flat norm that we have now, but it's not precise enough to start adjusting the manpower resource allocation of the hangar yet… getting close though.

We also did a Deep Learning project on Engine Bleed systems, which are notorious problem makers in any legacy aircraft type. The dataset had 12000+ flights and 500 failures messages of 12 different categories from aircraft the central maintenance computer. The model was able to detect and label these failure messages quite accurately itself from the raw temperature and pressure sensor data recordings. Very promising indeed, but we need to scale-up on our processing power before we can provide these analytics on a daily basis.

Featured Article by Bruno F. Santos & Farbod Farhadi
Interview with Wouter Kalfsbeek at KLM:
Innovations in Air Travel Through Analytics (cont.)

Farbod Farhadi
Assistant Professor
Roger Williams University
AAS Newsletter Guest Editor

3. Data analytics has been increasingly popular in the airline industry. According to you, how much will data analytics change aircraft maintenance practices in the future?

Data analytics can potentially change the game in the aircraft maintenance business. For now, analytics are only applied for economic aspects of aircraft maintenance. But imagine that predictive maintenance becomes so advanced that indicate that health or condition of a particular aircraft system or structure becomes better than a physical/visual inspection or operational check. In that case, data analytics can relieve the airline mechanics from all the periodical inspection work, and only trigger a mechanical when a maintenance action/repair is required. As inspections make up about 80% of the aircraft ground time for maintenance, the gain in aircraft availability for the airline can be huge! The concept is called "Condition Based Maintenance" (CBM), where the condition is derived by data and analytics, instead of human intervention.

4. How do you see the collaboration between airlines and academia? Given your experience, do you think that there is currently a mismatch or a win-win situation?

The problems that we're starting to tackle with the E&M Big Data program are becoming increasingly complex. Since the airline business and aircraft maintenance is already highly optimized today, the gains are not tremendous. Combined with the inherent uncertainly of aircraft maintenance, makes investing in research and development by the industry itself quite hard. Do I invest in R&D and optimization of the process/decision making? Or do I just buy an extra spare part to fill me inefficiency… (some people just preferred simplicity and just go for the last option).

My drive is to make aircraft maintenance as efficient and hassle-free for the Airline as possible, which cannot be done without developing Analytics. We've got an abundance of data and business/mathematical challenges for academia to research with… but making available the research problems and data to academia can be quite a pain due to data sharing policies. Partnering-up through more formal research projects definitely helps to set a decent framework between industry and academia to start sharing data in a more controlled manner, instead of - for example – individual student research and graduation projects.

We've recently engaged in a Horizon 2020 research program together with TU Delft and 11 other European partners; which will research the concepts of Condition Based Maintenance from sensor/subsystem design to setting the requirements for which data-driven inspections can be accepted as a maintenance credit (instead of the aircraft mechanic doing an inspection), including all prediction and dynamic planning aspects.

Featured Article by Bruno F. Santos & Farbod Farhadi
Interview with Wouter Kalfsbeek at KLM:
Innovations in Air Travel Through Analytics (cont.)

5. What are the future opportunities for research and development in the aircraft maintenance industry?

It is going to become quite a challenge to develop technologies and techniques to cover the full scope of maintenance program inspection tasks… So plenty of opportunities here! Structural Health Monitoring will have to make giant leaps before it can be applied in commercial aviation to replace the Structure inspection program. Also, maintenance planning methods have a lot more potential… most airlines still plan using standard maintenance letter checks, but task-driven planning optimization on dynamic maintenance opportunities could already bring significant gains in aircraft availability without CBM technology today!

So much still left to do and discover! Very exciting times and a very exciting job to keep spearheading this development at KLM.

Alexandre Jacquillat
Assistant Professor
Carnegie Mellon University
AAS Vice Chair

Meeting held on November 4, 2018 at 6:15pm in Phoenix, AZ. Approximately 60 were in attendance.

AAS Chair Vikrant Vaze opened up the meeting by introducing the 2017-2018 AAS Board.

AAS Secretary/Treasurer Alexandre Jacquillat provided an overview on finances and membership:

There has been a slight decrease in membership from last year, but membership is stabilizing. Overall, membership has been down for a few years following the termination of the joint membership agreement between AAS and TSL and the increase in registration fees. Those in attendance were encouraged to invite friends and others to join AAS to grow the membership.

A net financial gain of $1,000 is expected in 2018. The AAS will therefore consider increases in its yearly activities. Participants were encouraged to provide ideas regarding potential activities.

Membership dues for 2019 are the same at $20/$5/$20/$20 for regular, student, retired and non-INFORMS members.

AAS Vice-Chair Andrew Churchill introduced the INFORMS Committee on Diversity, Equity and Inclusion to the AAS members. Members were encouraged to update their INFORMS profile per the Committee's guidelines, and to discuss opportunities to enhance diversity within the section.

Heng Chen, AAS Cluster Chair, presented the activities at the 2018 INFORMS Annual Meeting. The 2018 AAS cluster involved 24 sessions, which shows a 30% increase compared to previous years. Topics were varied, ranging from predictive analytics, simulation, and optimization in different domains of aviation and air traffic management (e.g., airport capacity management, airline scheduling, airline operations, etc.). The AAS cluster also involved three sessions for the Best Student Presentation. Unlike previous years, the program also included three joint sessions with TSL. Finally, Heng Chen reminded the audience of the keynote talk from Jon Petersen of Uber titled "The Dawn of Urban Aerial Ridesharing".

Heng Chen, AAS webmaster, reported on the AAS website and LinkedIn group. The website lists recent publications, featured jobs, research funding opportunities, and news from the section.

Senay Solak, AAS Dissertation Committee chair, announced the 2018 Dissertation Award. The Committee included Emmanuel Carrier, from Delta Airlines, Bruno Santos, from TU Delft, Richard Wu, from UNSW Australia, and Yu Zhang, from the University of South Florida. The Committee awarded the award to Dr. Chiwei Yan. His dissertation was entitled "Airline Scheduling and Air Traffic Control: Incorporating Uncertainty and Passenger and Airline Preferences", and submitted to the Massachusetts Institute of Technology. He was recognized for the combination of theoretical grounding and practical implications, as well as for the clarity of his writing.

Susan Hotle, Chair of the 2018 AAS Best Student Presentation Competition, presented the Best Student Presentation Competition. The Committee included Farbod Farhadi, from Roger Williams University, Yi Liu, from Amazon, and Peng Wei, from Iowa State University. The competition included 10 entries across 8 universities, and spanned a very wide range of topics. The results to announce the winner had not yet been tabulated.

AAS Chair Vikrant Vaze introduced the new leadership of the section. The Chair position is held by Andrew Churchill. The Vice-Chair/Chair-elect position is held by Alexandre Jacquillat. The Secretary/Treasurer position is held by Bruno Santos. The Cluster Chair position was given to Chiwei Yan, who received the Dissertation Award. The 2019 dissertation prize committee chair will be Susan Hotle. The 2019 Best Presentation Award Committee chair will be Heng Chen. The 2019 Newsletter Guest Editor will be Farbod Farhadi. The 2019 Webmaster/Communications Coordinator will be Reed Harder. Vikrant Vaze then invited members to join the Committees of the Dissertation Prize and the Best Student Presentation Award.

Vikrant Vaze provided a final reminder of the keynote talk from Jon Petersen of Uber.

The meeting was adjourned and the group headed for dinner at Chico Malo in downtown Phoenix.

2018 Dissertation Award

A committee consisting of Senay Solak (Chair) from University of Massachusetts Amherst, Emmanuel Carrier from Delta Airlines, Bruno Santos from TU Delft, Richard Wu from UNSW Australia, and Yu Zhang, from the University of South Florida awarded the 2018 AAS Dissertation Award to Chiwei Yan from the Massachusetts Institute of Technology for his dissertation entitled " Airline Scheduling and Air Traffic Control: Incorporating Uncertainty and Passenger and Airline Preferences." He was recognized for the combination of theoretical grounding and practical implications, as well as for the clarity of his writing.

Senay Solak
Associate Professor
University of Massachusetts, Amherst
2018 Dissertation Committee Chair

Chiwei Yan
2018 AAS Dissertation Award Winner

AAS extends its congratulations to Dr. Yan, and all the participants, who submitted exceptional research across the board.

2018 Student Presentation Award

AAS held its Best Student Presentation Competition at the 2018 INFORMS Annual Meeting. The presentations considered for the award had to be presented by an undergraduate or graduate student, and required the submission of an extended abstract. The committee consisted of Susan Hotle (Chair) from Virginia Tech, Farbod Farhadi, from Roger Williams University, Yi Liu, from Amazon, and Peng Wei, from Iowa State University. The committee selected the presentation of Xiaojia Guo from the University College London for her presentation entitled "Forecasting Airport Transfer Passenger Flow Using Real-Time Data and Machine Learning."

The committee also elected to name Maryam Torabbeigi from the University of Houston as the honorable mention for her presentation entitled "Impact of Payload Amount on Battery Consumption Rate in a Delivery Application of Drones."

Susan Hotle
Assistant Professor
Virginia Tech
2018 Presentation Committee Chair

Xiaojia Guo
2018 AAS Student Presentation Honorable Mention

2019 AAS Dissertation Award

Susan Hotle
Assistant Professor
Virginia Tech
2019 Dissertation Committee Chair

The INFORMS Aviation Applications Section awards a prize for the best dissertation in any area related to aviation Operations Research (including air traffic management Operations Research and/or airline Operations Research). The winner will receive a plaque and an honorarium of $500. Other finalists will receive an honorable mention and a certificate.

Doctoral dissertations meeting the following criteria are eligible for consideration:

- Dissertation must be completed and submitted between June 1, 2018 and May 31, 2019.
- Dissertation must be in an area relevant to aviation research or practice.

To apply, submit the following documents in portable document format (PDF) via email to Dr. Susan Hotle (shotle3@vt.edu), the committee chair, before midnight Friday, July 19, 2019:

- The completed dissertation
- An extended abstract (4 to 5 pages, single spaced) describing the work and its relevance
- A letter of nomination from the dissertation supervisor supporting the submission and highlighting the importance of the research
- A short paper (20 to 25 pages, double spaced) that is based on the dissertation (optional, but welcome)

Award Committee
Dr. Susan Hotle, Chair
Assistant Professor
Virginia Tech

Dr. Farbod Farhadi
Assistant Professor
Roger Williams University

Dr. Laura Kang
Associate Technical Fellow
Boeing

Dr. Soheil Yousefsibdari
Associate Professor
University of Massachusetts Dartmouth

2019 AAS Student Presentation Award

Heng Chen
Assistant Professor
University of Nebraska - Lincoln
2019 Presentation Committee Chair

The INFORMS Aviation Applications Section will hold a Best Student Presentation Competition at the 2019 INFORMS Annual Meeting. AAS is sponsoring this competition for undergraduate and graduate students who are members of the INFORMS Aviation Applications Section. A certificate of recognition and a cash prize will be awarded.

To enter the competition, the following criteria must be satisfied:

- The presenter must be a member of AAS for the year 2019.

- The presenter must provide an extended abstract (one or two pages in length) as per the Extended Abstract Template provided on the AAS website by July 1, 2019. The extended abstracts should be emailed to Heng Chen (heng@unl.edu), the Committee Chair, by 5 p.m. CDT on July 1, 2019.

- The presenter must be an undergraduate or graduate student at the time of extended abstract submission deadline (i.e. on July 1, 2019), and the presentation must be based on the research conducted while he/she was a student.

- Each presenter is allowed to submit at most one abstract for the competition.

- The presentation must be in an area relevant to aviation research or practice (e.g. airline operations or air traffic management including unmanned aerial systems).

The winner will be chosen based on both the quality of the presentation itself and the extended abstract. We look forward to an exciting set of submissions this year!

The AAS is compiling a list of recent publications to support aviation researchers. Following is a list of sample recent papers that have appeared in INFORMS journals. You are invited to submit your published or working papers to be listed on the AAS website. Please send your papers to the AAS webmaster Reed Harder.

Reed Harder
Dartmouth College
AAS Webmaster

Decision Analysis

Dillon, Robin L., William J. Burns, and Richard S. John. "Insights for Critical Alarm-Based Warning Systems from a Risk Analysis of Commercial Aviation Passenger Screening." *Decision Analysis*, 2018. [URL]

INFORMS Journal on Computing

Sumida, Mika, and Huseyin Topaloglu. 2019. "An Approximation Algorithm for Capacity Allocation Over a Single Flight Leg with Fare-Locking." *INFORMS Journal on Computing*, 2019. [URL]

Management Science

Cui, Yao, A. Yeşim Orhun, and Izak Duenyas. "How Price Dispersion Changes When Upgrades Are Introduced: Theory and Empirical Evidence from the Airline Industry." *Management Science*, 2018. [URL]

Manufacturing & Service Operations Management

Cui, Yao, Izak Duenyas, and Ozge Sahin. "Unbundling of Ancillary Service: How Does Price Discrimination of Main Service Matter?" *Manufacturing & Service Operations Management*, 2018. [URL]

Transportation Science

Agatz, Niels, Paul Bouman, and Marie Schmidt. "Optimization Approaches for the Traveling Salesman Problem with Drone." *Transportation Science*, 2018. [URL]

Bertsimas, Dimitris, Allison Chang, Velibor V. Mišić, Nishanth Mundru. "The Airlift Planning Problem." *Transportation Science,* 2019. [URL]

Büsing, Christina, Daniel Kadatz, and Catherine Cleophas. "Capacity Uncertainty in Airline Revenue Management: Models, Algorithms, and Computations." *Transportation Science*, 2019. [URL]

De Jong, Gerben, Christiaan Behrens, Hester van Herk, Erik Verhoef. "Domestic Market Power in the International Airline Industry." *Transportation Science,* 2019. [URL]

Gambella, Claudio, Andrea Lodi, and Daniele Vigo. "Exact Solutions for the Carrier–Vehicle Traveling Salesman Problem." *Transportation Science*, 2018. [URL]

Haouari, Mohamed, Farah Zeghal Mansour, Hanif D. Sherali. "A New Compact Formulation for the Daily Crew Pairing Problem." *Transportation Science,* 2019. [URL]

Jacquillat, Alexandre, and Vikrant Vaze. "Interairline Equity in Airport Scheduling Interventions." *Transportation Science*, 2018. [URL]

Wei, Keji, and Vikrant Vaze. "Modeling Crew Itineraries and Delays in the National Air Transportation System." *Transportation Science*, 2018. [URL]

Agatz, Niels, Paul Bouman, and Marie Schmidt. "Optimization Approaches for the Traveling Salesman Problem with Drone." *Transportation Science*, 2018. [URL]

Solak, Senay, Gustaf Solveling, John-Paul B. Clarke, and Ellis L. Johnson. "Stochastic Runway Scheduling." *Transportation Science*, 2018. [URL]

Upcoming Meetings

INFORMS International Conference
Cancun, Mexico
June 9-12, 2019

AIAA AVIATION 2019
Dallas, Texas
June 17-21, 2019

23nd Air Transport Research Society World Conference
Amsterdam, Netherlands
July 2-5, 2019

INFORMS Annual Meeting
Seattle, Washington
October 20-23, 2019

AGIFORS 59th Annual Symposium
Seattle, Washington
September 30 - October 4, 2019

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