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May 15, 2018

Dear AGIFORS Conference Delegate,

Welcome to Hong Kong, the location of the 2018 AGIFORS Revenue Management and Distribution Study Group Conference. The AGIFORS organization has a distinguished history of providing a forum for the top operations research and revenue management professionals to exchange thoughts and ideas.

This year’s conference, hosted by Cathay Pacific Airways, continues our great tradition with an outstanding agenda of presentations on timely topics and leading edge concepts from airlines, academics and vendors. During our time together you will hear presentations on important research in the following areas: Revenue Management, Inventory Control, Forecasting, and Revenue Management Technologies.

Our focus is to make this time together productive and informative, as well as enjoyable. The conference organizes a number of events that provide opportunities for you to network with your peers to further discuss ideas and challenges. A complete schedule of each day’s program and each evening’s networking opportunities is provided inside.

We are pleased that you have joined us for this year’s AGIFORS Revenue Management and Distribution Study Group Conference. We look forward to providing you a meaningful and memorable experience.

Sincerely,

Tassio Carvalho  
AGIFORS RM Chair  
tassio.carvalho@aa.com

Sunny Ja  
AGIFORS RM Chair  
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2018 AGIFORS RM Study Group - Conference Agenda

Tuesday – May 15

18:30 – 20:30  Welcome Reception  
at Regal Airport Hotel  
*Sponsored by AGIFORS*

Wednesday – May 16

08:00 – 16:00  Conference Registration

08:30 – 08:45  Conference Overview  
*Tassio Carvalho – AGIFORS Revenue Management Study Group*

08:45 – 09:00  Airline Update  
*Sunny Ja – AGIFORS Revenue Management Study Group*

09:00 – 09:45  Multi-purpose Clustering-Algorithm for  
Revenue Management Applications  
Felix Meyer – Swiss

09:45 – 10:30  Predicting demand for intra-urban air taxi service  
*Laurie A. Garrow – Georgia Institute of Technology*

10:30 – 10:50  Coffee break

10:50 – 11:35  Estimating market size observing only sales  
Kalyan Talluri - Imperial College Business School

11:35 – 12:20  Call-back air tickets: resell capacity to high yield passengers  
Pierre Mathieu & Thierry Delahaye - Amadeus

12:20 – 13:30  Lunch at Regal Airport Hotel

13:30 – 14:10  Classless RM Forecasting and Optimization: Overview of  
PODS Consortium Developments  
Peter Belobaba - MIT International Center for Air Transportation

14:10 – 14:50  How Does "User Influence" Work?  
*Bill Brunger - PODS Research LLC*
14:50 – 15:30  How to measure RM forecast quality  
Anubhav Jain and Wen Zhao – United Airlines

15:30 – 15:50  Coffee break

15:50 – 16:35  Callable Products with Early Exercise and Overbooking  
Guillermo Gallego & Haengju Lee - Hong Kong University of Science and Technology & Pusan National University

16:35 – 17:20  Dynamic Availability  
Amit Agarwal, Hunkar Toyoglu, and Madhusudan Rao - Sabre & Etihad Airways

18:30 – 21:30  Networking Dinner  
Sponsored by Sabre

Thursday – May 17

09:00 – 09:45  The Implications of Dynamic Pricing for Airline Revenue Management  
Michael D. Wittman – Amadeus

09:45 – 10:30  Total Revenue Optimization with Ancillary Marginal Demand Forecasting and Ancillary Marginal Revenue Transformation  
Adam Bockelie – MIT International Center for Air Transportation

10:30 – 10:50  Coffee break

10:50 – 11:35  From Revenue Management to Dynamic Offer Management  
Matthias Viehmann & Jost Daft – Lufthansa Group

11:35 – 12:20  The end of RMS as we know it? (Deep) reinforcement learning for airline revenue management  
Quan Nguyen & Thomas Fiig - Amadeus

12:20 – 13:30  Lunch at Regal Airport Hotel

13:30 – 14:10  Measuring Forecast Accuracy in Revenue Management Systems  
Larry Weatherford & Thomas Fiig – Univ. of Wyoming & Amadeus
14:10 – 14:50  Measuring RM's Performance through Predictive Analytics  
Victor Guardia – Copa Airlines

14:50 – 15:30  Joint Forecasting for Airline Pricing and Revenue Management  
Kavitha Balaiyan - IIT Madras

15:30 – 15:50  Coffee break

15:50 – 16:00  AGIFORS Introduction  
Eric Ruhlin – AGIFORS Treasurer

16:00 – 16:15  Closing Award Ceremony  
Tassio Carvalho & Sunny Ja – AGIFORS Revenue Management Study Group
Airlines

Multi-purpose Clustering-Algorithm for Revenue Management Applications
Felix Meyer – Swiss
In modern applications of revenue management, estimation, forecasting, and clustering of demand as well as the transformation of these into a machine-readable and a manageable form is particularly important. This paper shows how a multi-purpose clustering algorithm is able to tackle all aforementioned tasks at the same time by using the method of model-based recursive partitioning. While belonging to the family of tree-based algorithms, especially appealing for forecasting, model-based recursive partitioning establishes a functional structure defining demand. Therefore, the resulting model is both flexible and stable at the same time by relying on well-established methodologies of machine learning and statistics.

Besides presenting the theoretical framework of the multi-purpose clustering algorithm, this paper also demonstrates applicability by practical examples that concern capacity steering, pricing and forecasting. We also show how each example is easily implemented by open source software, which makes our approach particularly appealing for practitioners.

How to measure RM forecast quality
Anubhav Jain and Wen Zhao – United Airlines
United successfully rolled out a new RM system, Gemini. It is built on the foundation of conditional demand forecast (CDF), which also adapts to changes in schedules and fares filed in the market place using demand elasticity and passenger choice models. Live A/B test confirmed the LF/Yield patterns of the new system vs. old system. However, no matter how advanced/good the science is, it is imperative to design a control process that understands the quality of the forecast. It would not only help resolve any systematic issues, but would also enable business users to make informed adjustments, when needed. We will review the metric, to measure forecast quality, and some examples how we used to help correct the issues and steer the project to success.

From Revenue Management to Dynamic Offer Management
Matthias Viehmann & Jost Daft – Lufthansa Group
While Airlines today increasingly depend on modern distribution of offers via the internet their actual offer creation systems are still mostly based on pre-internet technology. To fully leverage the new opportunities of modern data analytics tools and internet-based distribution airlines need to digitalize their Revenue Management approaches initially developed decades ago and still based on RBDs and statically defined products and prices. By transforming the current RM methods into RBD-independent modules will allow for a truly holistic Dynamic Offer Management that considers product design, pricing and distribution alike.

In this presentation we want to discuss the basic setup to transform current Revenue Management approaches of airlines into a Dynamic Offer Management. To do so we will first shed light on our definition of Dynamic Offer Management as this term is still vaguely described both in academia and industry practice. We will then describe what major changes of Revenue Management approaches and systems are required to pave the way towards RBD- and filing-independent offer creation. Splitting up demand forecasting and customer oriented willingness-to-pay estimation is the foundation to develop both modules in a most flexible and scalable way. Based on this setup the implementation of dynamic pricing is enabled and gradual extensions can be added in the future for optimized ancillary pricing and dynamic bundling.
Measuring RM’s Performance through Predictive Analytics
Victor Guardia – Copa Airlines

Prescriptive analytics are commonly used throughout all industries in order to evaluate performances. In the aviation industry, we measure: ASMs, RPMs, Load Factor, Revenue, Yield, PRASM, etc. It can be argued that our performance in these metrics directly depends on RM, so the question we must answer is: given RM’s current demand expectation for all future flights, how will my network perform in terms of Load Factor, Revenues, Yield for all future flights? Is this demand distribution realizable, given the current booking behavior? We propose to use Predictive Analytics in order to gauge our future performance, and guide RM through their daily decision-making process.

We will dive into our classification algorithm that determines in-risk flights and our RM-based simulation which predicts Load Factors, Spoilage, Denied Boarding, etc. The rise of predictive analytics and algorithms empowers us to understand our history, learn from it, accurately predict our future and improve upon our performances. Measuring the past is always important as it gives us a sense of what has been possible. Measuring the future, however, gives us the ability to change and improve upon what is possible.

Academic

Predicting demand for intra-urban air taxi service
Laurie A. Garrow – Georgia Institute of Technology

Improvements in battery technologies offer the potential for dramatically lower operating costs for new classes of electric propulsion aircraft. By reducing aircraft operating costs, electric propulsion could transform both air and surface transportation. “On-demand mobility” (ODM) has been interpreted in an aviation context as an air service between origin-destination pairs located at dispersed locations – not necessarily airports – that operates in an unscheduled (“on-demand”) paradigm. There is now widespread belief that ODM missions could be served by smaller electric propulsion aircraft with vertical take-off-and-landing (VTOL) capabilities that operate from vertiports or similar infrastructure. It is envisioned that these electric-VTOL (eVTOL) aircraft could provide air-taxi service for trips of two to four passengers between 10 to 70 miles within congested urban areas. Uber is planning demonstration flights in Los Angeles and Dallas of these eVTOL aircraft within the next five years. Imagine a world where instead of sitting in traffic on the downtown connector, you could simply drive to a vertiport near your home, fly over traffic, land on a rooftop near your work, and either walk or have an Uber driver take you to your office. In this presentation, we provide an overview of ongoing research in ODM flights, describe the methodology we are using to estimate commuting demand and willingness to pay for eVTOL flights and present an “eVTOL index” to show the potential profitability of eVTOL flights in different cities in the U.S.

The Implications of Dynamic Pricing for Airline Revenue Management
Michael D. Wittman & Peter Belobaba – Amadeus and MIT International Center for Air Transportation

New distribution technologies will soon allow airlines to dynamically adjust prices based on the characteristics of each shopping request. In this presentation, we discuss the implications of these next-generation pricing mechanisms for traditional airline revenue management. First, we discuss how airlines could provide targeted increments and discounts to traditional RM fares based on session segmentation and estimates of conditional willingness-to-pay. Using results from MIT PODS simulations, we show how these dynamic pricing mechanisms can lead to revenue gains by increasing conversion, in the case of discounting, and by increasing yields, in the case of incrementing. We close by addressing several common practical concerns with dynamic pricing, including potential customer and regulatory reactions, the possibility of forecast spiral-down, and the risks of a race to the bottom.
CLASSLESS RM FORECASTING AND OPTIMIZATION:
OVERVIEW OF PODS CONSORTIUM DEVELOPMENTS
Peter Belobaba - MIT International Center for Air Transportation
This presentation describes the recent evolution in the MIT PODS Consortium of new forecasting and optimization algorithms for airline revenue management without fare classes. A classless price-demand forecast for each time frame is fed into an optimizer that determines an optimal fare to be offered in each time frame during the booking process, with the objective to maximize revenue contribution (fare minus bid price). New iterative variants of both the Probabilistic Bid Price (ProBP) and Unbucketed Dynamic Programming (UDP) algorithms will be presented. The Passenger Origin-Destination Simulator (PODS) is used to illustrate the revenue performance of these new Classless RM methods relative to traditional class-based RM in a competitive airline network.

TOTAL REVENUE OPTIMIZATION WITH ANCILLARY MARGINAL DEMAND FORECASTING AND ANCILLARY MARGINAL REVENUE TRANSFORMATION
Adam Bockelie - MIT International Center for Air Transportation
We present a dynamic programming formulation for total revenue optimization, incorporating the revenues and passenger choice impacts of ancillary services in addition to ticket revenues. An estimate of conditional passenger choice probabilities is used to compute the choice-adjusted total expected revenue of each fare class, which is combined with a demand volume estimate from the Ancillary Marginal Demand (AMD) forecasting model. Combined with an Ancillary Marginal Revenue transformation on the expected class revenues, this approach converts existing RM optimizers (such as EMSR) to become both ancillary-aware and choice-aware. We discuss implementation challenges and use the Passenger Origin-Destination Simulator (PODS) to illustrate the revenue benefits of our approach versus traditional RM models.

Callable Products with Early Exercise and Overbooking
Guillermo Gallego & Haengju Lee - Hong Kong University of Science and Technology & Pusan National University
Capacity providers such as airlines have traditionally increased revenues by practicing market segmentation and revenue management. However, they have left money on the table by neglecting to broker capacity between consumers with different willingness to pay. With the introduction of callable products, some consumers who buy capacity at low-fares grant the option to the capacity provider to recall capacity at a pre-specified recall price. These options in turn allow the capacity provider to buy back capacity to satisfy demand from high fare consumers when capacity is exhausted. Although the idea of callable products was introduced before for the special case of two fares, we make the procedure more operational by allowing multiple fares and restricting the option exercise policy to allow displaced low-fare customer to make alternative plans. Our model allows the service provider to keep their booking limit and overbooking policies in place. Our numerical study illustrate how callable products are win-win-win, providing additional revenues to the capacity provider, better service to high-fare consumers, and higher expected surplus to low-fare consumers who grant recall options.

Measuring Forecast Accuracy in Revenue Management Systems
Thomas Fiig & Larry Weatherford- Amadeus & University of Wyoming
Demand forecasting is an integral part of a revenue management system (RMS), which means that measuring forecast accuracy is paramount when evaluating the performance of the RMS, both from a theoretical and a practical point of view. Unfortunately measuring forecast accuracy is not so simple, since we cannot directly compare demand forecasts with observed bookings. The observed bookings have been exposed to the RM-controls (e.g., capacity constraining, user-intervention, etc.) and therefore we do not directly observe the true underlying demand, but rather constrained observations.

It has been well documented over the years from numerous PODS studies, as well as in the literature, that the maximum revenue is generated with a (positively) biased forecast, which is generally obtained by applying a forecast
multiplier. From a theoretical point of view, this is a disappointing outcome. We would ideally prefer that the most accurate forecast produces the maximum revenue:

\[ \text{min forecast error } \implies \text{max revenue} \]

However the failure of this requirement, raises fundamental questions of the value of forecasting – until we are able to more accurately measure forecast accuracy, we essentially cannot tell a good forecast from a bad one.

Therefore, we took a step back and introduced a new method to evaluate forecast accuracy – based on conditional forecast accuracy. We point out that this measure is completely general and applicable to any demand model (independent as well as dependent demand). We undertook a series of PODS experiments to see if this measure satisfied the fundamental requirement above. In this presentation we will report our efforts with a miniature PODS Network (A1one—a single O&D market with a single airline).

**Joint Forecasting for Airline Pricing and Revenue Management**
Kavitha Balaiyan, R K Amit, Atul Kumar Malik, and Xiaodong Luo- IIT Madras & Sabre

Demand forecast plays a critical role in the performance of airline pricing and revenue management systems. Traditional airline forecasting models assume that the historical price, fare structure and flight schedule roughly stay the same for the future. They also sometime assume that demand for the products are independent and often ignore the dependency of the demand on the airline inventory control policy or real time price changes.

In this talk, we develop three progressively more complex new forecasting models, which take all of the above into consideration. In addition, these new models try to better capture the underlying customer behavior by including the maximum willingness to pay of the customer and the choice attributes of the available options (services). The choice component in our models is similar to a mixed logit model.

Our first model excludes price from the set of choice attributes. The second model considers price as one of the choice attributes. The utilities of maximum willingness to pay and choices are combined in the third model. We propose a method to calibrate the forecasting models. We compare the models and analyze the results by utilizing Airline Planning and Operations Simulator (APOS) on real airline data. The parameters and the availabilities are then used to compute the expected demand forecast and forecasting accuracies. The forecasts can be used as inputs to optimization modules for dynamic pricing and inventory control.

**Estimating market size observing only sales**
Kalyan Talluri - Imperial College Business School

We consider the following generic estimation problem. A firm sells a single product over a finite selling season. It can only observe purchases. It wishes to estimate (i) market-size (ii) price-sensitivity. This problem is not estimable. However in many RM and retail settings there is competition and firms have access to competitor price information. This by itself is not enough for identification, but in many industries firms have access to aggregate competitor demand information. We exploit this to estimate not just market-size and price-sensitivity but also a competitor attractiveness factor. Further complications in the real-world are endogeneity of price and market-size, unobservable competitor initial capacity, capacity-constrained sales and network effects. We address all these problems to estimate on a hotel data set. Extensions to multiple customer segments are discussed using similar ideas. (Joint work with Muge Tekin, UPF).

**How Does "User Influence" Work?**
Bill Brunger - PODS Research LLC

Continuing his study of User Influence from previous years, Dr. Bill Brunger will use PODS Simulation results to examine how "smart" RM algorithms and well-crafted post-forecast adjustment heuristics (which resemble User Influence) improve economic results. Bill will focus on two heuristics which have proven effective in past PODS studies -- "DUI" uses current booking levels to adjust forecasts in future time periods and "LocoFM1" compares the host carrier's lowest fare to OA current lowest fares, taking into account relative historical fare levels.
**Vendors**

**Call-back air tickets: resell capacity to high yield passengers**
Pierre Mathieu & Thierry Delahaye - Amadeus

During the reservation period of some flights the demand significantly fluctuates due to changes in business environment. Some demand variations can hardly be anticipated by the airline revenue management system. Therefore it often happens that sale policy applied at a given time in a flight turns out to be sub-optimal a posteriori. A mechanism of ticket buy-back can then be an interesting tool for the airlines aiming at boosting revenue from these flights. This presentation addresses main stages of a buy-back process triggered by the airline.

This process includes the revenue management based solutions to support the selection of the tickets and the computation of the asked prices to get them back. We specially study three schemes of compensation that could be put in place by an airline to spur some of their passengers. A new mathematical model which optimizes airline expected revenue from buy-back according to the probability of passenger acceptance will be presented. The model has been assessed in a simulation environment for three compensation schemes. We played buy-back campaigns for several flights from actual airline and passenger data. Results emphasize our assumption that business benefits can be expected from a well automated mechanism of ticket buy-back and resell.

**Dynamic Availability**
Amit Agarwal & Hunkar Toyoglu - Sabre

In today's competitive landscape, understanding how an airline is positioned relative to its competitors is key to maximizing revenue. Revenue management systems rely primarily on the airline's historical booking data to forecast demand and optimize the inventory controls; RM systems do not have visibility into how an airline is positioned relative to its competitors. Airlines typically rely on their RM analysts to observe and react to market conditions; in turn, they depend on data sources such as ATPCO, OAG and INFARE to understand what competitors are doing.

Analyzing and taking actions based on these data is manual and time consuming (making the airline responses sub-optimal and slow).

For several years, Sabre Consulting has been using a new solution which augments existing RM systems to help airlines dynamically react to market conditions to maximize profits. This solution uses existing airline inventory controls to make real-time adjustments to availability rather than dynamically changing airline prices (which is currently difficult to achieve across multiple distribution channels). This dynamic availability solution identifies potential availability changes based on customer shopping & booking activity, competitive positioning, and quality of service offered using customer choice and optimization models and price positioning logic. In this talk we are going to present the challenges we faced, our solution approach and the value this solution adds to an airline.

**The end of RMS as we know it? (Deep) reinforcement learning for airline revenue management**
Quan Nguyen & Thomas Fiig - Amadeus

Reinforcement learning (RL) is an area of machine learning concerned with how machines take actions in order to optimize a given reward (e.g., revenue) by interacting with its dynamic environment. Some well-known recent applications include self-driven cars and machines playing games better than humans (e.g., chess and go). One of the main advantage of this approach is that there is no need to explicitly model the nature of the interactions with the environment. In this work we present a new airline revenue management optimizer based on reinforcement learning.

The model does not need neither a demand forecasting nor customer modeling (i.e. to estimate willingness to pay) to work. It is theoretically proven that RL will converge to the optimal solution, however in practice, the system may require a lot of data (e.g., thousands of years of historical bookings) to learn the optimal policies. To overcome these issues, we present a novel model that integrates domain knowledge powered by a deep neural network trained in specialized hardware. The results show very encouraging results with different numerical / simulated scenarios. We believe this opens the door to a new generation of revenue management system that could automatically learn by interacting with the competitors and customers, so it can react much faster to changes in the market conditions.
Hong Kong Night Tour with Chinese Dinner at Jumbo Floating Restaurant

5/16 18:30 - 21:30

Pick up from Regal Airport Hotel followed by Hong Kong Night Tour. Enjoy Chinese Dinner at Jumbo Floating Restaurant (include Chinese Tea). After dinner, transfer to Victoria Peak with sparkling views of Hong Kong as your backdrop. Tour end, transfer back to Regal Airport Hotel.
Conference Evaluation Form

Section I: Conference Content
Please answer the following questions
1=Strongly Disagree - 5=Strongly Agree

This conference met my expectations: 1 2 3 4 5
The pace of the conference was appropriate for the subject: 1 2 3 4 5
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Please list any topics that you would have liked to discuss:

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Section II: Presenters
Please answer the following questions
1=Poor - 5=Outstanding

Rate the presenters’ overall knowledge of the subject: 1 2 3 4 5
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