CEE 8813: AIRLINE PLANNING AND REVENUE MANAGEMENT

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Instructor

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Introduction

Revenue management (RM) integrates multiple concepts from demand modeling, operations research, and economics. The sheer volume of booking transactions combined with limitations of distribution channels has shaped the historical evolution of demand forecasting and optimization approaches used in RM. This course covers demand forecasting, inventory control, and revenue optimization approaches that are used by airlines as part of their RM systems. Students will gain practical experience in implementing these approaches in Python and have the opportunity to use a competitive RM simulator to explore how RM demand forecasting and optimization approaches used by one airline influence revenue outcomes for that airline as well as its competitors. Industry experts from airlines and travel technology companies will help mentor students on class projects using the competitive RM simulator.

Required Background

This course will use concepts from probability, statistics, and operations research and will require you to complete homework assignments and projects using Python. I have designed this course to be accessible to students who have had an undergraduate probability and statistics course, but I am not expecting you to have prior programming experience in Python or exposure to operations research models. As part of the course, you will learn about different forecasting and optimization techniques (including time series, expectation-maximization, linear programming, dynamic programming, etc.), and learn how to apply these techniques to airline RM problems.

Course Evaluation

The course grade is based on performance in several areas.

1 Midterm Exam	20%
7 Homework Assignments (5% each)	35%
3-4 Simulation Assignments (weighted equally)	15%
Final Project Presentation	18%
Class Attendance for Guest Speakers	12%

There will be opportunities throughout the course to earn extra credit (see the individual assignments for details).

Course Organization

The course is organized into nine teaching modules.

Module 1: Introduction to Revenue Management and the Airline Industry

This module defines revenue management, explains its origins in the airline industry, and provides an overview of how RM and the airline industry have evolved since deregulation. This module also explains how revenue management and pricing fit into the larger airline planning process and influences fleeting, network planning, and schedule development processes.

Module 2: Introduction to Python
This module provides an introduction to Python and will show you how to use training resources available through GT's LinkedIn Learning subscription.

Module 3: Overbooking
Ever been bumped from a flight or accepted compensation in exchange for waiting to take a later flight? This module explores how US denied boardings have evolved over time and reveals how airlines decide when and how to overbook flights. You will learn the difference between deterministic and risk-based overbooking policies and how to calculate overbooking limits based on these two policies.

Module 4: Demand Forecasting and Unconstraining Methods for Differentiated Products
Ever try to buy an airline ticket at the last minute and wonder why the fares were so high (or have you tried to buy an airline ticket recently and wondered why the fares were so high?) Well the first step in understanding how airlines decide how many tickets to sell for each product is learning about how airlines forecast demand for fare products. This module explains why demand forecasting for RM applications is important, yet challenging and how exponential smoothing (or time series) methods, moving averages, classic and advanced additive pickup models, and classic and advanced multiplicative pickup modes are used to forecast demand for differentiated products. This module also covers methods that are used to account for censored or constrained demand; these include naïve methods, imputation methods, and expectation-maximization (EM) and projection detruncation (PD).

Module 5: Leg-based Inventory Controls
In this lecture, you will learn about how airlines decide how many seats to offer for sale for each fare product on a flight (translation: why do you see a particular fare when you go to book a flight?) We'll start by learning about different inventory controls and how they are implemented in distribution systems and why Littlewood's Rule is fundamental to finding booking limits. We will then cover different methods that are used to find leg-based inventory controls, including those based on expected marginal seat revenues (EMSR-a and EMSR-b), linear programming (LP), and dynamic programming (DP).

Module 6: Path-based Inventory Controls
This module introduces methods that incorporate network-level information into optimization models that find booking controls. We'll start by learning about greedy algorithms, virtual nesting, and displacement adjusted virtual nesting (DAVN), and then cover advanced optimization models including network linear programs (NetBP), DAVN/NetBP with leg EMSR-b, probabilistic bid price (Pro-BP), and unbucketed dynamic programming (UDP).

Module 7: Demand Forecasting for Undifferentiated Products
Just when you thought things couldn't get more interesting, along came low cost carriers and the introduction of one-way pricing! This was a major change for the airline industry and drove new developments in demand forecasting and optimization methods for undifferentiated products. In this module, we'll learn about "Q-forecasting" for undifferentiated products, hybrid forecasting for mixed fare structures, and fare adjustment techniques based on marginal revenues (MR) and a technique developed by Karl Isler (KI).

Module 8: Ancillary and Matrix Pricing
Remember when you used to buy any airline ticket and you always got your first checked bag for free? Well, not today! This module covers the evolution of airline pricing strategies and provides a preview of what may be coming with New Distribution Capability (NDC).

Module 9: RM Simulation Tools for Competitive Markets
There are many more extensions to the basic models we learned about, but alas, we have to wrap

up our discussion of RM methods so we have time to see how these methods work in competitive markets!

The last part of the course will introduce you to different simulation tools for evaluating the impacts of RM strategies in competitive marketplaces. Stated another way – it's great that we've learned about the ***many*** ways that airlines use to forecast demand and optimize revenue, but why are there so many methods used in practice? Well, because the "best" set of approaches depends on many factors that are outside the control of one airline – like what RM systems your competitors are using, their products, seasonality, etc. In this module, we will use an RM simulator to explore how the concepts we learned about earlier in the class play out in competitive marketplaces.

For this part of the class, we will begin with a set of "lab assignments" and use the competitive RM simulation tool to see the revenue and load factor impacts associated with using (or not using!) more sophisticated forecasting and inventory allocation methods in multi-competitor airline RM networks. As part of a final class project, you will use the competitive RM simulator to explore a topic of interest to you and industry experts. Industry experts will be invited to listen to your presentations and may serve as mentors/resources for the simulation projects.

Learning Objectives

By the end of this course, you will be able to

- Explain what RM is, why it is important, and how it has evolved since the 1980s.
- Explain the basic steps of the airline planning process, and different types of factors that are considered in fleet planning, network planning, and schedule development
- Calculate overbooking limits
- Unconstrain demand using EM, PD, and pick-up methods
- Compute nested booking limits and protection levels using leg-based and path-based optimization methods
- Modify demand inputs to account for undifferentiated products, mixed fare structures, and fare families
- Modify algorithms to account for buy-up and buy-down behavior
- Understand where the industry is headed with ancillary and matrix pricing and offer management
- Conduct simulations to understand how different network structures, demand forecasting techniques, and revenue optimization approaches impact RM outcomes
- Be comfortable programming in Python
- Be familiar with a host of methods you can use beyond revenue management (time series, linear programming, dynamic programming, expectation maximization, etc.)
- Have the knowledge you need to pursue an internship or career in airline RM.

Course Textbook and Other Resources

There is no required textbook for this course. As part of each module, I have compiled a set of resources that include journal articles, book chapters, M.S. theses and Ph.D. dissertations, and online videos that I used to develop the lectures. In addition, I have pre-recorded my lectures and will make these available through a private YouTube channel. Note that I do not intend to run this course virtually – the reason I prerecord lectures is so that you can review material while doing homework assignment or preparing for exams and so that you can manage your workload and meet course deadlines. I realize that things come up – job interviews, being sick, etc. I have designed the course so that if you need to you can work ahead or catch up when unexpected things happen (all HW assignments and lectures are available at the start of the semester).

Course Website

All materials are available on Canvas. However, to facilitate training of industry experts, I have also created a course website that contains all of the resources for the course, located here:

https://sites.gatech.edu/ce-atlatgt/courses/cee-8811-airline-revenue-management/. The site is password protected and the password will be distributed in class. Course communication will be through Canvas.

Policies on Homework and Exams
Please note that all assignments must be turned in via Canvas. on the due date at the beginning of class. Only medical reasons will be considered for late assignments. Only in extreme cases will late homework will be accepted with a penalty.

Collaboration and Group Work
Collaboration on homework assignments and projects is strongly encouraged. I realize that we have a wide variety of skill sets and background coming into the course, and I am a firm believer that one of the best ways to learn new material is by collaborating with others, particularly when you have complementary backgrounds. Students may work in groups of two or three for the homework assignments and submit a single assignment. Also, if you are particularly proud of the way you completed an assignment, let me know! As part of this collaborative learning environment, I ask for volunteers to present their solutions so that other students can learn and see how others approached the problem (and get programming tips!) You will have the opportunity to demonstrate how well you have mastered the course concepts on your own as part of the midterm exam.

Requests for Regrade
All requests for regrade must be made in writing using the "request for regrade form." I reserve the right to regrade the entire exam, homework, or project, thus please be aware that requests for regrades may result in raising OR lowering your grade OR having it stay the same. All requests for regrades must be submitted in writing within one week of when the instructor returns the HW/Exam/Project. There are no exceptions to this policy. I will not consider regrades at the end of the semester.

Academic Integrity
Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on GT's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/. Any student suspected of cheating or plagiarizing on an exam or homework will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities
If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404) 894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Course Outline

Week	Date	Assignment Due Dates	Lab Due Dates	Topics
1	8/21/2023 8/23/2023			Introduction to the course and the airline industry
2	8/28/2023 8/30/2023	HW 1 (introduction)		Python
3	9/4/2023			Labor day - no class
	9/6/2023			Overview of the airline planning process
4	9/11/2023			
	9/13/2023			Overbooking
5	9/18/2023			Ben Bubnovich (Director of Network Planning at Delta)
	9/20/2023	HW 2 (Python)		Matt Schrichte (Director of Fleet Planning at Delta)
6	9/25/2023 9/27/2023	HW 3 (overbooking)		Demand forecasting for differentiated products
7	10/2/2023		Lab 0 (access)	Intro to competitive RM simulators and evaluation metrics
	10/4/2023	HW 4 (demand forecasting)		Emmanuel Carrier and Brian Rexing (Delta)
8	10/9/2023			Fall break - no class
	10/11/2023		Lab 1 (demand)	Leg-based inventory control methods
9	10/16/2023			
	10/18/2023	HW 5 (leg-based controls)	Lab 2 (leg)	Path-based inventory control methods
10	10/23/2023			
	10/25/2023			Demand forecasting for undifferentiated products
11	10/30/2023	HW 6 (path-based controls)		
	11/1/2023	HW 7 (demand forecasting)	Lab 3 (path)	Ancillary and matrix pricing
12	11/6/2023		Lab 4 (demand)	
	11/8/2023			Review for exam
13	11/13/2023			Midterm exam
	11/15/2023			Prep for final projects
14	11/20/2023			Jonas Rauch (PROS)
	11/22/2023			Thanksgiving - no class
15	11/27/2023			Michael Wittman (Amadeus)
	11/29/2023			Prep for final projects
16	12/4/2023			Sergey Shebelov (Sabre)
17	12/13/2023			Student presentations in final exam period 8:00 AM - 10:50 AM

DISCLAIMER
The instructor reserves the right to amend this syllabus as necessary. Any changes will be announced in class. (Updated: July 28, 2023)