Assignment 2

AE4423 – Airline Planning & Optimisation 2024/2025

Deadline: **17h, 17th January 2025**

First read the entire assignment carefully (including the appendices) to extract all information required to adapt the models presented in the lectures!

For each problem, describe the mathematical model, your assumptions, results and KPIs for each of the assignments in detail in a comprehensive report. Use figures and tables to present your results and KPIs and support your conclusions.

The report shall not contain any computer **code**. Add your Python code in BrightSpace. Make sure that it is clear and well commented.

Submit your report and model script file(s) through BrightSpace at the latest on January 17th, 17h. Don't forget to include the group number, names and student IDs in the report and script file(s). Files submitted by email will not be considered. If you fail to meet the deadline, 0.5 points will be deducted from your grade for each day after the deadline.

Minimum grade: If you fail to obtain a grade of 5.5 or higher you will fail the assignment. In that case, you will get a chance to improve your work and pass the assignment. Your final grade cannot become higher than 5.5 in that case.

Grading of the report code is:

- 30% - Mathematical modelling. Correct declaration of objetives, contraints
- 50% - Programming. Correct logic of the simulation. The simulation answers the question.
- 20% - Reporting. Clear report with proper conclusions. Proper use of use figures and tables to present results.

Individual Workload: To distinguish between workload in the group, provide an indication of each member's workload in three separate disciplines. This workload distribution should be in a separate file uploaded along with the assignment. Follow the template below.

Student Name/Number	Mathematical Modelling	Programming	Reporting
Name/Number #1	#%	#%	#%
Name/Number #2	#%	#%	#%
Name/Number #3	#%	#%	#%

Contacts: Marta Ribeiro – m.j.ribeiro@tudelft.nl
Pieter-Jan Proesmans - p.proesmans@tudelft.nl

Contents

Introduction

A new cargo airline that is starting operations in the next quarter of the year. Your first task is to design the flight schedule and the aircraft routings for your operations, to maximize the profits. The chosen business model is to transport cargo overnight with fully dedicated second-hand freight aircraft that your airline has.

Do not take values from Assignment 1 into account. For this assignment, consider the new data files:

- *AirportData.xlsx* - information on 20 airports
- *FleetType.xlsx* - information on the available aircraft fleet
- *GroupX.xlsx* - information on the cargo demand (X indicates your group number)

Question 1 - Aircraft Routing Problem

With the data available in the Excel data files and the Appendices, determine the flight schedule and aircraft routing for a period of **five days (120-hour period)**. You must determine which aircraft to fly a specific route as well as the departure time of each flight. Assume that all your aircraft **must start and end the period of five days at the hub airport** and that **only flights to and from the hub** are considered. The goal is to maximize the profit over this period.

To achieve this goal, you need to:

1. Apply the **dynamic programming** framework presented during the lectures to solve the problem.
2. Setup a Python computer model according to the dynamic programming framework. You should not use any commercial solver. In your report, add the pseudo-code of your computer model.
3. Determine the optimal routing of each aircraft and corresponding departure times, assuming the data in the Excel file (airport list, demand matrix and fleet information), and the data in the appendices from this assignment.

Additional information:

- You do **not** have to use all the aircraft in your fleet. Only if it is profitable.
- Your airline will only consider adding aircraft routes that:
  - Have a minimum of 6 hours of **block time** per day.
  - Respect **range** and **runway** constraints.
- Besides the flight time and the TAT, assume that:
  - The aircraft takes **15 min extra** for take-off and get to cruise position.
  - The aircraft takes **15 min extra** for approaching the destination airport and landing.
- Divide your scheduling horizon (24 hours) into **time stages of 6 minutes**. That is, each hour will be divided into 10-time stage, where, e.g., 5.4 = 5h24min.

Appendices

A - Demand Management

The demand is given in 4-hour bins. The input Excel file shows the demand associated with each 4-hour bin. Observe that demand only occurs at night from 20:00 until 08:00.

Additionally:

- The demand is given per route and they already consider the connection of cargo at the hub.
- The demand for a 4-hour bin will be available at any time within this 4-hour bin.

When you fly at hour t, assume that you can capture **all the demand of the associated 4-hour bin** and a **maximum of 20% of the demand associated with the two previous 4-hour bins** (so earlier during the **same night**).

Note as per the example below: if your flight departs between 04:00-08:00, you can still capture demand associated with the time bins 20:00-00:00 and 00:00-04:00:

+20%

+20%

Day 1						Day 2	
00:00-04:00	04:00-08:00	08:00-12:00	12:00-16:00	16:00-20:00	20:00-00:00	00:00-04:00	04:00-08:00
0.0	0.0	0.0	0.0	0.0	81048.7	101352.5	28186.2

However, you cannot capture from the bins before 20:00, as this would be more than 2 bins away.

Finally, assume that you can fly at **maximum capacity** (load factor = 100%).

B - Revenue

Revenue is generated by transporting cargo. To determine the revenue, yield is expressed in € per Revenue-Ton-Kilometer (RTK), which in this assignment is constant and equals 0.26 €/RTK. The following revenue formula must be used, which depends on the distance flown:

$$R_{i,j} = Yield_{ij} \times d_{i,j} \times flow_{i,j}$$

where:

- $R_{i,j}$ is the revenue generated in € between origin i and destination j.
- $Yield_{ij}$ is the yield in € per Revenue-Ton-Kilometer (RTK) between airports i and j.
- d_{ij} is the distance in km between origin i and destination j.
- $flow_{i,j}$ is the cargo flow in tons being transported between airports i and j.

C - Costs

Operating your aircraft induces costs. Consider the same operating costs breakdown as in *Assignment 1*:

- All aircraft are **leased**, and therefore a leasing cost needs to be accounted for. The weekly leasing cost is a fixed amount depending on the type of aircraft.
- **Operating costs** consist of three components:
  - **Fixed operating costs** (C_X^k) are costs per **flight leg** and represent costs such as landing rights, parking fees and fixed fuel cost. They depend only on the aircraft type k.
  - **Time-based costs** (C_T^k) are costs that are defined in € per flight hour, and represent time-dependent operating costs such as cabin and flight crew. They depend on the distance of the flight leg and the aircraft type k. Time costs can be defined as follows:

$$C_{T_{ij}}^k = c_T^k \frac{d_{ij}}{V^k}$$

    where:

    * $C_{T_{ij}}^k$ is the total time cost for a flight leg between airports i and j operated by aircraft type k.
    * C_T^k is the time cost parameter for aircraft type k.
    * V_k is the airspeed of aircraft type k.
  - **Fuel costs** C_F^k are dependent on the distance flown, and can be expressed as follows:

$$C_{F_{ij}}^k = \frac{c_F^k \times f}{1.5} d_{ij}$$

    where:

    * $C_{F_{ij}}^k$ is the fuel cost for a flight leg between airports i and j operated by aircraft type k.
    * c_F^k is the fuel cost parameter for aircraft type k.
    * f is the fuel cost, equal to 1.42 USD/gallon.

The **total operating cost** for a **flight leg** between airports i and j operated by aircraft type k can then be expressed as:

$$C_{ij}^k = C_X^k + C_{T_{ij}}^k + C_{F_{ij}}^k$$