## Description of the Airline Industry

Airline Industry Outlook: In 2020, the pandemic caused a massive drop in air travel demand, resulting in a significant financial hit to the industry. Many airlines were forced to ground their planes, cancel flights, and furlough or lay off employees. Governments around the world also implemented travel restrictions and border closures to try to contain the spread of the virus, further impacting the industry. The airlines have been able to bounce back after vaccine rollouts and an increase in travel demand, however with the recent war in Ukraine oil prices have skyrocketed, negatively affecting airlines profit margins.

There are 3 considerations an airline needs to consider if it wants to establish itself at an airport

1. Locations to consider
2. Fixed hangar costs
3. Routes to reach destination

As the world continues to open up following the endemic, airline companies are required to navigate through this shifting market to meet the demand of the consumers

## Description of Our Problem

The application involves helping an airline determine where to set up hangars at several different airports in order to minimize the cost of connecting flights between California (LAX and SFO) and New York (LGA and EWR).

The model involves us crafting a network flow model: airports as the nodes and flights connecting the hubs as arcs. Further characterizing this application, the problem will involve the following constraints: hangar costs, allocating resources, and fulfilling node demand – all of which are further detailed below.

Demand: LAG - 516 incoming flights, EWR - 356 incoming flights

Supply: SFO - 467 outgoing flights, LAX - 437 outgoing flights

Dataset

- Fuel cost was determined by the product of distance between airports and the cost of oil per mile flown
- Fixed cost from hangar is determined from public information shared in financial reports, demand flown in airports, and public government details
- Supply and Demand is determined by averaging the number of daily flights flown during the peak season of summer

Assumptions Made

- Hangar Cost:  An estimation determined by state tax rate and demand for the airport. Estimation is based on published financial report
- Fuel Cost: $4 per mile flown; determined by average mileage on plane
- Big M: Determined from public information shared of by the airport
- Demand: Based off the average number of daily flights flown out of demand nodes from June-August

- Supply: Based off the average number of daily flights flown out of supply nodes from June-August

Decision Variables

- Flow[i,j]: Number of flights departing from location i and arriving to location j
  - Integer Value: The number of flights taken from airport I to airport J
- Hangar[j]: Paying the start-up fee for having access to hangar in airport J
  - Binary value: Don't pay the start-up cost, 1 pay the start-up cost

Objective

Objective: Minimize the total cost that fulfills that supply and demand constraints placed on the model. Cost is determined by the total sum of fuel costs and fixed hangar costs.

- Minimizing total costs ( (Fuel Cost (Ci) * Flow[i,j])+ (Hangar Cost (HCj) * Hangar[j]):
  - Fuel cost is determined by the product of distance between airports and the oil cost per mile.
  - Hangar cost is the one-time cost to ground a plane and use an airport

Constraints

In order to ensure that our model remained intact, we had to establish several constraints across each node in the network. Firstly, we created supply and demand constraints which ensure that total outflow does not exceed total supply, and total inflow meets total expected demand at each of the supply and demand nodes. Since total supply exceeds total demand, the difference between inflow and outflow must be less than or equal to supply. Next, for our transhipment nodes, the difference between total inflow from any airport to airport J to the outflow from airport J to any airport must be greater than zero. Finally, to establish a relationship between our integer and binary variables, we created linking constraints that also doubled as the capacity constraints. If the start-up binary hangar cost is paid, then United is able to fly into that airport, if it is not paid, then the flow into the airport is zero. The big M in this constraint is the maximum number of flights that can land and take off in each airport.

<u>Optimal Solution</u>

Given our constraints and objective, we were able to get the lowest optimal cost of $434,889,133.96. As illustrated in the network model, the airports where hangers were setup were in Detroit, Dallas Fort Worth, and Chicago O'Hare. Another thing to consider is that our goal was to minimize the cost of sending passengers from California to the greater New York Metropolitan area. Our supply nodes were located in San Francisco and Los Angeles, and our demand nodes were Newark and New York LaGuardia airports. This allowed us to minimize the cost of sending passengers from California to the greater New York Metropolitan area.

| Variable | X |
|---|---|
| flow[SFO,ORD] | 436 |
| flow[LAX,DFW] | 436 |
| flow[DFW,LGA] | 80 |
| flow[DFW,DTW] | 356 |
| flow[DTW,EWR] | 356 |
| flow[ORD,LGA] | 436 |
| hangar[DFW] | 1 |
| hangar[ORD] | 1 |
| hangar[DTW] | 1 |