A Forced Market Optimization   
of LA Basin Delays

Team J4 + B

Table of Contents

Introduction…………………………………………………………………………………………....…..1

Background Research……………………………………………………………………………....…...2

Methodology……………………………………………………………………………………....………3

Expected Results………………………………………………………………………………….……...5

Introduction

**Primary Research Question:** How should LA air traffic be redistributed among the 5 major LA airports to minimize delays and what incentives would be required to achieve that distribution?

Our project is to investigate the capacity and limitations of the 5 Los Angeles area airports (LAX, LGB, SNA, ONT, BUR) and determine a way to optimally redistribute traffic among them for the primary purpose of reducing delays and associated carbon footprint. Two of these airports already cooperate to some extent under LAWA (Los Angeles World Airports, LAX and ONT). However the other three are separate entities, and all are subject to market forces. We will be considering a situation where all five airports are able to cooperate to determine and implement the most efficient traffic distribution and what incentives would be required to achieve that distribution.

By reducing airline delays, passengers may enjoy a smoother traffic experience, aircraft fuel burn may be reduced, and air travel carbon footprint will be reduced.

However, implementing such traffic redistribution will come with costs, including possible increased total travel time, increased fare, and increased psychological/convenience costs. The study will seek to determine what incentives are necessary to encourage travelers to follow the offerings of the redistributed traffic.

Background Research

We started by doing background research on the 5 distinct airports that are stationed at the LA basin, getting a general idea on the airport layouts, airport capacities, runway lengths/orientation, and other information to gain a better understanding of our locations.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Gates | Total Operations | Yearly Passengers | Runway lengths | Hours |
| BUR | 14 | 130,756 | 3,943,629 | **15:** 6886x150 **8 :** 5801x150 | 5:30 am -10 pm |
| LAX | 121 | 655,564 | 74,937,004 | **24R:** 8925x150 **24L:** 10285x150 **25R:** 12091x150 **25L:** 11096x200 | 4am - 1 am every day |
| LGB | 11 | 304,720 | 2,523,686 | **25L:** 5423x150 **25R:** 6192x150 **30:** 10000x200 | 7am - 10pm |
| ONT | 19 | 153,715 | 4,209,311 | **26R:** 12198x150 **26L:** 10200x150 | 4am - 1:30am |
| SNA | 26 | 260,689 | 10,180,258 | **19R:** 5700x150 | 5am - 1am |

Professor Rakas granted our team access to the ASTM FAA database, and we have been analyzing this data for our research.

Methodology

Our analysis will begin by writing a Mixed Integer Linear Program (MILP) that takes individual FAA flight data for the five airports on a given day, and determines a schedule that minimizes total delays with respect the scheduled arrival times they would otherwise have. This is achieved by some reassigning flights to different airports, by reducing aircraft velocity in the terminal area, and through holding patterns at the beginning of the approach.

All arrival points of origin and departure destinations will be divided into n approach directions to determine an approximate time penalty for choosing an airport that is either closer or farther away from the intended destination. There will be R different destinations considered where R is the number of runways with independent operations across all airports. A decision variable xi r will be used to determine which destination is chosen for each aircraft i. The total number of aircraft considered are Na for arrivals and Nd for departures. Furthermore, an additional order decision variable di j will be used to record any changes in the overall order that aircraft are allowed to land.

At this point, the model only models arrivals for simplicity and proof of concept. The reason we are focusing on arrivals first is because minimizing airborne delay is our first objective to to its large expenditure of fuel. MATLAB coding is still in progress but once it is complete, the model can be expanded to include departures for mixed operations.

In terms of constraints, aside from the functional constraints to operate the program, an additional delay limit will be imposed on individual aircraft, to avoid solutions that prevent certain aircraft from landing for excessive amounts of time. This limit is yet to be determined but we will conduct further research to determine a suitable limit.

The MILP will be formulated as follows:

**Variables:**

|  |  |  |
| --- | --- | --- |
| Physical Meaning | Variables | # of variables |
| Wheels on time | t1 ……...tN | N (A/C) |
| Runway decision variables | x11 ……...xNR | N\*R (A/C \* runways) |
| Order decision variables | d21 ……...dij (for i>j) | N(N-1) |
| # of holds | H1 ……...HN | N |
| Delay on approach | D1 ……...DN | N |

**Problem Formulation**

|  |  |
| --- | --- |
| Minimize air delays relative to estimated arrival. | Min |

**S.t.**

|  |  |
| --- | --- |
| Purpose | Constraint |
| Wheels on time equals estimated air time + additional rerouting time + hold delay +approach delay (Aeq) |  |
| Delay limit per A/C |  |
| Single destination constraint |  |
| Minimum headway constraint (inactive for A/C with different destinations) | equation preview |
| Runway capability constraint |  |

Once we are have a program that can generate our optimized schedules, the bulk of our investigation will be on comparison of it with the status quo. We should be able to compare delays between the two scenarios and to determine the percent utilization of each airport after rescheduling and the percent change from actual utilization. We will be able to analyze what times of day are seeing delay reductions and which times might see increases, as well as see which individual flights were rerouted and sort them by categories like aircraft type, point of origin, and airline. There is also an opportunity to investigate the effect of error on delay by introducing error to the actual arrival time of aircraft, thus simulating the effect weather and point of origin delays that are beyond our control.

If time permits, the amount of delay reductions can be paired with engine efficiency and fleet mix data to determine the fuel savings due to reduced air delay. This way, we will be able to assign a value to the solution and propose financial incentive methods for its implementation.

Expected Results

We expect to create a optimal airplane schedule that would minimize delays across the LA basin’s airports cumulatively, solving the congestion problems in LAX. Our hope is to create a schedule that we can propose to the airline authorities. A schedule exceptionally better than their current plan that would force the airlines to acknowledge our brilliance and adjust their schedule accordingly.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Total Operations | Yearly Passengers | Runway lengths |
| BUR | 130,000 | 4,000,000 | **15/33:** 6886 **8/26:** 5801 |
| LAX | 655,000 | 75,000,000 | **24R/6L:** 8925 **24L/6R:** 10285 **25R/7L:** 12091 **25L/7R:** 11096 |
| LGB | 300,000 | 2,500,000 | **25L/7R:** 5423 **25R/7L:** 6192 **12/30:** 10000 |
| ONT | 150,000 | 4,200,000 | **26R/8L:** 12198 **26L/8R:** 10200 |
| SNA | 260,000 | 10,000,000 | **20R/2L:** 5700 |