**Scheduling Aircraft Landings – The Static Case**

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**Abstract:** This paper presents the problem of Scheduling Aircraft Landings, an important practical problem in today's world, as the industry suffered an overall tremendous growth in the past decades, and in many countries, effective use must be made of the available runway capacity. The problem consists of determining how to land aircraft approaching an airport and involves assigning each aircraft to an appropriate runaway, by computing a landing sequence for each runaway and scheduling the landing time for each aircraft. The main objective is to achieve effective runway use. For this purpose, the Aircraft Landing problem is considered. Two techniques will be presented: Mixed Integer Programming and Constraint programming. Computational results are then presented comparing the two techniques used and for tests using …**FINISH/COMPLETE/CHANGE**

**Keywords:** Aircraft landing scheduling, Delay minimization, sequence-dependent scheduling, Runway operation, Mixed integer programming, Constraint programming.

# Introduction

Over the past few decades, air traffic has experienced tremendous growth, as air transport become one of the fundamental modes of transport for personal and business travel, and commercial delivery. However, in 2020 due to the worldwide COVID pandemic (that started that same year), the industry observed a setback in their numbers, with less traffic for passengers and freight traffic their growth has dropped tremendously [1]. In the next year (2021) the numbers rose to show an improvement from 2020, but they are still very far away from the pre-pandemic numbers [2].

As air traffic developed, the limitation of resources, like manpower but special the limitation of runways become a bottleneck during airport operations. Located in Europe, London Heathrow airport is one of the busiest airports in the world and has only two runaways. When the number of approaching flights overpasses the airport capacity, some of these aircraft can’t be landed on their “target” landing time. Resulting in an extra cost mainly on a waste of fuel for each plane flying faster than its most economical speed. Airlines will have to deal also with costs for delays of their fights and unsatisfied customers. Transfer customers can miss their connecting flights. The crew operating the current flight can be needed on another flight, which has now to be rescheduled resulting in another extra cost. Flights that are on land (departing flights) can also be affected by this, as they can also be delayed and not authorized to depart due to the lack of available runaways, this will also have an impact on the operations of the destination airport of these flights. Other possible costs are crew overtime payments, crew rescheduling, etc. Back in 2017, it was reported that congestion cost to airlines and passengers around 25 billion euros, according to FAA/Nextor estimated [3].

Therefore, even now that the air industry is not growing or even having the same results as in past years it's important to solve the problem of Scheduling Aircraft Landings (SAL), which consists of the problem of assigning each aircraft an optimal landing time and runaway in a way that the cost is minimized. This can be achieved by reaching the maximum efficiency of resources and overcoming the problems observed in the past decades when the increase in air traffic causes a drastic increase in the number of aircraft take-offs and landings within a given period at a certain airport or runaway, that results in an overload issue in terms of airport capacity and delay issue in terms of aircraft scheduling.

Air traffic control (ATC) aims to control air traffic, to prevent collisions and delays. ATC is usually operated by humans and therefore human error can happen. An important part of their responsibility is the planning of airport operations, such as the arrival and departure of aircraft, which is the focus of this paper. Automating this solution, will not only save time but overcome human error.

Aircraft landing scheduling can be understood as giving priority to different aircraft, that need to land at a certain time. This problem becomes more complex, as previously explained, in busy airports with limited runaways and with several aircraft trying to land at the same period.

But there are different ways of formulating this problem, depending on the perspective used. For instance, from a point of view of an airline, their main objective would be to minimize the deviation from the “target” landing time, while from an airport management perspective is to maximize the airport capacity usage and therefore minimize their cost in losses. Both objectives are directly related to cost and the final objective is to minimize direct and indirect costs associated with aircraft landing for both airliners and airport managers.

In resume, air transportation has established itself as one of the most important means of transport, which directly implies the increase in air traffic, and therefore the efficient management and scheduling of aircraft take-offs and landings (given the limited resources such as time, budget, etc..) have become a very challenging and complex problem for air traffic controllers.

Therefore, in this paper, Mixed Integer Programming and Constraint programming will be used to address the problem of SAL, formulating this from the point of view of airport management. The main goal is to find an optimal landing sequence based on the available runaways, number of flights, and expected delays and therefore minimize their cost.

The organization of the paper is as follows. In section 2, an overview of the problem context is given. In section 3, … In section 6, the results obtained in sections 4 and 5 are discussed.

In section 7, the paper is concluded. **FINISH/COMPLETE/CHANGE**

# Problem Context

# Methodology

# Problem Formulation

# The MIP Model

# The CP Model

# Computational Results

# An analysis of the tests and results (including some KPIs on the difficulty of the instances and resolution time) (asked by the teacher)

# Conclusions

# References

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