Flight Scheduling Optimiser

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Analysis

# Problem Identification

Flight scheduling considers the arrival/departure times and block times for a specific flight. However, many other factors also affect a flight’s schedule, such as the specific airport, connecting flights, turnaround time, flight route, other airlines and destination. These flight schedules are created by software months in advance by the airline so that flights can run smoothly and with minimum disruptions.

However, unexpected events can happen, such as bad weather or a health problem holding a plane up. This can mean that the original scheduling done in advance needs to adapt and change. This is done by a human team of schedulers. This takes time and means the airlines must employ people to do this task, costing them money that could be used elsewhere. The airline will also further lose money for staying on the aircraft apron docked into a gate as it has exceeded the time it was allocated. Therefore, airlines want disruptions to be handled has quickly and as efficiently as possible, which can only be done to a limit with a human team.

Instead, a solution to this problem of dealing with unexpected events could be computational. This is because it will be faster to solve, meaning that scheduling changes can be made with minimum disruptions to other airlines. Also, this will reduce the long-term costs for the airlines, as they wont have to pay wages for people to do the scheduling, and also the costs for disruptions when at the airport.

# Stakeholders

The clients for this project will be airline owners and managers in charge of current flight scheduling, so will respond well to how the project is solving the problem of efficiency and time management. Not many other users with have access or use this software, so the demographic for this project is quite small. The clients will use the software in airports or in airline businesses that help schedule the flights for specific companies.

The stakeholders should represent the opinions of different airlines, and how they would want a computational solution to deal with different situations. The stakeholders should be people who will use this software to schedule flights on their airlines, as they will want to implement the software in replacement of the scheduling team that currently exists.

My stakeholders are Becky, Giacomo and William, who are all graduate airport planners for Atkins. Atkins is a British multinational engineering, design, planning, architectural design, project management and consulting services company. They will be helping me with the areas to include with the flight optimiser, as there are many factors I could include and will help me make choices in that area. They are representative of my demographic as they are people who could handle the software that is being made. They will be representing managers of airlines who would use this software to schedule flights in their airline, so will be looking for the software to foremostly be a scheduling technology, with the added advancement of the adaptability to unknown variables.

# Why is it suitable to a computational solution?

The solution is suitable to become computational because of the implemented use of algorithms. The solution will use an algorithm to schedule the flights for the airport, considering different variables, which the algorithm can solve faster than a human. It is also suitable for a computational solution because the software will be able to change variables and update the schedule with a higher accuracy and efficiency rate than currently can be done, which will aid to solve the problem of having to wait for flights to be rescheduled.

# Computational methods that will be used

## Problem Decomposition

This problem can be divided into steps that then can further be divided into sub-problems (see Divide and Conquer). My original plan to decompose the problem is:

1. Take in the flight data
2. Schedule a flight with this data
3. Check for any external variables that have been added
4. Move any flights that are affected

This should mean that the program runs smoothly, and that each variable is checked and there are no clashing flights. It should also mean that the programs runs more efficiently than if the whole problem was solved as one as variables could get missed.

## Divide and Conquer

This method is divided up into three sections; divide, conquer and combine. Divide is when the problem is split into two or more sub-problems that are similar to the original problem but are smaller in size. Conquer is when the sub-problems are solved recursively and then the problems are combined to create a solution to the original problem.

Some of the sub-problems will include:

* Creating a working button for the instructions menu
* Create a function that puts all the flights into a list
* Check the user interface in functional and working correctly
* Create an algorithm that can organise the flights

Using this method means that again, like problem decomposition, everything is checked and that each aspect of the problem is looked at and solved. It also means that the problem is solved faster whilst still being accurate.

## Representational Abstraction

This is when unnecessary detail is removed to provide a simpler version of a complex problem.

Some details that can be removed using representational abstraction are:

* Physical details of the planes (e.g. mass, colour)
* Some external factors (this still needs to be decided which ones will be removed)
* The exact amount of plane docking areas there are on the apron in representation of an airport imitation (e.g. not copying Heathrow Airport exactly)

This is key to making the problem computational, as having to code every detail would be impossible to achieve in the time-frame set. This will also mean that the focus can be on more important

## Information Hiding

Information hiding is when the complexity of the code is hidden behind interfaces or encapsulated in classes.

Ways that information hiding could be used:

* GUI that the user will interact with to use the program (e.g. PyQt, Kivy)
* Using object-oriented programming to utilise encapsulation

This will be an advantage to this problem as a GUI will make the software useable to my stakeholders, as it will be a simple design compared to having to deal with information in the command line.

# Success Criteria - First Draft

|  |  |
| --- | --- |
| **Criteria** | **How to Evidence** |
| Shows the flight schedule on main window | Screen shot of the main window with schedule on it through use of GUI |
| The option to change environmental/disaster variables | Screen shot of the buttons that can change the variables |
| The option to stop simulation | Screen shot of the buttons that can stop/pause the simulator |
| Able to add/delete flights | Screen shot of the buttons that can change the number of flights in the schedule |
| Shows that the software is fast and efficient | Show an efficient use of an algorithm (screen shot the code) |
| Instructions with how to use the software through a pop-up window | Screen shot the options to view the instructions and the instructions button |
| Settings menu were the changing variable and adding/deleting flights option will be stored | Screen shot of the menu and the settings button |
| Simple, usable design | Screen shot of the main window which shows a simple design were everything is clearly labelled and everything is explained |
| All functions are working | Screen shot evidence of testing, with all the inputs and outputs that are made |
| GUI is interactable | Screen shot of the simulation in use |

# Research

## Factors affecting flight scheduling

The airport that the flight is arriving or departing from could affect the flight schedule. This is due to the capacity or the airport and how busy it is, which is caused by:

* Limited slots available for airplanes on the tarmac
* Different window allowances by airport
* How many gates are available and at what times they are available
* How many runways are available
* Is there any construction occurring at the airport

Flights don’t always go from A to Z, as connecting flights can occur. This would mean that the schedule would need to take into account the time it takes for passengers to depart the first flight, walk to the connection gates and go through customs whilst also taking into account any refuelling that needs to occur for the planes.

Other factors that can affect the scheduling include:

* Turn-time
  + the amount of time it takes the plane to empty out and the crew to [clean and board the next flight](http://www.cntraveler.com/stories/2016-07-11/how-and-how-often-airplane-bathrooms-are-cleaned), as well as whether there are crews that need to be swapped out who might be flying in from another destination.
* Time plane is in the air
  + Air traffic, so might opt for night-flights when going a bust route to avoid traffic
* Marketing factor
  + Is the airport a certain hub for an airline
  + Whether there is a morning or evening departure depending on destination
* Weather
* Maintenance/Re-fuelling
* Unexpected events
* ‘Padding’

## Other Types of Scheduling

### Clock-Face Schedule

This type of scheduling is commonly used for train timetables in the US, UK, Switzerland and Germany.

Clock-Face Scheduling is called this because the departure usually take place around the same time in the hour during the day (e.g. 6:30, 7:30, 8:30). This type of scheduling is easy for passengers to remember due to the consistent repeated intervals. A regular scheduling can also improve services and make planning easier. [1]

### Block Scheduling

This type of scheduling is commonly used for school timetables.

This way of scheduling is with the idea that student should have fewer classes per day but for longer periods of time. There are usually three main types of block scheduling [2]:

* Diagram

  Description automatically generated4x4 – 4 blocks of extended (80-90 minute) classes each day, with students taking the same subjects each day. They take 4 subjects over one term and then have 4 different subjects in the following term.

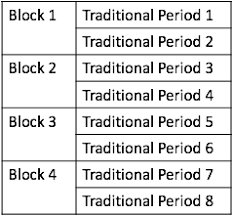
*Figure 1a – 4x4 Block Scheduling Example* [3]

* Table

  Description automatically generatedA/B – 3 or 4 blocks of extended (70-90 minute) classes each day, covering the same ¾ subjects on alternating days, meaning students take 6/8 subjects per term.

*Figure 1b – A/B Block Scheduling Example* [3]

* Hybrid – a mix of traditional models and A/B, students have 5 classes per day, each of between 60-90 minutes.

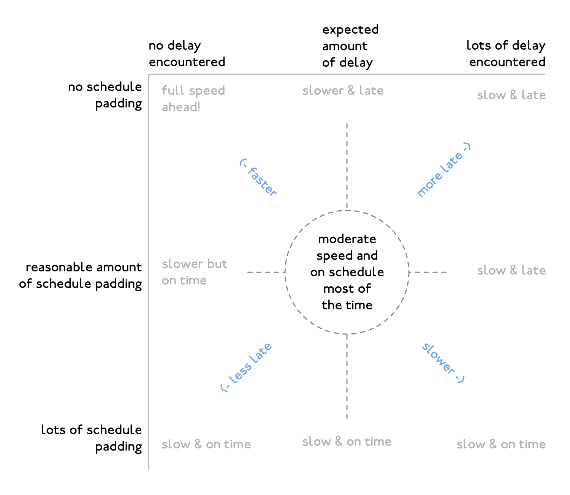


*Figure 1c – Hybrid Block Scheduling Example* [3]

## Scheduling Considerations

### Schedule Padding

Scheduling Padding (also known as ‘padding’ or ‘recovery time’) is the amount of excess time added to the schedule that allows for delays. In airlines, they use padding to improve on-time performance as the percentage of ‘on-time’ trips is a key performance indicator for operators (see On-Time Performance below). The scheduled flight time is usually increased to around 110% of the expected flight time, however some airlines are only padding by around 50%.

Departure delays are normally caused by passengers arriving late or unexpected events at the airport. Delayed flights can cause ‘knock-on’ effects in terms of missing departure slots, which may be a problem in busy time-periods. By padding the schedule, the aircraft is less likely to miss slots in airspaces it has to fly through and slots at airports, and may still arrive on time (or even ahead of schedule) at the destination airport.

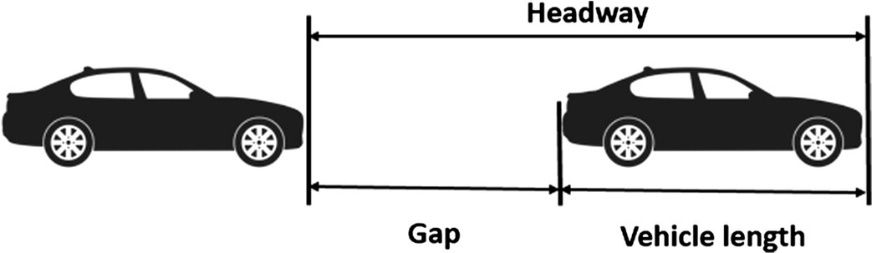
*Figure 2a – Schedule Padding Graph* [4]

Padded flight arrival times also help airlines reduce their financial liability under the [Flight Compensation Regulation 261/2004](https://en.wikipedia.org/wiki/Flight_Compensation_Regulation_261/2004), as compensation for delays is calculated based on the scheduled arrival time published by the airline. As well as this, financial costs can be caused if passengers miss their connection flights[4].

### Headway

Headway is the distance or duration between vehicles in a transit system measured in space or time, which is most commonly measured as the distance from the tip (front end) of one vehicle to the tip of the next one behind it. It can either be expressed as the distance between vehicles or as time it will take for the trailing vehicle to cover that distance.

[Airplanes](https://en.wikipedia.org/wiki/Airplane) operate with headways measured in hours or days whilst vehicles on a motorway can have as little as 2 seconds headway between them.

Headway is key to calculating the overall [route capacity](https://en.wikipedia.org/wiki/Route_capacity) of any transit system. A system that requires large headways has more empty space than passenger capacity, which lowers the total number of passengers or cargo quantity being transported for a given length of line. On the other end of the scale, a system with short headways can offer relatively large capacities even though the vehicles may carry fewer passengers [5].

*Figure 2b – Headway on two cars* [6]

### Layover and Stopover

A layover is a point where a vehicle stops, with passengers possibly changing vehicles. For air travel, where layovers are longer, passengers will exit the vehicle and wait in the terminal, often to board another vehicle traveling elsewhere. A stopover is a longer form of layover, allowing time to leave the transport system for sightseeing or overnight accommodation.

The maximum time depends on many variables, but for most U.S. and Canadian itineraries, it is 4 hours, and for most international itineraries (including any domestic stops), it is 24 hours. In general, layovers are cheaper than stopovers, because notionally layovers are incidental to traveling between two other points, whereas stopovers are among the traveller’s destinations. [7]

#### Pros/Cons of a Layover [8]

|  |  |
| --- | --- |
| Pros | Cons |
| * Opportunity for passengers to explore new locations if long layout time | * Long range of times (2hours – 24 hours), which can mean passengers are stuck in the airport; this can lead to low passenger moral |
| * Cheaper flights | * Possibility for passengers to miss connecting flight if first flight is delayed or boarding time changes, which can lead to unexpected airline costs |

#### Pros/Cons of a Stopover [9]

|  |  |
| --- | --- |
| Pros | Cons |
| Break up a long flight for both passengers and crew | Adds time to the journey, so passenger and crew moral will decrease |
| Passengers can catch up on business work | Increased chances of in-transit delays |
| Passengers can explore new places | Increased chances of missed flights for passengers |
| Health of passengers(can prevent things such as jet lag and DVT) |  |

### On-Time Performance

On-Time Performance (or schedule adherence) is the success of the service with keeping to the published schedule, which is normally expressed as a percentage. The level of on-time performance for many transport systems is a very important measure of the effectiveness of the system and its schedule (e.g. right amount of padding has been used).

Airlines are closely monitored on their on-time performance. Numerous websites exist for reporting on punctuality for airlines, often operated by government departments. The 15 minutes rules for on time performance is commonly applied throughout the airline industry. Airlines typically perform well when their on-time performance reaches 90%. It is simple to calculate on-time performance; as aircraft depart and arrive at [airports](https://en.wikipedia.org/wiki/Airport) are clear points to complete the calculation. [10]

#### Calculations

On-Time Performance calculations compare service to it’s schedule:

The scale of delays are often calculated in delay minutes:

### Night Service

Xiucvids

# Interview

Needs to be done when email set up with stakeholders for initial meeting

# Limitations to the Proposed Solution

* Lots of factors/variables to take into account, so implementing all will not be possible, so abstraction needs to occur
* Lots of airports have multiple terminals; for this project writing for multiple terminals will complicate the project as it means the amount of connection flights will increase which will affect the schedule

# Stakeholder Feedback

After meeting for interviews

# Requirements

## Hardware Requirements

* A computer capable of running the software

## Software Requirements

* Windows, Linux or macOS operating system (as these are the OS supported by Python)
* Python Interpreter

# Success Criteria

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Requirement | | User Requirement | Solves | Evidence | Justification | Criteria |
| 1 |  | Schedule Menu | Sorting the flight data and scheduling all of the flights |  | | |
| 1.1 | Schedule Table | Shows the user the schedule in a readable format |  | The user needs to be able to read the schedule in a clear format. | - Table with data in  - Only shows the necessary information  - Clear and readable font/size and layout |
| 1.2 | Schedule Data | Shows the flights, what time they are departing and from where (e.g. what gate). |  | This is the actual schedule data, without this information the software would be useless. | - What time the flight is departing  - What time a flight is arriving  -What gate the flight will be in |
| 1.3 | Amend Flights | Useability, so that it can still be used even if an error/changes in the data has occurred. |  | The program becomes un-usable quickly if there is no ability to change the fundamental data, so this makes sure errors/changes can be fixed | - Add button  - Delete button  - Buttons need to be clicked to do function  - When button is clicked should carry out function  - Buttons should be a readable size and a colour that stands out |
| 1.4 | Clear Flights | Useability, so that it can still be used even if an error/changes in the data has occurred. |  | The software needs to be used for multiple flight data sets, so having the ability to clear the data and start with a new data set is key. | - When clicked, data should clear quickly (up to 10 seconds if big data is used)  - Buttons should be a readable size and a colour that stands out and labelled appropriately  - Button should ask for confirmation that user wants to clear all data |
| 1.5 | Instructions Menu Button | Lets users access the instructions menu |  | So that first-time users of the software can understand how it works | - Button needs to be clearly labelled  - Button needs to be of an accessible and noticeable design  - Wil bring up a separate pop-up menu with the instructions on it |
| 1.6 | Variables Menu Button | Lets users access the variables menu |  | So that factors can be adjusted and changed easily | -Button clearly labelled  - Button needs to be an accessible design  - Will bring up a separate section with the variables that can be changed |
| 2 |  | Instructions Menu | Shows the instructions on how to use the software |  | | |
| 2.1 | Instructions | How to use the software |  | If a new employee is introduced to the software, they need to know how to use it. | - Clear, readable font and size  - A suitable colour font and colour background that makes the text clear |
| 2.2 | Pop-Up Window | How the instructions will be displayed |  | The display needs to be noticeable so opening a pop-up will grab the attention of the user | - When button is pressed, a sperate window is opened  - Needs to be a readable size and colour |
| 2.3 | Exit Button | Exits the pop-up menu |  | User will want to be able to get back to the main scheduling screen | - When the button is pressed, pop-up menu will close  - Button should be clearly labelled and noticeable size |
| 3 |  | Variables Menu | Shows the variables that can be changed to effect the schedule |  |  |  |
| 3.1 | Variables | How the schedule can be effected, and will mean the software can deal with different situations |  | Variables will change the schedule, so the software will take the variables into account when making the schedule, and make the changes itself | - Options to change the variables  - Variables are clearly labelled  - Option to delay flights (and by how much)  - Option to close a runway  - Option to close a gate  - Option to change what the weather status is |
| 3.2 | Pop-Up Menu | Shows the contents of the variables menu |  | This will mean that the user can deal with changing the variables on a different window, so it will not effect the scheduling | -When variables button is clicked the menu comes up  - Shows a reasonable sized menu  - Font is of a readable colour and size |
| 3.3 | Exit Button | Exits the pop-up menu |  | User will want to be able to get back to the main scheduling screen | - When the button is pressed, pop-up menu will close  - Button should be clearly labelled and noticeable size |

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