

Analysis of Communication and Transport Systems

Analysis of the Typical Fleet Mix for Stockholm Arlanda Airport Arrivals (FMA)

Lucie Smetanová, Adam Ulanovský, Pavel Hluska

Abstract

The fleet mix at airport is important to study because different categories of aircraft landing after each other could cause struggles for safe landing. The maximum homogeneity in aircraft arriving could minimize the probability of problems caused by this phenomenon. The target of the project is to analyze the fleet mix which came to Stockholm Arlanda airport during the year 2018. This analysis will be used for further studies focused on optimization. Number of different aspects of fleet mix are going to be analyzed in this project but the focus will be on the wake turbulence categories given by International Civil Aviation Organization. The methods for data separation and data clean-up will be used as well as some statistical methods.

Keywords: airport, analysis, Arlanda, traffic intensity, plane, type of aircraft, Wake Turbulence Category

1 Introduction

The phenomenon of airspace thickening over Euroasia, but also on other continents, is steadily growing. In 2017 four billion people around the world used air transport, at the same time 202,157 aircraft were moving. [4.] This trend is expected to increase steadily. That is why the Arlanda airport is trying to solve the problem of the limited airspace capacity. However, they usually do not have enough space to build new terminals and airfields. Therefore, the Arlanda airport management seeks to optimize the composition of aircraft landed at their airport according to the Wake Turbulence Category. [2.] Aircraft are divided into four categories – Light, Medium, Heavy and Super Heavy. Safe spacing between successive aircraft is defined. At Stockholm Arlanda Airport they serve only the first three categories. The Super Heavy category includes only the world's largest airliner – the Airbus A-380 and the largest freighter – the Antonov An-225 Mriya, which was originally developed to carry shuttles.

ICAO Wake Turbulence Category Light includes all aircraft whose maximum take-off mass does not exceed 7 tons. The Medium category is intended for aircraft with a maximum take-off mass of more than 7 tons but less than 136 tons. Due to the wide range of these weights, most conventional aircraft belong to this category. Heavy categories include aircraft with a maximum take-off mass of over 136 tons, such as the Boeing 777 or the Airbus A-330. As mentioned above, only Airbus A-380-800 and the Antonov An-225 Mriya belongs to the Super Heavy category. [6.]

The ICAO had made the categorization of wake turbulence categories by RECAT-EU design methodology which is built on gained knowledge about wake physics during several projects. The safety validation is based on a relative and quantitative wake turbulence risk assessment. The aspects considered during the categorization are aircraft geometry and final approach speed profiles characterized by aircraft types. Also, aircraft wing geometries have been taken into account. The wake turbulence risk assessment is based on extensively measured wake datasets collected at London Heathrow airport and Frankfurt. The categorization is based on logical aircraft type clustering and safety criteria. [2.]

In this project we study the arrivals to Stockholm Arlanda Airport in 2018. It is the largest airport in Sweden and the third largest airport in the Nordic countries. In 2018 there were 26,846,720 passengers handled, which represents a year-on-year increase of 1 % (2). According to the International Air Transport Association (IATA), the airport has an ARN code, and the International Civil Aviation Organization (ICAO) is assigned an ESSA code. The airport has two parallel runways marked 01/19R (3,301 x 45 m) and 01R/19L (2,500 x 45 m) and a third runway marked 08/26 (2,500 x 45 m). All these runways have an asphalt surface. The runway 01L/19R is therefore ready to take off the Airbus A-380 belonging of the Super Heavy category, as the required runway length of the A-380 is at a maximum take-off mass of 2,950 m (3). In the case of Antonov An-225 is needed 3,000-3,500 m (11,500 feet) (4) and therefore could not take off at the airport. [7.] The airport has four terminals, of which terminals number two and five are used to handle international flights. Terminals number three and four serve domestic flights. Terminal number five is a part of the main building, which was built in 2003 and serves all the flights of SAS (Scandinavian Airlines) and its Star Alliance partners. This terminal is also the largest and has the necessary equipment for handling the Airbus A-380. [9.] There are also five cargo terminals at the airport. There are two train stations at the airport, as the high-speed train connects the airport with the center of Stockholm.

The aim of this work is to analyze the composition of the traffic flow to Arlanda Airport. A dataset was received from the supervisor of this work, which had to be modified to allow further work with the data and subsequent interpretation. Then data cleaning had to be done. For example, there were several flights from New Year's Eve 2017 between the dates of 2018. From this dataset, the six most important columns were selected from other entities such as the first time interval of each aircraft, the date, the unique flight number, the callsign and the aircraft type other entities needed to be searched manually such as Wake Turbulence Category, type of engine of the aircraft, origin of flight, time of arrival, number of engines, or name of the carrier.

1.1 Aim

The aim of the paper is to analyze types of all aircraft arriving to Arlanda airport for a given time period. The Arlanda airport in 2018 reported 121,860 units of arrivals at the airport. [7.] This number in comparison with the years 2014-2015 shows an annual decrease in the movement around 1%. [1.] On the other hand, the number of checked passengers annually increased by around 1% which is given by the trend of using an aircraft with higher passenger capacity. [1.] The Arlanda airport aims to serve a maximum number of passengers with the minimum number of movements at the airport. This approach will bring the most effective passenger and aircraft handling, what is crucial for bigger and bigger demand on air travel these days.

1.2 Methodology

Methodology for this project is a data analysis and extract relevant data, which gives us answers for the aim for this project. For working with large scale data are suitable some statistical tools, like R, in which very large data can be handled. Data in such programs are not greatly interpretable, but sufficiently provides an option how to reduce data we need and then work with it in other tool. More user friendly with many more options is program Office Excel, which is wide spread. This tool offers many diagrams and charts, which helps understand and visualize data very well.

1.3 Limitations

Limitations for this project are computational capacity, which can be easily reached when received dataset is too wide, and lack of information, when the dataset does not contain enough information to reach the aim for this project.

1.4 Outline

The paper is structured as follows. In Section 2 there is a Methodology of project. Section 3 belongs to Literature review. This chapter describes all the literature that was used to create the project. Chapter 4 describes the model in more detail. Chapter 5 includes the results achieved with the use of statistical tools, including a description of each figure. Chapter 6 is intended to analyze these results. This chapter is followed by a conclusion of the thesis, a list of tables and figures.

2 Methodology

First, the dataset was loaded into R – free software environment for statistical computing and graphics. This was done by using a “read.csv” command, even though the dataset was not in csv format. As we figured out later, this

command worked correctly. In this command two additional attributes were set – that the dataset has a header and that the data are separated by space. Then there were extracted six columns, which were appropriate for this work – Wake Turbulence Category, type of engine of the aircraft, origin of flight, time of arrival, number of engines, or name of carrier, numbers of columns 2, 4, 5, 10, 11 and 17, respectively. Secondly, as long as in or dataset there were information about each flight and its trajectory in 97 rows, for this work just one was enough. So, by the “!duplicated” command applied to column 17, there were obtained unique flights. Final table was exported to csv file by “write.csv”. Whole command is here:

```
data = read.csv("2018_ESSA_arrivals_m3.so6", header = TRUE, sep = " ")
data2 = data[,c(2,4,5,10,11,17)]
data3 = data2[!duplicated(data2$X214174076), ]
write.csv(data3, 'data3.csv')
```

This file is then loaded into Microsoft Office Excel. This program is a spreadsheet developed by Microsoft and features calculation, graphing tools, pivot tables, and a macro programming language. This was used for later analysis of data. Using “Text to Columns” feature, the csv file was converted to casual Excel spreadsheet and this database was analyzed to obtain as much information about flights in Arlanda Airport as possible.

3 The model

This analysis was carried out from several points of view. First, aircraft intensities were examined by period. A monthly and annual traffic intensity analysis was created. The traffic intensity was also examined regarding Swedish national holidays and seasons. Subsequently, an aircraft analysis was conducted to examine the type of aircraft and the amount of its occurrence at the airport, the ICAO Wake Turbulence Category, aircraft manufacturer, number of engines and engine type. The last analysis to be carried out was an analysis of the carriers operating at the Arlanda Airport.

Several sources have been selected for this project. These were the EUROCONTROL website (the European Organization for the Safety of Air Navigation) [5.], the Stockholm Arlanda Airport website, but also an Airbus document related to the Airbus A-380. [9.] In addition, help for individual functions in Excel was used during data processing. A very helpful literature was a document published by EUROCONTROL on minimum spacing between aircraft and the ICAO Wake Turbulence Category. SKYbrary was used to search for aircraft specifications. [6.] This is a web-based encyclopedia created by the EUROCONTROL, the ICAO, and the Flight Safety Foundation, which is completely online and free of charge.

4 The data

The dataset given as a project input is a dataset containing information about the arrivals during the 2018 year to Stockholm Arlanda airport. The dataset is presented as .so6 data type. The dataset contains about 9 million observations with 20 parameters. Regarding the quantity of the data it was decided to load this data into a software using R program language to handle large quantities. The software chosen is called R and it is a software using R program language. The choice of the software was given by previous experience. The dataset contains information about approximately 121 000 arrivals during 2018 and each of these arrivals is shown as 97 rows of the table because of the different time and space segments recorded. For this project, just every 97th row was needed to analyze, so from around 9 million observations in original dataset was got over 121 000 observations.

This analysis was very time-consuming due to its computational demand. It has been done on Surface Pro 4 computer with Intel Core m3-6Y30 chipset working with 2.2 GHz at maximum and 4 GB of RAM. Whole analysis of the data and extraction of the data took approximately 40 minutes. Final file of data (in .csv format) had approximately 9 MB, what is perfectly fine to work with

5 The data

As mentioned in Chapter 4, several analyzes have been made that map aircraft types and their intensities at Sweden's largest airport. After clearing some error data, it was found out that a total of 121,485 aircraft landed at the airport all year round. This number is consistent with the information given in the source. [1.]

During the analysis of the seasons it was found out that the busiest period at the airport was spring with the occurrence of 32,116 aircraft, on the contrary the calmest period was winter with the number of 27,014 aircraft. This analysis can be seen in Figure 1.

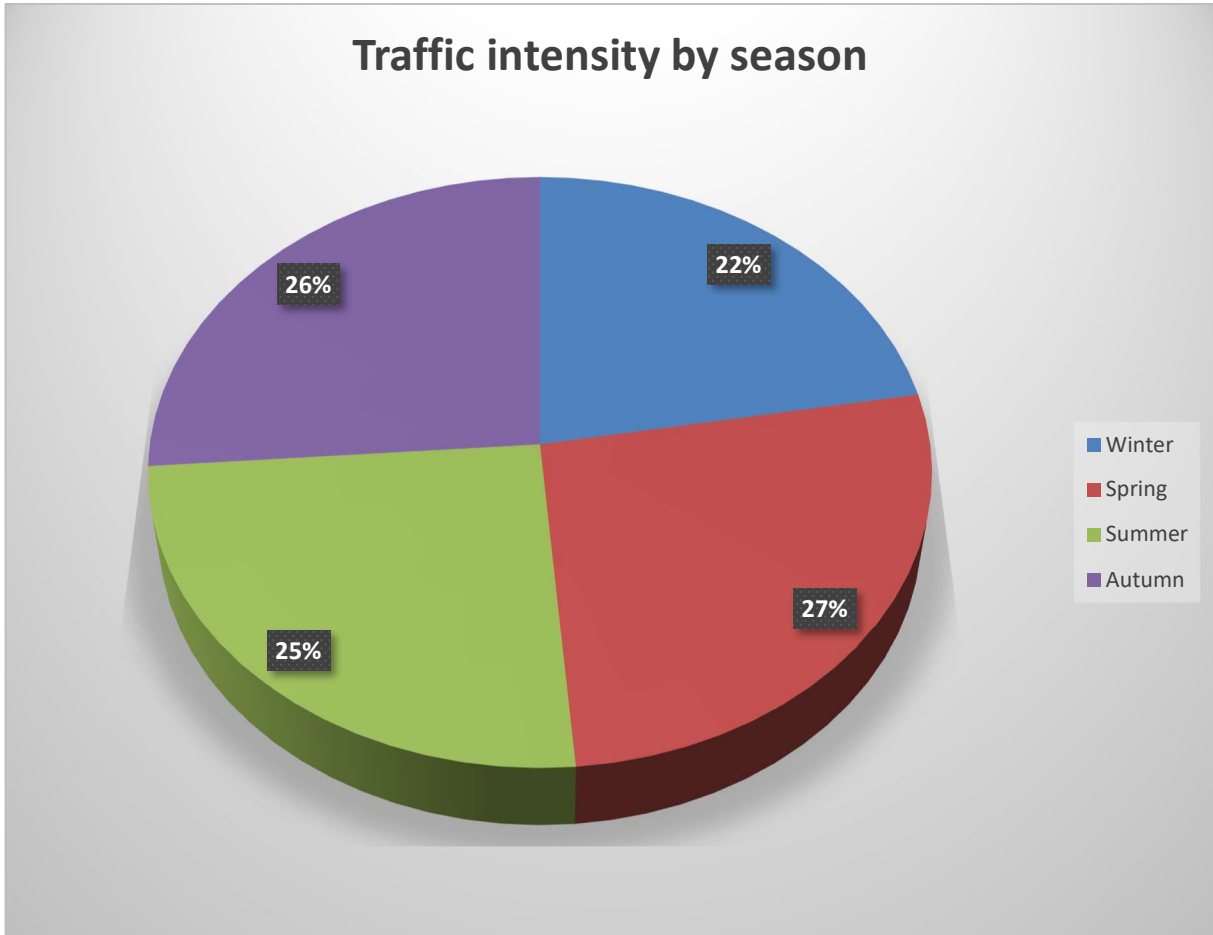


Figure 1: Traffic intensity by season at Arlanda. As can be seen from the graph the traffic intensity is fairly divided between seasons and there are no major steps in the distribution of flights

Figure 2 shows that there were 28,558 aircraft at Arlanda Airport in the first quarter of 2018. This quarter has also the least number of arrivals. The second quarter, from the beginning of April to the end of June, at the airport landed 31,995 aircraft. This number is also the highest. In the third quarter, at the airport landed 30,961 aircraft, in the fourth only 29,971 arrivals.

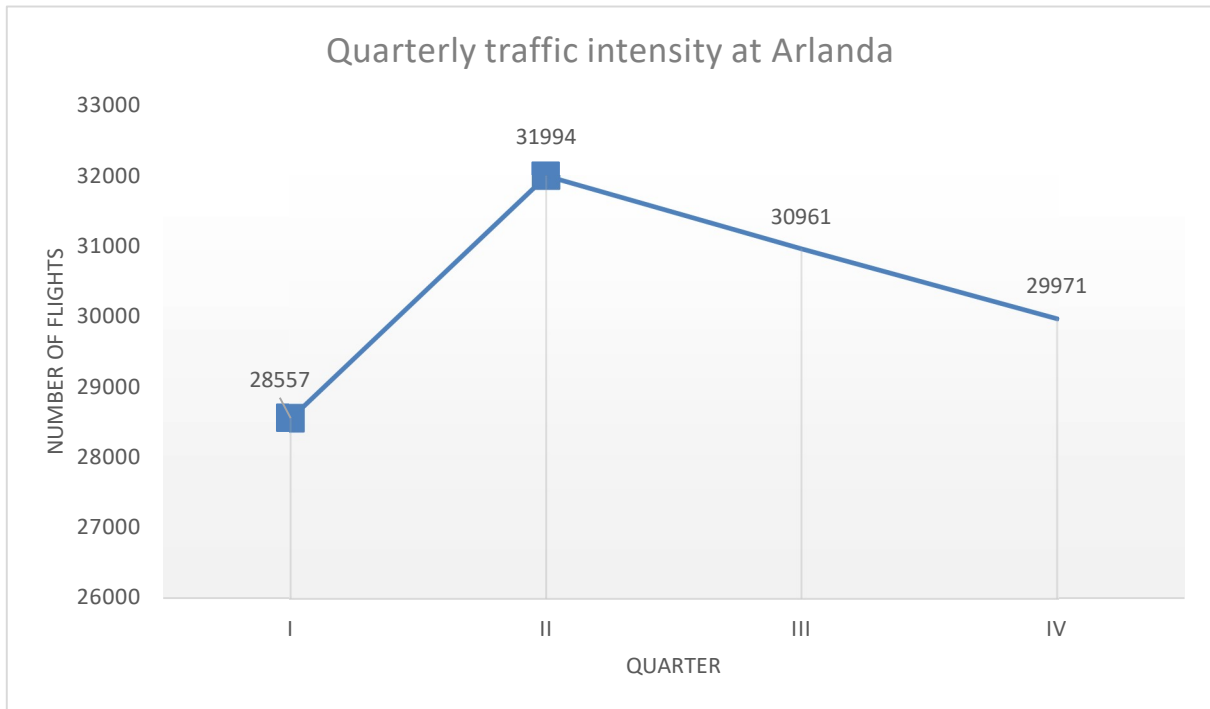


Figure 2: Quarterly traffic intensity at Arlanda, x-axis refers to the number of quartal and y-axis refers to the number of flights. The peak was during the year 2018 in the second quartal and the lowest was first quartal

The busiest day was Thursday, April 12, when 423 aircraft landed at the airport, see Figure 3. This figure shows the increase in traffic around 4 am, when 45 aircraft landed at the airport. This morning peak then ceased, in saddle that followed the peak, landed about 25 aircraft per hour. Afternoon peak was then at 2 pm, when 35 aircraft landed per hour.

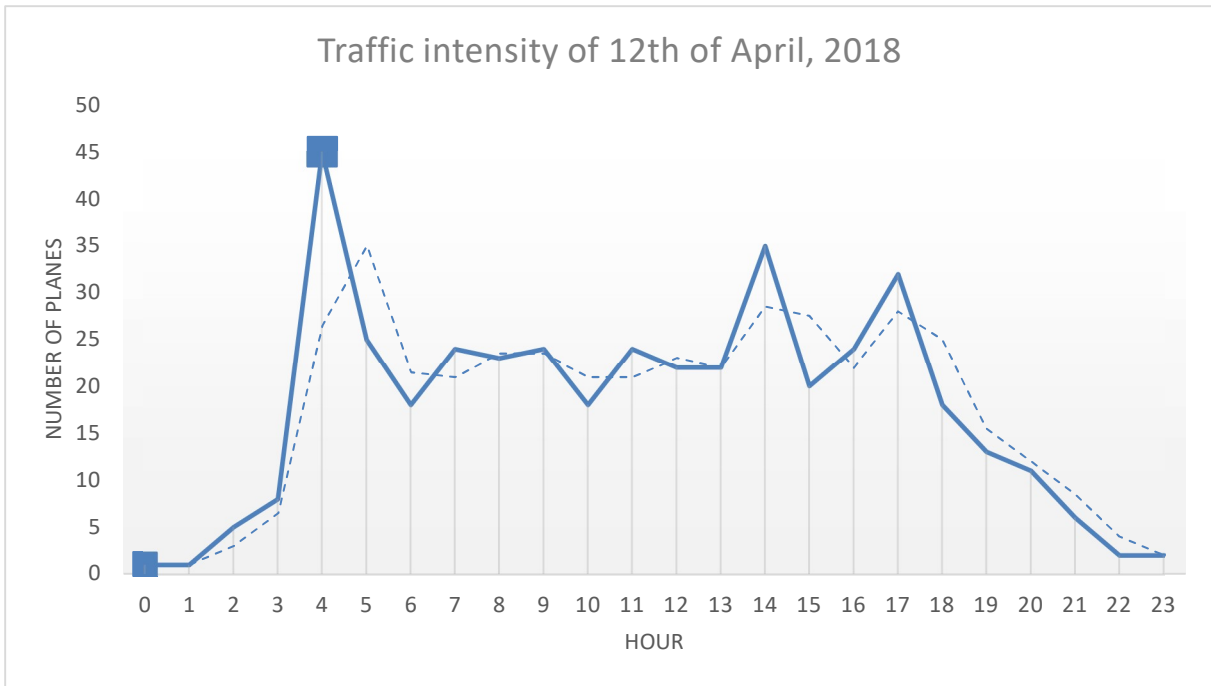


Figure 3: Traffic intensity of 12th of April, 2018. X-axis represents hours in a day, y-axis represents number of flights. Peak is at 4 am and the lowest traffic intensity is around midnight. Thinner line shows moving average.

On the contrary, the calmest day was Tuesday, December 25, when at the airport landed a total of 116 aircraft. Looking at Figure 4, the traffic intensity on this day did not go through the classic course. It is not possible to define peak or saddle from the figure, the number of aircraft landing per hour is around 8 aircraft. Maximum traffic intensity was reached at 6 pm.

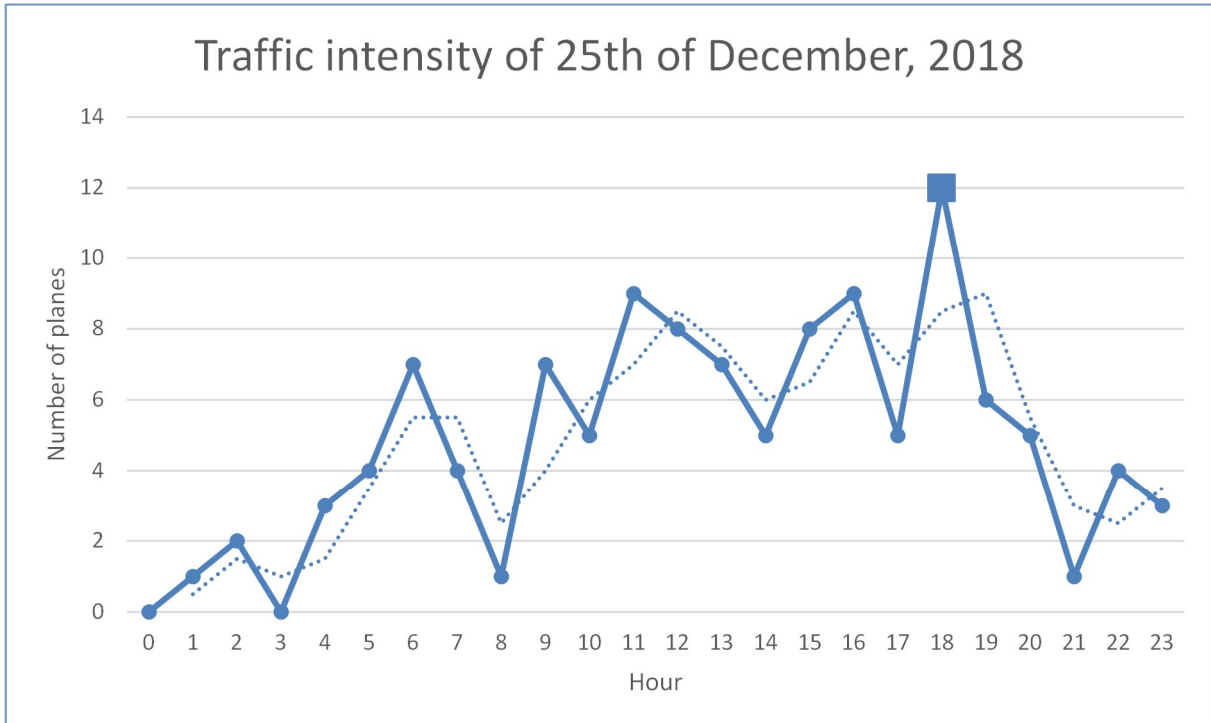


Figure 4: Traffic intensity of 25th of December 2018. The peak of the flights is at 4am and the lowest traffic intensity is around midnight, this phenomenon can be seen in both figures (3 and 4)

Furthermore, the analysis of arrivals in the airport in 2018. The first comparison was the analysis of aircraft categories according to ICAO Wake Turbulence. There are currently four categories of aircraft and the most important characteristic is the maximum take-off weight of the aircraft. In 2018, 864 Light aircraft, 112,956

Medium and 7,665 Heavy aircraft landed at Stockholm Arlanda Airport. A plane belonging to the Super heavy category on Arlanda never landed in 2018. This category includes only Airbus A-380 and Antonov An-225 Mriya. This statistic can also be seen in Figure 5.

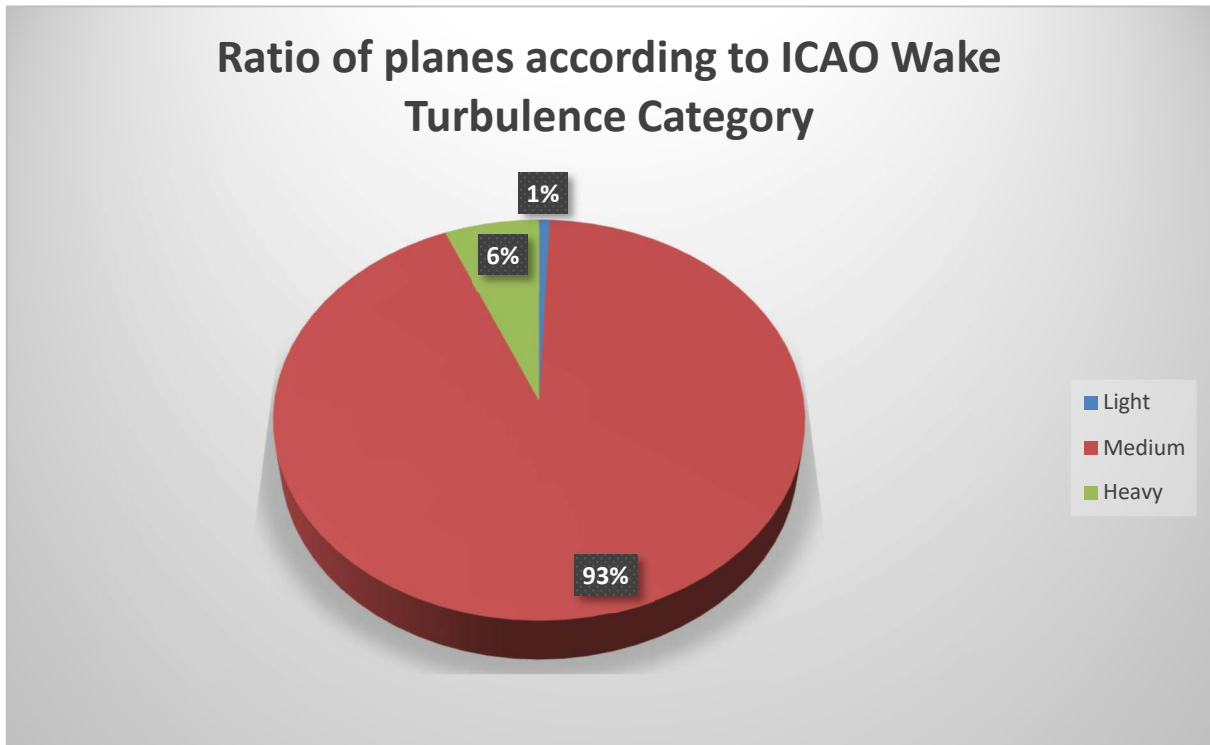


Figure 5: Ratio of planes according to ICAO Wake Turbulence Category, the majority of airplanes is medium category.

The analysis revealed that in 2018 152 different types of aircraft landed at the airport. Therefore, only 18 most frequent types were selected for further statistics. For example, Boeing 737-800, which landed 33,335 times at the airport, Airbus A-320neo, which appeared at the airport 11,444 times, Boeing 737-700, Bombardier Regional Jet CRJ-900, etc. Statistics of the most frequent aircraft at Arlanda airport can be seen in the Figure 6.

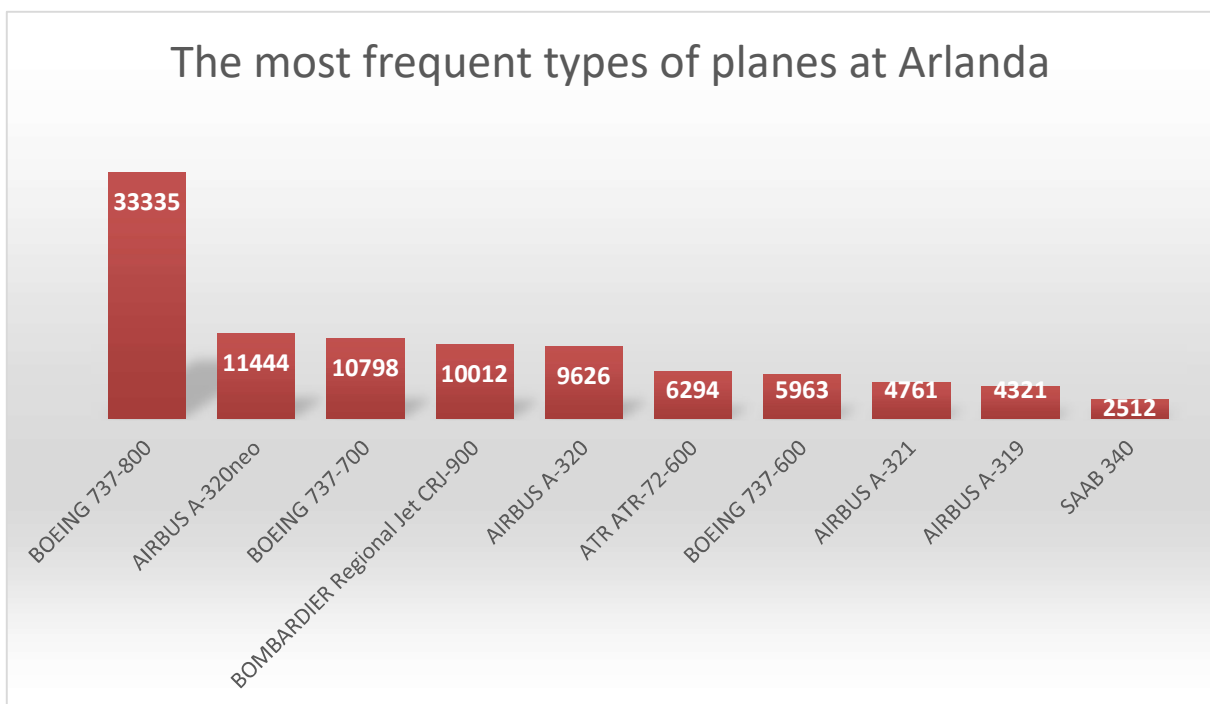


Figure 6: The most frequent types of planes at Arlanda. The most frequented is BOEING 737-800

Another analysis that was carried out was the number of aircraft landing by engine type. These were piston engines, turboprop and jet. The most common were jet engines, in 106,702 cases. Turboprop aircraft at Arlanda landed 14,749 times and aircraft with a piston engine only 34 times. The ratio can be seen in Figure 7.

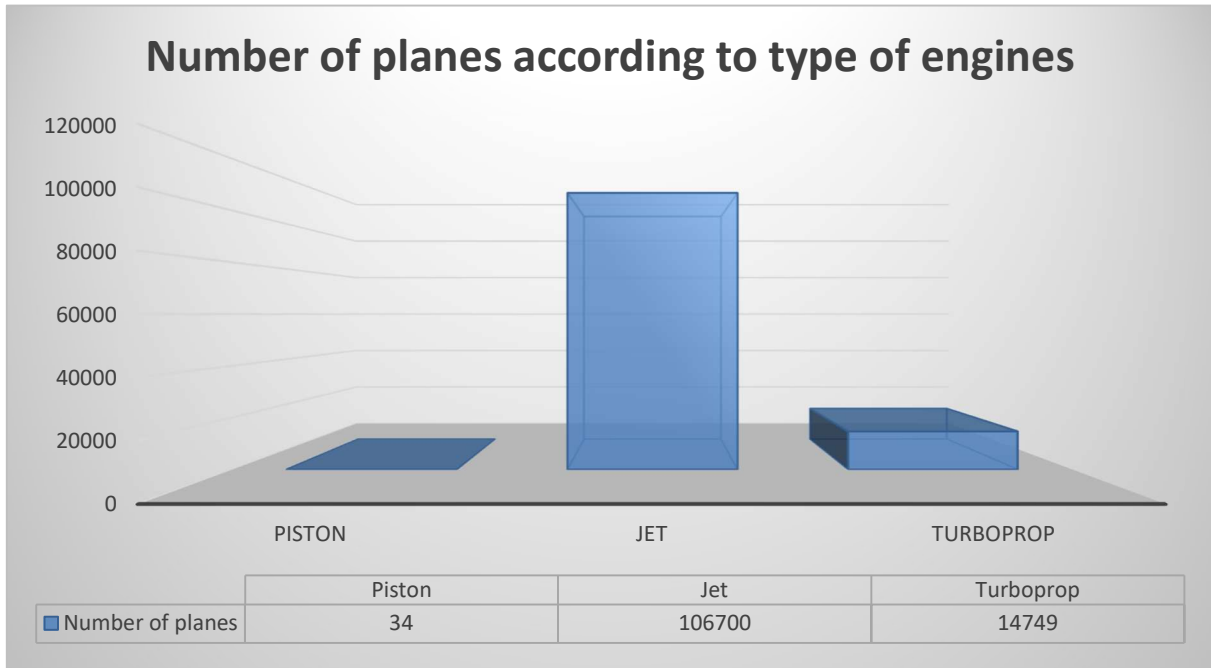


Figure 7: Number of planes according to type of engines. The most frequented type of engine is Jet engine. By this type of engine have been powered 106,700 planes at Arlanda in 2018

Another analysis carried out in this category was the analysis of landing aircraft by number of engines. Figure 8 shows the clear dominance of twin-engine aircraft, which landed at the airport 120,753 times out of a total of 121,485 aircraft. Four-engine aircraft landed here 566 times. This statistic shows that Arlanda Airport is operated rather by smaller aircraft.

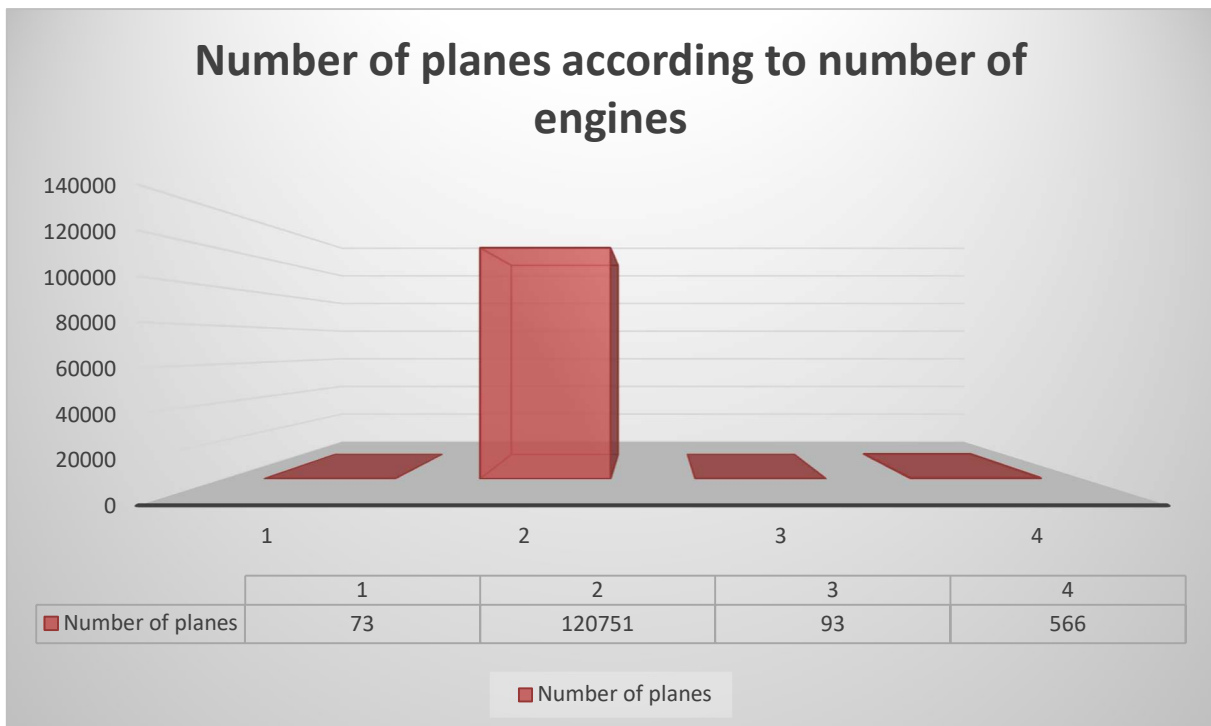


Figure 8: Ratio of planes according to number of engines. Majority of airplanes arrived to Arlanda airport during the year 2018 had 2 engines

Another very interesting analysis is the analysis of the carriers who operated flights to Arlanda Airport in 2018. It was a total of 358 subjects who landed at this airport at least once. The data of the 19 most frequent carriers were used for the Figure 9.

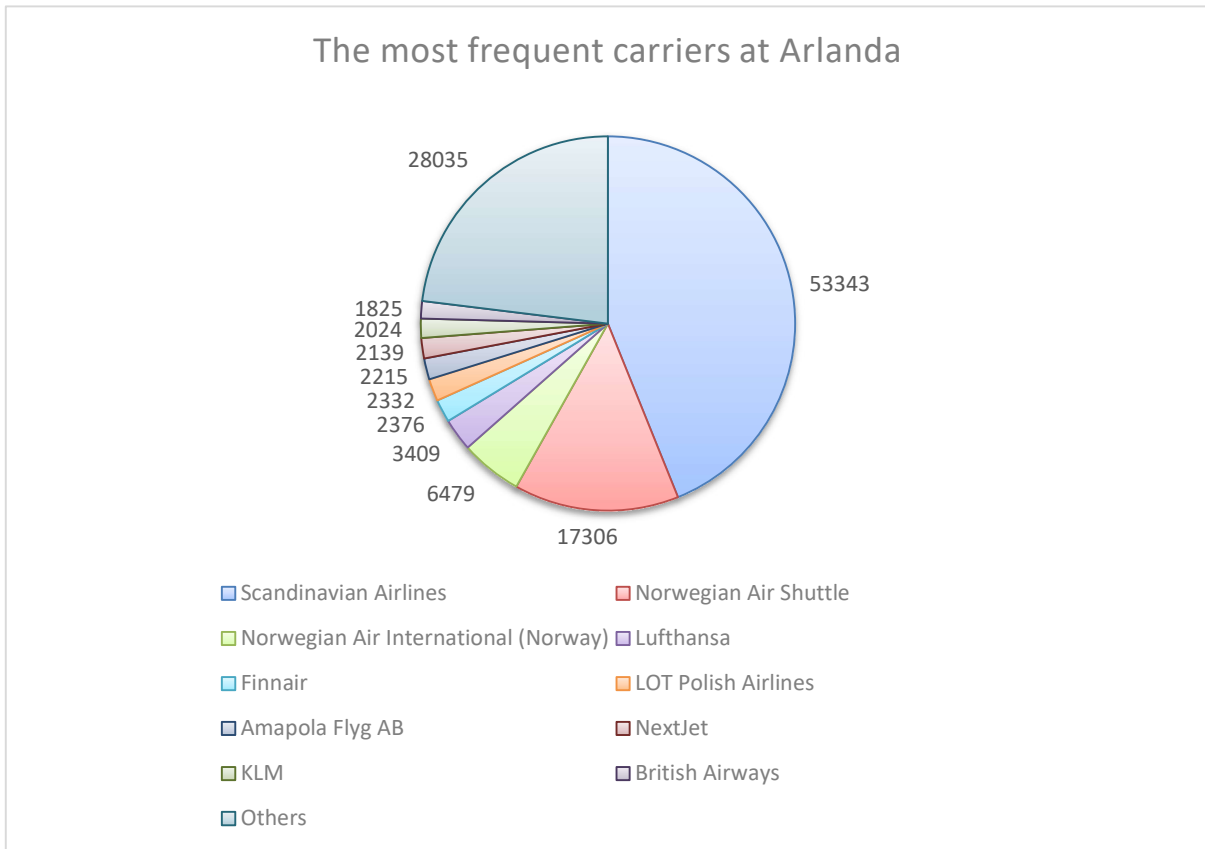


Figure 9: The most frequent carriers at Arlanda. The most frequented carrier at this airport was SAS (Scandinavian Airlines) because there is a hub of these airlines at Arlanda

One of the last analysis that was carried out in this section was the analysis of landing aircraft by manufacturer. Aircraft from 42 different manufacturers landed at the airport. For statistics, however, the number of aircraft used was only those whose aircraft occurred at least 1000 at the airport. It was therefore 10 producers. The statistics of this comparison is shown in Figure 10.

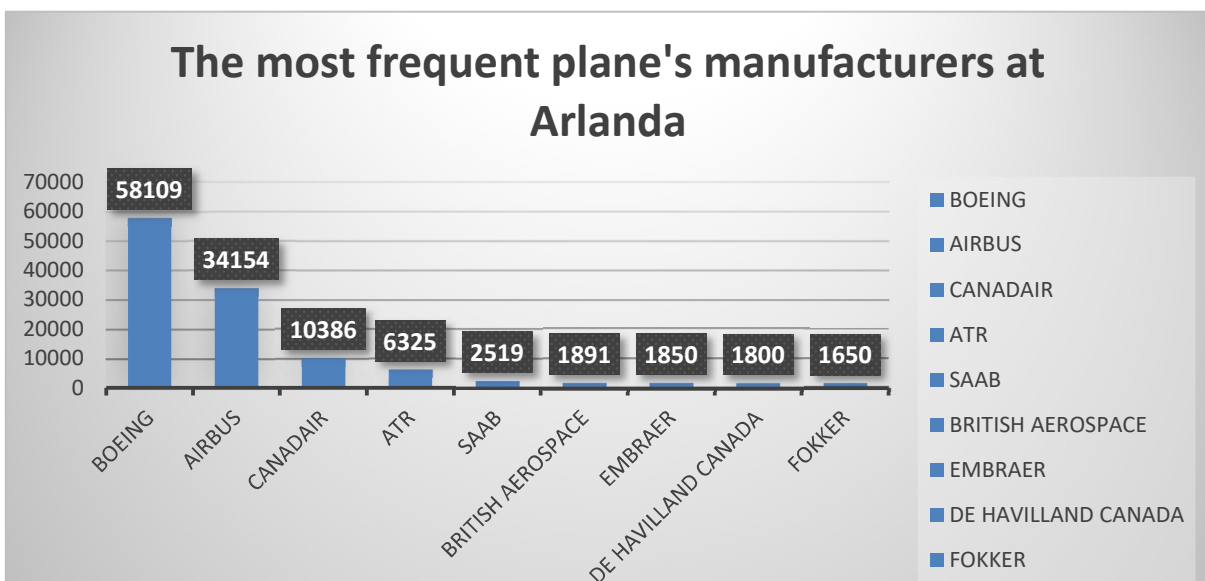


Figure 10: Nine the most frequented plane's manufacturer's at Arlanda. It can be seen clear dominance of Boeing.

The very last analysis is boxplot. Boxplot is a graphical representation of five values – minimum, first quartile, median, third quartile and maximum. The box consists of three parts – the first quartile that terminates the box at the bottom, a median that is represented by a horizontal line in the box, and a third quartile that borders the box from above. The beard is brought out of each box, the upper beard indicates maximum, the lower beard indicates minimum. For some months blue dots are displayed under the lower beard. These points indicate extreme value.

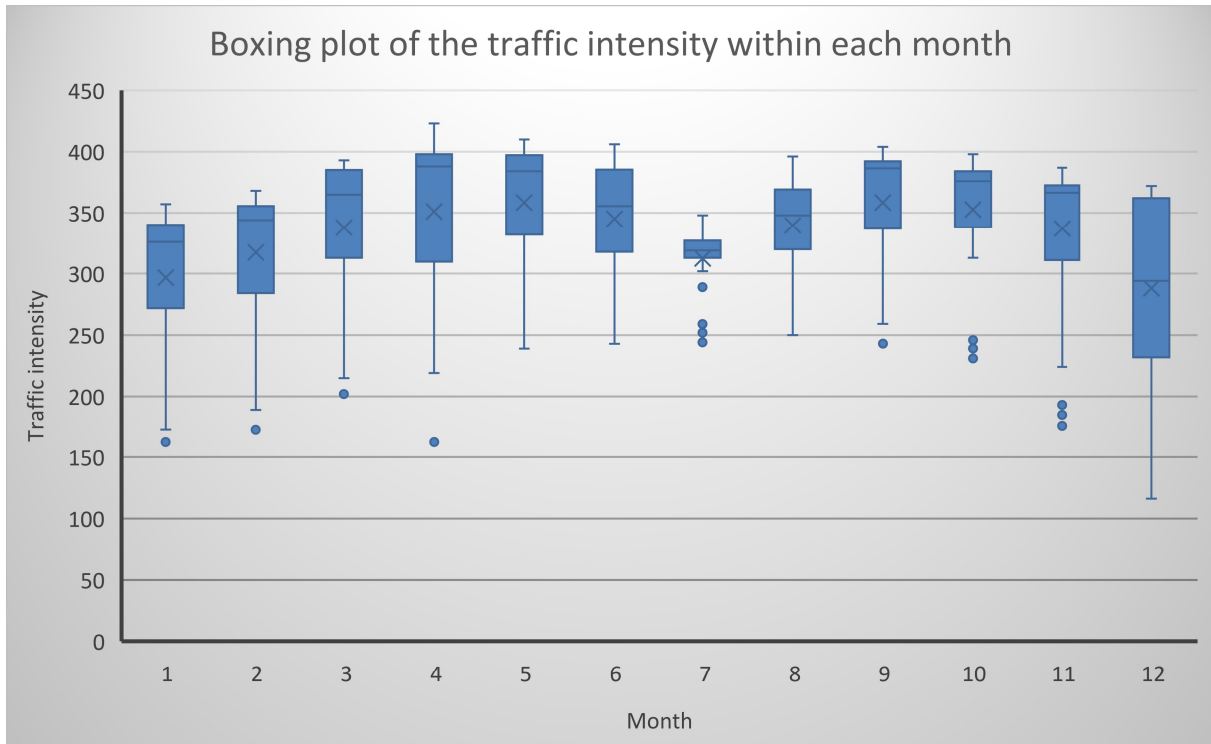


Figure 11: Boxing plot of the traffic intensity within each month. There are 12 boxes with beards that indicates minimum, first quartile, median, third quartile and maximum.

On the last note, one extra task was performed. Its aim was to try to cluster flights to 4 groups, each represents one side of the quadrangle, which represents an area, in which when an aircraft is approaching for landing, Approach control service takes a control of the aircraft. It should have shown the distribution of flights, which are heading from NW, NE, SW and SE to the Arlanda Airport. Unfortunately, this task has not been performed well, because of lack of computational capacity. The aim was to compute a parametrical equation of the line segment, which connects two neighboring points of flight trajectory in a row. And when this line segment and the line segment of the quadrangle has any intersection, it should be claimed that this flight enters a quadrangle by this line segment. Although there are too many restrictions to analytically compute an equation of the line segment, that this cannot be performed in our computes. This whole analysis has been made in MS Excel 2019, but when another environment would be used, this task could be performed well.

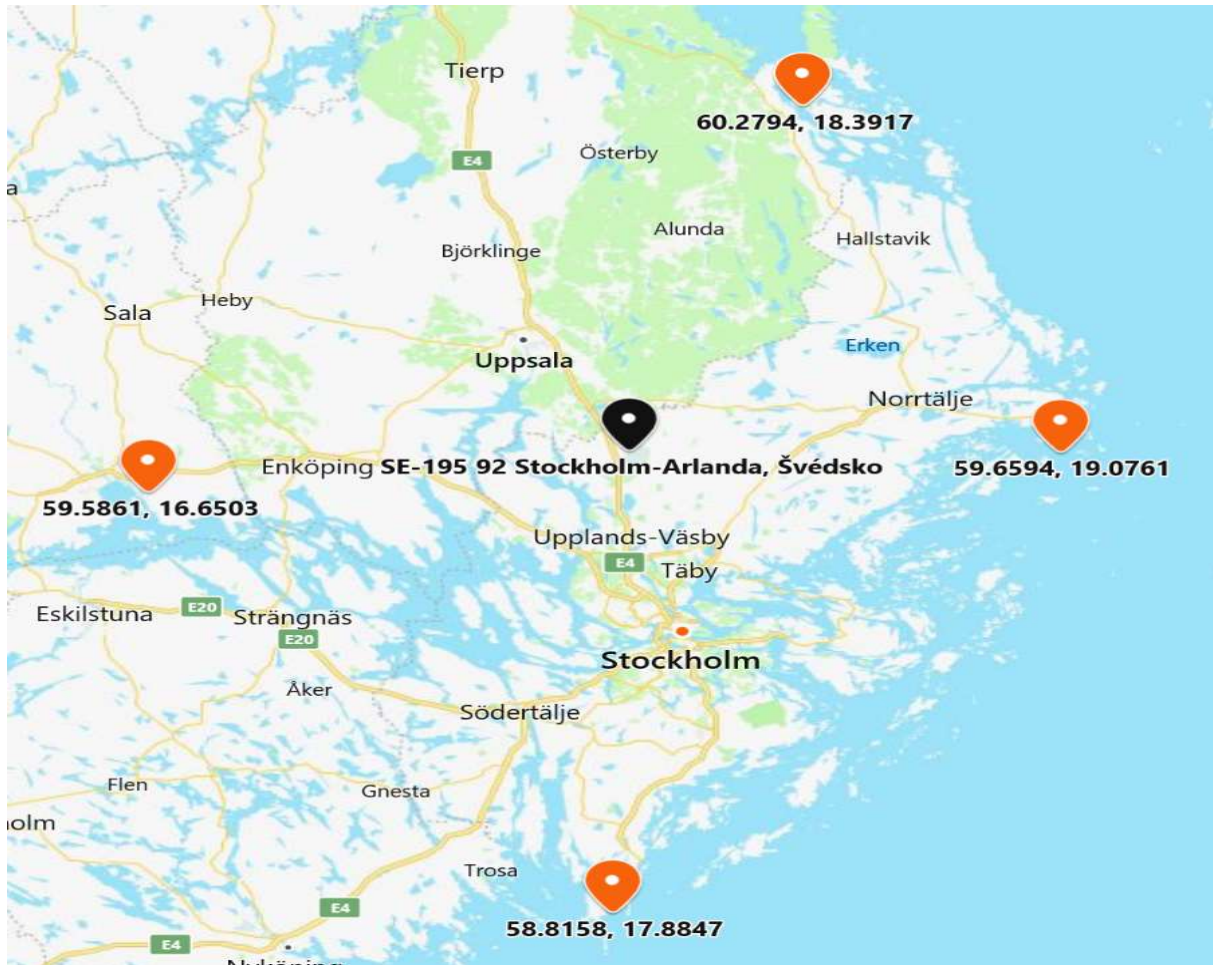


Figure 12: Quadrangle of approaches at Arlanda

Although this task has not been completed, Figure 13 shows the trajectories of several aircraft drawn on the basis of the provided data using the 3D map in MS Excel.

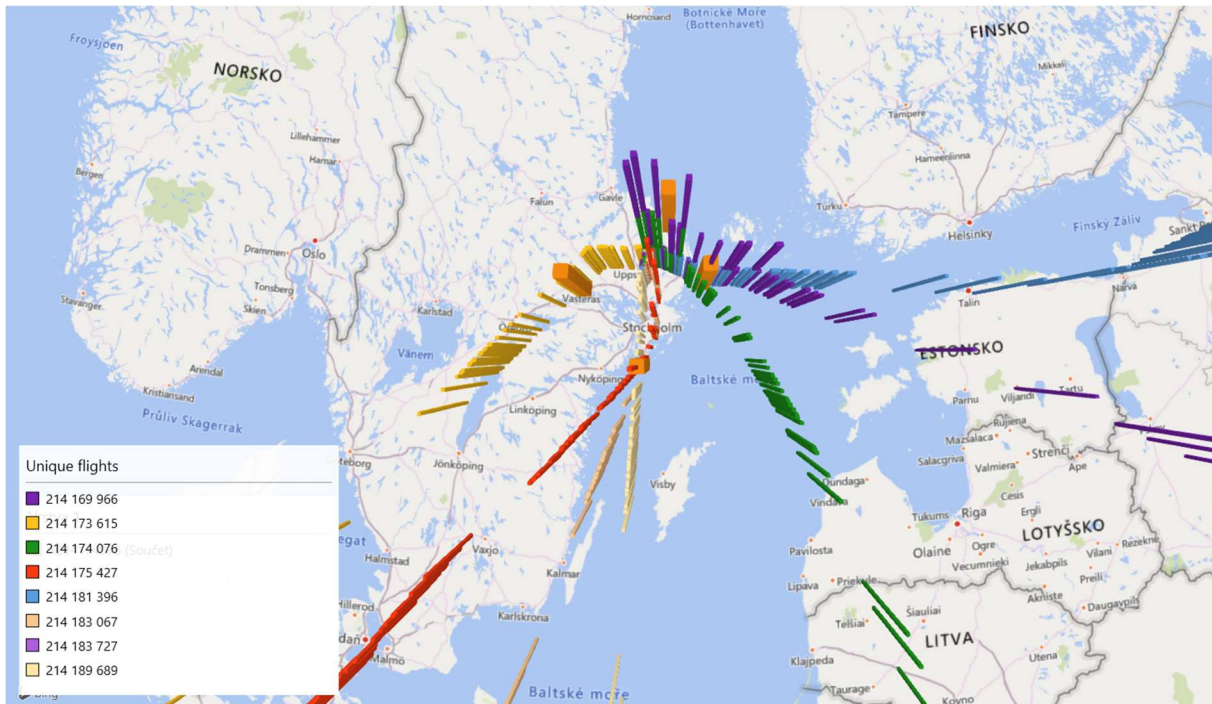


Figure 13: Trajectories of several aircraft in unfinished additional task

6 Evaluation of the results

In this section, the results that were presented in the previous sections are analyzed. We believe that the first high season at Arlanda is spring. The autumn season lasts from August to November. These months show the highest intensities. In July, the airport dropped by 667 aircraft compared to the previous month. This is most likely caused by shifting flights rather to seaside destinations. In December, the second lowest traffic intensity was recorded due to the Christmas holidays, through which the traffic intensity usually drops at all airports in the world. Another assumption is that the decline in the traffic intensity over the winter is because people prefer to rest for other destinations located either in the southern countries or flying north of the country to ski.

Looking at Figure 2, all seasons are balanced. This is due to the fact in each season there is a month with a higher traffic intensity, but also a month with a lower traffic intensity. Table 1 shows the beginning and end of each season, including the overall intensities achieved during the seasons. High traffic intensity in spring was achieved mainly due to high traffic intensity in each of the spring months, which was already mentioned in the paragraph above.

SEASONS	START DAY	START MONTH	END DAY	END MONTH	Intensity
Winter	1	12	28	2	27014
Spring	1	3	30	5	32116
Summer	1	6	31	8	30561
Autumn	1	9	30	11	31794

Table 1: Seasons, the START DAY entity means the first day of the season (usually first day of the month), START MONTH entity means the number of month the season is starting, END DAY entity means the number of day in the month the season ends (different numbers caused by the different duration of months. END MONTH entity means the number of the month the seasons ends

Figure 4 shows the classic traffic intensity of the day. Unlike other modes of transport, the morning peak starts at 4 am. We believe that this is mainly due to arrivals of aircraft from other continents.

Figure 7 shows that most aircraft landing at Arlanda are twin-engined, which mostly belong to medium category. The big surprise was that Airbus A-380 doesn't fly at Arlanda. Emirates, the world's largest fleet of aircraft of this type, provides connections between Stockholm and Dubai with the Boeing 777-300ER, on the largest twin-engine jets in the world. This Boeing, however, belongs to the Heavy category.

There was nothing surprising to be found in Figure 8 with regard to the compositions of the carriers operating flights to Stockholm. Boeing 737, which is on the list of 19 most common aircraft three times due to different specifications, together with Airbus A-319, A-320 and A-321 are very frequent aircraft for short and medium-haul flights. Among the most landing aircraft is also Airbus A-330, which is a direct competitor to Boeing 777 and also belongs to the Heavy category. The SAAB brand is not very common, however, since it is a Swedish manufacturer, we believe that it is mainly used on domestic flights.

It is also not surprising that most aircraft landing at the airport had jet engines. Piston engines were used only in older types of aircraft. Likewise, turboprop propulsion is one of the older types of propulsion, but still today are used to a lesser extent on shorter flights.

Figure 10 analyzing aircraft according to number of engines shows that more engines don't necessarily mean more aircraft capacity, see Boeing 777 or Airbus A-330 described above. The longest flights in the world are also provided by twin-engined airplanes because of lower fuel consumption compared to four-engined airplanes. Boeing 787-9 Dreamliner operates the world's longest flight connecting New York, USA and Sydney, Australia.

Scandinavian Airlines (SAS) has its Hub at Stockholm Arlanda, so it is understandable that the number of total arrivals is 51 %. The top 5 places of this analysis are occupied 4 times by Nordic Airlines (Scandinavian Airlines, Norwegian Air Shuttle, Norwegian Air International, and Finnair). It was expected that Turkish Airlines would be placed higher due to the high frequency of their international flights to other countries.

7 Conclusions

In this project a various aspect of fleet mix at the Arlanda Stockholm airport had been analyzed. There had been analyzed mainly the wake turbulence categories and number of other aspects. For example, the most frequent airplane's manufacturer at Arlanda airport statistics wasn't any surprise since the BOEING is the most common aircraft all around the world, but the statistics of the most frequent carriers at Arlanda airport with the threshold of 19 most common carriers doesn't include the American Airlines and neither the Delta airlines which are considered as the largest airlines in the world. Also, the aircraft AIRBUS A380 which is used every year more and more and is very favorite aircraft for a long- haul flights haven't showed at the Arlanda airport even once.

The analysis work is important to get a general idea about the fleet mix at Arlanda airport. Once there is the information and general idea about the fleet mix and different aspects and classifications of the fleet mix the further studies could follow this work. For example, the optimization in the arrivals could be handled at the Stockholm Arlanda airport.

The potential extension of the project could be to suggest to the Arlanda airport the optimal plan for aircraft arriving during given time period. The optimization of arrival plan could ensure higher capacity at the Arlanda airport since different categories of aircraft has to maintain given time gap between arrivals to ensure safety but if there would be arriving the same category aircraft at the time, the time gap would be smaller so the airport would have higher capacity.

References

- [1.] **Swedavia Airports.** Flygplatsstatistik 2018. *Swedavia Airports*. [Online] 2018.
https://www.swedavia.se/globalassets/statistik/fpl_201812.pdf.
- [2.] **EUROCONTROL.** *European Wake Turbulence Categorisation and Separation Minima on Approach and Departure*. [Document] Brussels : EUROCONTROL, 2015.
- [3.] **Wikipedia.** List of airline codes. [Online] Wikipedia. [Citace: 16. 11 2019.]
https://en.wikipedia.org/wiki/List_of_airline_codes.
- [4.] **Flightradar24.** Live Air Traffic. [Online] Flightradar24 AB. [Citace: 16. 11 2019.]
<https://www.flightradar24.com/43.23,1.88/8>.
- [5.] **EUROCONTROL.** Operator list. [Online] EUROCONTROL. [Citace: 16. 11 2019.]
<https://www.eurocontrol.int/rmalive/operatorList.do>.
- [6.] **SKYbrary.** SKYbrary. *ICAO Wake Turbulence Category*. [Online] SKYbrary. [Citace: 14. 11 2019.]
https://www.skybrary.aero/index.php/ICAO_Wake_Turbulence_Category.
- [7.] **Swedavia Airports.** Stockholm Arlanda Airport. *About the airport*. [Online] Swedavia Airports.
[Cited: 14 11 2019.] <https://www.swedavia.com/arlanda/about-the-airport/>.
- [8.] **Dutchops.** Antonov An-225. *Dutchops.com*. [Online] Dutchops. [Citace: 19. 11 2019.]
http://www.dutchops.com/AC_Data/Antonov/Antonov_225/An_225.htm.
- [9.] **Airbus.** *Aircraft Characteristics - Airport and Maintenance Planning*. [Document] místo neznámé : Airbus s.a.s., 2013.

List of figures

Figure 1: Traffic intensity by season at Arlanda. As can be seen from the graph the traffic intensity is fairly divided between seasons and there are no major steps in the distribution of flights	4
Figure 2: Quarterly traffic intensity at Arlanda, x-axis refers to the number of quartal and y-axis refers to the number of flights. The peak was during the year 2018 in the second quartal and the lowest was first quartal.....	5
Figure 3: Traffic intensity of 12th of April, 2018. X-axis represents hours in a day, y-axis represents number of flights. Peak is at 4 am and the lowest traffic intensity is around midnight. Thinner line shows moving average.	6
Figure 4: Traffic intensity of 25 th of December 2018. The peak of the flights is at 4am and the lowest traffic intensity is around midnight, this phenomenon can be seen in both figures (3 and 4).....	6
Figure 5: Ratio of planes according to ICAO Wake Turbulence Category, the majority of airplanes is medium category.....	7
Figure 6: The most frequent types of planes at Arlanda. The most frequented is BOEING 737-800.....	7
Figure 7: Number of planes according to type of engines. The most frequented type of engine is Jet engine. By this type of engine have been powered 106,700 planes at Arlanda in 2018.....	8
Figure 8: Ratio of planes according to number of engines. Majority of airplanes arrived to Arlanda airport during the year 2018 had 2 engines	8
Figure 9: The most frequent carriers at Arlanda. The most frequented carrier at this airport was SAS (Scandinavian Airlines) because there is a hub of these airlines at Arlanda	9
Figure 10: Nine the most frequented plane's manufacturer's at Arlanda. It can be seen clear dominance of Boeing	9
Figure 11: Boxing plot of the traffic intensity within each month. There are 12 boxes with beards that indicates minimum, first quartile, median, third quartile and maximum.	10
Figure 12: Quadrangle of approaches at Arlanda.....	11
Figure 13: Trajectories of several aircraft in unfinished additional task	12

List of tables

Table 1: Seasons, the START DAY entity means the first day of the season (usually first day of the month), START MONTH entity means the number of month the season is starting, END DAY entity means the number of day in the month the season ends (different numbers caused by the different duration of months. END MONTH entity means the number of the month the seasons ends	12
--	----

Appendix A

The project is submitted including calculations in MS Excel, where graphs are also present. A presentation is also included. The file in which the additional task was made is submitted as well.