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Study of air traffic over KLFIR

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Abstract. This paper shares the overview of the work currently being conducted with the Department of Civil Aviation Malaysia related to the air traffic. The aim is to study air traffic performance over KL and KK FIR, and the area of interest in this paper is the Kuala Lumpur Flight Information Region (KLFIR). The air traffic performance parameters includes general air traffic movement such as level allocation, number of movements, sector load analysis and also more specific parameters such as airborne delays, effects of weather to the air movements as well as ground delays. To achieve this, a huge effort has been undertaken that includes live data collection algorithm development and real time statistical analysis algorithm development. The main outcome from this multi-disciplinary work is the long-term analysis on the air traffic performance in Malaysia, which will put the country at par in the aviation community, namely the International Civil Aviation Organization (ICAO).

1. Introduction

The aviation industry is huge. There is a daily movement of more than 2000 flights over the Malaysian airspace. Such big traffic can create significant challenge in air traffic management. The solution is to have short-term, mid-term and long-term strategies [1]. Short-term strategy involves understanding the current available technologies, limitations and technical skills. It is important to identify the strengths, weaknesses and potential opportunities, which will help to prepare for mid-term strategy that involves development of the required human capital and technology. Having the right human capital and also technology enables the independent strive for long-term strategy in improving air traffic management procedures, processes and capabilities.

Among common issues in air traffic management include bad weather, airspace closure, aerodrome closure and inefficient schedules. In general, this can be seen as a complex and multi-faceted problem. The International Civil Aviation Organization (ICAO) is currently spearheading several initiatives to improve efficiency of the air traffic such as Air Traffic Flow Management and Collaborative Decision Making (ATFM/CDM) [4]. For ATFM/CDM initiatives to succeed, all relevant data is required before it can be processed and analyzed to obtain the right information. With the right information, planning of air traffic movements can be made more efficient and seamless between airports, and subsequently delays can be minimized and improved. With this in mind, the aim of this paper is to share a general overview of the work done on the air traffic data in Kuala Lumpur FIR that is illustrated in Figure 1. A brief explanation on the methodology is also provided and some selected outputs are shared.

2. Methodology

Several tools have been developed in this study, which will be utilized for data collection, data storage and data analysis. The methodology that is followed in this study is as shown in Figure 2.

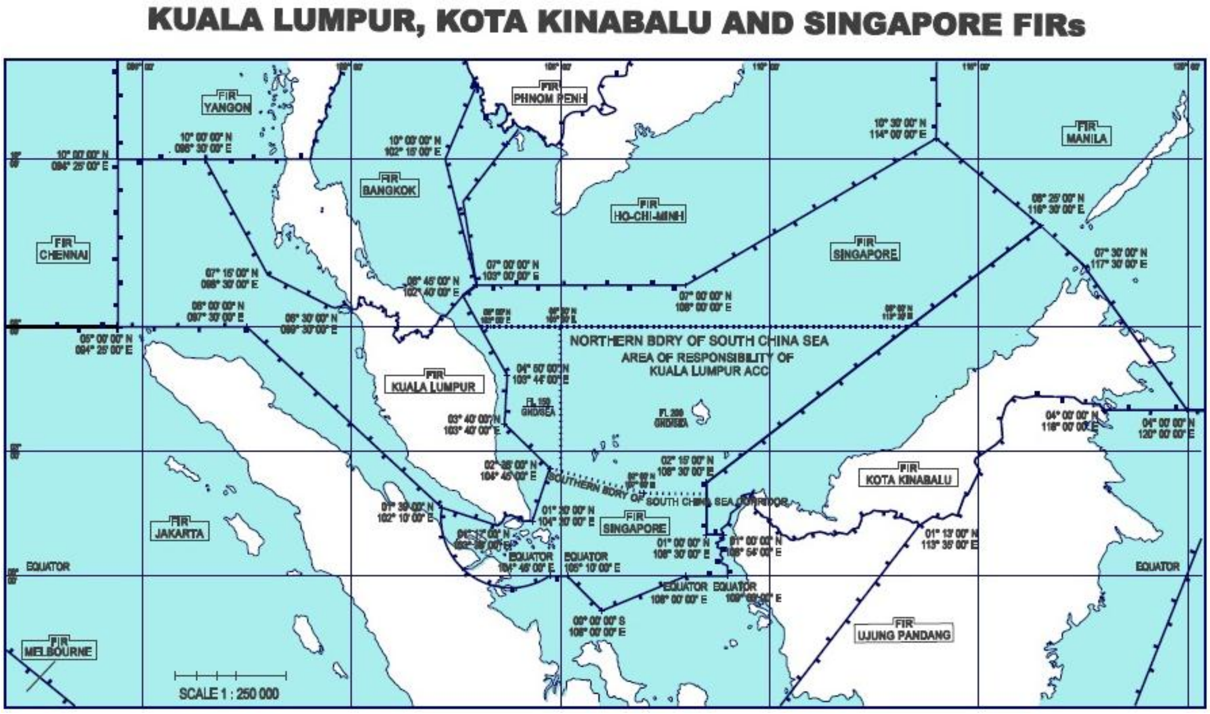

Figure 1: Kuala Lumpur FIR

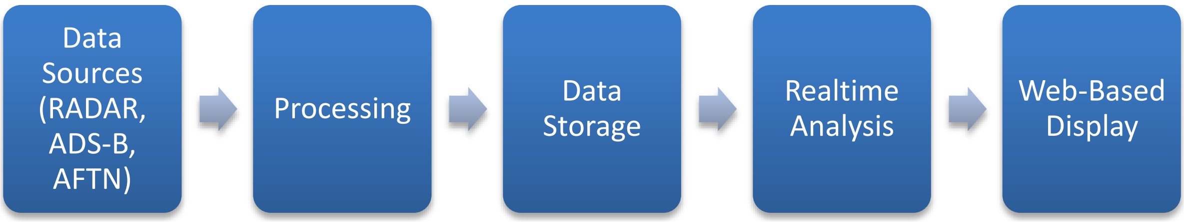

Figure 2: Flowchart of the data analysis process

The developed data collection tools are a set of computer programs that read and decode raw data from various sensors in real time. To decode these raw format data, the protocol used has to be known. For raw radar data, the protocol is the EuroControl ASTERIX [2]. Some of the data are in the form of specialized text-based AFTN format such as the flight plans, NOTAMs and METARs. The decoded data are then stored into a dedicated database. In this project, MySQL is used as the database server.

On the other hand, the data analysis tools are consisted of computer programs that perform various statistical analyses. These tools are developed based on evolving requirements that are tailored to the given inputs by the Air Traffic Control (ATC) and airlines. An example of data analysis is the number of aircraft being delayed during their approach to the Kuala Lumpur International Airport (KLIA). To obtain this information, specific algorithm has to be designed. The algorithm will perform the required data collection that would give enough data to perform the analysis.

3. Overview of Malaysian Airspace Air Traffic Performance

The number of air traffic movements over KLFIR is depicted in Figure 3. The project started its data collection initiatives in year 2012. Since then, an increase in the number of air traffic movements over KLFIR is observed. This increase is contributed to several factors, including addition of new aircraft into the fleet of the major airlines within the region (not only Malaysia-based airlines but also airlines from neighboring countries) and increase of flight destinations due to increase of passengers' demands. New low-cost airlines also contribute to the increase of traffic in the region.

On daily basis, the average number of instantaneous aircraft counts (IAC) observed within KLFIR is as shown in Figure 4. IAC is defined as the number of aircraft in a given time instant. Since the time is recorded in Universal Time Coordinated (UTC), 0000 UTC is 0800 local Malaysia time. From 6am, the number of detected aircraft started to increase until it reached the peak period around 2-4pm. The AIC then started to decrease after 9pm and reached its lowest point in between 2-3am in the morning. This data is mainly used to determine the suitable workload for the air traffic controllers. An example is given in Figure 5, which shows the IAC for Sector 3. Sector 3 is an area in KLFIR that is located in the eastern part of Johor. A group of air traffic controllers is responsible to manage all aircraft entering Sector 3. In order to ensure that the workload of the controllers is within permissible limit, the IAC in Sector 3 is monitored in real time. As indicated in Figure 5, the peak time (i.e. the IAC is more than 11 aircraft) was between 12pm and 11pm. At this period of time, the workload of the air traffic controller is at the highest point and special attention is required to ensure that the controllers are able to work efficiently.

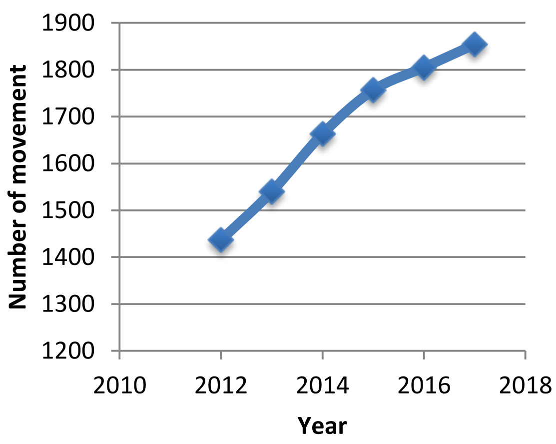

Figure 3: Average increase of movement in KLFIR

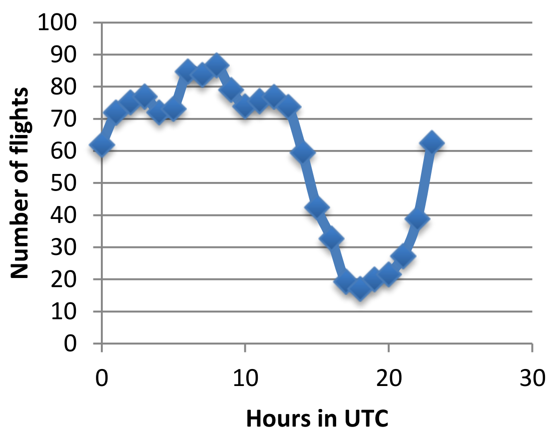

Figure 4: Daily movements in KLFIR (data in 2017)

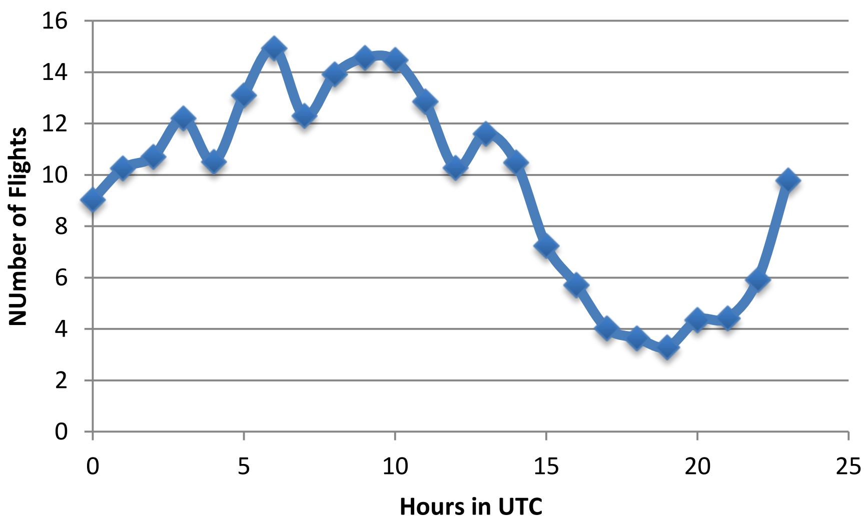

Figure 5: IAC recorded in Sector 3 KLFIR

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It is observed in Figure 6 and Figure 7 that there is an increase in the number of departures between the years 2014 and 2017. The introduction of the Kuala Lumpur International Airport 2 (KLIA2) has increased the capacity of KLIA to accommodate more aircraft. The rationale behind the move can be seen in Figure 8. Figure 8 shows the number of flights experiencing airborne delays between 10 to 30 minutes. Prior to KLIA2, there were only two runways in operation: one for departure and the other one for arrival. This configuration has created a demand-capacity problem since demands for arrivals and departures were more than the actual capacity of the airport.

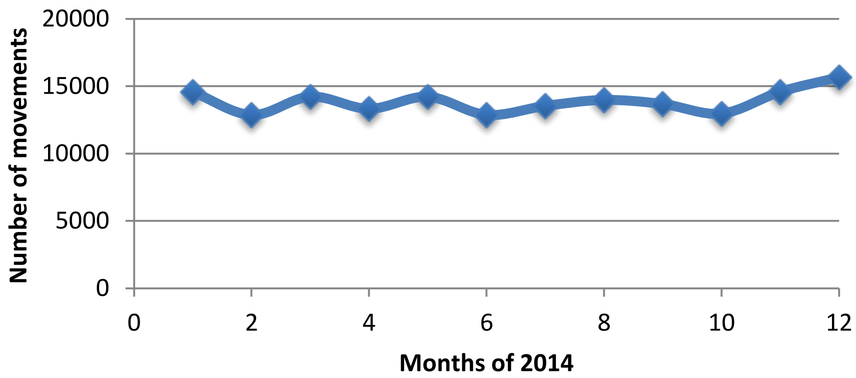

Figure 6: KLIA departures in 2014

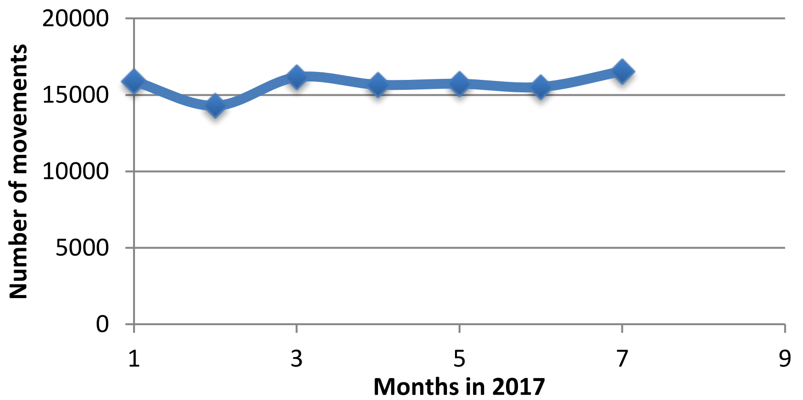

Figure 7: KLIA departures in 2017

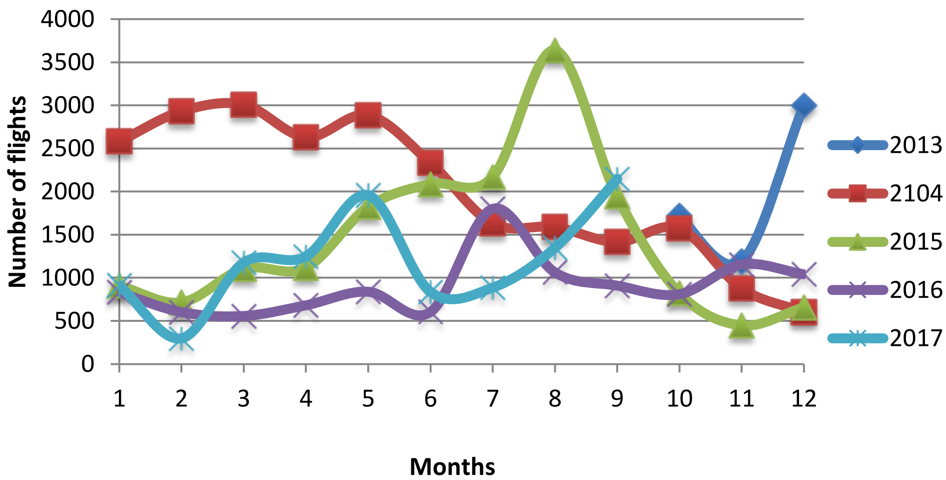

Figure 8: Airborne delays to KLIA from 2013 until 2017

On 1st May 2014, KLIA2 was officially in operation. This in turn has changed the operation of the runways around the airport. Previously, KLIA used runway 32L/14R and 32R/14L for departures and arrivals, respectively. Depending on the wind conditions, one runway is used exclusively for departure and the other one is for arrival. After KLIA2 is operational, runway 33/15 is used for both departures and arrivals. Despite the mixed mode operation, the overall capacity of the airport has improved. Low-cost airlines used runway 33/15 most of the time, and occasionally the other runways if the conditions permit. Figure 8 shows a significant drop of flight delays that are over 10 minutes. The transition was on the 1st May 2014, which coincides with the introduction of KLIA2. An improvement from delays involving 2000 or more flights per month to less than 2000 flights per month is an achievement.

In Figure 8, it can be deduced that there is a spike in the number of delays in the months of June until August. Similar trends are observed in years 2015, 2016 and 2017. The spike was most probably caused by the increase in number of flights over KLIA due to summer schedule. Airborne delays in 2015 were observed to be extraordinary. The obvious reason was the haze season. As Time magazine reported, the haze problem in 2015 was the worst in history [3]. Many aircraft were put on a holding pattern at longer period of time or being diverted elsewhere. This is a good example where the data collection and analysis system was able to correlate airborne delays with major event in KLFIR.

4. Conclusion

The development of data collection and analysis system is a difficult task. It takes a group of experts from multiple disciplines to work together to develop such a complex system at a large scale, which include features such as live data feed, raw data processing and real-time analysis with minimal data loss. It took around six years of development to get from the conceptual idea to a working model. The understanding of aviation technology is paramount for this project to succeed. The data is stored in a large database for further processing. Algorithms have been developed to find optimal methods so that the processing time is kept to the minimum. The use of load balancing is important for this project. Each task is equally distributed to keep the computing load as low as possible. The output from each analysis is stored in another database for fast retrieval. A good knowledge is database programming is essential. An optimal database design would allow for fast storage and retrieval of data. The project has managed to collect a lot of information related to air traffic movement, some of which are shared in this paper.

Acknowledgement

The project is a joint research work with Department of Civil Aviation (DCA) Malaysia. The project team wishes to thank DCA Malaysia for the cooperation and ideas that make this project a reality. The project is still far from its objective and more work still need to be done.

References

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[2] EuroControl 2012 *EUROCONTROL Specification for Surveillance Data Exchange - Part 1 All Purpose Structured EUROCONTROL Surveillance Information Exchange (ASTERIX)*
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[4] International Civil Aviation Organisation (ICAO) 2012 *Manual on Collaborative Decision Making (CDM)*