Optimisation Model based Dashboard for Managing Airport Aeronautical Revenues

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ABSTRACT

Main sources of airport revenues are from aeronautical revenue and non-aeronautical revenues. Many airports put more emphasis on improving non-aeronautical revenues despite the fact that aeronautical revenue is still the main income contributor to most airports in sustaining their business. Airport's aeronautical revenues depend on the number of air traffic where relatively high number of traffic is assumed to generate greater aeronautical revenues. However, seldom airports analyse the impact of various factors related to air traffic such as flight types, aircraft types, flight time and day, and types of passengers arriving or departing, which can indicate the trend in passenger's preferences and potential aeronautical revenues. This research took into consideration these factors when developing the mathematical optimisation model, known as Aeronautical Revenue Optimisation Model (AROM), for generating maximum aeronautical revenues of regional airports. Based on the model and solutions, a Graphic User Interface (GUI) dashboard system has been developed for assessing the aeronautical revenue generated by different variables of the air traffic movements. The dashboard allows user to extract existing data, run the model and view results, including the potential revenue generated by each aircraft. Thus, it provides managers with in-depth information of each flight and its impact on potential revenue generation, which guides them in decision making, operations planning and improving the billing efficiency.

Keywords: *airport, aeronautical revenue, dashboard, graphic user interface (GUI)*

ISSN 1823- 5514, eISSN 2550-164X

Received for review: 2017-06-23
Accepted for publication: 2017-09-26
Published: 2018-03-15

Introduction

Airport main revenues are mainly from aeronautical and non-aeronautical revenues. As reported in the 2015 financial report by the Airports Council International (ACI), 55.5% of the 2014 global revenues was contributed by aeronautical revenues, 40.4% was from non-aeronautical revenues and the remaining came from non-operating resources [1]. Aeronautical revenues are obtained from charges for services or facilities which are directly related to the processing of aircraft and passengers and cargo in connection with facilitating travel, either at the airside or in the terminal.

The core sources of aeronautical revenues are mostly from aircraft landing fees which is calculated based on aircraft maximum take-off weight (MTOW) and passenger departing service charges and security service charges, which also known as airport tax. Other charges such as cargo service, landing bridges charges, aircraft parking and hangar, ground handling service, en-route navigation, aircraft noise, noxious emission, fuel surcharges and night surcharge are also considered as aeronautical revenues but the contribution is less significance [2, 3]. From the aeronautical revenues, income from aircraft related charges was 33.6% while passenger-related charges accounted for 55.8% and other aeronautical revenues (terminal rentals) (10.6%). Thus, the ratio of aircraft-related charges to other charges is 34:66 [1]

As for the non-aeronautical revenue, the sources are from charges related to ancillary commercial services, facilities and amenities available at an airport especially in the airport terminal/complex and airport's property. The key contributors of non-aeronautical revenues are from retail concessions (28%), car parking (22%), property or real estate income (15%) and the rest were generated by other sources as such as car rental, advertising and Food and Beverages (F&B) [3]. Although aeronautical revenue is still the main source of income of most airports in the world in sustaining their operations, consultants and researchers have given more attentions to increasing non-aeronautical or commercial revenues [4]-[5]. Nevertheless, it is also crucial for airports to be able to assess the activities that generate more aeronautical revenues for them and to evaluate the performance of the airport in order to generate sufficient revenues to maintain and sustain their operations.

An airport has millions of little pieces of information, which are essential to airport operators in conducting planning and decision-making. Making these data manageable and meaningful to the airport operators is crucial. In addition, the need for predictive capabilities has become vital to the decision-making process of airport operators. Airport operators need a simple but comprehensive tool that can enable them to quickly predict and evaluate the impact of certain parameters and factors that have influence on the generation of aeronautical revenue and increase the airport operational performance based on quantitative data. These factors include passengers and aircrafts arrival/departure patterns and trends, types of flights, i.e. either domestic or international, time or day performance, and types of airlines. However, seldom airports analyse the impact of various factors related to air traffic. In addition, research that concerns with utilizing factors related to air traffic movements as basis for revenues generation and tool for planning and scheduling is still lacking. Therefore, it is the aim of this research to investigate the impact of such factors towards the generation of aeronautical revenues of an airport and to enable these analytical data to be utilised in the airport management's decision making.

This paper presents a graphic user interface (GUI) dashboard that has been developed based on our research. The dashboard allows airport operators to evaluate the aeronautical revenues generation by making appropriate decisions concerning various factors based on traffic movements at the airport. Aside from that, the summary of analysed micro data of flights made available through the dashboard can be useful for future planning and scheduling that could be carried out to provide more efficient service to the passengers and airlines other than providing strategies for generating aeronautical revenues for the airport.

Airport Performance Dashboard

In the market, currently there are several types of GUI dashboards that have been developed either by independent business organisations or by academic institutions for managing and analysing airport revenue and operational performance. These GUIs are mainly for providing global view as well as accurate and complete information of the airport operations which include facilitating the daily operations and processes efficiently, increasing productivity and customer satisfaction and reducing transaction and training costs.

One of the commercial airport performance software available in the market is the Analytical Scorecards for Transit and Airports (ASTRA). It is an application for airport reporting and performance measurement dashboards created by AST Corporation [6]. Meanwhile, GrayMatter's Airport Analytics (AA+) enables users to conduct historical data analysis with insightful dashboards [7]. As for Concessionaire Analyzer + (CA+) software solution, the dashboard is designed for analysing non-aeronautical revenues only such as retail and F&B revenues [8]. In addition, Gentrack Airport 20/20 has a complete set of software solutions for airport operations and revenue management system [9]. Table 1 provides the summary of capabilities and features of these airport GUI dashboards. Based on Table 1, a common feature of these GUIs is their capabilities in revenue management.

Table 1: Capabilities and Features of Existing Airport GUI Dashboards

	GUI Dashboard	Capabilities	Features
1.	Analytical Scorecards for Transit and Airports (ASTRA) - 100 pre-built dashboards on aeronautical and non-aeronautical revenues, and costs associated with passengers servicing activities at airport and from airline perspective.	• Analytics on revenues, operations, maintenance, safety and security service, environmental sustainability, and productivity. • Insights on airport resources utilisation, service efficiency with airport's constraints and the airport administration.	• Data integration from multiple sources • Dashboard configuration to suit requirements • Easy to navigate dashboard with drilldown capabilities, export functionality and customization
2.	GrayMatter's Airport Analytics (AA+) - A pre-built Enterprise-wide solution for Airport Operators	• In-depth airport analytics and data integration, data analysis and forecasts, and real-time data-driven actions. • Revenues management (analysis, trends, what-if modelling, revenues by top 10 airlines, aircraft types and sectors, etc.).	• Quick data integration • Product alignment to domain best practices • Risk free rapid deployment • Ad hoc on demand slice and dice capabilities • Scalable and future proof solution
3.	Concessionaire Analyzer (CA+) • Control, manage and boost non-aeronautical revenues and concession-based revenues	• Enabling airports and shopping malls to strategically manage and sustainably increase non-aeronautical revenues. • Gathering sales data from concessionaires, automate billing, understand retail sales patterns in terminal, assess performance and calculate sales per passenger per flight, by destination, carrier and gate.	• Business Intelligence engine (integrated with flight and passenger info) for richer performance analysis on concessionaire sales. • Commercial contract management that automates revenue calculation and billing with

			speed and efficiency
4.	Gentrack Airport 20/20 • A set of interactive dashboards for airport operators	• Enable airports to run efficient operations, improve flight turnarounds and support rapid growth. • Fully integrated Airport Operations and Revenue management suite - designed for seamless data exchange, real time insight and complete billing flexibility.	• Five Airport Operations System Modules • Real time dashboards that can be configured by users. • Colour coding display automatically appears if any problem arises and for airport operators to take immediate action.

Although there are a number of well-developed interactive and real-time dashboards available in the market now, the price for these sophisticated and high technology airport solution packages can be costly to be installed especially by small and medium airports. Most of the airports that bought and utilised these softwares are major hub airports. For examples, among the users of AA+ are Stuggart Airport, Hyderabad Rajiv Gandhi International Airport, Delhi Indra Ghandi Airport, Queen Alia International Airport and Montreal Airport. On the other hand, Gentrack Airport 20/20 have wider customers of over 100 airports around the world after the acquisition of Concessionaire Analyzer (CA+) and Blip Systems, which include Schiphol International Airport, JFK Terminal 4, Aberdeen International Airport, Glasgow Airport, Southampton Airport, London City Airport, and Antigua International Airport.

Academic institutions are also taking this opportunity to build a smaller scale solution for airports to improve their revenues and operational performance. University of Western Australia developed a system dynamic (SD) model to explore the relationship between airport revenues and passenger volumes and later forecast the airport revenues based on different scenarios [10]. The SD model is also able to forecast the impact of airport fee increase on the airport's revenue and airlines' revenue. However, this model did not utilise dashboard to display the visual results. Zeng and Zhang (2013) demonstrated the use of dashboard for lean revenue cycle management [11], where positive feedback received by users were highlighted using dashboards. Their findings showed that the frontline staffs were found to be more focused on business rather than the data. By having visual performance dashboard, the culture and environment of transparency and accountability can be inculcated. It enables the lean concept to be fostered thus reducing waste, and allowing clinical, operational and financial efficiencies to be achieved.

Nevertheless, commercial airport performance packages may offer variety of state-of-the-art solutions to manage or monitor airport operational performance, however, it is important to analyse the fundamental source of airport revenues for airports especially small and medium airports to sustain their business. Hence, this research proposed a modest GUI dashboard for medium airports to view the generation of airport aeronautical revenue based on airlines operations and other external factors that influence the generation aeronautical revenues.

Modelling Aeronautical Revenue Management

For this research, Langkawi International Airport (known as Langkawi Airport in this paper) was chosen as the case study in analysing the generation of aeronautical revenue for year 2012. Langkawi Airport is one of the international airports in Malaysia. This airport is situated on the duty-free island of Langkawi in Kedah, North of Malaysia. It serves flights to and from Penang, Kuala Lumpur, Subang, Kuching and Singapore. Airlines operating from Langkawi Airport are scheduled legacy airlines such as Malaysia Airlines, and Finnair, low cost airlines such as Air Asia, Firefly, and Silk Air, charter flights such as Berjaya Air and also government flights. To cater to the increasing demand of tourists and business travellers, the airport has extended its terminal to accommodate a maximum of 2.5 million passengers annually and 1000 passengers during peak hours. It has one single runway of 3.8 km and the runway is capable of handling A320, B737-800, and B747 aircrafts.

The data on Langkawi Airport operations, obtained from the Malaysia Airport Holdings Berhad (MAHB), showed that the types of traffic operating at Langkawi Airport were: Schedule (J) flights, Additional (G) flights, Technical Test (T) flights and Charter (C) flights. The main traffic type was Schedule (J) flights, which constitute about 99.98% of total flight movements for year 2012. There are about 15,149 flight movements in 2012; with 7,573 arrivals and 7,576 departures. Total numbers of passengers in 2012 were

1,563,708 where, domestic passengers were 1,438,835 per annum and international passenger were 124,873 per year. In this research, only landing charges of the aircraft during arrival and departing passenger service charge (PSC), which includes the security service charge (PSSC), were taken into consideration as Langkawi Airport aeronautical revenues. Hence, equation for total aeronautical revenues for Langkawi Airport can be written as follows:

$$AR = ALF + DSF \tag{1}$$

where,

AR	:	Total aeronautical revenue
ALF	:	Aircraft landing fee
DSF	:	Departing passenger service fee and security service fee

The landing fee for Malaysia is calculated in accordance to the maximum take-off weight (MTOW) of the aircraft. Table 2 shows the tariff of landing fee for year 2012 and Table 3 indicates the PSC and PSSC as of 2012. Besides the landing charges and the passenger services charges, Wan Mohamed (2016) highlighted that the external parameters which have influence on the generation of aeronautical revenues at airports are operational mode, traffic types, time of day, day of week, engine type, aircraft MTOW (maximum take-off weight) category, and also flight types [12].

Since an airport's operations and derivation of revenues involve various direct and indirect factors such as number of passengers, weight of aircraft, time of the day and passenger service charges, thus it is important to explore the interrelationships among these factors in influencing the generation of aeronautical revenues.

Table 2: Landing Fees Charges of Langkawi Airport as of 1 January 2012

	MTOW Category 1	MTOW Category 2	MTOW Category 3	MTOW Category 4	MTOW Category 5
Landing fee (Single Landing)	MTOW not exceeding 5000 kg	MTOW exceeding 5000 kg but not exceeding 45 000 kg	MTOW exceeding 45 000 kg but not exceeding 90 000 kg	MTOW exceeding 90 000 kg but not exceeding 135 000 kg	MTOW exceeding 135 000 kg
Initial weight	-	5000 kg	45 000 kg	90 000 kg	135 000 kg
Initial charge	-	RM32.70	RM381.50	RM842.57	RM1362.50
Charge per 500 kg	RM 3.27	RM4.36	RM5.12	RM5.78	RM6.21

Table 2: PSC and PSSC Tariff as of 1 January 2012 (Langkawi Airport)

	PSC (s_1)	PSSC
Domestic	RM 9.00	RM 3.00
International	RM 65.00	RM 6.00

The objective functions of the mathematical optimisation model as described in Wan Mohamed (2016) are to maximise the revenue generated based on landing and night surcharge fees of arrival flights at Langkawi Airport, which can be written as follows:

$$\text{Maximise } LNF = \sum_{i=1}^{n_{TT}} \sum_{j=1}^{n_{FT}} \sum_{k=1}^{n_{FD}} \sum_{l=1}^{n_{FE}} \sum_{m=1}^{n_{FM}} \sum_{n=1}^{n_{FR}} [f_0 + ((W_m - W_0)/500) * f_1] X_{ijklmn} \quad (2)$$

and to maximise the revenue generated from departure flights (through passenger departing fees and security fees) for the airport, formulated as in (3):

$$\text{Maximise } DSF = \sum_{i=1}^{n_{TT}} \sum_{j=1}^{n_{FT}} \sum_{k=1}^{n_{FD}} \sum_{l=1}^{n_{FE}} \sum_{m=1}^{n_{FM}} \sum_{n=1}^{n_{FR}} (s_1) P_n Y_{ijklmn} \quad (3)$$

where,

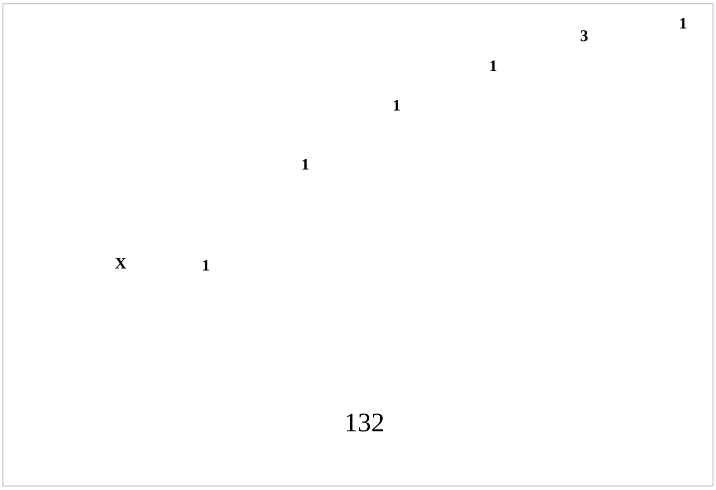
LNF		Landing and night surcharge fees.
DSF		Passenger departing and security fees
TT	:	Set of traffic type, $TT = \{1,2,,\ldots,n_{TT})$
FT	:	Set of flight time, $FT = \{1,2,\ldots,n_{FT}\}$
FD	:	Set of flight day, $FD = \{1,2,\ldots,n_{FD}\}$
FE	:	Set of flight engine type, $FE = \{1,2,\ldots,n_{FE}\}$
FM	:	Set of flight MTOW category, $FM = \{1,2,\ldots,n_{FM}\}$
FR	:	Set of flight route type, $FR =\{1,2,\ldots,n_{FR}\}$
I	:	Index representing traffic type, $i = 1,2,\ldots,n_{TT}$
J	:	Index representing flight time, $j = 1,2,\ldots,n_{FT}$
K	:	Index representing flight day, $k = 1,2,\ldots,n_{FD}$
L	:	Index representing flight engine type, $l = 1,2,\ldots,n_{FE}$
M	:	Index representing flight MTOW category, $m = 1,2,\ldots,n_{FM}$
N	:	Index representing flight route type, $n = 1,2,\ldots,n_{FR}$
X_{ijklmn}	:	Number of arrival flights based on traffic type, time of flight, day of flight, flight engine type, flight MTOW category and flight route type.
W_0	:	Initial aircraft weight base on the given MTOW category
W_m	:	Aircraft weight based on MTOW category

f_0	:	The initial aircraft landing fee based on MTOW category
f_1	:	The subsequent landing fee per 500 kg of aircraft MTOW
Y_{ijklmn}	:	Number of departure flights based on traffic type, time of flight, day of flight, flight engine type, flight MTOW category and flight route type.
P_n	:	Departing passengers based on flight route type
s_1	:	Departing passenger service charge (PSC) inclusive of PSSC

To simplify the understanding of the mathematical model in calculating the aeronautical revenue generated, a decision tree model was developed to illustrate the parameters that influence the generation of the aeronautical revenue for the airport. The decision tree model is a sequential model, which combines a sequence of alternatives available to provide possible consequences, where all the possible choices can be visually seen in its graphical representation.

The technique has been widely used to build classification models and it is easy to understand [13]. The tree can be expanded easily where the large sub-trees can be duplicated many times therefore, making it more complicated eventually [14]. Decision tree model is simple, easy to comprehend, easy to implement, allows the trace of paths, and takes into consideration minute details and can be used for multi stage/phase decisions.

Figure 1 illustrates how the decision tree model has been used to represent the sequence of alternatives related to the arriving flights for the Langkawi International airport. In the aeronautical revenue optimisation model for the Langkawi International airport, arrival flights have been denoted as X while Departure flights are represented by Y. Thus, based on the tree diagram of Figure 1, X_{111131} indicates that the flight is for Arrival-Schedule-Day-Weekday-Jet-MTOW Category 3-Domestic flight. By having this code (based on certain path in the tree diagram), it is easier to see which category has the greater influence in generating aeronautical revenue for the airport.



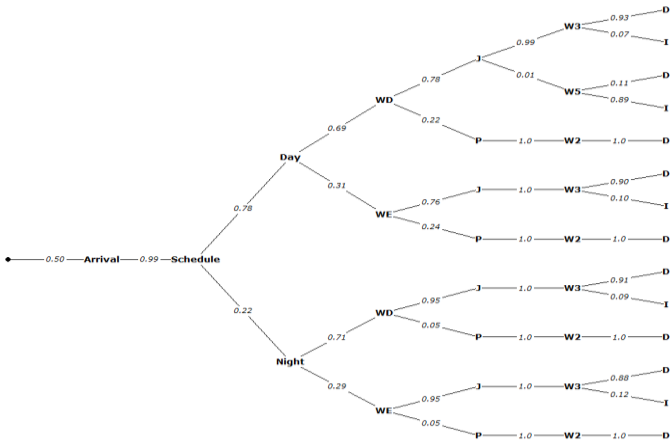


Figure 1: A Sample of Tree Model for Arriving Flights at Langkawi Airport
Source: Wan Mohamed (2012)

Development of the Aeronautical Revenue Dashboard

The airport data stored in MS Access database and NetBeans IDE 8.1 was used to develop the system. Data were categorised according to arrival and departure, time, day, month, type of aircraft engine, aircraft MTOW, number of passengers, and type of airlines. The calculation of the arrival revenue is based on Equation (2) and, for departure revenue, Equation (3) is used.

Among the limitation of the GUI dashboard developed is that it generates the gross aeronautical revenues, which is derived from landing charges and passenger service and security charges only and does not take into account of other aeronautical charges obtained from aerobridges services, aircraft parking charges, etc. [3]. It also does not take into consideration of the operating costs of the airport.

Structure of the Dashboard

The home page of the dashboard consists of the main menu, as shown in Figure 2. The user will have to select the file which consists of the data that the user wants to analyse. Once the selected file is uploaded, then the listed menu will be activated and the user can select the category that he/she wants to evaluate. The description of quantitative results being displayed by each tab is described in Figure 2.

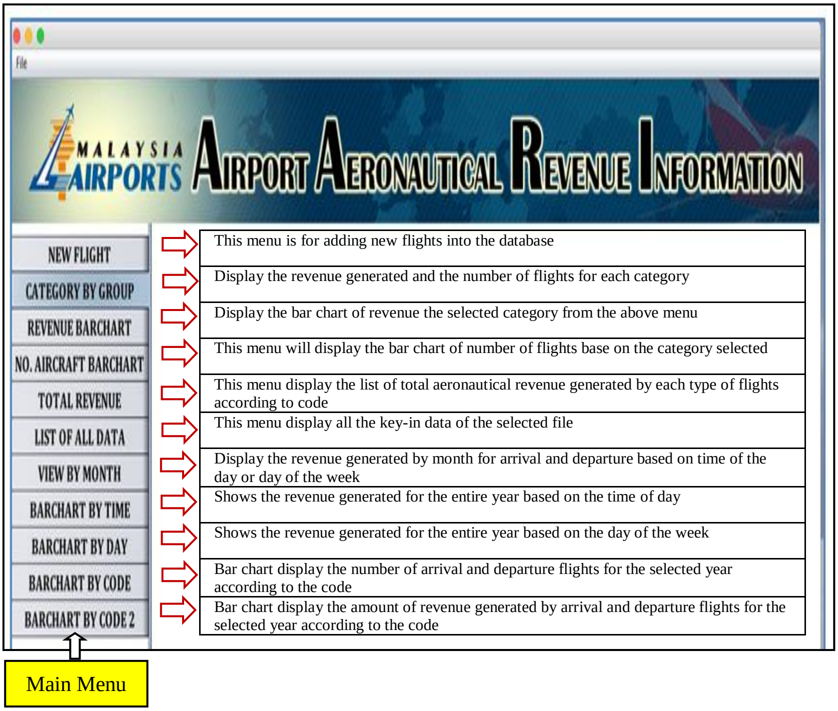


Figure 2: The main menu of the airport aeronautical revenue dashboard

Dashboard Capabilities

The capabilities of the dashboard can be described as the following. i) **the user (airport operator) can add additional flight information** in the selected file using 'NEW FLIGHT' module. The system will automatically save and add the data, and it will calculate the latest total flights and aeronautical revenue in the existing file. ii) **The user can choose the type of quantitative analysis on the flights and revenue**. 'CATEGORY BY GROUP' module enables user to have output be displayed according to group (traffic types, time of day, day of week, engine type, aircraft MTOW, and airline). If 'Airline' is chosen, types of airlines will be displayed according to category (refer Figure 3). The dashboard will exhibit the list of airlines flying to and from Langkawi Airport in 2012 and present the potential revenue generated by each airline and the total number of flights in term of value and percentage.

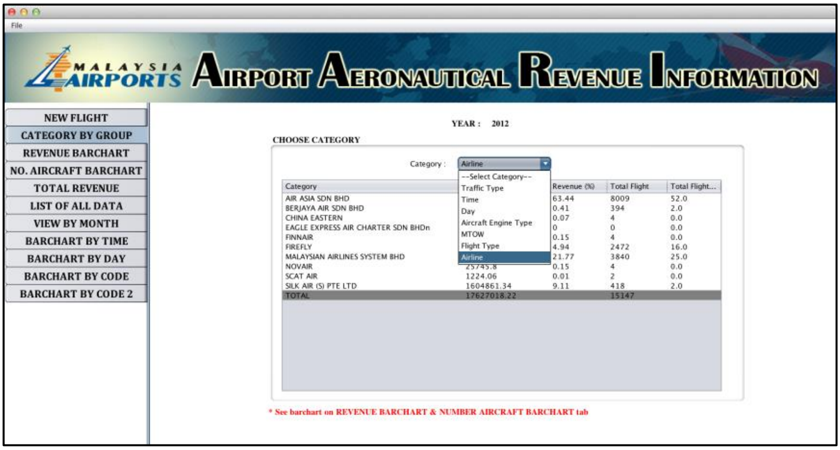


Figure 3: The selection of output based on categories

In addition, iv) **the user can select the output graphical representation**. For example, from Figure 4, the user could select the category of output display. By clicking on the REVENUE BAR CHART tab, the visual bar chart will appear as shown in Figure 4 and Figure 5. Figure 4 displays the bar chart of revenue generated by each airline in 2012 where it can be seen that Air Asia is the highest contributor to Langkawi Airport aeronautical revenue, followed by Malaysia Airlines, and Silk Air, respectively.

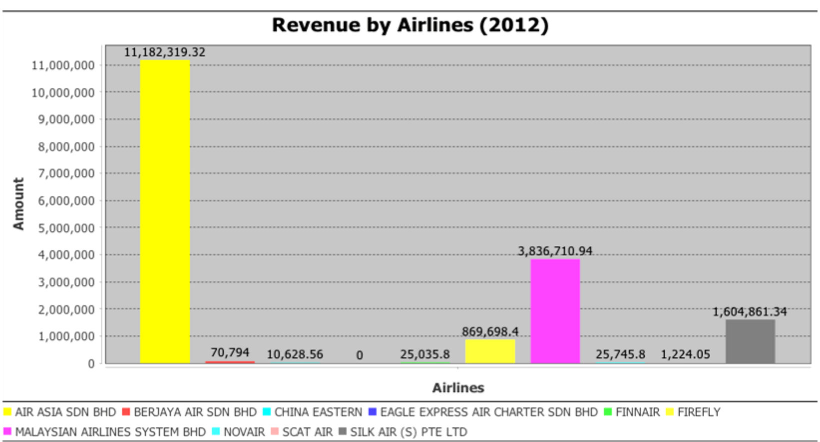


Figure 4: The amount of aeronautical revenue generated by each airline

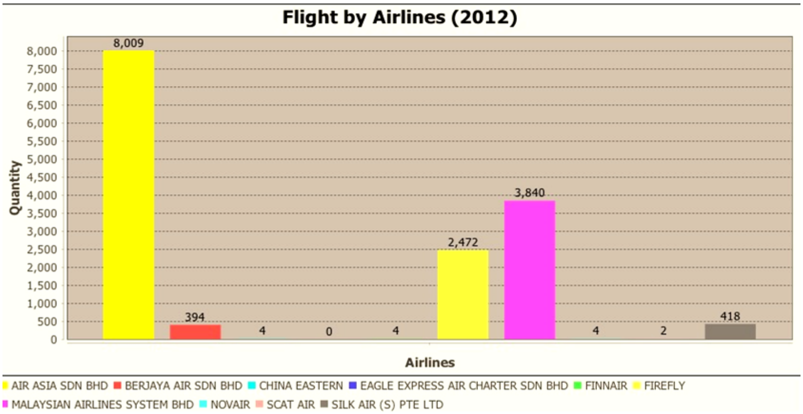


Figure 5: Number of flights based on airlines

Aside from that, v) **the airport operator gains in-depth understanding on the revenue generated by airlines**. From Figure 5, it can be seen that Air Asia has the most number of flights (8,009 flights) and contributed the highest aeronautical revenue (total of landing and passenger services charges) of RM11,182,319.32 on average for Langkawi Airport in 2012. Air Asia flight brings in about RM1,396.22 per flight. However, for the case of Silk Air, the number of flights is about 418 flights but the amount of aeronautical revenue generated is quite substantial (RM1,604,861.34) as compared to the revenue generated by Firefly and Berjaya Air. Slk Air flight brings in RM3,839.38 per flight which is higher than that of Air Asia. This is because Silk Air is a Singapore owned airline, thus it is an international flight and therefore the service charges for international passenger are higher than domestic passenger.

Based on these results, the airport operators can understand better the reason why certain airlines do not necessarily generate higher revenue for the airports even though having high number of flights per year. Meanwhile, Firefly and Berjaya Air are using propeller engine aircraft such as ATR70 and business jet, which have lower payload and thus give an average of RM351.82 and RM179.68 per flight, respectively. Such quantitative results give valuable information on potential aeronautical revenues Langkawi Airport could receive from the airlines and hence, can assist the airport in deciding on the slot allocations and preferences to be given to the airlines.

Next, vi) **the user (airport operator) is able forecast based on data analysis provided**. The dashboard user can also select to view the number of flights arriving or departing from the airport and the respective revenues received according to month using 'VIEW BY MONTH" module. The analysis is as shown in Figure 6. For example, in the month of January 2012, the highest number of flights arriving and departing to and from the

Langkawi Airport was on Sunday, and Sunday also recorded the highest revenue generated. Monday and Tuesdays also have the highest number of flights, and Thursday seem to have the lowest number of flights. With this information, the airport managers are able to schedule the right number of manpower and forecast on the expected demand.

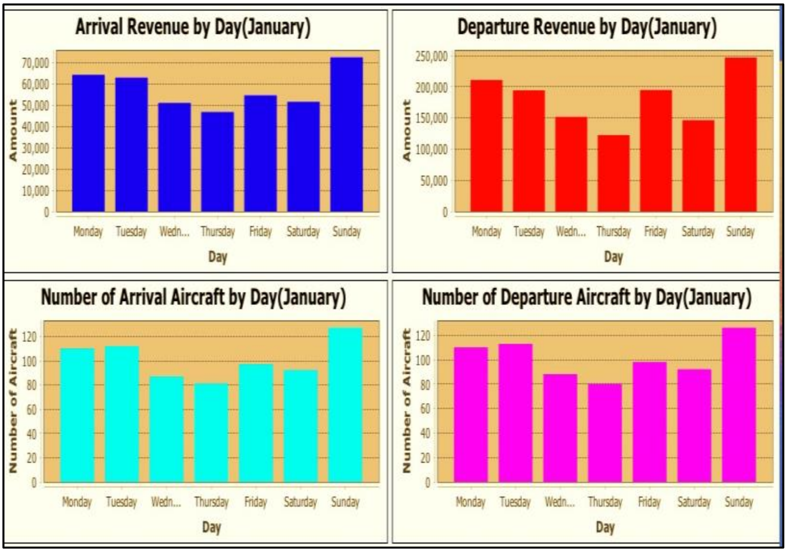


Figure 6: Arrival and departure revenue by day for January 2012

Besides that, vii) **the user can view micro analysis on airport operations and the revenues generated**. Further details on arrivals and departures and their revenues can also be obtained by using the ‘BAR CHART BY TIME’ or ‘BARCHART BY DAY’. Figure 7 shows the compilation of flights arrival and departure by the hour in the respective year, where there is an interesting correlation between arrival and departure revenue. For arrivals, the number of flights and the revenue generated were seen as almost linear growth, the more number of flights, the higher the revenues generated. However, departure time during 08.00 – 09.00 hours seem to record the lowest number of departing flights but generated the highest revenue. Looking into the recorded data, it was found that flights departing in the morning have the highest payloads and can reach to a maximum of 175 passengers per flight. Having this micro level information can assist airport to plan and schedule their staff in handling passengers more efficiently.

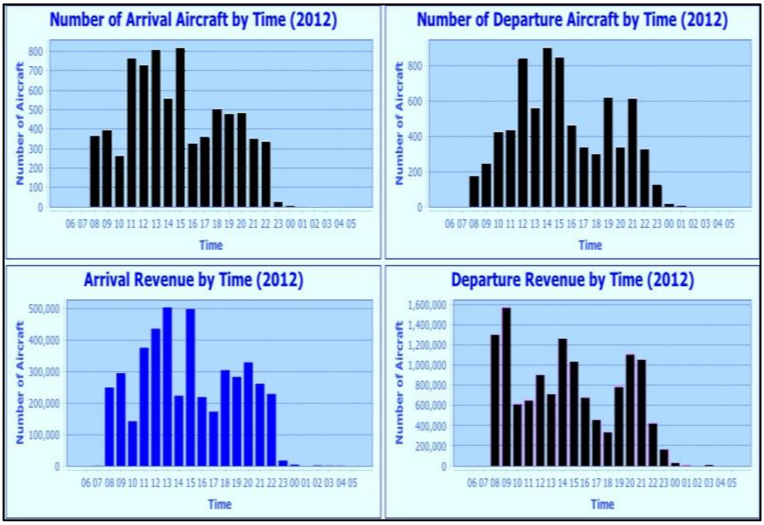


Figure 7: Arrival and departure flights by time in 2012 at Langkawi Airport

In addition, micro details concerning flights based on results in 'BARCHART BY CODE' module also allow the airport operators to gain insights on flight details and revenues generated. Figure 8 and Figure 9 show the number of flights and aeronautical revenue generated by each category. It can be seen that from both graphs, arrival and departure for category X_{111131} and Y_{111131} have the highest number of flights and also generate the highest aeronautical revenue.

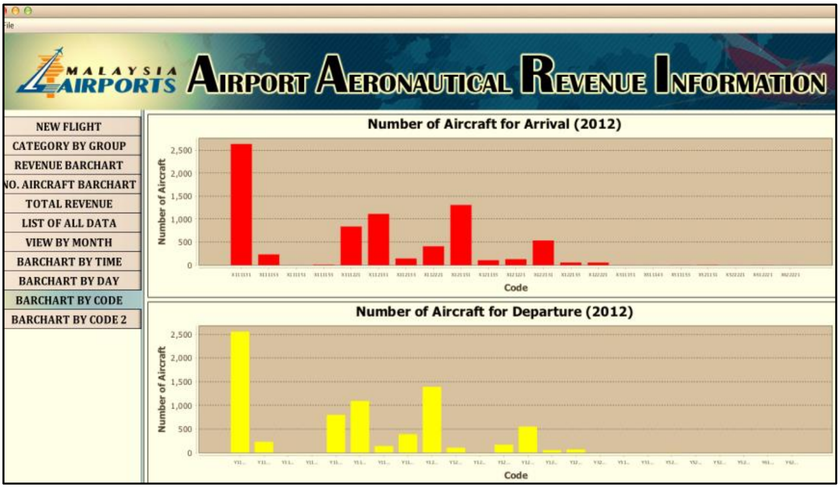


Figure 8: The number of flights based on coding category

However, the correlation between number of flights and aeronautical revenue generated for departure does not have a linear correlation. This confirms that the external variables such as time, day, type of aircraft size and engine do have influence on passenger choice.

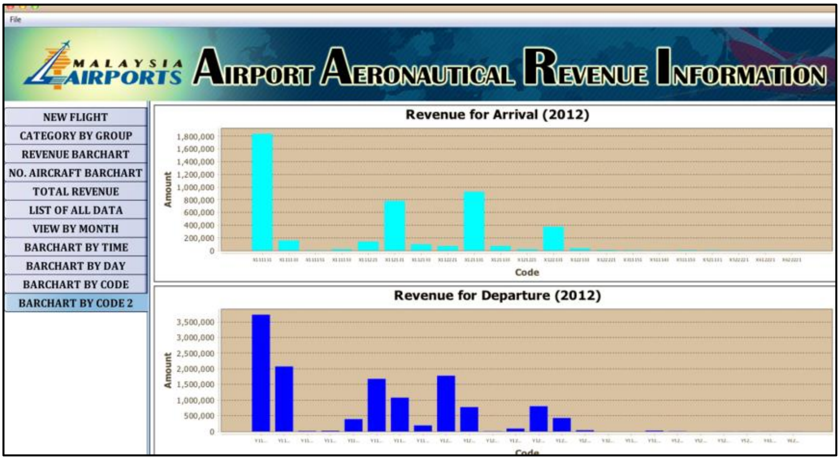


Figure 9: The aeronautical revenue generated based on coding category

Conclusion

This paper introduces the visual GUI dashboard tool, which allows the airport operators to be able to have an overall picture of the aeronautical revenues generated by their airport. It assists the user to analyse the trend of the airside operations and observe the factors of passenger preferences to fly such as types of airlines, types of aircrafts, time of day and day of the week. From the information, airport operators could anticipate the future or possible demand scenarios and the potential aeronautical revenues that could be generated for their airport. The GUI dashboard allows the airport to analyse the aeronautical revenues contributed by the airlines based on other factors, and not just limited to number of flights only.

Minute details of flights through the simple dashboard enable the airport management to strategise schedules of flights, even for per hour window, of various airlines that could potentially generate optimum revenue. Thus, the dashboard helps airport operators to plan the slot allocations and manage the resources in operating the airport efficiently. It could also be used, as a revenue-enhancing tool since the airport operators is able to see the potential aeronautical revenues generated by the airlines and will improve billing efficiency.

It is important to keep the visual performance dashboard simple so it would be easy to be understood and to be updated by the user. The establishment of this dashboard is just a starting tool focusing only on the aeronautical revenue performance. This dashboard has many more potential enhancements that could be explored further. It could be integrated with statistical tools, optimisation tools and predictive modelling tools. More detail information and data are required from the airport management in order to develop a more comprehensive and dynamic reporting of the performance of the airport in terms of aeronautical and commercial revenues generated.

Acknowledgement

We would like to thank Universiti Teknologi MARA (UiTM) for supporting us in conducting this research and we also we like to express our sincere gratitude to Malaysia Airport Holdings Berhad (MAHB) for sharing the data with us in order to develop the GUI. Without their support, the research outcome would not be materialised.

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