1.231 Planning and Design of Airport System
Term Project

Case Study: Capacity Issues facing the
Hong Kong International Airport

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1. Introduction

1.1 Background

Hong Kong International Airport (HKIA), colloquially known as Chek Lap Kok Airport is the main airport in Hong Kong, People's Republic of China. It is operated by the Airport Authority Hong Kong (AAHK). The airport was built on the island of Chek Lap Kok by land reclamation and opened for commercial operations in 1998, replacing its predecessor Kai Tak. In recent years, Hong Kong’s air transport industry has benefited directly from the rapid growth of the Asia-Pacific and Chinese markets, and is now an important regional trans-shipment centre, passenger hub and gateway for destinations in mainland China, with over 40 destinations and the rest of Asia. The airport has been gaining excellent reputation from the aviation industry and travelers worldwide since its early days of operation. Despite a relatively short history, Hong Kong International Airport has already won seven Skytrax World Airport Awards in just ten years [8].

HKIA also operates one of the world's largest passenger terminal buildings and operates twenty-four hours a day. It is the primary hub for several carriers such as Cathay Pacific, Dragon Air, Hong Kong Express Airways, Hong Kong Airlines, Air Hong Kong (cargo) and Asia Jet (private), with flights from 90 airlines in operation to over 150 cities across the globe. In 2008, it was the 4th and 12th busiest airport worldwide in terms of international and total passenger throughput respectively, registering a total of 48.6 million passengers [9]. In terms of cargo traffic, it was the second busiest airport in the world, handling 3.6 million tons of cargo. HKIA is also an important contributor to the Hong Kong economy, with over 60,000 people employed at the airport.[9]

![Figure 1: Ten Busiest Airports in 2008 in terms of International Passenger Throughput [5]](attachment:image)
1.2 Construction and Operation

Hong Kong International Airport was built on a large artificial island, formed by leveling Chek Lap Kok and Lam Chau islands (3.02 km² and 0.08 km² respectively), and reclaiming 9.38 km² of the adjacent seabed. The 12.48 km² airport site added nearly 1% to Hong Kong’s total surface area, connecting to the north side of Lantau Island near Tung Chung new town.[8] The airport is operated by the Airport Authority Hong Kong, a statutory body wholly owned by the Government of Hong Kong Special Administrative Region. The provision of air traffic control services and the regulation of general civil aviation activities is controlled by the Civil Aviation Department (CAD).

HKIA consist of two independent parallel runways, with a separation of 1,525m and operating current capacity of 58 movements/hour. Due to the mountainous terrain near the South Runway, it is mainly used for take-off, while the North Runway is used primarily for landings. The ultimate capacity of the two runways i.e. the maximum expected number of movements that can be performed in one hour of a runway system without violating air transport management (ATM) rules, assuming continuous aircraft demand is estimated at 60 aircraft movement/hour [HKSAR, 2007]. However because of the idealization, this ultimate capacity is unlikely to be achievable consistently in day-to-day operations.

Figure 1. Hong Kong International Airport Airfield [2]
Both the runways, are 3800 metres in length and 60 metres wide, enabling them to cater to the next generation of aircraft. The south runway has been given a Category II Precision Approach, while the north runway has the higher Category IIIA rating, which allows pilots to land in only 200 metre visibility. At present there are 49 frontal stands, 28 remote stands and 25 cargo stands. Five parking bays at the Northwest Concourse are already capable of accommodating the arrivals of the next generation of aircraft. A satellite concourse with 10 frontal stands for narrow body aircraft is under construction to the north of the main concourse for commissioning by the end of 2009, bringing the total number of frontal stands at the airport to 59.[8]

The operation of scheduled air services to and from Hong Kong is facilitated by air services agreements between Hong Kong and other countries. Since the opening of HKIA, the Hong Kong Special Administrative Region Government has implemented a policy of progressive liberalisation of air services with the intention of promoting consumer choice and competition. Many low-cost airlines have started various regional routes to compete head-on with full-service carriers on trunk routes. Despite its size, the passenger terminal is designed for maximum convenience. A simple layout and effective signage, moving walkways and the automated people mover allow quick and easy movement throughout the building. Facilities for the disabled are in keeping with world requirements. The airport is also served by a complete transport system operational from the very beginning. [9]
Quality ramp handling services are provided by Hong Kong Airport Services Limited, Jardine Air Terminal Services Limited, and Menzies Aviation Group (Hong Kong) Limited. The airport also has an advanced baggage handling system (BHS), the main section of which is located in the basement level of the passenger terminal, and a separate remote transfer facility at the western end of the main concourse for handling of tight connection transfer bags. The BHS processes departure, arrival and transfer bags and utilises a conveyor of more than 24 kilometres long. Majority of the arrival bags are conveyed to 12 reclaim carousels within 20 minutes from aircraft landing carousels within 20 minutes from aircraft landing.

1.3 Competition from other airports

Despite the strong growth of the aviation industry in the Asia Pacific and Chinese markets, Hong Kong faces fierce competition from the big Asian aviation hubs, its regional neighbours in mainland China and even within the same catchment area (the Pearl River Delta Region, PRD). As a result, airspace and ground congestion have both become more serious over time.

1.3.1 Competition from Asian aviation hubs

The rate of growth of the aviation industry in Asia is much higher than that in the more mature markets of Europe and North America. Airports such as the Seoul Incheon Airport, Bangkok Suvarnabhumi Airport, Singapore Changi Airport, Tokyo Narita Airport, Taipei Taoyun Airport and Kuala Lumpur Airport are all major international hubs and competing directly with Hong Kong for both passenger and cargo traffic. All these airports are seriously considering the expansion of their airport infrastructures to capture the anticipated growth of demand in the region. For example, Seoul Incheon Airport and Kuala Lumpur Airport are both having the third
runway under the planning stage, while Singapore Changi Airport opened a new low cost terminal in March 2006, besides extensively upgrading Terminal 2 costing S$240 million.[1]

1.3.2 Rapid growth of aviation industry in mainland China

For Hong Kong, airports in Mainland China also generate significant competition. All the ‘Big Three’ airports in China: Shanghai Pudong, Beijing Capital, Guangzhou Baiyun have invested huge sums of money to construct new passenger terminals, runways and upgrade and expand their existing infrastructure in the recent past.

![Figure 5. Ten busiest airports in mainland China in terms of passenger throughput in 2008 [5]](image)

Given the rapid growth and size of the Chinese economy, China will significantly influence and shape the pattern of airline networks in Asia and linkages with other continents. Hong Kong, being a Special Administrative Region of China, has obvious advantages over regional competitors such as Singapore and Taipei to expand into the China market. [1] However, at present, one of the difficulties that China is facing is insufficient runways for a population of 1.3 billion. According to Civil Aviation Administration of China (CAAC), there are only 147 airports for civil aircraft to serve this population [CAAC, 2007], which compares very unfavorably with developed countries such as the US, which has 14,807 airports serving a country with 270 million people [1]. Huge infrastructure investments were made in both the 10th and the current 11th Five-Year Plan (2005-2010), and some 190 civil airports are expected to be in operation by 2010 in China [1], and the number expected to further increase to 220 by 2020 [1]. However, despite these expansion efforts, it is anticipated that demand will continue to outpace supply in China.

1.3.3 Competition from airports in PRD region

All the five PRD airports are growing at an astonishing rate with passenger growth at an annual rate exceeding more than 5%, and Shenzhen having an average annual growth rate of nearly 15% between 2000 and 2006. HKIA aircraft movements have been growing at 6.7%, much higher than the original official forecast of 3%. In fact all the PRD airports except Zhuhai have experienced higher growth rate than Hong Kong. By assuming growth rates as observed in past
historical data for other airports, and including the case where HKIA grows at the AAHK predicted rate of 3%, the aircraft movements at Shenzhen and Guangzhou airports are expected to surpass HKIA by 2009 and 2011 respectively, and by 2014/15 using past growth rate of 6.7% for Hong Kong. [1]

![Projected Aircraft Movement Growth of the PRD Airports](image)

**Figure 6. Projected Aircraft Movement Growth of the PRD Airports [1]**

2. **Airside Capacity Concerns**

2.1 **Current Issues facing HKIA**  
Since the opening of the Hong Kong International Airport (HKIA) in 1998, actual air traffic volume at HKIA has grown tremendously to reach a total of 301,000 aircraft movements in 2008, which well exceed the 202 200 movements forecast for 2005 in the 1991 New Airport Master Plan. With regards to passenger movements, at the time of its opening the airport capacity was forecast to be 87 million passengers per year to be reached in 2030-40, based on a forecast of 348 passengers per movement by 2040. However, over the years, with the rapid growth of domestic traffic in China and increased hubbing operations, the average aircraft size has declined rapidly since 1998 from 295 seats per movement to 240 seats per movement in 2007, [2] which has resulted in a reduction in the capacity of the airport which is now estimated at 55 – 60 million. In 2008 itself, the airport handled about 48.6 million passengers. Thus, although the airport was originally designed with a maximum capacity of over 80 million passengers, the imbalance in the operational capacities of landside and airside facilities at HKIA has led to congestion at even the current levels of air traffic, which gives a clear indication that
the airport will run out of capacity at some point in time in the not-too-distant future. As an example, shown below is a typical weekly schedule of the runways at HKIA in summer 2006, which indicates the saturation of its airside capacity.

![A Typical Week in Summer 2006](image)

Fig 7. A typical week in Summer 2006, the table on the left clearly shows how busy the runways are during the season [1]

To cope with the increasing air traffic demand and competition, the Airport Authority Hong Kong (AAHK) published a report ‘HKIA 2025’ in December 2006: a master plan outlining the airport potential plan to meet the future demand. The plan suggested constructing a third parallel runway with around 1km separation from the current north runway, besides proposing a HK$ 4.5 billion investment programme which enhance the existing Passenger Terminal Building and construction of a new satellite concourse for smaller aircraft. According to The Basic Law (Chapter 5 Economy, Section 4 Civil Aviation, Article128), *The Government of Hong Kong Special Administrative Region shall provide conditions and take measures for maintenance of the status of Hong Kong as the centre of international and regional aviation* [HKSAR, 2007]. Thus, HKIA and the HKSAR Government must address capacity constraints both on the ground and in the air in the short term and long term, in order to sustain Hong Kong’s position as an international aviation hub.

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Passenger Throughput</strong></td>
<td>48.6 million</td>
<td>80 million</td>
</tr>
<tr>
<td><strong>Cargo Throughput</strong></td>
<td>3.6 million tonnes</td>
<td>8 million tonnes</td>
</tr>
<tr>
<td><strong>Aircraft Movements</strong></td>
<td>301,000+</td>
<td>490,000</td>
</tr>
</tbody>
</table>

*Table 1. Projection of air traffic at the Hong Kong International Airport as per HKIA 2025*
Table 1 compares the current annual traffic figures to the numbers projected for year 2025 as per ‘HKIA 2025’. The report forecasts that by 2025, 80 million passengers, 8 million tonnes of cargo and 490,000 annual aircraft movements will be achieved [AAHK, 2006], equivalent to an average annual growth rate of about 3% for both passengers and aircraft movements, which is much lower than the actual observed past growth rate of 6.7% for aircraft movements and 5.4% growth for passenger traffic for Hong Kong, as can be seen in the data below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Passengers ('000)</th>
<th>Aircraft Movements ('000)</th>
<th>Cargo ('000 Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>30394</td>
<td>167.4</td>
<td>1974.3</td>
</tr>
<tr>
<td>2000</td>
<td>33374</td>
<td>181.9</td>
<td>2240.6</td>
</tr>
<tr>
<td>2001</td>
<td>33065</td>
<td>196.8</td>
<td>2074.3</td>
</tr>
<tr>
<td>2002</td>
<td>34313</td>
<td>206.7</td>
<td>2479.0</td>
</tr>
<tr>
<td>2003</td>
<td>27433</td>
<td>187.5</td>
<td>2642.1</td>
</tr>
<tr>
<td>2004</td>
<td>37142</td>
<td>237.3</td>
<td>3093.9</td>
</tr>
<tr>
<td>2005</td>
<td>40740</td>
<td>263.5</td>
<td>3402.0</td>
</tr>
<tr>
<td>2006</td>
<td>44443</td>
<td>280.4</td>
<td>3580.0</td>
</tr>
<tr>
<td>2007</td>
<td>47783</td>
<td>295.6</td>
<td>3742.0</td>
</tr>
<tr>
<td>2008</td>
<td>48585</td>
<td>301.0</td>
<td>3627.0</td>
</tr>
<tr>
<td>% growth (in last 10 years)</td>
<td>5.4%</td>
<td>6.7%</td>
<td>7.0%</td>
</tr>
</tbody>
</table>

Table 2: Air traffic statistics at Hong Kong International Airport for last 10 years

The current capacity of the two runways is around 58 movements per hour during peak hours, which is still below the ultimate capacity estimated by the government [HKSAR, 2007] to be around 60 movements per hours. With this forecast growth of 3% and ultimate capacity given by the Government, we can attempt to estimate when this ultimate capacity will be exceeded. Due to the dynamic nature of capacity, an exact value for this ultimate capacity is not given (as indicated by the Government as over 60 movements/hour). Assuming the ‘current’ ultimate capacity to be 65 movements per hour, which is the highest recorded aircraft hourly movement of HKIA according to CAD,[1] the time for saturation of airside capacity is estimated to be around 2013 as can be seen in the plot below.
2.2 Reduction in air capacity due to change in aircraft mix

In recent years, HKIA has been experiencing a more non-homogenous aircraft mix. The use of private and corporate jets is on the increase, resulting in a growing number of narrow-body operations. The share of the narrow-body short-haul aircraft such as the Airbus A320 and Boeing 737 has risen much above the initial predicted value of 10% of the total traffic [1]. Data shows that the average seats per passenger aircraft at HKIA has dropped from 295 seats in Summer 1998 to less than 250 seats in Summer 2006 [2]. Together with the growth of the existing large aircraft operations by the long-established carriers, the introduction of A380, expanding LCCs and increasing number of private business jets in the region, the slot constraints at HKIA have further worsened and led to further airside capacity reduction, and as discussed before, the once estimated capacity of 87 million passengers now stands at only 55-60 million.[2]

3. Capacity Enhancement measures

From the above discussion, it is clear that Hong Kong International Airport will eventually reach its “ultimate capacity” and thus suitable enhancement measures need to be implemented to expand its capacity to some extent during the interim period. The airport capacity can be enhanced in the following three ways:

- Cooperation with other airports
- Maximize the capacity of the two existing runways
- Construction of a third runway
In this study, we attempt to study the feasibility of all possible measures and examine the operational and environmental issues, as well as assess the economic impact of building a third runway.

3.1 Cooperation with other airports

3.1.1 Resolve airspace issues in PRD region

![Figure 9. The airspaces and airport runway layouts of Pearl Delta River Region. SIERA is the Standard Terminal Arrival (STAR) reporting point and BEKOL is the Standard Instrument Departure (SID) reporting point for Hong Kong International Airport [7]](image)

The restructuring of PRD airspace can allow HKIA to handle more flights and therefore further enhance its runway capacity. The Pearl River Delta (PRD) region in Southern China consists of a multi-airports system which includes five major airports: Guangzhou New Baiyun International Airport, Hong Kong Hong Kong International Airport (HKIA), Macau International Airport, Shenzhen Baoan International Airport and Zhuhai Airport. All these airports, especially Guangzhou, Hong Kong and Shenzhen have been facing serious capacity constraint and congestion in recent years. Their proximity and respective airspace arrangements create tremendous operational complexities, with the variations in runways orientations (conflicting traffic) at each airport rendering the airspace issues even more complicated. According to the forecast by CAAC, the PRD region will experience around 200 million passenger with 1.76 million aircraft movement per annum by 2020. The airports in the PRD have altogether 7 runways, with considerations to add 4 to 5 more in the foreseeable future. However, more runways will not help in enhancing the capacity unless the airspace congestion issue is solved. Furthermore, the military plays a significant role in the arrangement of airspace in China and any change in the civil airspace requires the approval of the military. All these limitations has
significantly reduced the flight operational efficiency and capacity in the rapid growing PRD region. Hong Kong is located at the Southern-most of the PRD region. Aircraft to and from HKIA are required by the Chinese aviation authority to cross the Hong Kong and Zhuhai airspace boundary at a high altitude (15,000 ft or about 5,000 m). The purpose of this is for minimizing the impact of the aircraft movement to/from the other four airports from the traffic to/from HKIA. This height restriction forms a so-called ‘invisible wall’ between Hong Kong and mainland China, owing to which aircrafts leaving from HKIA are required to circulate in the Hong Kong airspace to gain sufficient altitude to climb over the wall, which leads to unnecessary flight time and fuel consumption. The extra fuel cost due to the “invisible wall” for Hong Kong alone was estimated to be over HK$600 million in 2006.[7] To alleviate the air traffic demand, the Mainland Chinese authority recently lowered the altitude requirement for aircraft entering and leaving the Mainland airspace from 11pm to 7am each day (that could save 40 nm flight distance and 7 minutes flight time per flight), however the savings would be modest as the number of flights during those hours is rather small. Thus, despite the effort, the PRD airspace usage is still very constrained. International Air Transport Association (IATA) has estimated that an extra 15-20% operating capacity could be provided to the PRD region by restructuring the airspace [1]. This calls for all involved parties to work in close cooperation with each other to optimize the use of the PRD airspace. In fact, a Tripartite Working Group consisting of the General Administration of Civil Aviation of China (CAAC), the Hong Kong Civil Aviation Department (Hong Kong CAD) and the Civil Aviation Authority Macau (CAA Macau) was set up in February 2004, to resolve this issue, and aims to establish a seamless coordinated ATC system that would be able to cope with the PRD air traffic by 2020. [10] With foreseeable growth in both future passenger and cargo flow, there is great urgency for appropriate modifications in the airspace structure and flight procedures to be implemented.

3.1.2 Cooperation with mainland and PRD airports to relieve air traffic
Hong Kong Airport Authority should also cooperate with other airports in the mainland and PRD region to relieve its air traffic. In fact Hong Kong Airport Authority (HKAA) is already a shareholder of the Shenzhen airport, which has an approximate tourist throughput of 7 million per year. Talks are underway to practice division of labour between the two airports, and while Hong Kong will primarily focus on international flights, Shenzhen may act as a regional airport for domestic operations. The Guangzhou Baiyun Airport has also shown a certain level of collaboration with Shenzhen and Hong Kong airports. Shenzhen has opened a terminal in Hong Kong and started a Shenzhen-Hong Kong express service, while Hong Kong has opened several cross-border express shipping services and joint logistic networks in Shenzhen and parts of Guangdong province.[11] After several years of rapid development, HKIA has become aware of its limited capacity and its over-reliance on the hinterland’s economy, and is now trying to expand its market and network in the hinterland, using its extensive international network and the domestic networks of Shenzhen and Guangzhou Baiyun airports. In the 2030 Master Plan of HKIA, the Hong Kong Airport Authority is looking at strengthening its integrated, multi-modal transport network with the Mainland, especially the PRD to enhance the connectivity of the HKIA with the these other airports. The Government is undertaking several initiatives such as the Hong Kong–Zhuhai–Macao Bridge which includes the Hong Kong Boundary Crossing Facilities (HKBCF), and the Tuen Mun–Chek Lap Kok Link. In conjunction with the Shenzhen
Municipal Government, the Hong Kong SAR Government is also studying the feasibility of building an airport rail link (ARL) between HKIA and Shenzhen International Airport. Such coordinated development of the PRD region can help relieve air traffic at HKIA besides possibly enhancing its own capacity.

3.2 Maximize the capacity of the existing two runways

3.2.1 Air Transport Management Approach

ATM enhancement is about how the runways at a particular airport could be operated in order to give the maximum possible capacity. Due to the mountainous terrain near the south runway of HKIA, the south runway is mainly used for take-off, while the North Runway is used for landing. However, it may be possible to enhance the capacity of the airport to some extent by switching to ‘mixed mode’ runway operations, that is, rather than using one of two parallel runways only for landings and the other for takeoffs, it is possible to feed some takeoffs between landings, and vice versa. Single-mode operations are usually conducted to cut noise around the airport and can simplify traffic patterns to separate approaching and departing aircraft. The advantage of mixed mode is that it can reduce potential wake vortex problems and speeds up the overall flow rate, thus enhancing the overall airside capacity. Thus, if the number of departures are significantly more than the number of arrivals, the aircrafts can take off from both runways instead of lining up on a single runway. Thus, both runways could be used for both take-off and landing at different times. The runways at HKIA are far apart enough for full independent mixed mode. However, the two constraining factors are high ground and messy politics. The high ground is on Lantau Island, adjoining the airport, which blocks the air corridors to use the south runway for landings, and the politics comprise the border with China. There is no scope for mixed mode without a revised airspace with both Macau and China. In fact a Pearl River Delta working group is already set up between Hong Kong and the mainland to try to resolve some of the airspace problems involving both sides, and a possible deal is believed to be in the works.

3.2.2 Enhanced ATC procedures and manpower

Technology and human factors also play a decisive role in airport capacity improvement. Air traffic controllers in Hong Kong are generally considered highly skilled professionals and they form the core element of the ATM system. However, as per studies conducted by the National Air Traffic Services in UK of the Hong Kong airspace, HKIA needs to seriously consider changing its ATC operating philosophy. Currently, the air traffic controllers are offered a high degree of flexibility in handling aircraft movements for a more liberal use of airspace. While the current operations can meet the existing traffic demand, CAD should adopt a more systemized and standardized approach in its ATC operations with a view to enhancing and sustaining its air traffic handling capacity in the long term. It also recommended creating additional control positions in both the terminal and enroute areas within the Hong Kong Flight Information Region to handle the expected traffic increase and also establish a new position for air traffic flow and capacity management, to enhance the existing local flow control arrangement by monitoring and taking into account the tactical and strategic flow management arrangements in the PRD region. Another important recommendation was to enhance the ATC staff strength
and sickness cover in order to cater for a higher traffic load, extended operating hours and sickness replacement. With the use of modern ATC/ATM equipment and advanced navigation-aids, air traffic controllers can provide more timely, effective and accurate communication with pilots. To cope with capacity constraints at major airports, ATMs in the US and Australia have introduced new technology such as the Automatic Dependent Surveillance-Broadcast (ADS-B). The ADS-B allows air traffic controllers to reduce separation in increasingly crowded skies. ADS-B differs from conventional radar in that it uses electronic equipment onboard an aircraft to automatically broadcast position, altitude, velocity and other data every second via digital datalink using a navigation system like GPS. In future, ADS-B data will also be used by other aircraft and controllers to show an aircraft’s position and altitude on display screens without the need for extensive radar coverage. Regarding the influence of terrain on HKIA capacity, this issue can partly be mitigated via more advanced air navigation procedures such as the Area Navigation (RNAV) and Required Navigation Performance (RNP). The new RNAV/RNP navigation procedures using GPS can reduce the air congestion and flight distance without the use of ground beacons and adopt satellite-based communications instead. [1] The HKSAR Government has decided to invest HK$1.56 billion in a new ATM system schedule to come online in 2012. At the same time, CAD has also begun looking at the options of satellite-based navigation aids (navavids). According to studies, for the case of Hong Kong, the ATC improvements being considered by CAD, together with the help of extra manpower, can potentially provide an extra runway capacity of around 10%. [1]

3.2.3 Expansion of Auxiliary Airside Facilities
The location of runway exits plays a very significant role in runway capacity. There are two main types of runway exits: Conventional and High Speed exits. A conventional exit forms a 90° angle with the runway and requires pilots to slow down the aircraft considerably (to 10 kts or 18 km/h) to make the tight turn. [1] On the other hand, a high-speed exit is having an inclined layout along the runway’s direction. This permits the aircraft to vacate the runway rapidly, at speeds up to (50 kts or 92 km/h), by making a relatively high speed and smooth turn. [9] Therefore, if mixed mode is used it would help utilizing the runway movement by allowing the landing aircraft to vacate more quickly and hence expediting the next departure. Regarding taxiways, delays can arise due to inefficient taxiing patterns. Taxiway layout designs for HKIA is based on the principle of unidirectional flow management for the achievement of minimizing taxiway conflicts and delays. However, often the departure queue causes severe delays at HKIA and thus mixed-mode operation may alleviate the problem by diverting some aircraft to the other runway. The apron area can also occasionally be a constraining factor on the overall airside capacity. This points to the need for overall planning and optimization of the various elements on the airside so as to maximize the operational capacity of the airside system under varying conditions which the airport may be subjected to.

3.2.4 Peak Spreading
Peak spreading refers to the process of reducing a proportion of traffic demand in the most severely congested or critical part of the peak period with corresponding increases in demand at time periods immediately before and after the critical peak. [14] This leads to a general flattening of the travel demand profile across a broader time period. Thus, by spreading some
of the demand from the peak period of the day to a less busy period, airport capacity can be improved. However, peak spreading is easier said than done, as it involves the convoluted consideration of optimizations of the individual airlines schedules and interests. Airlines design their flight schedules with the dual objective of meeting their market demands and optimize their fleet utilization. Thus, they would aim at choosing slots of a particular time of the day to offer the best travel services for customers and balance resource utilization within its service network. At Hong Kong International Airport, the peak period occurs from 07:00 to 20:00 in summer. During this period, airport slots are basically full (for both departure and arrivals), and the situation is particularly worse on Tuesday and Friday.[1] Airlines, especially hub-and-spokes legacy carriers which heavily depend on smooth and accurate transits from one flight to another on their networks are generally reluctant to re-organize their flight schedules, as this will bring inefficiencies to the airlines operation and can significantly affects the bottom line of their company. However, this approach may be applicable with less technical difficulty to freighter flights which usually operate on a 24-hour basis. The slot requests of LCCs and chartered services can also be more flexible.

3.2.5 Aircraft Size Restrictions
In general, the smaller the aircraft relative to the preceding aircraft, the more severe would be the impact of the wake vortice effects, thus requiring more separation distance between the aircraft. Using similar size aircraft, or larger/wide-body type aircraft would minimize the required separation distance and enhance runway movement capacity. However in practice, the selection of aircraft type is mainly dictated by the operational characteristics of the aircraft for the routes to be flown, market demands, and economics. Because of numbers of seats provided, wide-body aircraft would have lower seat-kilometre costs than a small narrow-body aircraft. It will also have a higher operating hourly cost than a smaller aircraft due to its large size. Hence it would often form a question for the airline management on choosing the aircraft with lower seat-kilometre costs or the one with the lower trip costs. The flexibility and services to the passengers is also an important consideration. Therefore, it is very unlikely that an airline will choose a B747-400 Jumbo for short-haul and low-capacity routes, as compared with an A320 or B737. On the other hand, this approach might be possible to impose on high capacity short-haul routes such as the Hong Kong-Taipei route. Thus, this approach to improve runway capacity will likely be limited to a very small amount of routes and airlines, while it is almost impossible to impose such an approach on short-haul low cost carriers (LCCs).

According to studies, taking into account the effects of airspace issues and terrain, the runway capacity is expected to improve by 12% through mixed-mode. Thus, if all possible ATM (Air Traffic Management) and ATC (Air Traffic Control) enhancement measures are implemented, the “ultimate capacity” of the parallel runways of HKIA is estimated to be 80 movements per hour under the most ideal situation.

3.3 Construction of a third runway

A proposal to build a third runway at the airport to enhance its airside capacity has also been under feasibility study and consultation. The construction of the runway would be very expensive as it would involve additional reclamation from deep waters, and the building cost of
may be as high as the building cost of the entire airport. [8] Besides the huge cost of construction, concerns regarding environmental protection and reclamation are also important factors to be addressed. The Aviation Policy and Research Center (APRC) at The Chinese University of Hong Kong has carried out a study to evaluate the importance of the third runway and to estimate the timing when this third runway “should be ready” so as to prevent significant impairment to the Hong Kong economy due to delay of the project. In this study, we attempt to look at the possible time schedule for the planning & construction of the third runway, and assess the environmental and economic impact of building the runway.

3.3.1 Criticality of timing of construction
As discussed in the previous section, it may be theoretically possible to achieve a maximum runway capacity of 80 movements per hour by implementation of various ATM and ATC enhancement measures.

![Figure 10. Proposed schedule for HKIA Third Runway Development under 5% Growth](image)
Based on the past experiences of building runways for international airports and the current prevailing political and social environment in Hong Kong, it can take easily take up to 10 years or even more to build a new runway. This would include 2 years for detailed planning and design, another 4-5 years for public consultation, undertaking environmental impact assessment (EIA), arrange funding and the possibilities of legal challenges from the public, followed by another 4-5 more years for the actual construction until completion. [1] Given, the conservative forecast of 3% for annual growth of air traffic ,as estimated by HKIA, the ultimate capacity of 80 movements per hour can be expected to reach by around 2019, to be shown later. However, given the past growth of air traffic at a much higher rate of around 6.7%, traffic growth rate of 5% seems a more reasonable assumption. Under this scenario, the ultimate capacity will reach around 2015, that is much before the completion of construction of the runway, which as of today, is still under feasibility studies. Thus, assuming HKIA is committed to the third runway at this point in time, HKIA will still suffer at least 4 to 7 years of saturation while potentially losing business and market share to alternative airports in the region. Shown in Fig.10 is the proposed schedule for HKIA Third Runway Development under 5% Growth.

3.3.2 Environmental Impact Assessment

One of the most significant obstacles to the consideration of the third runway for HKIA is its impact on the environment. With the increase in the awareness of environmental issues affecting our daily life, this has often been the stumbling block for most major infrastructure projects. The environmental impact assessment of the proposed runway needs to be carried out in accordance with the Environmental Impact Assessment Ordinance (EIAO) which includes detailed assessment of the major environmental issues to ensure compliance to the regulation. We will examine each of the three major environmental issues of noise, air and water quality in the following sections:

Noise: Enhanced airport capacity inevitably means more aircraft movements and more noise. Impacts could range from impaired hearing to psychological annoyances. Though, the effects could be mitigated through the reduction of aircraft noise at the source, community noise insulation projects and other such procedures, effective communication between the community and airport operator is always of crucial importance in airport planning. However, in the case of HKIA, since it is located in a much more remote location away from the major urban areas, and the fact that AAHK was very successful in managing its environmental impact and gained tremendous experience during the initial phase of the HKIA planning and construction, it is reasonable to believe that the construction and operation of the third runway will not present any significant new challenge to the airport authority in managing the noise and its impact.

Emissions: Aircraft produce emissions of carbon dioxide, carbon monoxide, nitrogen oxide, sulphur oxide, and other hydrocarbons. Many of these emissions are considered greenhouse gases which affects climate and contributes to global warming. Although the total amount of emission is relatively small, estimated to be around 2% of all greenhouse gas emissions [1], the
emission of such gases at high altitude greatly magnifies its greenhouse gas effects. It is also anticipated that the growth of aviation traffic in the coming decades will bring about significant increases of such emissions from aircraft, despite potential technological advances in fuel efficiency. Given the growing public awareness of global warming and the resulting potential devastating scenarios for humankind, public concern and their perception on the magnitude of the problem on the environmental threat from aircraft emissions has been growing in recent years. Ground transport to the airport, aircraft emissions and ground activity are also emission sources at the airport. Beside the global warming effect, aircraft emissions and noise could also be perceived to affect the community’s health around the airport area. This is a more sensitive issue which the third runway proposal must adequately address in order to minimize the delays which can result from prolonged inquiries and unnecessary bad publicity from public outcry.

**Marine Ecology**: Water pollution at airports can occur for a number of different reasons, from domestic sewage, airport-related effluents and construction erosion. The water pollution issue is especially important for Hong Kong’s case as massive land reclamation will be involved. One of the more sensitive issues would be the impact on the Chinese White Dolphins, which are protected under the Wild Animal Protection Ordinance (Cap 170) and the Animals and Plants (Protection of Endangered Species) Ordinance (Cap 187) in Hong Kong. Marine parks have been established by the Agriculture, Fisheries and Conservation Department to the northwest of Lantau Island for the protection of these dolphins. Many of the Chinese White Dolphin's habitats are near estuaries, such as those in the western waters of Hong Kong where the Pearl River joins the South China Sea, and there is a very large area of these waters between Lantau Island and Macau which has been designated as restricted areas by the Chinese Government to protect these Chinese White dolphins.

![Figure 11. The recorded locations where Chinese Dolphins were found [13]](image)

Physical removal of seabed causes damages to the natural communities in the area of the borrow pits, reclamation and dump sites. Clouds of suspended sediments would adversely
affect sensitive marine life through decreased light penetration, clogging of respiratory apparatus and direct burial. This in turn could lead to a reduction of food supply for marine life higher up the food chain such as fish and dolphins [1]. HKIA adopted a 1 km exclusion zone for the Chinese White Dolphins during the initial airport construction phase. It was set up to ensure that their sensitive hearing would not be harmed during the blasting work. The potentially massive reclamation needed for the 3rd runway will likely be a hotly debated and highly publicized issue, with the conservation of the ecology and the plight of the Chinese White dolphins being foremost on the agenda.

3.3.3 Economic Impact Assessment

3.3.3.1 Estimation of generated revenue to HKIA

The cost of construction of the third runway, as discussed before, is expected to be huge and may well equal to the cost of building another airport. In the HK International Airport (HKIA) Master Plan 2030, expected to be announced early next year, the AA has initially estimated that $13 billion investment will be required to build the third runway and expand the Terminal Two to meet the growing demand for aviation services in the next 20 years [12]. It further expects construction works to start as early as two years later and the construction to complete by 2020. While the cost figure may only be treated as a rough approximation, it provides some idea of cost involved in the additional reclamation of land from deep waters. Once the runway is constructed it will enhance the runway capacity of HKIA and thus expected to significantly contribute to the Hong Kong economy by bringing in additional flights. According to studies conducted by the Aviation Policy and Research Center (APRC), the aviation sector contributed 8.67% of GDP to Hong Kong, and around 7% of Hong Kong’s employment in 2005. The 8.67% captures both the direct and indirect benefits of the aviation industry, including air transport, services that are incidental to air transport, tourism, trade services, courier services, land transport supporting air cargoes and miscellaneous services that support the air cargoes. We shall now try to provide approximations on how much the expansion of capacity brought by the new runway may contribute to the Hong Kong economy.

As discussed previously, it is believed that with the implementation of proper ATM and ATC measures it is believed that possible the ‘ultimate capacity’ of the airport can go up to 80 movements per hour under most ideal conditions. The third runway will further enhance the capacity of the airport to an extent depending on the separation of the new runway from the current north runway. According to studies done by APRC, the runway system capacity may be expected to increase by roughly 20%, 30% and 40% for the closely spaced, medium spaced and wide spaced runway configurations respectively. [1] Thus, the ultimate capacity of the airport under these three different scenarios is 96, 104 and 112 respectively. In the year 2008, the runway capacity of the airport during peak hours was 58 movements per hour, and the total annual aircraft movements recorded was 301,000. Thus, using the fact that the total annual aircraft movements is proportional to the runway hourly capacity, the total annual aircraft movements for all three different runway configurations can be estimated. The projected runway system capacity under the three different separation scenarios is summarized in the table below (Table 3):
### Scenario | Runway Ultimate Capacity (movements per hour) | Annual Aircraft Movement Handling Capacity
---|---|---
Current Ultimate Capacity | 65 | 337328
With possible ATC and ATM enhancement measures (w/o third runway) | 80 | 415172
Closely spaced configuration | 96 (20% increase) | 498206
**Medium spaced configuration** | 104 (30% increase) | 539724
Wide spaced configuration | 112 (40% increase) | 581241

Table 3. Projected Runway Capacity, aircraft movements and passenger capacity under different scenarios

Since the second scenario of medium spaced configuration provides a kind of ‘middle-of-the-road’ benchmark, in this study we attempt to estimate the accumulated value brought in to the airport, by the addition of third runway, under this scenario. Let us also assume, for the sake of analysis, that by 2020, the runway construction is complete together with all the ATC and ATM measures implemented. Thus, the airport commences operation at its new enhanced capacity of 104 aircrafts movement per hour by year 2021, as is also believed to be the tentative plan of the airport authority. We project the aircraft movements till 2030 using growth rates of 3% which pertains to the conservative traffic forecast for year 2025 by HKIA, 5% derived mainly from the ICAO’s international routes demand and ACI’s predicted Asia-Pacific demand, and the actual past growth rate of 6.7%. Similarly, keeping in mind that the original design of the airport had a capacity of 87 million passengers, we also project the passenger traffic till year 2030, using the growth rate of 3% as predicted by HKIA, and the past growth rate of 5.4% for passenger traffic. These projections are shown in Table 4.
<table>
<thead>
<tr>
<th>Year</th>
<th>3%</th>
<th>5%</th>
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<th>Year</th>
<th>3.0%</th>
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<td>575719</td>
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<td>82.2</td>
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<td>614292</td>
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<td>1253671</td>
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<td>93.1</td>
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</table>

Table 4. Projected aircraft movements at HKIA till year 2030 in the left table. The projected number of passengers till year 2030 shown on the right side.

Thus, as seen in the table above, the ultimate capacity of 65 movements per hour, will be reached by as early as 2010, 2011 and 2012 under the 3%, 5% and 6.7% growth rates respectively. It is also seen, that even after the construction of the third runway under scenario 2 with medium spaced configuration, the traffic demand will exceed the airport capacity by 2028 for 3% growth and by 2021 itself for 5% and 6.7% growth. Similarly with regards to passenger traffic, the actual passenger traffic exceeds the capacity of 87 million, for which the airport was originally designed, by 2028 and 2020 for 3% and 5.4% growth rates respectively.

We now proceed with the estimation of additional revenue that this enhanced runway capacity will bring to the Hong Kong economy. The number of additional aircrafts (the difference of the number of flights that can be actually handled by the airport after and before the construction of the third runway & enhancement of ATC/ATM measures) that can be handled in that particular year if the third runway is built with medium spaced configuration (scenario 2) is given in Table 5.
Table 5. Number of additional aircrafts that can be handled by HKIA in that particular year after construction of runway with medium spaced configuration

<table>
<thead>
<tr>
<th>Year</th>
<th>3%</th>
<th>5%</th>
<th>7%</th>
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</thead>
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<td>104701</td>
<td>202396</td>
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<td>160179</td>
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<td>2026</td>
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<tr>
<td>2030</td>
<td>202396</td>
<td>202396</td>
<td>202396</td>
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</table>

Under the assumption of 3% annual growth in traffic, zero discount rate and the value added per flight (in 2005 HK$) of HK$0.4500 million,[1] the third runway can contribute an addition of HK$12.07 billion (in 2005 HK$) in 2021 by handling an extra of 26,857 flights a year. In 2025, the extra contribution will be accumulated to HK$121.7 billion (in 2005 HK$). Similar results have also be computed for 5% and 6.7% growth rates and are summarized in Table 6.

<table>
<thead>
<tr>
<th>% Growth</th>
<th>Contribution in billion $ in 2021</th>
<th>Accumulated VA by 2025 in billion $</th>
</tr>
</thead>
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<td>3%</td>
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<td>5%</td>
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<tr>
<td>6.7%</td>
<td>12.8</td>
<td>64.2</td>
</tr>
</tbody>
</table>

Table 6. Contribution of additional aircrafts to the local economy

In conclusion, although these are very approximations figures under a lot of restrictive assumptions on economic and market environments, they however do provide us some ideas on how the construction of the third runway could impact the local economy of Hong Kong.

3.3.3.2 Other Associated Costs

The increase of flights enables the aviation sector to contribute more to Hong Kong Economy, but the associated costs due to its environmental impact and possibly congestion cost also increase. Let us briefly look at each of these costs:

Environmental Cost: With increase in number of flights, the resulting emissions from the burning of aviation fuel containing carbon dioxide (CO2) and nitrogen oxide (NOX) will also be more, both of which are estimated to contribute to global warming and climate change. As per studies done APRC, the estimated total pollutants cost p.a. by the additional aircrafts (include selected type of aircrafts only) will be several million dollars. The increased flights will also produce extra noise to the environment. The noise cost figures are generally estimated by measuring householders’ willingness to pay to reduce noise through house purchase prices.
**Congestion Cost:** Congestion at the airport imposes costs on both airlines and passengers, as well as to business, society and also environment. Under congestion, aircrafts have to bear the cost of additional hours of ground holding which includes due to added fuel and crew cost. Besides, more air pollutants will be emitted from the burning of extra aviation fuel. On the other hand, passengers also suffer delay cost depending on the time value of each type of passengers, etc. This projected congestion cost of delays can be expected to exhibit non-linear behavior as a function of the interplay between traffic growth and the capacity of the airport., which we don’t address in this study.

4. Conclusions

The key findings and conclusions from this study are summarized in the paragraphs below:

1. Hong Kong clearly has a severe capacity problem, with congestion problems already being felt with two wide-spaced parallel runways an ultimate capacity of 65 movements per hour.

2. There is an urgent need to carry out a detailed capacity assessment of the airport and all major stakeholders in Hong Kong and China should be involved in finding the best solution.

3. It is believed that under ideal conditions, the ‘ultimate capacity’ after the implementation of all the possible ATM and ATC enhancement measures has been estimated at 80 movements per hour, and after the construction of the third runway with medium-spaced configuration the capacity can further go up by 30% to 104 movements per hour.

4. According to HKIA’s more conservative forecast of traffic demand growth of 3% annually, the ultimate capacity of 65 movements could be reached by 2012. If we assume a 5% growth rate as forecasted by ICAO or actual past growth rate of 6.7% , HKIA would reach its capacity by 2011 and 2010 respectively instead. The ultimate capacity of 104 movements per hour after construction of runway and implementation of all ATM/ATC measures will be reached by 2028 for 3% growth and 2020 & 2018, that is even before the first year of operation of the third runway runway, for 5% and 6.7% growth of air traffic. Similarly, the passenger handling capacity of 87 million people is expected to reach by 2028 and 2020 for growth rates of 3% and past growth rate of 5.4% respectively..

5. One of the most significant obstacles to the consideration of the third runway for HKIA is its impact on the environment, particularly the issue of greenhouse gas emissions and the ecological impact to the oceans around HKIA, including the impact to the Chinese White dolphins. The proposal for the third runway should thus carefully address these concerns, keeping in mind the interests of all the concerned parties including the general public.
(7) By using the latest official statistics, we estimated that one additional flight would bring an economic contribution to Hong Kong by HK$0.45 million. Using a “middle-of-the-road” benchmark of 5% traffic growth rate, and an average runway capacity increase of 30% for the third runway scenario, it is estimated that the annual economic contribution to Hong Kong’s economy from a fully utilized 3rd runway would be 41.9 $ Billion for 3% growth rate and 64.2 $ billion for 5% and the actual past growth rate of 6.7%.

[8] The construction of the runway will also have many associated costs of the order of several millions, such as the cost of environmental impact and congestion cost.
References

[1] Department of Decision Sciences and Managerial Economics, The Chinese University of Hong Kong ‘HKIA’s Third Runway —The Key for Enhancing Hong Kong’s Aviation Position’


[6] ‘National Air Traffic Services Report’, UK, on Recommendations to enhance Hong Kong Runway Capacity by ATM and AT approaches


Online Sources


Note: Much of the analysis relied on data originating from a wide array of data sources; airport websites, operator websites and annual reports, press releases, reports etc.