An Investigation of Airspace Congestion & Possible Air Traffic Management Integration in the Pearl River Delta Region of Southern China

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Abstract

With five airports in close proximity, air traffic in the Pearl River Delta (PRD) of Guangdong Province is one of the most congested areas in Asia. The complexity of ATC facilities arrangement has escalates the operational challenges to both the air navigations service providers (ANSPs), airports and airspace users.

This study attempts to examine the special features of airspace arrangement and management in the PRD, involves also some case studies from around the world. A set of operational suggestions and a list of policy-based recommendations to improve the current tripartite institutional approach to the issue are provided.

Keywords: Pearl River Delta Region; Airspace congestion; ATM/ATC facilities integrations

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(1) Background of the PRD Airspace Congestion

The Pearl River Delta (PRD) region[1] has one of the busiest air traffic environment in Asia. The region consists of a multi-airports system which includes five major airports: Guangzhou New Baiyun International Airport, Hong Kong Chek Lap Kok International Airport (HKIA), Macau International Airport, Shenzhen Baoan International Airport and Zhuhai Airport. These airports vary in sizes and business models. All of them (especially Guangzhou, Hong Kong and Shenzhen) have been facing serious capacity constraint and congestion in recent years. This paper attempts to: 1) introduce the major features of the PRD airspace problems; 2) highlight the latest efforts by various government authorities to tackle the problem; 3) summarize the recent experiences of the US and EU in restructuring their air traffic management (ATM) to enhance their airport capacity and flight efficiency; and based on the relevant international experiences, 4) suggest a broad institutional framework and identify critical issues for the consideration of relevant authorities.

The five PRD airports are growing at an astonishing rate. Their proximity (Guangzhou Airport is about 140km from Hong Kong while the other three are less than 60km from Hong Kong) and respective airspace arrangements create tremendous operational complexities. There are three different air navigation services providers (ANSPs) in the region: Guangzhou, Zhuhai and Hong Kong. Macau airport traffic operates through Hong Kong approach airspace. Aircraft flying near or across sector boundaries are frequently delayed as they would be transferred from one controlling facility to another. The lack of common integrated communication platform and

inconsistency in operating procedures and standards have worsened the situation. The variations in runways orientations (conflicting traffic) at each airport also render the airspace issues more complicated (see Fig 1 below). The airspace congestions over the PRD skies have attracted a great deal of political and operational attention in Hong Kong and in the Mainland in recent years.

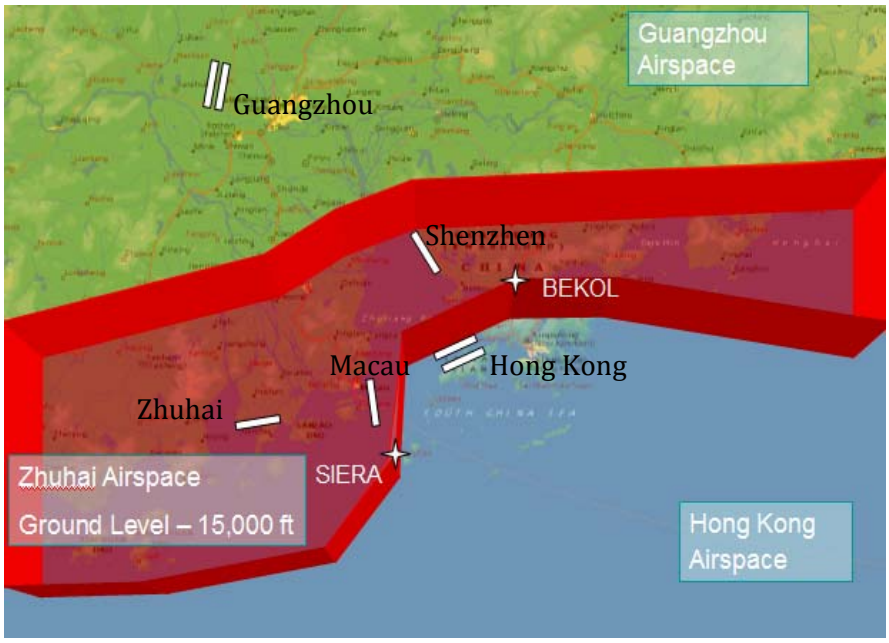

Fig 1. The airspaces and airport runway layouts of Pearl Delta River Region. SIERA is the Standard Terminal Arrival (STAR) reporting point and BEKOL is the Standard Instrument Departure (SID) reporting point for Hong Kong International Airport [Picture source: Cathay Pacific Airways, 2007].

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, an arrangement that has been in place during the colonial days of Hong Kong. This height restriction has formed a so-called ‘invisible wall’ between Hong Kong and Mainland. Basically, aircraft leaving from HKIA are required to circulate in the Hong Kong airspace to gain sufficient altitude to climb over the wall. This increases unnecessary flight time and fuel consumption.

The PRD region also does not have sufficient 'air corridors' for aircraft to fly en-route from one airspace to another. All these limitations plus the complex operating environment of PRD region have significantly reduced the flight operational efficiency and capacity in the rapid growing PRD region. 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. This is about three times as much as the current figures [CAAC, 2007]. The airports in the PRD have altogether 7 runways, with considerations to add 4 to 5 more in the foreseeable future. However, more runways do not necessarily provide more capacity if the airspace congestion issue cannot be solved. Furthermore, the military plays a significant role in the arrangement of airspace in China. In fact, any change in the civil airspace requires the approval of the military. Figure 2 summarized the major issues of the PRD airspace congestion.

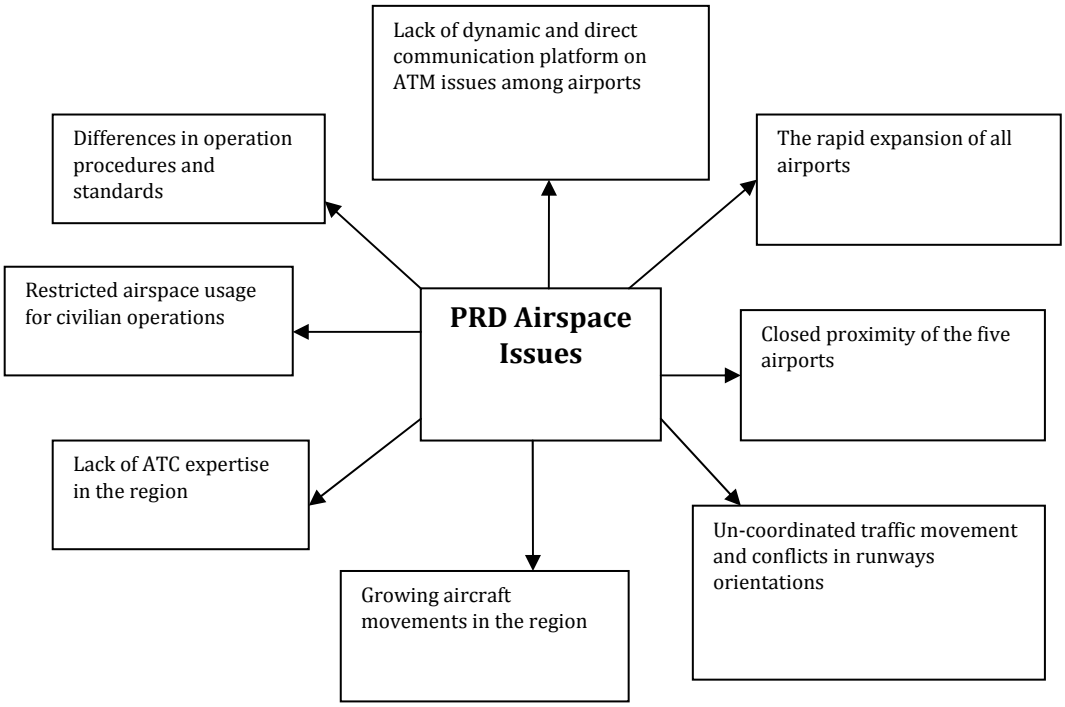

Fig 2: Causes for the PRD Airspace Congestion

(2) Hong Kong's Airspace Congestion

Within the PRD region, the congestion problem is most serious for the HKIA. Taking Dragonair (about 90% of the total flights are to the Mainland) as an example, about seven out of every ten flights were delayed in 2006. In 2004, only 36% of the flights had been delayed. The total loss of time was over 150,000 minutes, which was the highest record in recent years. According to a more restricted definition used by the Hong Kong Government, the number of delay of departure flights from Hong Kong in 2006 was over 3,000, which is three times more than the 973 delayed flights recorded in 2004. Cathay Pacific estimated that there could be a reduction in fuel wastage of nearly 100 million kilograms and over 531,000 minutes of flight time per year if some procedure redesign were undertaken by the Government [Cathay Pacific, 2007].

Although PRD represents only 2.4% of the People Republic of China (PRC) population, it accounts for 18.5% of China's GDP. It also represents 26.7% of the air passenger throughput as well as 48.7% of the cargo throughput in China in 2004[2]. With foreseeable growth in both future passenger and cargo flow, the air traffic inefficiency in the PRD region would continue to deteriorate unless appropriate modifications in the airspace structure and flight procedures are implemented.

Many flights entering or leaving Hong Kong have to detour for extra miles to fulfill the 5,000m requirement. These extra miles incurred would have increased fuel consumption. In this section, we attempt to estimate the extra cost incurred due to the "invisible wall". We classify all the arrival and departure flights of HKIA into different groups by their origin and destination respectively. For each group of flights (divided into departure and arrival), the additional fuel cost incurred is presented in Table1 and the fuel cost used in the estimation is the average fuel price in 2006.

		Extra distance incurred per flight (km)	Amount of extra fuel used per flight (kg)	Number of aircraft movements affected in 2006	Extra fuel cost incurred by all the flights that start from or end at HKIA in 2006 (in HK$)
Europe	Departure	60	80.0	8,881	42,628,277
	Arrival	300	61.7	9,672	178,925,751
North America (Polar ops)	Departure	60	80.0	919	4,411,481
	Arrival	300	61.7	1,552	28,720,828
Middle East / West Asia	Departure	60	46.7	7,041	19,714,155
	Arrival	300	35.3	6,932	73,474,165
China (exclude Shanghai & Xiamen)[3]	Departure	60	46.7	19,120	53,535,507
	Arrival	300	35.3	19,195	203,466,917
Total		**-**	**-**	**73, 312 (Total Aircraft Movement of HKIA in 2006: 280,387)**	**604,877,080**

Table 1: Extra Fuel Cost incurred by flights affected by 'the wall' at HKIA in 2006 (with Cathay Pacific Airways providing the primary data for estimation)

Judging from our estimation of the extra fuel cost due to the "invisible wall" for Hong Kong alone would have been over HK$600 million in 2006. Therefore, the total congestion and inefficiency costs due to airspace constraints for the entire PRD region (for all five airports, airlines, passengers, other users and stakeholders) would easily be over a billion Hong Kong dollars a year.

To alleviate the air traffic demand, the Mainland Chinese authority has 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). The vertical separation distance in China's upper space (within 8,900m to 12,500m[4]) has also been reduced from 600m to 300m for Reduced Vertical Separation Minima (RVSM) certified aircraft in late November 2007 [CAAC, 2007]. Despite the effort, the PRD airspace usage is still very constrained. The savings would be modest as the number of flights during those hours is rather small.

(3) Governments' Initiatives for Enhancing ATM

The various aviation authorities of the PRD region have recognized the urgency of this issue. In order to optimize the use of the PRD airspace and coordinate the PRD's traffic management, 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) have set up a Tripartite Working Group in February 2004. It held meetings on technical and policy issues. The Group aims to establish a seamless coordinated ATC system that would be able to cope with the PRD air traffic by 2020. The PRD airspace issue is mainly handled by the Air Traffic Management Bureau (ATMB) of CAAC. ATMB is a subordinate functional organization of CAAC, providing nationwide air traffic service, civil aviation aeronautical communication, navigation, surveillance, aeronautical meteorological and aeronautical information [CAAC, 2007].

As the traffic congestion became more serious, the Tripartite Working Group agreed in late 2006 to open a new handover point that would come into effect on December 21, 2006. The new handover point would be set between the Flight Information

Regions of Guangzhou and Hong Kong, which will serve flights that are overflying Hong Kong and landing in Guangzhou. It is expected that the new handover point can ease the burden of the existing handover point for flights to and from Northern China.

Furthermore, the Tripartite Working Group is also considering other measures to improve the air traffic congestion. These include: open another new departure air route (parallel to existing A470 route) which will serve flights flying to the Northeast of China, standardize the interface and protocol of air traffic control systems, computerize the process in exchanging airspace information between regions, unify the measuring unit, and upgrade the ageing computer system of Hong Kong CAD.

Beside the above preliminary measures, towards the end of 2006, ATMB of CAAC has drawn up a long-term plan to enhance PRD's airspace development. This long term plan involves significant changes of the current ATC hardwares, manpower standards and flight procedures re-designs. The development has been summarized into three different stages:

Stage 1: Up to 2010 -- This stage is further divided into 2 sub-stages. First, by 2007, based on the CAAC ATC criteria for the upcoming Beijing Olympic Game, it would modify the airways structures of the outer PRD areas, and develop and promote the Area Navigation (RNAV)[5] technology usage. Second, before 2010, it would set up the new Guangzhou Terminal Control Area based on the new constructional progress of the Guangzhou, Hong Kong terminal control centre and the renovation of the Zhuhai terminal control centre. At the same time, the boundary of the South of Guangzhou Terminal Control Area would be re-adjusted and part of the departure and

arrival routes would be modified. The air traffic control officers (ATCOs) training standards and the management of joint operational standards among Mainland, Hong Kong and Macau would also be standardized.

Stage 2: 2010 to 2015 -- The new Southern Terminal Control Area is expected to be established by coordinating the Zhuhai and Hong Kong ATCs. The Northern (Guangzhou) Terminal Control Area will continue to expand and operate independently. Other ATC procedures will also be improved and control areas expanded. This is referred to as a 'loose coordination' by CAAC.

Stage 3: 2016 to 2020 -- Based on the standardizations of ATC procedures and training of ATCOs of the three regions, the Northern (Guangzhou) and Southern Terminal Control Areas will further be integrated and expanded. The implementation of Area Navigation (RNAV) technology and other flight procedures will be completed. Through the modification of the departure/approach routes and operational procedures of each of the airports, a 'closer coordination' of the three ATCs will be accomplished.

According to the official document titled 'The Setting up of PRD ATC Implementation Steering Group' by CAAC, a new unit known as the PRD ATM Implementation Steering Group was established in 2007. This Group coordinates the implementation of arrangements agreed under the Tripartite meetings and further reviews its proposed plans [CAAC , 2007] .

(4) The "Functional Airspace Block "for ATM Integration

The PRD airspace congestion issue has been addressed by the highest authority in the Mainland, with the participation of both Hong Kong SAR and Macau SAR

Governments. The proposed setting up of the 'loose' and 'closer' coordination of the three ATCs by 2015 and 2020 respectively is the right way forward. However, this may not be a satisfactory solution given the complexity of the issues and new navigation technologies available. On the policy front, the challenge of the PRD air navigation integration seems not so much to be on the technical and operational aspect, as many developed countries have had years of valuable experience in integration their terminal ATMs. It is however a great challenge under the current 'One-country, Two-systems' framework governing the Mainland China, Hong Kong and Macau. Under this constitutional arrangement, Hong Kong and Macau's SAR Governments are delegated the authority of a high degree of autonomy by the Central Government to deal with aviation-related subjects[6]. Both SAR Governments can negotiate Air Service Agreement independently with other countries and plan for their own airport expansion.

In the following sections, we introduce some relevant international experiences to provide useful lessons for resolving the PRD airspace issues. Modern ATM operation is working under the concept of "functional airspace block" (FAB), rather than in terms of geographical, administrative or national boundaries. According to a Civil Aviation Authority, UK (CAA) document *'CAA Discussion Series No 2 - Functional Airspace Blocks (FABs)'*, it defines the FAB based on the Definition 25 within the SES Framework Regulation (No 549/2004) as an "airspace block based on operational requirements, reflecting the need to ensure more integrated management of the airspace regardless of existing boundaries". Based on this principle, the ATM in the US and EU has been going through significant changes since 1990s.

In the US, the Federal Aviation Authority (FAA) provides same services to the military as to the civilians. FAA owns and manages all the airspace, except blocking certain spaces for military uses. Civilian planes need to fly around them. There is total connectivity between military and FAA ATM facilities. When it comes to emergency and threat, military would be given priority (such as the case of 9/11). The military is represented in FAA. Each of the major airports can plan for its expansion and development. The Terminal Radar Approach Control (TRACON)[7] would provide services to all of them, and mitigates and co-ordinates their needs. There are currently five "consolidated" facilities in the US, namely Northern California, Southern California, Washington DC, Atlanta and New York.

Airports and airlines are having formal liaison channels at FAA's ATC System Command Center (ATCSCC[8]) located near Washington DC. Operationally, there are teleconferences among ATCSCC, Air Route Traffic Control Centre (ARTCC)[9], TRACONs, major airports, airlines in every one or two hours, discussing about weather changes, route changes, etc. Daily decision is based on a "Collaborative Decision Making" mechanism, to deal with the demand and capacity issues.

In metropolitan areas with several airports, the terminal airspace of adjacent airport may overlap, creating a complicated airspace structure. In these circumstances, consolidating two or more TRACONs into one single facility can simplify the airspace structure. The consolidation improves communications among controllers handling operations over a wide geographic range and increases their flexibility in

merging, maneuvering, and sequencing aircraft to and from the area airports. Additional flexibility can be gained by bringing portions of en route airspace under TRACON control, especially where comprehensive radar coverage allows a three-nautical mile spacing rather than the five-nautical mile spacing that is customary in the en-route environment.

Additionally, the FAA has been working on several near-term and long-term strategies to enhance airspace capacity and reduce congestion. Its airspace initiatives include the National Airspace Redesign Plan, the National Choke Points Initiative, the consolidation and expansion of terminal airspace control facilities, and the continuing development of navigation routes. The National Airspace Redesign Plan is a multi-year effort to increase the efficiency of the NAS through the re-routing of air traffic, the reconfiguration of the nation's airspace, and enhancing efficiency in air traffic management (ATM). The NAS is pursuing incremental changes to the national airspace structure, consistent with evolving air traffic and avionics technologies. In the following, we introduce the relevant experience of the US and EU ATM development for reference and consideration.

(4.1) Case Study I: Northern California Airports--NORCAL TRACON

Northern California is served by three different international airports: San Francisco (4 runways), Oakland (3 runways) and San Jose (3 runways). Their terminal airspace between the ground level to 15,000 ft. is managed by the North California Terminal Radar Approach Control (NORCAL TRACON). It consolidated 4 TRACONs (MRY (Monterey Peninsula airport), SCK (Stockton Metropolitan airport), MCC (McClellan Airfield airport) and Bay, plus some Oakland (ZOA) airspace) in 1999 [FAA, 2007]. It is also responsible for other 20 Towers. The Center manages 21,000 sq miles

of airspace. Currently, the Oakland Center (ZOA ARTCC) handles the higher altitudes.

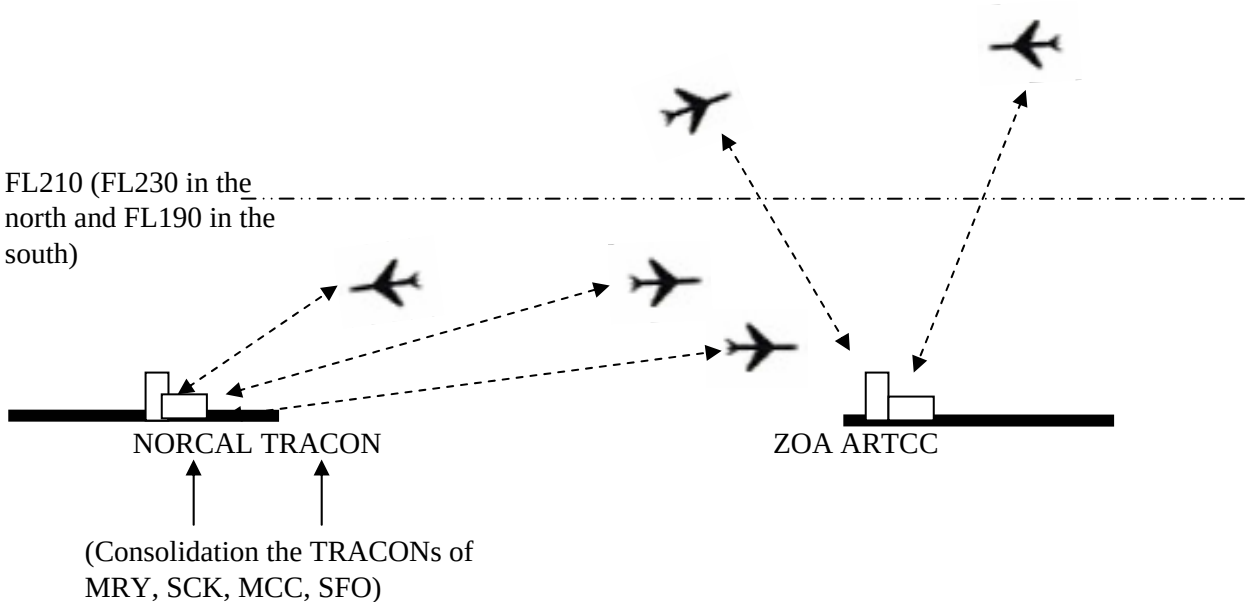

Fig 3: The operations of NORCAL TRACON and ZOA ARTCC

The TRACON and ATCSCC form a platform for resolving disputes on ATC matters between airports. For example, if there is a weather change due to strong wind affecting the operation of San Francisco Airport and Oakland Airport, flight arrival and departure patterns would need to be changed for both airports. NORCAL TRACON will coordinate such changes based on established procedures. If SFO or any of the control towers did not agree with the decision of NORCAL, it could appeal to ATCSCC for a final decision.

NORCAL TRACON is a truly “consolidated” facility, while Southern California (SOUCAL) TRACON is a “co-located” facility. Within the NORCAL TRACON Center, one sector of the operation is responsible for all arrivals to all airports under its control and another sector is for all departures from these airports. In the SOUCAL

TRACON, several major airports are keeping their own TRACON operations separately. But they are located in the same TRACON building.

(4.2) Case study II: New York Airports—NY TRACON and NYICC

There are also three major international airports in the New York metropolitan area, namely John F. Kennedy (JFK), La Guardia (LGA) and Newark (EWR). Although they are located in different jurisdictions, they are owned and managed together by the Port Authority of New York and New Jersey. More passengers fly in and out of the New York than any other comparable area in the US. Indeed, the congestion and delay in New York has always been a problem to global airline industry. According to the US Department of Transportation, a recent report shows that the three airports together were the worst in the country for on-time arrivals, with more than 40% of late incoming flights, and JFK was the most delay-prone airport in the US [Arnoult, 2007].

Several air traffic control facilities with responsibility for airspace that overlays the New York area complicate ATM. The two primary air traffic control facilities are the New York Terminal Radar Approach Control (NY TRACON) and the New York Air Route Traffic Control Center (NY ARTCC). NY TRACON is responsible for the ATC below 18,000 ft and the NY ARTCC is responsible for the airspace management above 18,000 ft. The Washington ARTCC, Cleveland ARTCC, Boston ARTCC and Philadelphia TRACON also feed traffic in and out of the New York Terminal area.

Within the NY TRACON Center, the layout of the Operational Floor is divided into 5 different sectors. Each of the three international airports is having its own sector and responsible for its own airspace. In case there is a weather change, e.g. a stronger

onshore wind, the approaching route to JFK from the east will shift further to the west and thus will cut into La Guardia's "original" airspace. This "part" of airspace will become JFK's airspace conditionally and temporarily. JFK will use this "part" of the airspace below 3,000 ft. and La Guardia will continue to use the airspace above 3,000 ft. If flights are approaching from the west to JFK, they will cut into the airspaces of Newark and La Guardia. These flights will use the higher-altitude airspace and flights into Newark and La Guardia will use the lower altitude. All eastbound flights from the three international airports are separated by routes and altitudes.

Furthermore, FAA has been developing the concept of The New York Integrated Control Complex (NYICC) since the end of 1990s, as a mean to resolve the operational and facility issues in the New York area. This goes beyond the historical FAA consolidation model by further integrating the best aspects of terminal and en-route air traffic control into one facility. The integration aims at removing many of the artificial boundaries that now divide the en-route and terminal environment, thus providing seamless transitions through all phases of flights. It would integrate the terminal airspace of the New York TRACON with portions of the airspace currently controlled by adjacent TRACONs and other centers abutting the New York TRACON. The NYICC is expected to be operational in the next few years (2002 ACE Aviation Capacity Enhancement Plan; 2003 ACE Plan Aviation Capacity Enhancement Plan)[10].

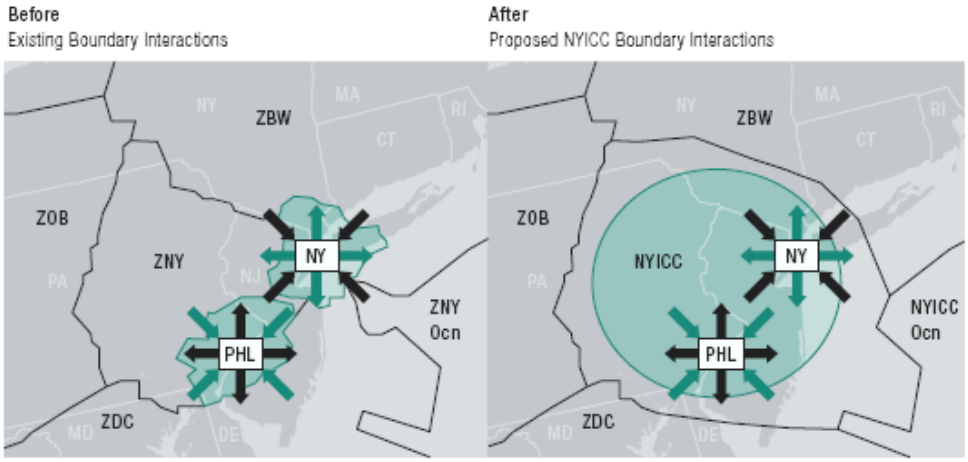

Fig 4 The Proposed NYICC Boundary [Source: FAA]

(4.3) Case Study III--EU's Single European Sky Initiatives

European air travel could reach up to 33,000 movements on a peak day. It is predicted that over 20 million movements a year could easily be reached by 2020, with a corresponding daily movements of 50,000. The continuous growth of LCCs has been rapidly increasing the number of short journeys. Additionally, military and civil requirements are different for its 42 ECAC States. The core issue is that 9% of the airspace handled around 65% of the total traffic in Europe [EUROCONTROL, 2007].

There are more than forty different ATC systems handling fifteen “skies” in Europe. A relatively short flight between Brussels and Rome passes through nine separate control systems. Furthermore, the airspace over the 15 EU Member States, Switzerland and Norway is divided into 39 Flight Information Regions and 19 Upper Flight Information Regions. The division level between lower and upper airspace of different states is not uniform. In view of this, the European Commission adopted the Single European Sky (SES) Initiative in 1999 and EUROCONTROL was commissioned as the implementation entity.

EUROCONTROL was founded in 1960 as a civil/military international organization dealing with ATC at the European level. It has 37 member states. Its primary objective is to develop a seamless pan-European ATM system, with the highest safety standards and cost effectiveness [EUROCONTROL, 2007].

The EU ATM restructuring was mainly divided into three phases: from 2001 to 2002, from 2003 to 2004 and post 2005. Subsequently, delays were significantly reduced. Another major accomplishment is that the minimum vertical separation of aircraft in the upper airspace was reduced from 2,000 feet to 1,000 feet in forty-one European and North African countries. This Program provides six additional flight levels between 29,000 and 41,000 feet, leading to an increase in the European's upper airspace capacity by about 20% and a reduction in airlines' annual cost by EUR 3.9 billion.

Within the SES Initiative, EUROCONTROL and EC have been undertaking the *Single European Sky ATM Research Program (SESAR).* The consortium joins the expertise of many companies and organizations, including airspace users, airports, air navigation services providers, supply industry, safety regulators, military, pilots & controllers associations and research centers. The SES is expected to be operational after 2014 [EUROCONTROL, 2008].

Both civil and military users have been increasing their demand for airspace. Their request for airspace needs to be optimized and equitably balanced in a dynamic framework. Therefore, a strong civil/military co-operation is a must. Within EUROCONTROL, the Military Harmonization Group co-ordinates positions of the military on ATM issues. The General Assembly and EUROCONTROL Council are the policy decision body and supervision body respectively. They consist of civilian

and military officials from all member states. The Agency is responsible for setting operational principles and rules for the Control Center. Different aviation stakeholders are involved in the route network development process.

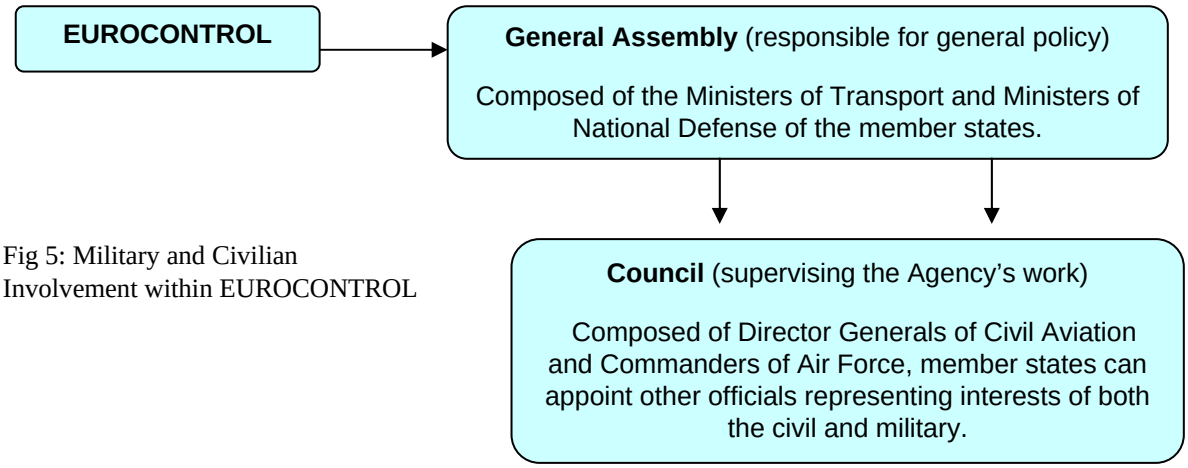

Fig 5: Military and Civilian Involvement within EUROCONTROL

EUROCONTROL emphasizes that no airspace congestion can be resolved if countries or regions do not work together. Communication and collaboration are the keys to obtain the best solution for each party involved. EUROCONTROL believes that airspace should not be designated as either pure civil or military. The Flexible Use of Airspace (FUA) Concept which was recommended by the International Civil Aviation Organization (ICAO) and developed by EUROCONTROL, aims at increasing airspace capacity and improving the efficiency of aircraft operations. Under the FUA, airspace is no longer designated as "civil" or "military", but is considered as one continuum and allocated according to users' requirements. This application ensures that any airspace segregation is temporary and should be based on actual usage during a specified time period.

(5) Conclusion: Relevant Lessons and Policy Considerations

Within the framework of "functional airspace block", the five international airports in PRD must be operating within an area which could be defined as a single FAB due to their proximity. To simplify the present operational complexity of the region, the fully "consolidated" NORCAL TRACON could be the model for reference. Furthermore, the NYICC can also be the model for providing air traffic services in the future, aiming at integrating the middle and upper airspace navigation all together.

In the EU's experience, a multinational institution has been mandated the task to create the Single European Sky. A top-level official framework is put in place, with the full participation of the military. Consultations and participation are thoroughly undertaken. Detailed planning schedules and implementation timetables are observed diligently.

The US and EU have accomplished a lot to improve their ATM. Based upon their valuable experience and under our "One-country, Two-systems" constitutional framework, we recommend the following policy considerations for enhancing PRD's ATM in the long term:

(a) Although both Hong Kong SAR and Macau SAR are operating under the 'One-country, Two-systems' principles, it is important to secure the full commitment of the Mainland Chinese Government to lead and monitor the PRD's ATM consolidation project given the military involvement in the issue[11], while obtaining the full co-operation and participation of local governments and other relevant parties. The objective of this Project is to enhance the efficiency of PRD's ATM to optimize airport capacity, flight time and fuel cost. A superstructure, probably along the line

of EUROCONTROL, needs to be set up for the PRD to achieve what EUROCONTROL and NYICC have been able to do.

As analyzed in the previous Sections, we suggested to establish a fully "consolidated" ATM facility to manage the mid-level (from 2,000 ft to 15,000/20,000 ft) terminal airspace for both Hong Kong and Zhuhai areas. This should be extended to cover the Guangzhou area and upper airspace as well in the long term. There could be two possible options for the necessary institutional arrangement.

The first option is similar to the EUROCONTROL's "multi-country" setting. Top government officials from CAAC from the Mainland China, CAD from HK, CAA from Macau, and Mainland's Military representatives should be members of the Governing Board of the consolidated facility. The Board is responsible for establishing major principles and policies. At the second-tier decision making body for operational principles and rules, representatives from the Board and other representatives from the airports and major airlines should be the core members. At the operational center of the ATM Consolidated Facility, military officers could sit side-by-side with their civilian counterparts in coordinating airspace management. The location of the facility should be explored in details with full consultation.

As for the second option, the Central Government could delegate the setting up of this Consolidated Facility to the Hong Kong Government, as Hong Kong's operation is generally considered more established. CAD can be the operational entity of this new Facility. There would be a top Council for major operational principles and policies. Top government officials from mainland's CAAC, the military, Hong Kong's CAD and CAA from Macau should be core members of the Council.

(b) It is vital to invite the Chinese military as an equal partner to participate in PRD's airspace redesign and management, aiming at an equitable redistribution and efficient use of airspace, while taking national security into full account. There should be a strong civil and military co-operation and interaction for the setting up of the new Facility. Military representatives should be presented at every level of the institutional arrangement.

The principle of "Flexible Use of Airspace" (i.e. the military could release the "military airspace" for civilian uses whenever possible) which is widely adopted by EUROCONTROL and FAA, should be examined for possible adoption

(c) It is essential to formulate an equitable cost-sharing and benefit-sharing mechanism for all parties concerned to facilitate the development of hardware and software for establishing an integrated ATM facility. The significance of this aspect would also mean that changes should be gradual and incremental. Currently, ATC services are provided by CAD in Hong Kong on a partial cost-recovery basis. CAD's revenue is mainly derived from the provision of air traffic services, en-route navigation services and licensing of airports, local airlines, aviation organizations and personnel. In 2006-2007, air traffic services (Air Traffic Control Charge) accounted for 72% and en-route navigation services (En-route Navigation Services Charge) contributed for another 21% of total CAD revenue [CAD, 2007]. The en-route charges (HKD$4.8 per nm flown, without landing at HKIA) are recovered directly from aircraft operators [HKSAR, 2004]. On the other hand, the ATC Charges applied to those aircraft taking off and landing at HKIA (including both ATC services fee and

terminal navigation fee[12]) are included in the HKIA landing charges, collected by Airport Authority Hong Kong (AAHK) on behalf of CAD.

Under the proposed 'consolidated' ATC facility, aircraft flying into and out of PRD region will pay for the integrated ATC services that provided by the 'consolidated facility' instead of to different ANSPs within the PRD region that the aircraft fly within. Care must be exercised in consideration of the future charging mechanism because like mentioned, different airports and ANSPs have different charging mechanisms. Unlike Hong Kong which en-route service charge is part of the airport's operating charges for aircraft originates and departs from Hong Kong; aircraft taking off and landing at China's airports have to pay such charges separately. Hence, how the costs would be collected, and how charges and benefits would be determined, shared and distributed efficiently and fairly in the case when the Consolidated Facility is a joint facility (1st Option), versus the 2nd option when Hong Kong is paying for all capital and recurrent expenses needs to be carefully studied.

(d) The National People's Congress of China will be required to pass a legislation to permit the new Facility to manage Zhuhai's mid-airspace jointly with (Option 1) or solely by Hong Kong SAR Government(Option 2). The legislation applicable for the new Joint Cross-border Facility between Hong Kong and Shenzhen commencing in July 2007 could be a useful reference. However, as military's ATM requirement would cut into the civilian ATM operation under emergency situations, some necessary provisions and overriding principles should be in place. Corresponding legislation will be required for Hong Kong and Macau as well due to their special administrative status under Mainland China.

(e)It is important to strengthen the CAAC's ATM research capability, in conjunction with that of Hong Kong and Macau. In the long term, PRD's airport developments such as new runways should be fully co-ordinated to avoid unnecessary flight operational conflicts over the PRD region.

Air traffic in the PRD region has been increasing very rapidly in recent years, leading to heavy traffic congestion. Based on the case studies research, the above suggestions would be able to optimize airport capacity, flight time and fuel cost for aviation stakeholders operating over the PRD area. In recent years, the relevant authorizes have been working together to derive short-term and long-term solutions to improve the situation. But some form of an integrated facility for the entire Region is still at a conceptual stage.

As Mainland China, Hong Kong and Macau are governed under the "One-country, Two-systems" constitutional framework, the institutional and financial arrangements for the integrated ATM facility will pose great challenges to policy makers. It is primary important to convince the Central Government about the necessity and viability for such ATM integrated facilities to be implemented in China for her rapid aviation development. A successful aviation market requires efficient ATC operations. ATM operations and investment must constantly make trade-off to ensure both safety, efficiency and cost. The implementation of the proposed measures to improve the air congestion in the PRD region, would be valuable to the fast-growing China economy to further develop itself to a world-class aviation market.

(Note: The idea of an integrated ATC facility for the PRD region has been suggested to the highest level of the Chinese Government by the authors. In June 2008, the CAAC responded to the authors on the issue. The authority stated the implementation of an integrated ATC operation should not be precluded in the longer term subject to the results of further ATC co-ordination of the three ATC centres.)

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Footnote:

[1] PRD Region includes Southern part of Guangdong Province of China. Include: Guangzhou, Shenzhen, Zhuhai, Foshan, Jiangmen, Dongguan, Zhongshan, urban districts of Huizhou, Huidong County, Boluo County, urban districts of Zhaoqing, Gaoyao County-level city, Sihui County-level City, Hong Kong Special Administrative Region (Hong Kong SAR)and Macau Special Administrative Region (Macau SAR).

[2] China Statistical Yearbook 2005, Guangdong Statistical Yearbook 2005, Hong Kong Civil Aviation Department, Hong Kong Census and Statistics Department, Macau International Airport and DSEC (Statistics and Census Service, Macau).

[3] Flights to Shanghai and Xiamen have their own category because the approach flight paths to the China Mainland to these destinations from Hong Kong are different, in comparison with other China flights from Hong Kong

[4] Different from most aviation standards, China Mainland airspace altitudes are measured in metres (m) instead of feet (ft). Airline pilots often have to refer to their latest navigation charts for appropriate altimetry adjustment on their flight instrument prior entering China's airspace

[5] RNAV refers to the capability for an aircraft to navigate directly between two defined points without having to adhere to the system of airways

[6] Hong Kong is a Special Administrative Region (SAR) of the People's Republic of China (PRC, Mainland China). Following British rule from 1842 to 1997, China assumed sovereignty under the 'One country, Two systems' principle. The Hong Kong Special Administrative Region's constitutional document: the Basic Law, ensures that the current political situation will remain in effect for 50 years. The rights and freedoms of people in Hong Kong are based on the impartial rule of law and an independent judiciary. The Basic Law has given the Hong Kong SAR the right to negotiate its own air traffic rights and provide conditions and take measures for maintenance of the status of Hong Kong as the centre of international and regional aviation. The similar situation applies to Macau SAR, which was under Portuguese colonial rule for nearly four hundred years until the handover of the region sovereignty back to Mainland China in 1999.

[7] TRACON is responsible for approach and departure control of airports in the US. TRACON responsible for airspace typically extending up to 40 nm + 10,000ft from the airport

[8] This facility located in Washington DC has the role as the national ATC co-ordinator and overlooks all ATC operations over the US airspace

[9] ARTCC is an en-route ATC facility mainly responsible for ATC during transition and cruise. Responsible for airspace typically 50-150 nm from airport up to 60.000 ft high.

[10] More details of the NYICC, please refer to "New York Integrated Control Complex (NYICC): Concept of operations" by Federal Aviation Administration.

[11] Even under the ‘One country, Two systems’ model, the Mainland Chinese Government is still responsible for the Hong Kong and Macau's defense and foreign affairs

[12] According to the TRI report ‘Review of Airport Charges’, it indicates that HKIA doesn’t have a separate terminal area air navigation fee charged to its users. This terminal area air navigation fee is based on the services provided for both the descent into and departure from an airport, also when maneuvering on the ground. In number of cases the ATC provider does not impose a terminal navigation charge on the aircraft operators (airlines), but enters into a contract for the provision of its services with the airport itself. In that case, this becomes part of the airport operating expenses, and the recovery of the cost from the airline user may be achieved through the landing charge [TRI, 2003].

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