Operational Evaluation of Air Traffic Flow Management in the Philippines*

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In the past decade, both the economy and air traffic demand have been growing rapidly in the Philippines. As a result, Ninoy Aquino International Airport (NAIA) has had to cope with increasingly heavy traffic. To mitigate the effects of this traffic, an air traffic flow management (ATFM) system was introduced in the Philippines. In this paper, background on introducing the ATFM system is presented and its successful results in reducing the holding time of flights waiting to land at the NAIA are reported on.

Key Words: Air Traffic Flow Management, Ground Delay Program, Air Traffic Management

Nomenclature

- N : the number of aircraft waiting to land in a unit of time
 A : the number of aircraft estimated to arrive in a unit of time
 L : the number of aircraft that landed in a unit of time
 H : estimated holding time
 n : working value for N
 T : time
 t : time variable

Subscripts

- i : current
 0 : initial

1. Introduction

In the past decade, both the economy and air traffic demand have been growing rapidly in the Philippines. Therefore, Ninoy Aquino International Airport (NAIA) has had to cope with increasingly heavy traffic. To mitigate the effects of this traffic, an air traffic flow management (ATFM) system was introduced in the Philippines.

2. Background

The Philippines is an archipelago comprising over 7,000 islands, including the main ones: Luzon Island and Mindanao Island. Figure 1 is a map of the country. To its north across the Luzon Strait lies Taiwan. West across the South China Sea is Vietnam. The Sulu Sea to the southwest lies between the country and the island of Borneo.

To the south, the Celebes Sea separates it from other Indonesian islands. It is bounded on the east by the Philippine Sea.

The Philippines' gross domestic product (GDP) increased 7.6% in 2010 year-on-year. Its GDP growth rate is reported by its National Statistical Coordination Board, as detailed in Table 1. The rate in 2011 slowed to 3.9% due to the effects of the global recession in numerous countries. However, in 2012, the economy recovered, expanding 6.4% in the first quarter of 2012 quarter-on-quarter.

Table 1. Economic growth in the Philippines.¹⁾

	FY2009	FY2010	FY2011
Nominal GDP (US\$100 M)	1,683	1,996	2,248
GDP growth rate	1.1%	7.6%	3.9%

As an archipelago, air transportation is essential for inter-island travel and international trips. Therefore, the Philippines has 86 airports around the country, and 10 are international ones. NAIA (International Civil Aviation Organization code: RPLL) is the main international airport. Clark Airport (RPLC) and Subic Bay Airport (RPLB) are also major airports and are well-known as former US airbases.

Other international airports are Laoag Airport (RPLI) on Luzon Island in the north of the country and Davao Airport (RPMO), Tumbler Airport (RPMR) and Zamboanga Airport (RPMZ) on Mindanao Island in the south. In addition, the central Philippines has Kalibo Airport (RPVK), Puerto Princesa Airport (RPVP) and Cebu Airport (RPVM) on the Visayas Islands.

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Fig. 1. Airports in the Philippines.

The other airports in the country are categorized into 15 Class 1 airports, 19 Class 2 airports, and about 50 community airports.

As of 2010, NAIA's air traffic was significantly greater than in 2002 and was expected to double by 2012, as indicated by Fig. 2. To accommodate such heavy traffic, NAIA has four terminals. Terminals 1, 2 and 3 are for international flights. Terminal 4 is for domestic ones.

As an international airport, NAIA has special characteristics. First, the types of aircraft range from long-haul international jets to various domestic planes, including those for general aviation (GA). A breakdown of instrument flight rule (IFR) traffic is shown in Fig. 3.

Fig. 3. NAIA's instrument flight rule (IFR) traffic for 2010.

Second, NAIA has two runways, but they intersect, and their lengths differ as shown in Fig. 4. These characteristics often make air traffic control at NAIA difficult due to varied separation minima which depend on the departure or arrival runway and types of aircraft.

Fig. 4. Map of NAIA.

Fig. 2. Traffic growth at NAIA.

Almost every day in 2010, the airspace around the airport was filled with a lot of airplanes during the busiest period, most waiting to land at the airport. In addition, the congestion around the airport was causing a lot of problems related to the environment, economy and safety. To solve these problems, the Civil Aviation Authority of the Philippines (CAAP) decided to implement a ground delay program (GDP) to manage the air traffic flow for NAIA. GDP which is one of the concepts of ATFM, may be implemented for airports when demand exceeds capacity.

3. System Description and Operational Procedure

Basically, the operation of ATFM in the Philippines is the same as the operation of ATFM at the Air Traffic Management Center (ATMC) in Fukuoka City, Japan. It is also the same as the operation of the Central Flow Management Unit of the European Organisation for the Safety of Air Navigation in Brussels, Belgium, and the Air Traffic Control Systems Command Center of the Federal Aviation Administration. Therefore, a detailed description of ATFM operation is not in this paper.

To alleviate the heavy traffic at NAIA, the GDP had to control the air traffic volume when the projected traffic demand was expected to exceed the airport's acceptable rate for a long time.

Therefore, flights to NAIA had to be issued an expected departure clearance time (EDCT) for each aircraft, as runway release time at their point of departure to mitigate constraints around the airport. Another requirement was to train the NAIA air traffic controllers and airline operators during trial operation.

3.1. System configuration

The system configuration for this ATFM is shown in Fig. 5. The ATFM is a Web-based client server system. The ATFM server was installed at the ATFM unit in Manila. The clients were installed at the Manila Area Control Center (ACC), Mactan sub-ACC which provides air traffic services over the southern part of the nation and is located close to Cebu Island, and Manila Tower at NAIA. They were connected via the Internet for coordination and information sharing.

Fig. 5. System Configuration.

3.2. Monitoring traffic volume

Calculating the traffic volume at NAIA requires the use of the acceptable arrival rate (AAR), which is the number of aircraft that can land at NAIA in a given unit of time.

The number of aircraft that are estimated to arrive is the summation of A which is based on the flight schedule data issued in the official airline guide (OAG). The summation of L gives the number of aircraft that have already landed. Thus, Eq. (1) gives the number of aircraft waiting to land at T_0 .

$$N(T_0) = \sum_{t=0}^{T_0} A(t) - \sum_{t=0}^{T_0} L(t) \quad (1)$$

$$i = 0 \quad (2)$$

$$n = N(T_i) + A(T_{i+1}) \quad (3)$$

$$i = i + 1 \quad (4)$$

$$\text{if } n > AAR \text{ then } N(T_i) = n - AAR \quad (5)$$

$$\text{else } N(T_i) = 0$$

$$H(T_i) = N(T_i) \div AAR \quad (6)$$

The calculations are done repeatedly, as indicated by Eqs. (3) - (6). This gives the number of aircraft that will be waiting to land at T . In addition, dividing the number that already landed by the AAR gives the airborne holding time. The results are displayed on the air traffic forecast windows of the workstations, as shown in Fig. 6. In this figure, the AAR is indicated as dots. The number of aircraft estimated to arrive is indicated as bars.

Fig. 6. Air traffic forecast window.

The number of aircraft is scaled using the Y axis on the left. The estimated holding time is indicated as curves and scaled using the Y axis on the right. The upper curve indicates the maximum and the lower one shows the average.

The number of aircraft estimated to arrive is based on OAG as mentioned before.

When a flight is canceled or delayed, its flight schedule is modified at a workstation by an operator at Manila ACC using the departures tab shown in Fig. 7. The holding time is then recalculated automatically on the server. The departures tab is also used when the aircraft departs.

User : TMC

Airport : RPLL

Date : 07/28/2010

Loading Data : 07102010.csv

Mode : Operating

Time : 07/28/2010 04:43

Air Traffic Information

Verify GDP

Recalculation

Save

Departures

Arrivals

Arrival ELDG & AHT List

Traffic Count

Traffic Flow

Airport Acceptance Rate

ATFM Information

STS	G/S	SSR	TYPE	D/I	DEP	STD	ECBT	ETD	EXCT	ATD	FIR-FIX	FIR-ETO	FIR-ATO	Gate	Gate-ETO	DEST	STA	ETA	ATA
3	UAE889		BT7P	I	RPLL	1620	1620	1625								OMC8	2140	2140	A
3	BAL824		BT44	I	RPLL	1620	1620	1625								PKS3	2180	2180	
3	CEB851		AS2N	D	RPPL	2020	2020	2025								RPVA	2195	2195	
3	CEB881		AS2N	D	RPPL	2025	2025	2030								RPML	2150	2150	
3	CEB451		AO1N	D	RPPL	2045	2045	2050								RPV1	2150	2150	
3	CEB961		AS2N	D	RPPL	2015	2015	2020								RPMD	2150	2150	
3	CEB559		AS2N	D	RPPL	2040	2040	2045								RPVH	2155	2155	
3	PAL468		AS2N	I	RPPL	1700	1700	1705								PKS3	2280	2280	
3	PAL849		AO1N	D	RPPL	2030	2030	2035								RPVH	2280	2280	
3	CEB473		AO1N	D	RPPL	2055	2055	2100								RPVH	2285	2285	
3	SRD001		OS2N	D	RPPL	2140	2140	2145								RPVH	2225	2225	
3	PAL809		AS3N	D	RPPL	2030	2030	2035								RPMD	2230	2230	
3	CEB021		AO1N	D	RPPL	2140	2140	2145								RPVH	2235	2235	
3	PAL199		AS2N	D	RPPL	2110	2110	2115								RPV1	2235	2235	
3	PAL191		AS2N	D	RPPL	2115	2115	2120								RPVH	2240	2240	
3	RJT065		OMC3	D	RPPL	2145	2145	2150								RPVH	2245	2245	
3	SRD003		OS2N	D	RPPL	2200	2200	2205								RPVH	2245	2245	
3	PAL129		AS2N	D	RPPL	2100	2100	2105								RPVH	2245	2245	
3	PAL189		AO1N	D	RPPL	2130	2130	2135								RPVH	2245	2245	
3	PAL181		AS2N	D	RPPL	2110	2110	2115								RPVH	2250	2250	
3	PAL475		AO1N	D	RPPL	2110	2110	2115								RPVH	2250	2250	
3	PAL041		OMC3	D	RPPL	2200	2200	2205								RPVH	2255	2255	
3	RJT021		OMC3	D	RPPL	2145	2145	2150								RPV1	2255	2255	
3	PAL095		OMC3	D	RPPL	2150	2150	2155								RPVH	2280	2280	
3	PAL179		AS2N	D	RPPL	2130	2130	2135								RPV1	2280	2280	

Update

Clear

Fig. 7. Departures tab.

User : TMC
Airport : RPLL
Date : 07/28/2010
Loading Data : 07102010.csv

Mode : Operating Time : 07/28/2010 04:47

Air Traffic Information

Verify GDP Recalculation Save

Departures Arrivals Arrival ELDG & AHT List Traffic Count Traffic Flow Airport Acceptance Rate ATFM Information

STS	C/S	SSR	TYPE	D/I	REP	STD	EDBT	ETD	EDCT	ATD	FIR-FLY	FJR-ETD	FJR-ATD	Gate	Gate-ETD	DEST	STA	ETA	ATA
S	DE3552		A211	D	RPM	2010	2010	2010								RPLL	2115	2115	
S	DE3554		A321	D	RPM	2045	2045	2050								RPLL	2200	2201	
S	FAL041		A321	D	RPM	2110	2110	2105								RPLL	2105	2105	
S	DE3552		A321	D	RPM	2215	2215	2210								RPLL	2320	2321	
S	DE3552		A311	D	RPM	2220	2220	2225								RPLL	2325	2325	
S	SR0002		D321	D	RPM	2245	2245	2250								RPLL	2330	2331	
S	DE3551		A321	D	RPM	2255	2255	2250								RPLL	2340	2341	
S	DE3551		A321	D	RPM	2255	2255	2250								RPLL	2345	2345	
S	SR0004		D321	D	RPM	2315	2315	2310								RPLL	2350	2351	
S	DE3574		A311	D	RPM	2340	2340	2345								RPLL	2355	2355	
S	DE3524		A311	D	RPM	2315	2315	2310								RPLL	0000	0001	
S	FAL044		A311	D	RPM	2345	2345	2350								RPLL	0010	0011	
S	RIT004		DHC3	D	RPM	2315	2315	2320								RPLL	0015	0015	
S	DE3551		A321	D	RPM	2330	2330	2335								RPLL	0015	0015	
S	FAL042		DHC3	D	RPM	2325	2325	2330								RPLL	0015	0015	
S	SR0006		D321	D	RPM	2335	2335	2340								RPLL	0020	0021	
S	FAL141		A321	D	RPM	2315	2315	2320								RPLL	0030	0031	
S	FAL191		A311	D	RPM	2325	2325	2330								RPLL	0035	0035	
S	RIT321		DHC3	D	RPM	2325	2325	2330								RPLL	0035	0035	
S	FAL182		A321	D	RPM	2320	2320	2325								RPLL	0035	0035	
S	FAL034		DHC3	D	RPM	2325	2325	2330								RPLL	0035	0035	
S	RIT382		CN85	D	RPM	2350	2350	2355								RPLL	0050	0051	
S	SR0001		D321	D	RPM	0015	0015	0010								RPLL	0050	0051	
S	FAL031		DHC3	D	RPM	2345	2345	2350								RPLL	0100	0101	
S	SR0481		L411	D	RPM	2350	2350	2355								RPLL	0100	0101	

Update Clear

Fig. 8. Arrivals tab.

When an aircraft lands at NAIA, an operator at NAIA enters the actual time of arrival into the system via the workstation arrivals tab shown in Fig. 8. The holding times are then recalculated automatically. The arrivals tab is mainly for NAIA.

The flight schedule is modified manually using a keyboard or mouse. Generally, an interface for flight schedule information exchange with an existing system is indispensable for ATFM.

However, this ATFM system does not have an interface with the existing system yet. Since information exchange can be done by operators at NAIA manually as an alternative way, initial full operation did not require it.

When the flight schedule is modified due to a delay, departure or arrival, the air traffic volume is recalculated immediately. During congested periods, the estimated holding time exceeds the acceptable arrival holding rate (AAHR). The AAHR is indicated by the horizontal line in Fig. 9.

Fig. 9. Air traffic forecast before GDP.

Fig. 10. Air traffic forecast under GDP.

3.3. GDP operation

Traffic management specialists at the Manila ACC continuously monitor the traffic volume. When they notice that the estimated holding time exceeds the AAHR, they start to use the GDP as necessary.

Traffic management specialists evaluate the impact of the GDP on NAIA using several parameters, such as a revised AAR and AAHR. The system has several measures for evaluating the GDP, as follows.

- Time to start GDP
- Duration of GDP
- Expected maximum holding time before GDP
- Expected average holding time before GDP
- Number of aircraft to be impacted by GDP

- Expected maximum holding time under GDP
- Expected average holding time under GDP

They also compare the traffic volume before the GDP and under it. In Fig. 9, the initial estimated holding time indicated by the curves exceeds the AAHR indicated by the straight line. However, Fig. 10 shows that the holding time is sufficiently mitigated under the GDP.

In addition, information on the aircraft that will depart first for NAIA during the GDP is evaluated. This information is useful for the air traffic controllers at the departure airport, since this information indicates the operational start time of GDP at the airport.

User : TMC Airport : RPLL										Mode : Operating Time : 07/27/2010 05:26									
Date : 07/27/2010 Loading Data : 07102010.csv										Air Traffic Information									
										Verify GDP Recalculation Save									
Departures Arrivals Arrival ELDG & AHT List Traffic Count Traffic Flow Airport Acceptance Rate ATFM Information																			
STS	C/S	DEP	DEST	ETO	EOT	DELAY	ETA	ELDG	AHT										
S	PALL05	PSM	RPLL	17:04			19:15		0										
S	PALL03	PSM	RPLL	17:45			19:10		0										
S	PALL08	NSIS	RPLL	18:24			20:00		0										
S	CEB004	NSIS	RPLL	18:45			20:05		0										
S	CEB050	RPW	RPLL	20:05			21:16		0										
S	CEB092	YBOS	RPLL	17:18			21:10		0										
S	CEB054	RPW	RPLL	20:08			22:10		0										
S	CEB002	NBIX	RPLL	18:28			22:10		0										
S	PALL02	RPW	RPLL	21:05			22:15		0										
S	PALL08	NTIT	RPLL	17:55			22:45		0										
S	CEB052	RPW	RPLL	22:18			23:10		0										
S	CEB452	RPVT	RPLL	22:25			23:25		0										
S	SR0002	RPVE	RPLL	22:38			23:30		0										
S	CEB060	RPW	RPLL	22:38			23:40		0										
S	CEB092	RPW	RPLL	22:25			23:45		0										
S	CEB074	RPVE	RPLL	22:45			23:50		0										
S	SR0004	RPVE	RPLL	22:18			23:50		0										
S	CEB020	RPW	RPLL	22:18			00:00		0										
S	PALL44	RPW	RPLL	22:38			00:10		0										
S	CEB862	RPW	RPLL	22:35			00:15		0										
S	PALL42	RPW	RPLL	22:38			00:15		0										
S	RI1884	RPVE	RPLL	23:28			00:15		0										
S	SR0006	RPVE	RPLL	23:48			00:20		0										
S	PALL40	RPVT	RPLL	23:28			00:30		0										
S	PALL10	RPW	RPLL	23:38			00:35		0										

Fig. 11. Estimated landing (ELDG) tab.

When traffic management specialists decide to implement the GDP, they click the execute button on the GDP window. Then, the stakeholders (such as the traffic management specialists, air traffic controllers, and airline operators) are informed of GDP implementation via the Internet.

Another notable feature of the ATFM system is the shaded rectangle shown in Fig. 10. It is for the duration of the GDP and is shared with the stakeholders.

Moreover, the stakeholders can check the ground delay time, airborne holding time around NAIA, and estimated time of landing for each aircraft by clicking the estimated landing (ELDG) tab to get the results shown in Fig. 11. The estimated landing time is calculated based on the ground delay time and airborne holding time.

4. Implementation Plan

The Filipino air traffic controllers and airline operators did not have ATFM experience. Therefore, the ATFM was introduced step by step, as shown in Fig. 12. First, an ATFM server and workstations were installed at the ATFM unit and NAIA in the middle of October 2010.

4.1. Training

Initial operational training was held between October 19 and 21. Five people from the ATFM Working Group of the CAAP attended so as to prepare to oversee ATFM operations in the Philippines later. In addition, 15 people from NAIA, the Mactan sub-ACC, and other facilities participated. A photo of operational training is shown in Fig. 13.

After the initial operational training, four weeks of preparation for trial operation was scheduled. ATFM workstations were installed at the Mactan sub-ACC, which is near Cebu International Airport. The people from the ATFM Working Group were the main ones who then conducted an

Fig. 12. Each step leading up to full operation.

ATFM seminar and operational training for the controllers at the Mactan sub-ACC. In the seminar, they reported on their training at Japan's ATMC, the philosophy behind air traffic flow management, and the ATFM system configuration. The Working Group also conducted the operational training. After that, they trained over 100 other controllers to deepen their understanding of ATFM features and operation.

4.2. Shadow operation

In December, ATFM shadow operation began. The purpose was to improve the ATFM operational skills inside

Fig. 13. Operational training.

the CAAP, not externally. Therefore, when the GDP was implemented, the EDCT was calculated along with the traffic scenario, but the EDCT was not issued to any airline operators.

The ATFM system consists of a server at the ATFM unit and five workstations. The workstations are installed at the Manila ACC, Mactan sub-ACC and Manila Tower. They are used to modify the flight schedules when there are flight delays, cancellations, departures or arrivals. However, to estimate the traffic volume accurately, it became necessary to improve the shadow operation data accuracy for the over 1,000 flights per day in the Philippines.

The shadow operation was conducted for over a month. However, it was not possible to make the data accuracy reach the desired level. To solve this problem, the CAAP hired about 10 specialists in charge of flight data modifications. After that, the accuracy of the estimated traffic volume improved and then reached the desired level for the next step: trial operation.

4.3. Trial operation

On January 28, 2011, trial operation started. Initially, it was only used to mitigate traffic congestion during the two busiest hours, and many issues to solve became apparent. Airline operators were involved in the trial operation. Therefore, cooperation with the airline operators was very important. The Working Group did its best to improve communications with the airline operators so the trial operation would go well. In particular, receiving information on flight delays from the airline operators and issuing EDCTs to them were very important.

The Working Group held ATFM meetings with the airline operators periodically. In addition, they set up points-of-contact to explain the reasons for ground delays.

In September 2011, the CAAP evaluated the trial operation and reported that the holding time decreased from 2,891 to 1,905 minutes for the same period in 2010. They therefore achieved a reduction of 34% compared with that in 2010.

4.4. Full operation

In 2012, full operation started with improved accuracy of air traffic volume forecasts and expanded GDP operations according to ATS orders,²⁾ as described below.

1) The airline operators provide daily estimated off-block time (EOBT) updates and flight cancellation information before 8 AM by fax or email.

2) Traffic management specialists check for constraints and change the AAR as necessary.

3) The flights subject to the GDP are all :

- domestic airlines' flights,
- general aviation flights, and
- other civilian flights flying VFR⁺ to IFR.

4.5. Expansion plans

The CAAP plans to provide flow control for flights operating at Tagbilaran Airport and to assist Kalibo Airport with flow control.

5. Conclusion

In 2012, the CAAP presented its second evaluation of GDP operations. The report stated there are seven reasons for airborne holding: 1) weather, 2) terminal congestion, 3) runway changes, 4) special operations, 5) incidents such as emergencies, 6) equipment failures and 7) others. Their ratios are shown in Fig. 14, with weather ranked first at 30%. In contrast, in 2010, almost all of the airborne holding was caused by heavy traffic. Proactive analysis of the reasons for airborne holding is important for improving operations and making them more efficient. This is because it gives traffic management specialists more options for dealing with heavy traffic in advance.

Fig. 14. The reasons for holding (2012).

As a result of the NAIA progress as of 2012, the holding time decreased to 1,030 minutes in the same period described above. Therefore, a reduction of 64.4% was achieved, as shown in Fig. 15.

Acknowledgments

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Fig. 15. Duration of airborne holding time.

⁺ Visual Flight Rules