A Case Study of Operational Delay at Japanese Airports

K. Kageyama*, Y. Fukuda*
*ATM Department
Electronic Navigation Research Institute (ENRI)
Tokyo, Japan
[kage | fukuda]@enri.go.jp

Abstract: This paper describes a data analysis instance for the study of aircraft operational delay. ICAO (International Civil Aviation Organization) has defined Key Performance Areas (KPA) for ATM (Air Traffic Management) performance assessment. KPA are comprised of efficiency, predictability and other areas. Delay is one of the most important elements in operational performance, because it is strongly linked to the areas of efficiency and predictability. Computations and comparisons were carried out on actual data to analyze arrival delay at Haneda and other Airports in Japan. In addition, the influence of ATFM (Air Traffic Flow Management) on the delay at the pre-departure phase was studied.

Keywords: Air Traffic Management, Key Performance Areas (KPA), Operational Delay

1. INTRODUCTION

This analysis was carried out to assess ATM performance. Delay is one of the most important elements in operational performance, because it is strongly linked to predictability and affects efficiency. Predictability is closely related to delay, because the uncertainty and fluctuation of delay reduces the ability to accurately predict flight event times. At the same time, because longer operation time induces higher cost, delay is associated with efficiency. Delay data analysis was focused on arrivals at Tokyo International (Haneda) Airport and other Japanese airports. Arrival delay at the airports was computed and compared. In addition, the influence of ATFM at the pre-departure phase was studied. For the purpose of this study, the actual data recorded in the ATM system were analyzed.

2. ATM PERFORMANCE

To accommodate the increase in air traffic demand, ATM has significantly improved its performance in the last few decades. However, since further traffic demand is anticipated, further ATM performance improvements and monitoring are required. For the definitions of the various performance assessment viewpoints, ICAO has defined KPA [1].

KPA are comprised of 11 distinct areas related to societal impact (Safety, Security, Environment), ATM prosperity (Access and Equity, Participation by the ATM community), and ATM operational performance (Cost Effectiveness, Capacity, Efficiency, Flexibility and Predictability).

To cope with expected market growth and meet societal requirements, the future ATM framework needs to be designed and implemented with a service-centric approach[2]. In order to verify implementation, benefits from the implementation should be monitored periodically and with a solid quantitative foundation. KPA serve as a guideline for this quantitative assessment. KPA definitions indicate the importance of ATM performance measurement. As mentioned earlier, delay is one of the most important elements in operational performance. For the purpose of ATM performance assessment, delay was analyzed.

3. DATA COLLECTION

3.1 DBMS ADOPTION

Since ATM can be seen as a mechanism for supporting and safeguarding aircraft flight operations, the benefits from any ATM performance will be reflected in aircraft operations partially recorded in ATM systems. Therefore, assessment results can be obtained from ATM system journal analysis.

Efficient analysis of ATM system journals entails challenges for the following reasons. Firstly, ATM is comprised of numerous systems resulting in data recordings in distinct journals. Secondly, due to traffic volume growth and the number of distinct data items to be recorded, the data volume in ATM systems has grown to be quite substantial.

The adoption of a database management system (DBMS) is a good countermeasure against these challenges. Since a DBMS is designed to control the organization, storage, management and retrieval of data, the adoption of a DBMS achieves the desired ATM performance analysis in an efficient way. For this reason, through the adoption of a DBMS, data from the ATM system journals were collected, correlated for identical operations, and stored in a database.

3.2 DATA SOURCES

Japanese ATM systems include FDMS (Flight Data Management System) for managing operational events across all operational phases, SMAP (Spot

Management And Planning system) for managing operational events data at gates, as well as radar systems such as ARTS (Automated Radar Terminal System) and RDP (Radar Data Processing system). Data are also recorded in ODP (Oceanic air traffic control Data Processing system), ASM (Air Space Management system) and ATFM (Air Traffic Flow Management system). In addition, scheduled times were obtained from published timetables.

4. ANALYSIS INSTANCES

4.1 CLASSIFICATION

In this analysis, delays were computed based on scheduled times. Thus, delay was classified in accordance with operational phases as follows;

- **Pre-departure Delay** corresponded to delay that occurs by push-back at departure airports. The delay was computed as follows:

  AOBT - STD.

  AOBT (Actual Off-Block Time) was obtained from SMAP jounals, whereas STD (Scheduled Time of Departure) was obtained from published timetables.

- **Block Delay** corresponded to the delay that is incurred between push-back and gate-in. The delay was computed as follows:

  (ABIT - AOBT) - (STA - STD).

  ABIT (Actual Block-In Time) and AOBT were obtained from SMAP jounals. On the other hand, STA (Scheduled Time of Arrival) and STD were obtained from published timetables.

- **Arrival Delay** corresponded to the sum of all delays incurred by the time an aircraft docks at its assigned gate at its arrival airport. More specifically, **Arrival Delay** was computed as the sum of the **Pre-departure Delay** and **Block Delay**. This delay computation was performed as follows:

  ABIT - STA.

The ratio of *Late Arrivals*- arriving later than 15 minutes after STA - is generally accepted as the indicator for air transport operations on-time performance [2].

4.2 APPLIED DATA

In this analysis, the **Arrival Delays** at Haneda Airport (RJTT), New Chitose Airport (RJCC), and Fukuoka Airport (RJFF) were studied and compared. In addition to *Late Arrivals*, the ratio of *Late Departed* – arrivals departing later than 15 minutes after STD – and *Block Delayed* – arrivals for which **Block Delay** was more than 15 minutes, were studied and compared. The data were recorded during the months of February, June, August, December 2007, as well as April, June, August, October 2008, and 6 to 7 days worth of data were gathered for each of these months. In total, 62 days worth of data were analyzed.

Table 1 Ratio at Each Airport

Airport	RJCC	RJFF	RJTT
Late Arrivals	.09	.10	.14
Late Departures	.07	.07	.07
Block Delayed	.02	.02	.04

For various reasons, the collected data included extremely high and low values that would have biased the analysis results if they had been included. Therefore, the range between -6 and 6 hours was used for the analysis and values outside this range were not considered.

4.3 RESULTS : DELAY AMOUNT

Table 1 represents the comparison of the ratio of *Late Arrivals, Late Departed* and *Block Delayed* across the entire data set. The ratio of *Late Arrivals* at Haneda Airport was greater than the ones at the other airports.

As mentioned above, **Arrival Delay** was the sum of **Pre-departure Delay** and the **Block Delay**. In order to study the contribution of each distinct flight phase to total **Arrival Delay**, the ratios of *Late Departed* and *Block Delayed* were compared separately. For all the airports, the ratios of *Late Departed* were higher than the ratios of *Block Delayed.* This implies that **Pre-departure Delay** had more impact on **Arrival Delay** than **Block Delay**.

In addition, the ratio of *Late Departed* proved to be almost constant among the airports. On the other hand, the ratio of *Block Delayed* of Haneda arrivals was

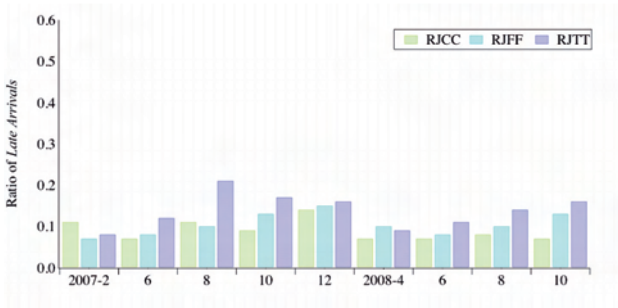

Figure 1 Monthly Ratio of *Late Arrival*

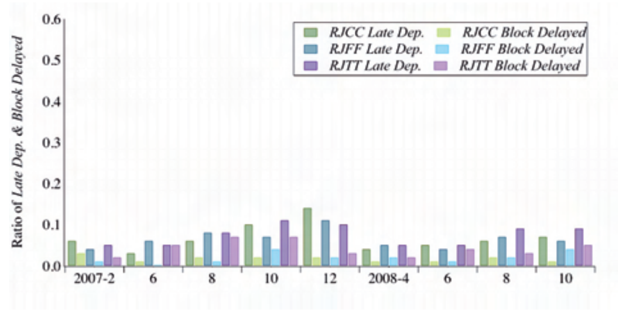

Figure 2 Monthly Ratio of *Late Departed & Blcok Delayed*

higher than theose of the others. As a result, the higher ratio of *Late Arrivals* at Haneda Airport was attributed to the higher ratio of *Block Delayed*.

At the same time, the monthly average of the ratios was studied. Figure 1 depicts the percentage of *Late Arrivals* for each month at the airports. The average value at Haneda Airport fluctuated between 0.08 (Februay 2007) and 0.21 (August 2007). The ratio flucuated among the months. Also, although the ratio at Haneda Airport was the highest across the entire data set, the magnitude relation fluctuated among the months.

Figure 2 depicts the monthly ratios of *Late Departed* and *Block Delayed*. Fluctuations in the values were observed. For instance, at Haneda Airport, the ratios of *Late Departed* ranged from 0.05 to 0.11 and the ratios of *Block Delayed* ranged from 0.02 to 0.07.

The daily ratios were also analyzed and are shown in Figure 3 and Figure 4 for *Late Arrivals* and *Late Departed*, *Block Delayed*.

From Figure 3, it can be seen that the daily average of the ratio fluctuated among the days. In particular, on some of the days for which data were gathered, the values at Haneda Airport were extremely high.

Figure 4 represents the daily trends of factors for the *Late Arrivals*. The days, on which high ratios of *Late Departed* and *Block Delayed* were observed, were identical to the days on which high ratios of *Late Arrivals* were observed. That is, the daily trend of *Late Arrivals* represented in Figure 3 was backed by the trend of *Late Departed* and *Block Delayed* represented in Figure 4.

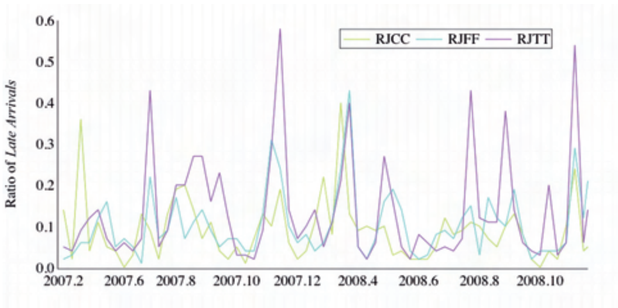

Figure 3 Daily Ratio of *Late Arrivals*

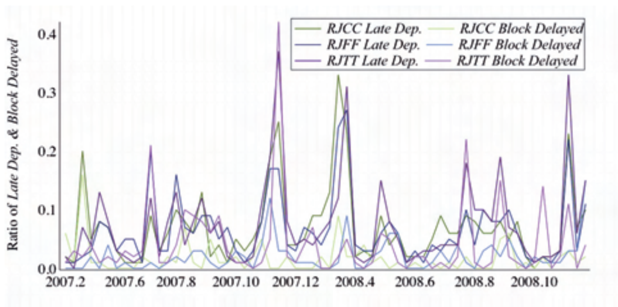

Figure 4 Daily Ratio of *Late Departed & Block Delayed*

4.4 RESULTS : ATFM

In this analysis instance, we focused on **Pre-depature Delay**. One of the factors that affect **Pre-departure Delay** is ATFM (Air Traffic Flow Management). To avoid airspace congestion, ATFM adjusts take-off times as EDCT (Expected Departure Clearance Time). As a consequence, push-back or departure-taxiing times can be delayed. This means part of **Pre-deparute Delay** can be caused by the issue of EDCTs.

Since issued EDCTs were recorded in the ATFM system, we defined the following delay, values for which were computed.

- **ATFM Delay**

  EDCT -ETD.

  EDCT was obtained from ATFM sytstem journals. Adding standard departure taxiing time to EOBT, ETD (Estimated Time of Departure) was obtained. The standard departure taxiing-time was defined for each departure gate and take-off runway pair.

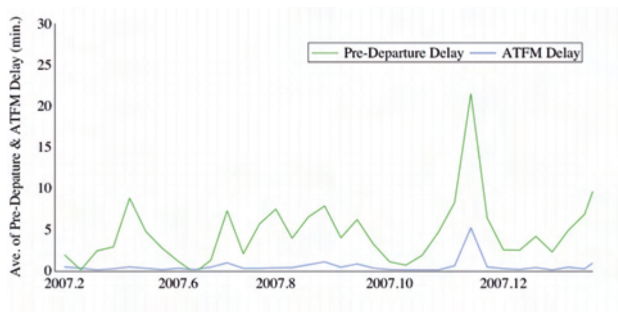

Figure 5 Daily Average of Pre-Departure Delay & ATFM Delay

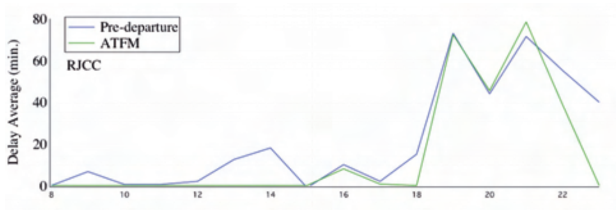

Figure 6 Average of Pre-Departure & ATFM Delay (RJCC)

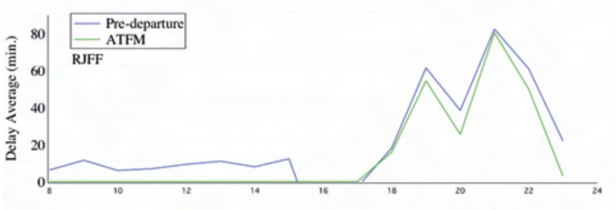

Figure 7 Average of Pre-Departure & ATFM Delay (RJFF)

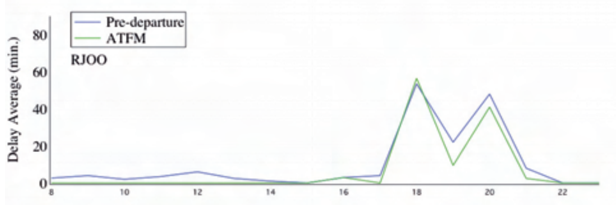

Figure 8 Average of Pre-Departure & ATFM Delay (RJOO)

Figure 5 shows daily averages for **ATFM Delay** and **Pre-departure Delay**. Due to the limitation on available data, averages were computed only for arrivals departing from Chitose Airport, Fukuoka Airport and Osaka Airport (RJOO).

From Figure 5, it appears that there was no correlation between **ATFM Delay** and **Pre-departure Delay**. However, on one day in October 2007, both averages took high values. On that day, bad weather conditions were recorded and such weather conditions should have required the use of ATFM.

The hourly averages on that day were studied. The averages were computed for each departure airport and are shown in Figure 6, Figure 7 and Figure 8, respectively. It should be noted that since EDCTs were issued for take-off time, **ATFM Delay** could exceed **Pre-departure Delay** in some cases.

From the figures, it was observed that after 18:00, the hourly averages of both **Pre-deparutre Delay** and **ATFM Delay** were high at all the airports. In addition, during these time periods, the averages of **Pre-departure Delay** and those of **ATFM Delay** were virtually identical. That is, after 18:00, the **ATFM Delay** amount covered the **Pre-departure Delay** amount. It was confirmed that although in the entire data set, **Pre-departure Delay** was slightly affected by **ATFM Delay**, in localized time periods, it was affected significantly.

5. CONCLUSIONS

In this paper, the comparison-instances of **Arrival Delays** at Japanese airports were presented. **Arrival Delay** was decomposed into **Pre-deparure** and **Block Delay**.

For all the airports studied, **Pre-departure Delay** proved to have the most impact on **Arrival Delay**. From the study of daily fluctuation, the delay proved to fluctuate considerbly among the days.

In addition, the effect on ATFM for the **Pre-departure Delay** was studied. From the study, it was confirmed that although in the entire data set, **Pre-departure Delay** was slightly affected by **ATFM Delay**, in the localized local time periods, it was affected significantly.

Without doubt, delay needs to be monitored continuously and trends must be studied for achieving a detailed ATM performance analysis. Continuous data analysis can offer significant insights into possible future ATM improvements.

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