

8. 福岡 FIR における 2013 年から 2030 年の空港需要予測

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1. INTRODUCTION

In a research project looking at Trajectory-Based Operations (TBO), we created forecasts of air traffic in the Fukuoka Flight Information Region (FIR) in 2030 to identify potential bottlenecks and capacity insufficiencies. As part of this effort, we examined airport and runway demand at the eight busiest airports shown in Table 1, and have reported preliminary results in [1]. In this paper, we present our methodology and results in further detail.

Table 1: Target airports

ICAO Code	Airport Name
RJAA	Narita International
RJBB	Kansai International
RJCC	New Chitose International
RJFF	Fukuoka
RJGG	Chubu Centrair International
RJOO	Osaka International (Itami)
RJTT	Tokyo International (Haneda)
ROAH	Naha

To create the 2030 air traffic scenarios, we applied a traffic growth forecast to 2013 air traffic data [2]. The forecast divided air traffic into flights between “regions” that are either states or groups of states aggregated roughly by economic characteristics, and gives traffic growth factors as multipliers of the number of flights between regions from 2013 to 2030. To forecast an airport’s future traffic, one could simply take annual traffic counts for 2013 between the airport and each region, multiply these by the corresponding forecast traffic growth factors and sum. This requires complete traffic statistics for each airport, but such data may not be so readily available. For this study in particular, we had data on all flights in Fukuoka FIR on each day in 2013 except for

February. Also, our available data contained only flights conducted under Instrument Flight Rules (IFR), omitting Visual Flight Rules (VFR) traffic.

We therefore used a simple method to estimate airport annual air traffic and to forecast future traffic. We selected two scenario days from 2013 which we assumed to be representative of summer and winter schedule season’s traffic, multiplied the IFR traffic on these days by six months and summed to obtain estimated annual totals for each airport. We then compared these estimates with the true annual traffic totals from landing statistics. If the selected days were indeed average, we assume that any significant error would be due to “missing” VFR flights, and derived “correction factors” for significant errors.

Next, we applied our traffic growth forecast to the 2013 scenarios to obtain 2030 traffic scenarios using a “copy-and-shift” method whereby growth traffic is added by taking random flights from the original scenario and shifting their times by ± 20 minutes to avoid overconcentration of traffic while preserving the airport’s characteristic traffic flow peaks. Finally, we applied our annual traffic estimation method to the 2030 scenarios including the correction factors, assuming VFR traffic growth to be static.

In this paper, we present our method to derive annual airport traffic estimates for 2030 and show its results. We also derive the typical runway demand (movements/hour) using histograms. Section 2 describes our data sources and methodology to estimate annual airport traffic, the traffic growth model and its application to create 2030 scenarios, and runway demand analysis method. The results are presented in section 3 and discussed briefly in section 4. Section 5 concludes the paper.

Note that the results presented here are based on 2013 information, and actual 2016 traffic was greater than anticipated. The emphasis of this paper is on our

methodology, and the results should be revised with later forecast data for practical use.

2. METHODOLOGY

2.1 Source Information

This study used Flight Data Management System (FDMS) data provided by the Japan Civil Aviation Bureau (JCAB). The data contains flight plan and operational information (including Actual Time of Departure (ATD) and Actual Time of Arrival (ATA) at Japanese airports) for IFR flights that operated in the Fukuoka FIR, omitting VFR and military flights. Available data included all days in 2013 except February, and complete data for 2014 and 2015.

Baseline traffic scenarios were derived from two days, 11 Jan 2013 in the winter and 6 Sep 2013 in the summer airline schedule periods respectively, selected because that they contained no significant weather that would cause delays. True traffic totals for each airport (numbers of movements, where a movement is a takeoff or a landing) were derived from airport statistics compiled and published by JCAB [3]. The data gives numbers of landings of civil IFR and VFR flights at each airport, as well as passenger and freight volumes.

Our traffic growth forecast [2] was derived from existing sources. For domestic and international traffic, we used JCAB forecasts based on research by the National Institute for Land and Infrastructure Management (NILM).

2.2 Estimation of Annual Airport Traffic

In Japan, airlines typically operate two schedule periods — summer and winter — coinciding with daylight saving time in Western Europe [4]. Overall demand is higher during the summer than in the winter. To estimate annual demand, we selected one day from each schedule period that had no significant weather-related delays and assumed these days to be “typical” of each approximately 6-month period. Let us denote the airport traffic (number of movements) on these days as w for the winter period day and s for the summer period day. Assuming these as averages,

an estimate of annual traffic T_{est} is

$$T_{\text{est}} = (365/2)(w + s) \quad (1)$$

If historical data are available on actual traffic, we can find the estimate errors. In this study, we used landing statistics for each airport. If the number of landings at an airport is L , then the actual annual number of movements T_{act} is approximately given by

$$T_{\text{act}} = 2L \quad (2)$$

assuming the number of aircraft parked at an airport remains constant over time. The error factor e between the actual and estimated traffic is then

$$e = (T_{\text{est}} - T_{\text{act}}) / T_{\text{act}} \quad (3)$$

Since our w and s include only IFR flights, if they are close to seasonal average then we assume that any significant e is due largely to VFR traffic.

To obtain an airport annual traffic forecast, we first create “growth” traffic scenarios from the historical baseline day traffic and obtain the corresponding w and s for the forecast year. We then use eq. (1) to obtain an annual traffic estimate and then correct for the VFR traffic to obtain a prediction T_{pred} as

$$T_{\text{pred}} = T_{\text{est}}(1 - e) \quad (4)$$

assuming that annual VFR traffic does not change over the forecast period. Our assumptions are summarised in Table 2.

Table 2: Annual traffic estimation assumptions

1	The one-day traffic totals w and s are typical (averages) for the summer and winter schedule 6-month periods respectively.
2	Significant discrepancy e between T_{act} and T_{est} is largely due to “missing” VFR traffic.
3	VFR traffic at an airport will not change significantly over the forecast period. Therefore, e can be used to correct a forecast T_{est} to derived a better traffic prediction at airports with significant VFR traffic.

2.3 Traffic Growth Model and its Application

Our traffic growth model treats states or aggregates of states as “regions” are shown in Table 3 and gives forecast growth factors of the numbers of flights

between them from 2013 to 2030. The growth factors are based on forecast passenger and freight volumes considering economic growth and are converted into numbers of flights assuming trends such as a reduction of average aircraft seating capacity and the growth of low-cost carriers. Japanese domestic flights are between the same region (JP–JP).

Table 3: Regions for traffic growth forecast

Code	States/Countries
KOR	Republic of Korea
CHN	People’s Republic of China & Mongolia, excluding Taiwan.
TW	Taiwan.
OCE	Oceania including Hawai’i.
SWASIA	India, Nepal and the Middle East.
ASEAN	Association of Southeast Asian Nations.
EUR	Europe, excluding CIS states.
CIS	Commonwealth of Independent States.
NAM	Canada, the contiguous United States and Alaska.
JP	Japan.

Figure 1 shows the overall traffic growth in the Fukuoka FIR. Data for 2011 and 2012 are historical, 2013–2030 are forecast. Domestic growth is largely flat (around 6%) while international traffic (between an airport in Japan and overseas) grows by ~80% and overflights grow by ~70%. Growth factors are given in [1].

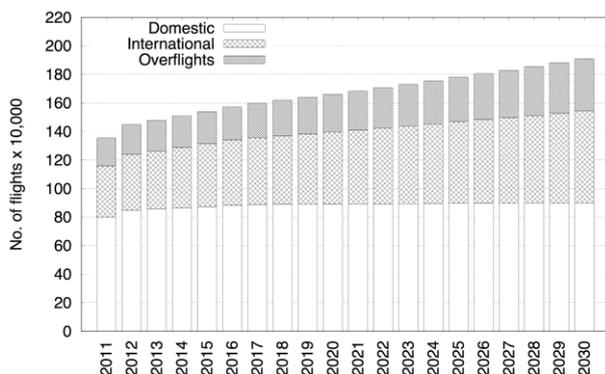


Figure 1: Overall traffic growth forecast

Given a baseline traffic scenario S and a set of growth factors $c(R_A, R_B)$ between regions R_A and R_B , we derive a forecast traffic scenario S' by a “copy and shift” procedure. For each region pair (R_A, R_B) , let the set of flights from R_A to R_B in S be $F(R_A, R_B) = \{ f_1, f_2, \dots, f_n \}$ and let $F'(R_A, R_B)$ be the corresponding traffic flow in the forecast scenario. If there are n flights in F , the number of flights n' in F' is obtained as $n' = \text{ceil}(c(R_A, R_B) \cdot n)$ where $\text{ceil}(x)$ is the smallest integer greater than x . To make F' , we take the set of n flights from F and add “growth” traffic, that is

$$F' = \{ f_1, f_2, \dots, f_n, f_{n+1}, \dots, f_{n'} \}$$

where the “growth” traffic $f_{n+1} \dots f_{n'}$ is created as follows:

1. Pick a random flight $f_k \in F$ where $k = \text{rand}(0, n)$ and $\text{rand}(a, b)$ is a function that gives a random integer in the interval (a, b)
2. Create a flight $f' = \text{shift}(f_k, \text{rand}(-20, 20))$ where $\text{shift}(a, b)$ is a function that shifts the arrival and departure times of flight a by b minutes.
3. Add f' to F' .
4. Repeat steps 1–3 until there are n' flights in F' .

Since growth traffic is selected randomly, each S' differs slightly. We therefore created 50 2030 forecast scenarios corresponding to each 2013 baseline scenario and took the averages.

The forecasts have the following characteristics:

- The growth traffic is added between existing city pairs. We do not model the creation of routes.
- The ratios of traffic between each airport and a region remain constant; that is, the traffic growth model does not account for competition for traffic between airports or changes in airport preference.

2.4 Runway Demand

To examine “typical” runway demand during normal operations, we plotted histograms of ATA and ATD for each airport binned at one-hour intervals for each schedule season.

Table 4: Estimated annual traffic and growth for each airport

Airport	T_{est} (2013)	T_{act} (2013)	e	T_{est} (2030)	Corr.	T_{pred} (2030)	Growth
RJAA	228,308	233,388	2.2%	383,980	0	383,980	72%
RJBB	141,255	131,930	-7.1%	223,198	-7.1%	216,641	64%
RJCC	137,780	134,312	-2.6%	148,738	0	148,748	11%
RJFF	157,681	170,640	7.6%	183,595	+7.6%	197,548	16%
RJGG	86,505	88,578	2.3%	116,983	0	116,983	32%
RJOO	129,210	136,132	5.1%	136,510	+5.1%	143,472	5%
RJTT	395,113	403,242	2.0%	448,403	0	448,403	11%
ROAH	120,450	147,302	18.2%	135,233	+18.2%	159,845	9%

We assume that the pattern of runway demand on each 2013 scenario day is “typical”, and verified this by comparing to the median and maximum runway demand in each one-hour bin for all days in the schedule periods for which data were available. (We selected the median rather than the mean because of its lower sensitivity to outliers that may occur when normal operations are disrupted.) For 2030 demand, we averaged the demand in each histogram bin over the 50 2030 summer and 50 2030 winter scenarios.

3. RESULTS

3.1 Annual Airport Traffic

Figure 2 shows actual annual airport traffic T_{act} and estimated traffic T_{est} for 2013. The values and errors e for 2013 are given in Table 4. The error magnitudes are within 5% except for RJBB, RJFF and RJOO and ROAH, and are within 10% except for ROAH. Comparing FDMS records for IFR flights 2014 and 2015 with landing statistics (which include VFR flights) reveals differences of around 6.6% for RJFF and 18.5% for ROAH. These figures are consistent with the RJFF and ROAH errors in Table 4, and we assume these errors are due largely to VFR traffic. The RJBB and RJOO errors are largely due to the difference between traffic on the scenario days and the true seasonal averages.

Taking estimates from the averaged 2030 scenarios, we applied corrections for errors in the 2013 data greater than 5% and derived forecast annual predicted traffic T_{pred} for 2030 and the growth over the 2013

traffic shown in Table 4. The actual 2013 and predicted 2030 traffic are shown in Figure 3.

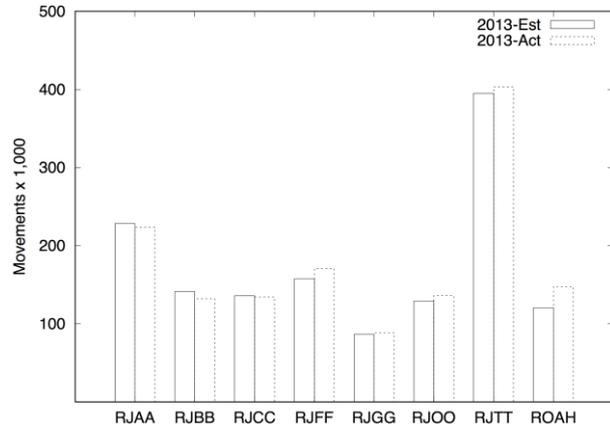


Figure 2: Annual traffic T_{est} and T_{act} for 2013

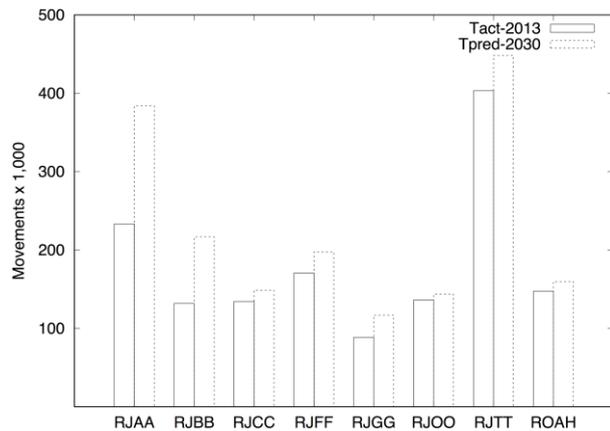


Figure 3: Actual 2013 and predicted 2030 annual traffic

3.2 Runway Demand

Figure 4 shows histograms of runway operations (ATA and ATD) at RJAA for the 2013 winter and

summer scenario days with “error bars” showing the maximum and median numbers of movements in each bin time interval during the schedule season. The closer the top of each bar is to the median (the bottom of the error bar), the nearer to seasonal average operations were during the scenario day. Operations at RJAA on the scenario days are close to average except for 18:00-19:00JST in the summer, where the traffic is at the schedule period maximum. The results for the other airports are similar. We conclude that the scenario days are reasonably representative of runway operations during the 2013 winter and summer schedule seasons.

Histograms for all airports are omitted due to lack of space, but as a typical example Figure 5 shows the RJAA runway demand histograms for the winter 2013 scenario day (top) and the average of the 2030 winter scenario days (bottom), with departures and arrivals indicated separately.

From these histograms, we extracted the peak hourly values from the summer and winter scenarios to determine the typical peak required runway throughput during normal operations for each airport. The results are shown in the summary table, Table 5.

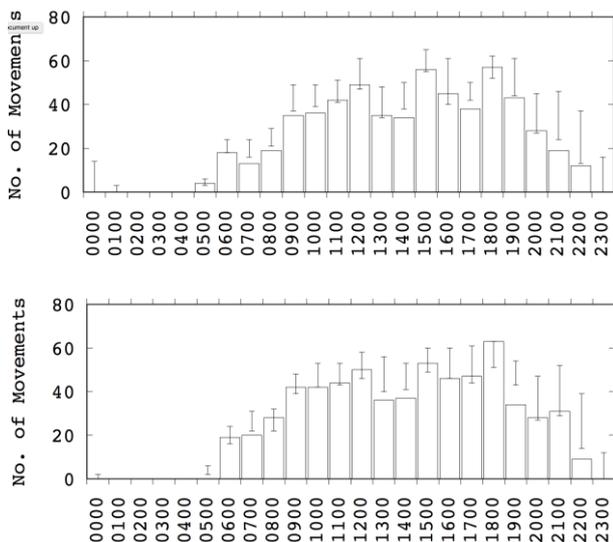


Figure 4: RJAA runway demand for winter (top) and summer (bottom) 2013 scenario days with schedule period median and maximum

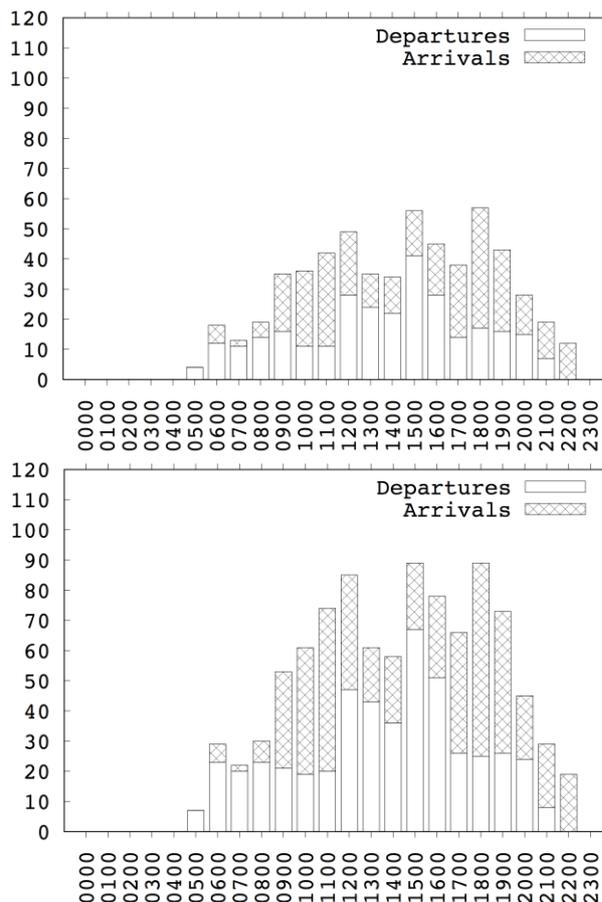


Figure 5: RJAA runway demand for winter scenarios: 2013 (top), 2030 (bottom)

3.3 Results Summary

Table 5 summarises our airport traffic forecast results. 2030 traffic values are T_{pred} from Table 4 rounded to the nearest multiple of 1,000. The numbers of runways at each airport and the 2016 operating times are shown to help judge whether airport capacity will be sufficient. For ease of comparison, the 2013 and 2030 traffic are plotted in Figure 6 with the airports in reverse 2013 rank order. The changes in peak hourly movements from 2013 to 2030 are plotted in Figure 7.

Figure 8 plots proportions of international and domestic traffic in T_{est} . (Note that these are not corrected for VFR traffic, which is entirely domestic.) The mainly domestic airports (RJTT, RJOO, ROAH) have only slight growth (<15%) while airports with significant international traffic grow more rapidly.

Table 5: Summary results

Airport	2013		2030		Growth	Runways	Operating Time (JST)
	Traffic	Peak/hr	Traffic	Peak/hr			
RJAA	233,388	63	384,000	101	72%	2 (3?)	06:00–23:00
RJBB	131,930	36	217,000	59	64%	2	24hr
RJCC	134,312	33	149,000	36	11%	2	24hr
RJFF	170,640	40	198,000	46	16%	1 (2 planned)	07:00–22:00
RJGG	88,578	23	117,000	34	32%	1	24hr
RJOO	136,132	38	143,000	39	5%	2	07:00-21:00
RJTT	403,242	78	448,000	88	11%	4	24hr
ROAH	147,302	35	160,000	39	9%	1 (2 planned)	24hr

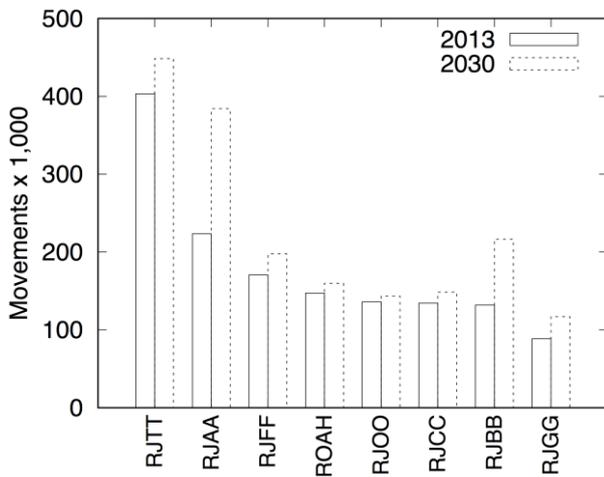


Figure 6: Traffic growth from 2013 to 2030 plotted in reverse rank order for 2013

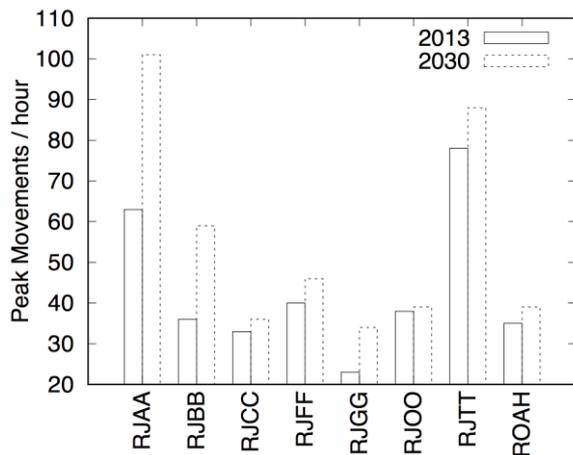


Figure 7 Peak hourly movements at each airport for 2013 and 2030

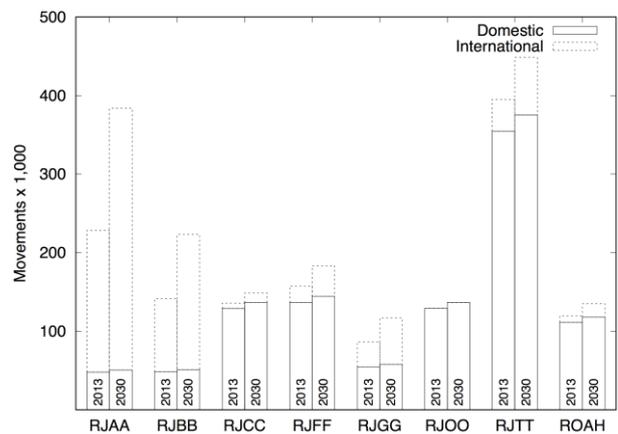


Figure 8: T_{est} for 2013 and 2030 with proportions of domestic and international traffic

In particular, traffic at RJAA is expected to increase by >70%, and RJAA will remain the top international airport in Japan, while RJBB will grow by more than 60% as the international gateway for the Kansai region. RJGG will grow by over 30% but the overall traffic level in 2030 is still relatively modest at 117,000 movements per year.

4. DISCUSSION

We now discuss airports in more detail based on our forecast and add speculations regarding the ability of airports to satisfy future demand. Capacity constraints differ at each airport and include environment (noise), air traffic control and management, parking and terminal constraints [4], but we do not consider these comprehensively in this

brief assessment.

4.1 RJCC, RJGG, ROAH

The projected demand for these three airports appears to be within capacity given the available and planned runways and their 24-hour opening (indicating fewer noise restrictions), provided that terminal and parking capacity are sufficient.

RJCC serves the metropolitan area of Sapporo, Hokkaido's largest city. Although the airport is inland, the surrounding population density is relatively low which allows it to operate 24 hours. In 2013, only around 5% of its traffic was international, and overall growth to 2030 is expected to be ~11% to 149,000 movements/year. There is almost constant hourly demand between 08:00 and 22:00 and a peak of less than 40 movements/hour.

RJGG was built on an artificial island to replace Nagoya Airport (RJNA), which is in a built-up area. It has a single runway and 24-hour operation. Its international traffic means that it will grow by ~32% from 2013 to 2030, needing a capacity of around 117,000 movements a year and runway capacity of around 35 movements/hour from its single runway to handle a traffic peak between 09:00 and 10:00 JST.

ROAH serves the island of Okinawa and is a hub for short services to smaller islands in the Ryukyu archipelago. The airport is 24-hour and there are plans for a second runway. We expect traffic to grow from around 147,000 movements in 2013 (including ~18% VFR traffic) to around 160,000 movements in 2030 assuming the proportion of VFR traffic remains the same. There is a single traffic peak in the middle of the day that in 2030 is expected to be around 40 movements/hour in the summer (excluding VFR). A second runway could better allow VFR traffic to coexist with IFR traffic during peaks by segregation.

4.2 Kanto Area (RJAA, RJTT)

RJAA is expected to remain Japan's primary international airport and will need to handle around 384,000 movements in 2030. Because it is built inland, noise concerns mean that it does not have 24-hour operation. To help meet demand, a third

terminal opened in 2015 and there are proposals to construct a third runway. Figures 4 and 5 indicate a mid-afternoon arrival peak around at 15:00 and an evening departure peak around at 18:00. There is currently an agreement with local communities to limit movements to 68/hour, but our analysis indicates that peaks could exceed 100/hour in 2030, and could exceed the current cap even if the traffic could be evenly redistributed within the current operating hours. Since RJAA has many long haul and connecting flights, the scope for redistributing flights may be limited.

RJTT will remain Japan's busiest airport and primary domestic hub. Our forecast shows ~11% growth to 2030. Hourly runway demand is much more constant than at RJAA during daylight hours, and peak demand grows from 78 movements/hour to 88 movements/hour divided between four dependent runways.

A limitation of our traffic growth model is that it does not take into account factors that could alter the distribution of traffic between airports. RJTT is closer to Tokyo, Kawasaki and Yokohama than RJAA and is hence more convenient, and its location in Tokyo Bay means that it can operate with fewer noise constraints. Its international growth is being actively promoted, and will be largely at the expense of RJAA. However, although demand is high, international traffic at RJTT has not grown as much as expected because of difficulties in increasing capacity. To meet high demand at both RJTT and RJAA, the application of recategorised wake turbulence separation standards, dynamic wake vortex separation and GBAS curved approaches could help increase runway capacity and reduce community noise.

4.3 Kansai Area (RJBB, RJOO)

RJOO, an inland airport in a heavily built-up area, was the primary international and domestic airport for Osaka and the Kansai region prior to the construction of RJBB on an artificial island. It was intended to close RJOO after RJBB opened in 1994, but RJOO remains open since it is more convenient to reach

from Osaka city and it remains as a domestic airport, while RJBB serves as Kansai's international airport. We expect RJOO to continue to handle most of the region's domestic traffic, and since it will grow only slightly from around 136,000 movements in 2013 to 143,000 movements in 2030, capacity should not be an issue.

While RJBB has only around a third of the domestic traffic of RJOO, it will grow by more than 60% due to international demand, requiring some 217,000 movements in 2030 and a peak runway demand of around 60 movements/hour. These are similar to RJAA traffic in 2013, but we have not considered terminal or parking capacity. In recent years, RJBB traffic has been growing more rapidly than expected, particularly international flights to Asia and with low-cost carriers.

4.4 Kyushu (RJFF)

RJFF is the largest airport in Kyushu and serves the area around the Fukuoka metropolis. It has a single runway and expansion is constrained by its location in a built-up area and nearby mountains. Operating hours are between 07:00 and 22:00. The airport is expected to grow by ~16% from 171,000 movements in 2013 to 198,000 movements in 2030. There are two peaks in demand, 10:00-11:00 and 17:00-18:00, and peak traffic is expected to increase from 40 movements/hour to 46 movements/hour. To meet demand, an additional dependent runway is planned within the airport's existing boundary, but space for additional terminal and parking capacity is limited.

As we have seen, RJBB, RJGG were built on artificial islands to relieve airports with limited space for growth in noise-sensitive areas. Kitakyushu airport (RJFR), built on an artificial island, opened in 2006 and is around 65 km from RJFF. However, it is a 40-minute bus journey from RJFR to Kokura railway station and an additional 30 minutes from Kokura to Hakata station in Fukuoka city centre. In contrast, Hakata station can be reached from RJFF in 6 minutes. It will therefore be hard to offload traffic from RJFF to RJFR to compete with RJFF without

significant incentives.

5. CONCLUSION

We present a forecast of airport demand for the eight busiest airports in Japan for 2030, based on a 2013 forecast. Due to a lack of complete data in our 2013 baseline, we devised a method to estimate annual traffic demand from two assumed typical days. We applied the method to averaged traffic growth scenarios, correcting for "missing" VFR traffic using historical data, to obtain traffic predictions.

It should be noted that our traffic growth model was based on 2013 projections and in fact, overall growth in 2016 has been greater than expected. The forecast should therefore be revised with later data.

A limitation of our forecast is that it does not take into account factors such as policy and competition that alter the distribution of traffic between airports. However, planning does not always give the desired outcomes.

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