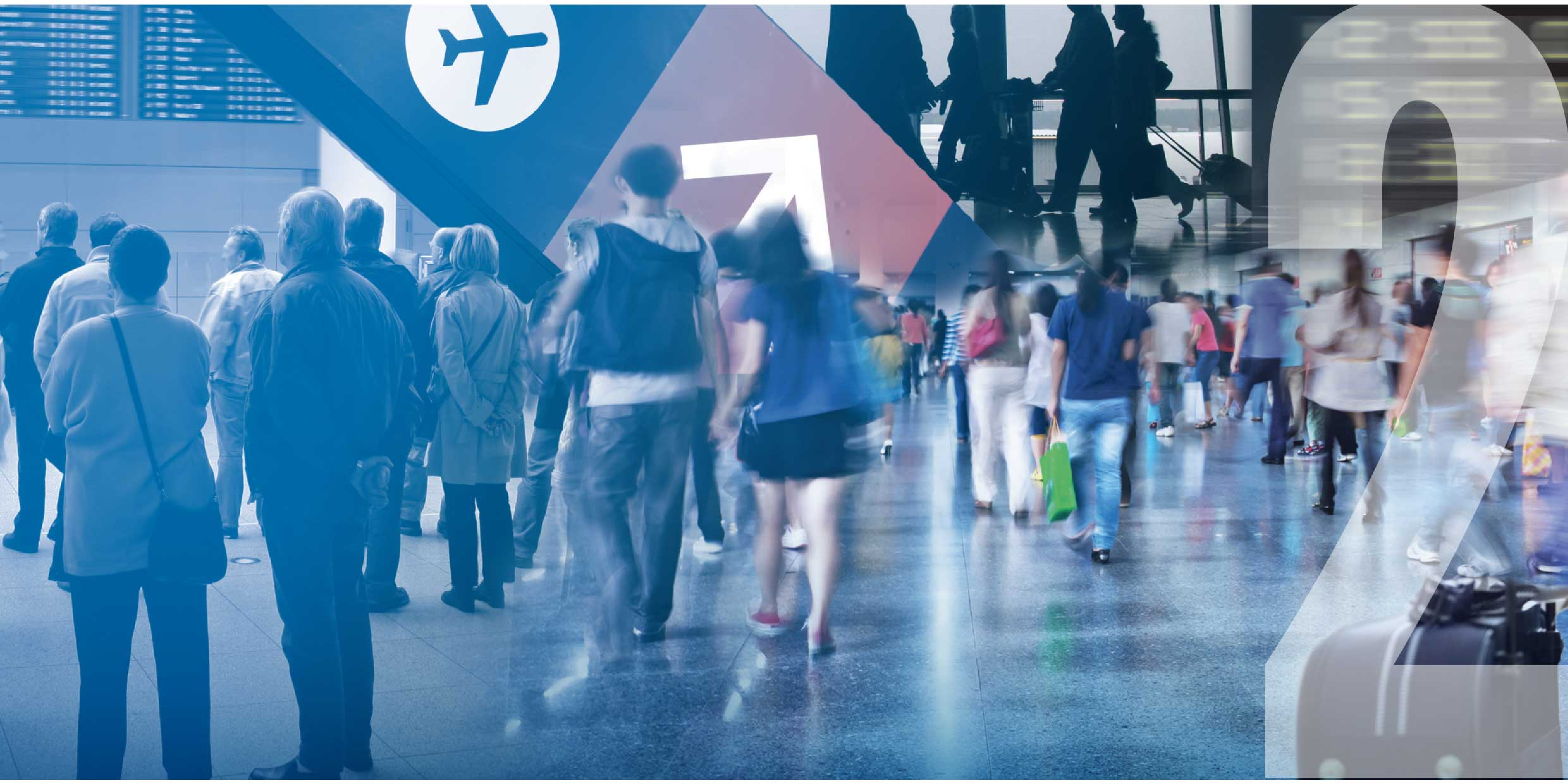
Joint Study on aviation capacity in the Sydney region

Volume 2

TECHNICAL PAPERS



REPORT TO

Australian Government

NSW GOVERNMENT

Sydney (Kingsford-Smith) Airport airfield capacity review

B1

AIRSERVICES AUSTRALIA

Sydney (Kingsford-Smith) Airport

Airfield Capacity Review

Final Report

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Sydney (Kingsford-Smith) Airport
Airfield Capacity Review

Final Report

December 2011

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Executive Summary

Introduction

Landrum & Brown (L&B) were appointed by Airservices Australia (AsA) on behalf of the Department of Infrastructure and Transport (DOIT) to assess, through simulation modeling, the ability of the existing and future ground capacity (apron and taxiways) at Sydney (Kingsford-Smith) Airport to meet forecast activity through 2035. There is an existing cap on runway movements (take-offs and landings) at the Airport of 80 movements per hour. With the 80 movement cap in place, the study was to consider whether the taxiway and/or aircraft stands (parking positions) were limiting factors to forecast demand.

Key inputs into this modeling study were aviation forecasts provided by Booz and Co. as well as planned Airport expansion layouts and associated staging from the Sydney Airport Corporation Limited (SACL) published Sydney Airport Master Plan 2009 (Master Plan 2009). The findings of this report are therefore greatly dependent on these key inputs. In addition, as this study was conducted independently from consultation with Sydney Airport Corporation Limited, some assumptions had to be made with regard to aircraft stand gauge (size), operating procedures and timing of implementation of expansion.

The terms of reference of this study were limited to demand/capacity assessment of the taxiways and aircraft stands and identifying capacity constraints that relate to these factors. Finding potential solutions to alleviate capacity constraints was outside the terms of reference.

The key finding of the modeling is that there appears to be a shortfall in aircraft stand capacity to meet forecast demand and that this shortfall is particularly significant in the short to medium term (next five to ten years). This is being driven by substantial forecast aircraft movement growth in peak periods but construction of additional aircraft stands will not be completed in sufficient time to accommodate this demand within the corresponding timeframe. It is possible that adjusting or limiting additional growth in the peak period of the schedule could alleviate some of this shortfall; however the magnitude of the shortfall does suggest concern. If confirmed through subsequent discussions with Sydney Airport Corporation Limited, then inability to provide additional stand capacity will constrain forecast growth with some potential loss of traffic for Sydney (Kingsford-Smith) Airport.

Modeling Approach

Stands (or gates) are aircraft parking positions that are required for the period of time that an aircraft is on the ground between arrival and departure. Ground times or "turnaround times" vary and are dependent on a number of factors relating to the airline network, the size of the aircraft, whether the flight is international or domestic and other factors. In essence, no matter what the airspace, runways or taxiways can sustain, there must be sufficient aircraft stands to accommodate the aircraft schedule (known as "gating the schedule") and reasonable variations of that schedule due to early or late arriving aircraft and late departing aircraft. To a certain extent it is possible to manage un-gated or off schedule aircraft movements on remote stands or by staging aircraft on un-used or non-critical taxiway sections. However, to sustain continued growth beyond these temporary operational measures it is essential to provide stands to match aircraft schedule growth. Otherwise too many arriving aircraft will be left stranded on the taxiway system which, in extreme incidences can lead to significant airfield congestion and delays. In a similar manner to insufficient runway or taxiway capacity, the effect of an aircraft stand capacity constraint is that if additional aircraft cannot be accommodated, growth of new aircraft schedules in peak periods will have to be restricted. Aircraft stand capacity can therefore become the limiting factor for continued aircraft movement growth and is a critical component of airfield infrastructure that needs to be developed to facilitate demand growth.

L&B utilized its proprietary Gate Management System (GMS) software to allocate flights to appropriate aircraft stands using operating rules and assumptions such as the size of aircraft that can be accommodated at a gate and airlines that are permitted to use a set of gates. The output of the GMS is a Gantt chart that shows how each stand is utilized throughout the design day and indicates arriving, departing and towed aircraft. Towed aircraft generally relate to long stay aircraft that are towed off and on contact (aerobridge) stands to optimize their use for embarking and disembarking passengers.

If there are insufficient stands to meet the schedule, and if further schedule adjustment is not feasible, then the "un-gated flights" that cannot be accommodated on aircraft stands are effectively lost and cannot operate to and from Sydney (Kingsford-Smith) Airport. Airlines can and do make adjustments to their schedules to minimize such limitations to the extent practical. But, it should be noted that schedule adjustment was not within L&B's terms of reference.

The subsequent "gated schedule" represents a stand-constrained level of demand and forms the key input into the airfield simulation modeling of the taxiway system using the internationally accepting Total Airspace and Airport Modeler (TAAM). The "un-gated flights" that cannot be accommodated on aircraft stands are therefore not modeled in the subsequent taxiway simulation. In this regard, the actual aircraft schedule activity that is simulated is lower than the unconstrained forecast aircraft movement demand in the original Booz and Co. forecast. This represents a practical scenario in terms of modeling achievable forecast growth. If stand constraints were removed, a higher number of movements would occur on the taxiway system resulting in potentially higher delays.

The TAAM model simulates and animates, in real time, the arrival, departure and towing of aircraft on the airfield to assess performance and, in this case, focusing on taxiway performance.

Ground Capacity Analysis Outcomes

Aircraft Stands – Demand vs. Capacity

The assessment of future aircraft stand capacity was based on future schedule forecasts for the years 2015, 2020 and 2035 prepared by Booz & Co. (July 2011). These forecast schedules identified information including aircraft types, airlines, origin/destination sector information and also flight arrival/departure times that dictate the flight turnaround time (or time on ground) for each aircraft in this gate allocation analysis. Figure 1.1 shows the forecast growth in aircraft schedule measured by hourly movements (arrivals or departures).

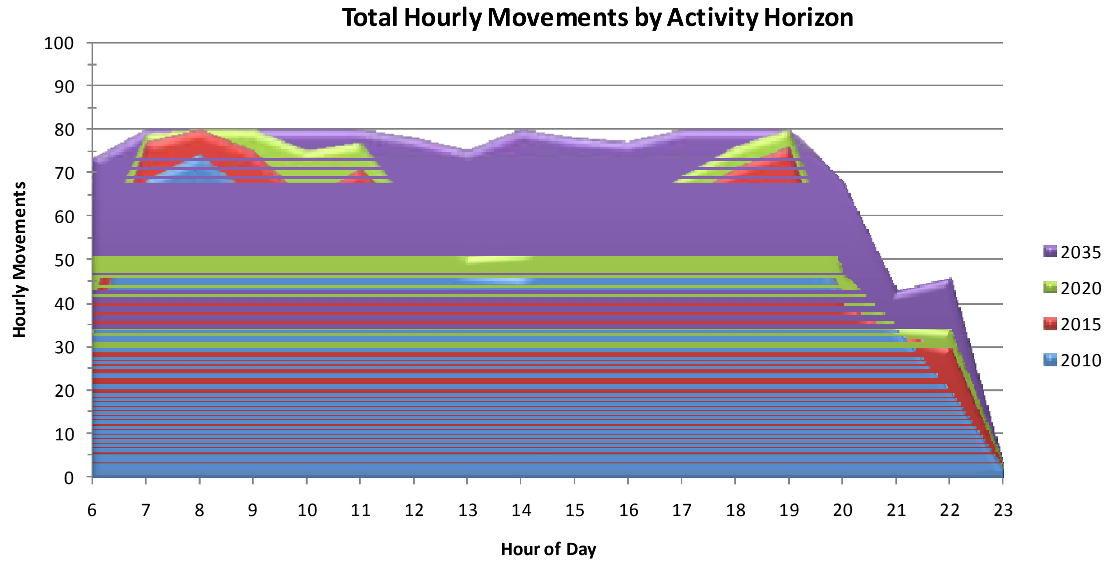


Figure 1.1 – Forecast Schedules - Comparison of Hourly Movements (source: Booz & Co., July 2011)

Analysis of existing demand (12th November 2010 baseline aircraft schedule selected by Booz & Co.) showed that aircraft stands / aprons are heavily utilised in peak morning and evening periods. In particular T1 and T3 have limited ability to accommodate additional aircraft during peak hours. Refer to gate allocation Gantt chart extracts in Figures 1.2 through 1.4 for illustration of the aircraft activity (coloured bars) allocated to each stand (row).

T1 (Intl) Peak Stand Utilisation

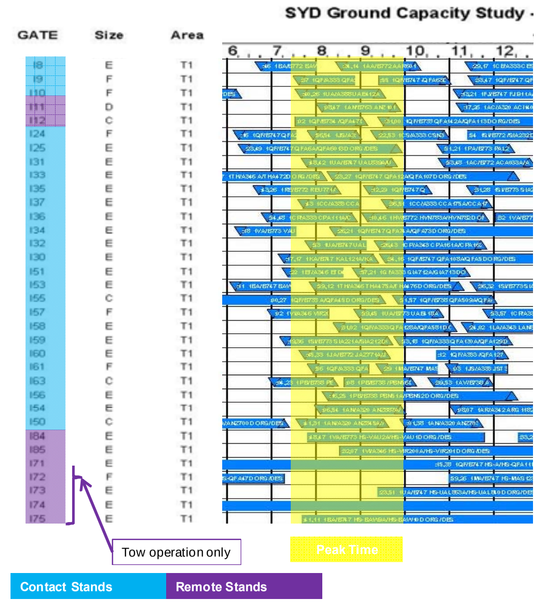


Figure 1.1 – T1 2010 Stand Allocation Chart Extract

Existing stands are heavily occupied through the morning. Between 07:30 to 10:00, there is no room available to accommodate extra arrivals on the contact stands. This is even the case for minimum 70 minute occupancy of an arrival prior to tow-off.

T2 (Dom) Peak Stand Utilisation

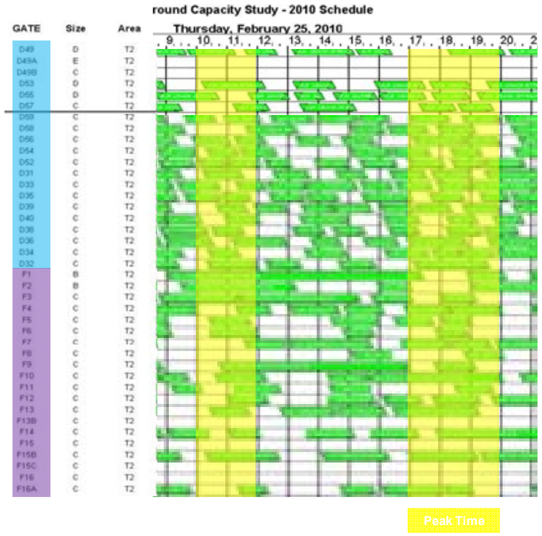


Figure 1.2 – T2 2010 Stand Allocation Chart Extract

The peak morning and evening periods (10:00-12:00 and 17:00-20:00) show some gaps available to accommodate extra demand, but mostly on 'walk-out' (regional aircraft) stands (F1 – F16). Some blank lines on the chart are stands that have alternate (dependent) positions.

T3 (QF) Peak Stand Utilisation

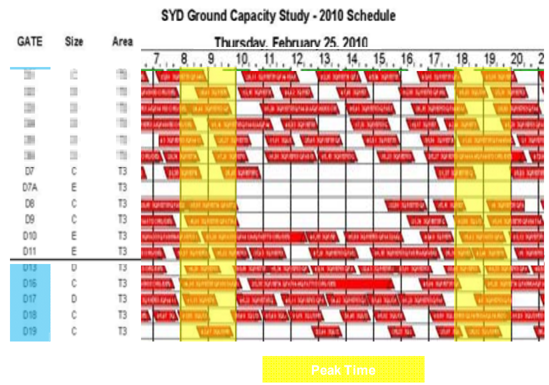


Figure 1.3 – T3 (Qantas Domestic) 2010 Stand Allocation Chart Extract

The chart demonstrates a consistently high level of stand utilisation throughout the day, with few gaps for accommodating additional demand. During morning and evening peak times (08:00-10:00 and 17:00-20:00) all stands are occupied.

Results from the aircraft stand allocation analysis from modelling forecast aircraft schedule demand versus planned stand provisions are summarised in Table 1.1.

Table 1.1 – Summary of Stand Allocation Analysis Results

Year	2010	2015	2020	2035
Aircraft Stand Provision[(1)]				
T1	34	34	38	38
T2	34	39	41	53
T3	16	16	16	14
Aircraft Movements in Peak 3hr Periods				
T1 (0700-0959)	53	65	69	74
(1600–1859)	36	32	36	40
T2 (0900-1159)	82	107	114	129
(1700-1959)	114	125	143	157
T3 (0800-1059)	45	52	52	46
(1800-2059)	43	46	43	43
Average Flight Turnaround Time[(2)]				
T1	3hr 19min	3hr 13min	3hr 10min	2hr 58min
T2	1hr 18min	1hr 20min	1hr 12min	1hr 11min
T3	1hr 24min	1hr 32min	1hr 45min	1hr 24min
Average Aircraft Turns per Stand[(3)]				
T1	4	4	4	4
T2	6	7	8	9
T3	7	6	6	9
Maximum Aircraft Turns per Stand[(3)]				
T1	6	6	5	7
T2	11	11	11	12
T3	9	8	8	10
Aircraft Turns not Accommodated				
T1	n/a	12	7	7
T2	n/a	19	14	27
T3	n/a	28	9	5
Total		59	30	39
Additional Stands Required to meet Forecast				
T1	n/a	8	7	6
T2	n/a	9	8	8
T3	n/a	8	4	2
Total		25	19	16

Notes: (1) Counted from Master Plan Concept airport layout for 2029 drawing. Contact plus remote stands used for each terminal. Does not include freight apron stands.

(2) Turnaround time is defined as the time between arrival and departure at the stand. The times shown are paired flights. Does not include overnight (Arrival Only or Departure Only) flights.

(3) Aircraft turns per stand per day. Does not include remote stands for aircraft tow-off.

The analysis showed that there is a shortfall in aircraft stands to meet the forecast 2015, 2020 and 2035 demand.

- Beyond the current plan to add five Code C (e.g. B737) stands to T2, the Master Plan 2009 shows no additional aircraft stand provision until after 2015, even though there is strong aircraft movement growth in the corresponding period. The implementation program from the Master Plan 2009 delivers additional stands by 2020 which will accommodate additional aircraft movements.
- The analysis showed a shortfall in capacity that is pronounced in the short term (2015, 2020) because planned stand expansion will be unable to keep pace with the expected aircraft schedule growth and aircraft up-gauging forecast by Booz & Co. Up to 59 daily aircraft movements from the forecast schedule cannot be accommodated in 2015 and 30 movements in 2020.
- The 2029 airport layout plan shows an increased provision of stands for large aircraft types to accommodate the up-sizing of aircraft over time. However, for T3 in particular and to a lesser extent T2, the Master Plan 2009 suggests that most up-sizing of stands occurs beyond 2020, whereas the forecast suggests a need to up-size the stands earlier.
- Based on demand vs. capacity analysis of the Booz & Co. forecast schedules vs. aircraft stand provision in the Master Plan Concept layout, approximately 1,200 daily movements appear to be the approximate capacity limit in terms of aircraft movements that can be accommodated on available aprons and stands.
- It should be noted that the current 20 year Master Plan Concept layout coincides with a 2029 planning horizon and the Booz & Co. forecast extends to 2035; so there is not a direct correlation in the out years.

Taxiways

Simulation modelling of the airfield and taxiway system was undertaken using the Total Airspace and Airport Modeller (TAAM) software. Future demand was based on the gated aircraft schedules from the stand capacity work. Influencing factors on the ability of the taxiway system to accommodate demand included:

- Runway mode of operation (flow direction);
- Departure queues for RWY 16R which, along with proximity of terminal aprons, result in more pronounced taxiway congestion in South Flow conditions (arrivals and departures on RWY 16L / RWY 16R);

- Aircraft tow-offs to remote stands due to long layovers to free up contact stands in terminal precincts;
- A single east-west taxiway (TWY Golf) only, is adjacent to the domestic terminal precinct;
- Arriving aircraft waiting for access to single taxi lane cul-de-sac aprons occupied by departure push-backs.

The taxiways are influenced by apron access/egress (and therefore any congestion on the aprons), runway usage and the movement of aircraft to/from runways. In this regard, these three elements form an integrated and dependent system that was modelled in the airfield simulation.

Runway allocation for flights is governed by factors relating to destination airport which dictates flight path/direction and also aircraft size. For example, large, heavy aircraft and long-haul international flights must use the main runway (RWY 16R/34L). Aircraft using the shorter parallel runway, RWY 16L/34R, for departure are limited to maximum B767 / A330 size aircraft for domestic routes. Historically, runway usage split averages 67% on the main runway and 33% on the shorter parallel runway and this was the case for the November 2009 typical busy-day aircraft schedule used as the baseline for the simulation analysis. This split remains the case for South Flow conditions (RWY 16L / RWY 16R) but in North Flow conditions (RWY 34L / RWY 34R), the difference is reduced slightly to 65%:35% through 2010 and 2011, and the split is even more balanced (as far as 58%:42%) for approximately four months each year.

The airfield simulation of future demand scenarios maintained aircraft size restrictions governing runway allocation but assumed greater balancing of runway usage in future, with a 55%/45% split of ‘main runway’ to ‘parallel runway’ in both North and South Flow conditions. This is a somewhat optimised situation with the simulation model attempting to limit delays on the airfield through more balanced traffic flow. It is acknowledged that achieving this on a more regular basis could be difficult, particularly in South Flow (RWY 16L / RWY 16R) where current flight path limitations for domestic flights apply. However, it should be noted that this level of split has been demonstrated historically in North Flow conditions (RWY 34L / RWY 34R), for example, through January 2011, and is therefore possible.

The airfield simulation included all aircraft that could be accommodated by available aircraft stands. Aircraft tow-offs to remote stands were also modelled to measure their interaction with other aircraft movements whilst crossing runways and on the taxiways.

The ability of the taxiway system to accommodate forecast aircraft schedule demand was based on identification of aircraft movement delays from the simulation model. In terms of what constitutes *acceptable delay*, each airport is different. Ideally airports should sustain minimal delays to operations and should expand capacity when required to avoid lengthy delays. However, in situation where adding capacity is not feasible, many busy airports around the world (and airlines operating at these airports) will accept and manage to a level of delay in which the airline schedule integrity can be maintained, and whereby the operation can recover from periods of high delays quickly, usually within an hour.

Based on international experience of "acceptable delay" at busy, site constrained airports, benchmarks of average daily delay less than 8 minutes and no more than two continuous hours of departure or arrival delay greater than 15 minutes, were assumed as delay threshold metrics for the analysis. In all cases, the modelling results did not exceed these thresholds. The average delay threshold assumed for peak hour was 16 minutes per aircraft movement.

Based on the more balanced runway usage split modelled in both modes, average peak hour delay results are shown in Table 1.2.

Table 1.2 – Airfield Simulation – Average Peak Hour Delay Results

Demand Level	2009		2015		2035 - Existing Taxiways		2035 – Master Plan Concept Layout	
Flow Direction	**North**	**South**	**North**	**South**	**North**	**South**	**North**	**South**
Aircraft Movements	888	888	911	911	1,187	1,187	1,187	1,187
Average Delay in Peak Hour (mins)	6.9	7.2	3.4	3.3	10.2	12.3	7.2	6.9
Average Peak Hour ARR / DEP delay (mins)(1)	5.7 / 12.0	5.4 / 11.1)	2.2 / 5.1	1.8 / 4.9	8.9 / 14.8	12.2 / 13.2	5.0 / 9.5	4.7 / 10.1
% Mvts > Peak Hour Average Delay	36%	29%	52%	52%	16%	20%	15%	18%

6.9	Average Peak Hour Delay
(5.7 / 12.0)	(Average Peak Hour Arrival / Departure Delay)

Note: (1) Averaging individual arrival and departure delays does not equate to the total average delay because the number of arrival and departure movements is not balanced.

When simulating the long-term 2035 demand on the existing taxiway system (without planned taxiway enhancements) average peak hour aircraft delays increased to 10.2 minutes in North Flow and 12.3 minutes in South Flow.

Incorporating all proposed taxiway enhancements in the Master Plan Concept layout improved the average peak hour delay results to 7.2 minutes in North Flow and 6.9 minutes in South Flow. This demonstrates a clear benefit of the proposed taxiway enhancements in terms of accommodating long-term aircraft demand on the airfield at a relatively good level of operational service.

Discussion of Ground Capacity Factors

By the nature of the configuration of Sydney (Kingsford-Smith) Airport with terminal apron areas all at the far north end of the airfield, most aircraft movements need to manoeuvre via Taxiways Alpha, Bravo and Charlie which are adjacent to the aprons. When the airfield is operating in South Flow (RWY 16L / RWY 16R) aircraft seeking apron access/egress compete for taxiway space with aircraft departure queues for RWY 16R.

International aircraft tow-offs, especially for the largest aircraft types (A340-600, B777-300 and A380) also have an effect on managing aircraft flows and taxiway congestion. Due to the nature of international schedules with long turnaround times for many flights and limited space for aprons in the T1 precinct, towing aircraft to other apron locations is necessary to make contact stands available for subsequent arrivals. When these slow moving tow operations are in motion on the taxiways (for example, aircraft crossing the main runway to the Northern Pond or Qantas Jet Base remote stands) this can exacerbate localised congestion and traffic management issues.

Unavailability of aircraft stands or aircraft push-backs into single taxi-lane cul-de-sac aprons can result in arriving aircraft being held on airfield taxiways whilst waiting for access. During a visit to the Air Traffic Control Tower (ATCT), a couple of such incidents were observed for Virgin Australia domestic aircraft waiting on TWY Golf and RWY 07/25 for access to T2 aprons, and also for Qantas domestic aircraft waiting on TWY Bravo/Charlie for access to T3 apron.

As aircraft movement demand grows over the coming five to ten years these issues will increase further, particularly in peak periods. If additional stands are not provided, then rather than additional flights being accepted and being held on taxiways until an apron stand is available, growth in the aircraft schedule will have to be curtailed in the peak hours. Otherwise, aircraft stand constraints will have cascading effects for the taxiway system causing ground traffic management, congestion and delay implications. This would affect the ability of the taxiway system to accommodate forecast demand within reasonable levels of delay.

Increasing aircraft stand provision to match forecast demand is therefore important to accommodate arriving / departing aircraft and protect against aircraft delays on the taxiway system.

Conclusions

a) The modelling predicts that a shortfall in aircraft stands will be the limiting ground factor in terms of accommodating forecast demand at Sydney (Kingsford-Smith) Airport.

b) In the short term (five years) in particular, provision of stands would appear to be well below the forecast demand with modelling showing up to 59 forecast daily movements not able to be accommodated at Sydney (Kingsford-Smith) Airport at 2015 forecast demand levels.

c) The current Master Plan Concept ultimate development plan shows significant up-sizing of aircraft stands to accommodate the forecast up-gauging of the aircraft fleet operating at Sydney (Kingsford-Smith) Airport. However, based on the forecast schedules and the staging plans shown in the Master Plan 2009, the rate of up-gauging of stands appears to fall below demand in the period leading up to 2020.

d) The aircraft stand modelling indicates that approximately 1,200 daily aircraft movements (dependent on aircraft schedule characteristics and aircraft turnaround time) appears to be the approximate limit of capacity at Sydney (Kingsford-Smith) Airport governed by available stands in the Master Plan Concept layout.

e) The simulation modelling of the airfield system, including enhancements planned in the Master Plan 2009, predicts that the taxiway system can accommodate the forecast aircraft movement growth within assumed 'acceptable' delay thresholds. This is based on simulating the 'gated aircraft schedule' from the aircraft stand modelling exercise, i.e. all flights that could be accommodated on aircraft stands. Any provision of extra aircraft stands will facilitate some additional aircraft movements in accordance with the full Booz & Co. forecast aircraft schedules. Additional movements in the peak period could result in higher airfield delay results than those identified in this simulation of aircraft movement. The simulation of future demand scenarios also assumed greater runway usage balancing than currently occurs. Where possible, pursuing greater runway balancing of runway usage should be a target as this will help facilitate improved ground traffic flow and reduce delays on the taxiways.

It is recommended that the above conclusions and the assumptions behind them be discussed with Sydney Airport Corporation Limited. If the assumptions and the conclusions that emanate from them are validated, it is recommended that alternative implementation strategy should be explored with the aim of maximizing and accelerating stand provision to ensure potential aviation growth at Sydney (Kingsford-Smith) Airport is supported to the extent possible.

1.0 Introduction

1.1 Background

L&B were commissioned by Air services Australia (AsA) on behalf of Department of Infrastructure and Transport (DOIT) to assess the ability of Sydney (Kingsford-Smith) Airport to support gate demand and surface movements on current and proposed airside infrastructure.

In terms of the taxiway component of the brief, the intent of the taxiway simulation modeling effort is to identify if the taxiway structure is sufficient to accommodate the projected demand at the Airport and, if not, to identify the demand level that can be accommodated with the proposed infrastructure.

In consultation with AsA, L&B employed an analytical approach utilising accepted industry airside simulation modelling techniques to provide the level of fidelity needed to support decision making.

Demand vs. Capacity modelling was undertaken for gates (stands) using Gate Management System (GMS) software and for apron/taxiways using Total Airspace and Airport Modeller (TAAM) software.

1.2 Project Scope

To assess the airfield ground capacity to accommodate future forecast demand out to 2035, the scope of the study was to address the following:

- Establish the current capacity of aprons and gates.
- Establish the current taxiway capacity.
- Determine, against traffic demand forecasts, when additional apron and gate development will be required.
- Determine, against traffic demand forecasts, when aprons and gates will be at capacity.
- Determine, against traffic demand forecasts, when additional taxiway development will be required.
- Determine, against traffic demand forecasts, when taxiways will be at capacity.
- Determine the effect of aircraft up-gauging forecasts on the future capacity of apron, gates and taxiway infrastructure, including the time at which capacity on aprons, gates and taxiways will be reached.

As part of the study it was assumed that existing demand management rules at Sydney (Kingsford-Smith) Airport are maintained.

As agreed with AsA, Runway Mode of Operation (RMO) 9 and 10 were modelled/assessed in this study. These represent North flow and South flow respectively and were chosen as they generate the highest throughput in terms of aircraft movement to/from the runways via key taxiway sections.

2.0 Approach

2.1 Introduction

The initial taxi-flow review undertaken at the commencement of the study identified that critical issues related in terms of capacity constraints were likely to be:

- Departure queuing on taxiways
- Apron/Ramp congestion implications
- Runway crossing issues

To properly address these issues in responding to the study requirements the proposed approach was to use the Total Airspace and Airport Modeler (TAAM) simulation software package as the basis for taxiway capacity assessment, and L&B's proprietary Gate Management Software (GMS) package to model gate demand requirements.

2.2 Gate Management System (GMS) Model

L&B utilised in-house developed Gate Management System (GMS) software model to determine the gate requirements for each apron / terminal area. This is a sophisticated software package developed in conjunction with and tested operationally at some major airports (e.g. Chicago and Los Angeles). Using aircraft schedules, the GMS model allocates flights to stands, incorporating operational rules and dependencies governing aircraft stand usage. For example, factors such as inter-gate time, aircraft size capabilities, multiple lead-in line flexibilities and airline allocation preferences are all taken into account. The output is a gate allocation chart for the full day schedule.

The models allow a number of scenarios covering different demand horizons, aircraft fleet types, or apron area allocations to be assessed relatively quickly. Where appropriate, input parameters and forecast scenarios were discussed with ASA.

Within the GMS model, the gate requirements were determined for each of the separate airline allocation areas due to the nature of terminal layout and airline use at Sydney (Kingsford-Smith) Airport. The existing Sydney (Kingsford-Smith) Airport layout was used as the baseline, whilst the future Master Plan Concept layout for 2029 was the reference layouts in terms of planned terminal / apron expansions.

L&B developed GMS as a gate planning tool that also provides input into airfield simulation modelling and therefore the output can formatted into a gated aircraft schedule that feeds into the TAAM simulation model.

Where aircraft cannot be accommodated on available aircraft stand provision ('un-gated flights') these are not modelled in the taxiway simulation. In this case the simulated aircraft schedule activity is 'gate constrained' and therefore slightly lower than the unconstrained forecast demand. Greater provision of stands would accommodate additional flights, increasing aircraft movements on the taxiway system.

2.3 Total Airspace and Airport Modeler (TAAM)

In terms of the taxiway component of the brief, the intent of the taxiway simulation modeling effort is to identify if the taxiway structure is sufficient to accommodate the project demand at the Airport and, if not, to identify the demand level that can be accommodated with this proposed infrastructure.

The Total Airspace and Airport Modeler (TAAM) simulation software package was used as the basis for taxiway capacity assessment. TAAM is an accepted industry wide software package for modelling airfield/airspace that models all aspects of airport operation related to aircraft movement. Based on an aircraft schedule, the TAAM model can be used to assess the impacts of future levels of demand on both existing and proposed airfield layouts.

TAAM simulation takes into account implications from critical elements such as departure queuing on taxiways, apron/ramp congestion, pushback operations onto active taxiways, runway exit utilisation and runway crossings. The simulation incorporates these important effects on taxiway capacity and facilitates assessment of delay metrics related to aircraft movement.

Results of the models are in the form of overall taxi times, overall taxiway delays, and taxi delays on specific taxiway segments, which facilitate identification of key congestion areas on the airfield.

AsA had made available a set of TAAM model of Sydney (Kingsford-Smith) Airport that was provided to L&B at the commencement of the project. Originally developed in 2004, the model databases required updating to reflect current facilities and operations including modifications to taxiways, aprons, SIDs/STARs, operational procedures, taxiway flow routes, etc. Once updated these models were then used as the basis for developing the changes needed to reflect the Master Plan Concept taxiway and terminal improvement for future demand scenarios.

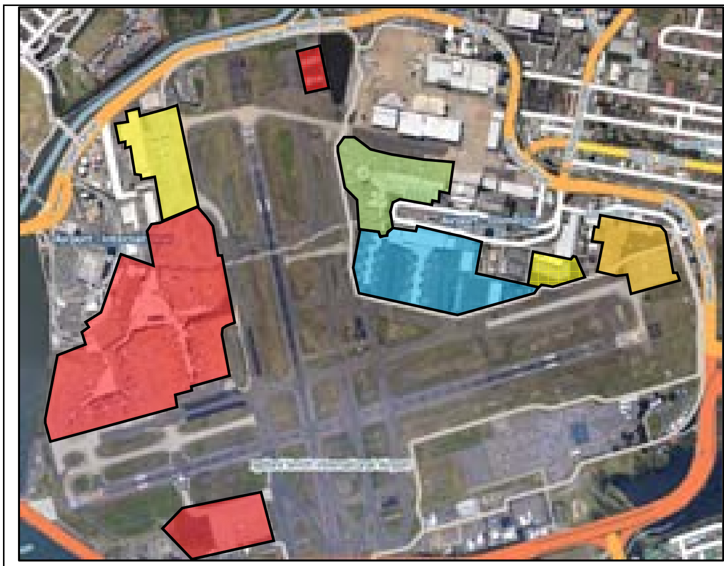
3.0 Airfield Layout

3.1 Existing Airfield Layout

The existing airfield layout at Sydney (Kingsford-Smith) Airport is comprised of two north-south parallel runways, a single crosswind runway and three key passenger terminals located to the northeast and northwest of the Airport site. Terminal 1 (international) is located on the northwest corner of the Airport site and is segregated from the other terminals by the main Runway 16R/34L. Both sides of Runway 16R/34L are provided with taxiway infrastructure to support the terminal operations with a single parallel taxiway on the west (TWY A) and two parallel taxiways on the east (TWY B & C).

3.1.1 Aprons/Gates

The following diagrams outline the provision of contact or remote stands for each of the apron areas within the existing airfield. The diagrams also provide an overview of the size of aircraft which can use each gate and the associated rules in which they must be operated under.



AC Type	Passenger						Freight		General Aviation
	T1		T2		T3		Int'l	Dom	
	Contact	Remote	Contact	Remote	Contact	Remote			
B1900				2					6
B737-800	3	1	15	14	7			5	2
B767-300		1	3		7				
B747-400	17	6			2		4		2
A380-800	5	1					1		
Total	25	9	18	16	16		5	5	10

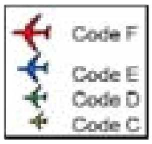
Figure 3.1 – Existing Aircraft Gate Provision

Terminal 1

Existing: 25 Contact Gates (5F17E3C), 9 Remote (1F6E1D1C)

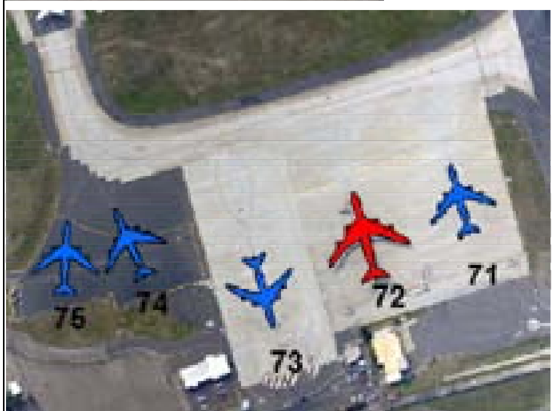
Gate	Capacity	Code
8	B747-400	E
9	A380-800	F
10	A380-800	F
11	B767-300	D
12	B737/A320	C
24	A380-800	F
25	B747-400	E
31	B747-400	E
33	B747-400	E
35	B747-400	E
37	B747-400	E
36	B747-400	E
34	B747-400	E
34A	B737/A320	C
32	B747-400	E
30	B747-400	E
51	B747-400	E
53	B747-400	E
55	B747-400	E
57	A380-800	F
58	B747-400	E
59	B747-400	E
60	B747-400	E
61	A380-800	F
[illegible]	B737/A320	C
56	B747-400	E
54	B777-200	E
[illegible]	B747-400	E

Rules:
All gates: Serve International flights
Gate12: No night operations allowed
Gate 34: not available if Bay 34A is occupied
Gate 54: Does not include B777-200LR



Gate	Capacity	Code
84	B747-400	E
84A	B777-300	E
83	B737-800	C
23	DHC8-300	C
24	DHC8-300	C
85	B747-400	E
85A	B777-300	E
20	DHC8-300	C
21	DHC8-300	C
22	DHC8-300	C
71	B747-400	E
72	A380-800	F
73	B747-400	E
74	B747-400	E
75	B747-400	E

Gate	Gates to be Vacant
20	85,85A
21	84,84A,85,85A
22	84,84A,85,85A
23	83,84,84A
24	83,84,84A
83	21,24,84,84A
84	23,24,83
84A	22,23,24,83A
85	20,21,22,85A
85A	20,21,22,85

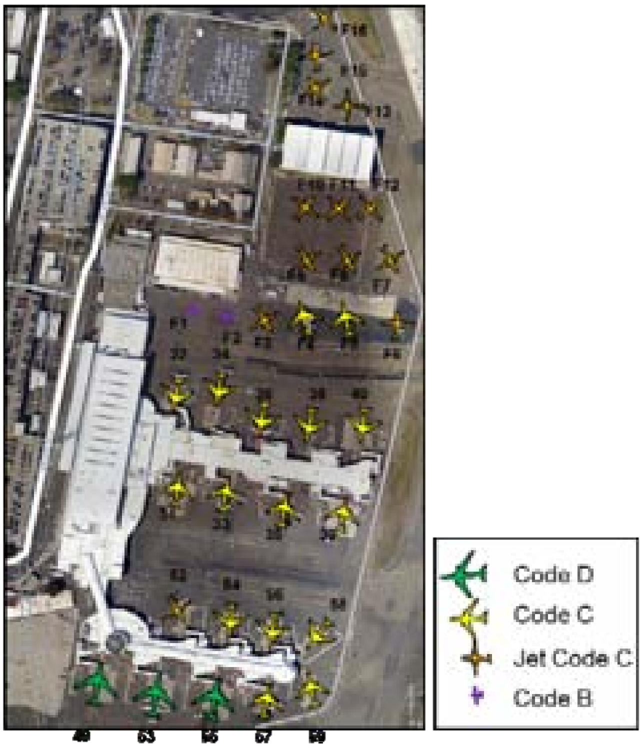


Rules:
All gates: Tow only
Gate 71-75:
•For layover parking only
•Not ava lable to facilitate passengers or freight.
•B777-300 and A340-600 is not permitted
•Gate 84A and Gate 85A: B777-300 only

Figure 3.2 – Existing Terminal 1 gate configuration

Terminal 2

Existing: 18 Contact Gates (3D15C), 16 Remote (14C2B)



Gate	Capacity	Code
49	B767-300	D
49A	B747-300	E
49B	DHC8-300	C
53	B767-300	D
53B	DHC8-300	C
55	B767-300	D
55B	DHC8-300	C
57	B737-700	C
57A	DHC8-300	C
57B	DHC8-300	C
59	B737-800	C
59B	DHC8-300	C
58	B737-800	C
56	B737-A321	C
56A	DHC8-300	C
54	B737-A321	C
54A	DHC8-300	C
52	B737-A321	C
52A	DHC8-300	C
31	B737-800	C
31B	DHC8-300	C
33	B737-800	C
33B	DHC8-300	C
35	B737-800	C
35B	DHC8-300	C
39	B737-800	C
39B	DHC8-300	C
40	B737-A321	C
40A	DHC8-300	C
38	B737-A321	C
38A	DHC8-300	C
36	B737-A321	C

Gate	Capacity	Code
36A	DHC8-300	C
34	B737-A321	C
34A	SAAB-340+	C
32	B737-800	C
32A	SAAB 340	C
F1	DHC8	B
F2	DHC8	B
F3	DHC8-300	C
F3A	DHC8-300	C
F4	B737-800	C
F4A	DHC8-300	C
F4B	DHC8-300	C
F5	B737-800	C
F5A	DHC8-300	C
F6	DHC8-300	C
F6A	DHC8-300	C
F7	DHC8-300	C
F7A	SAAB-340+	C
F8	DHC8-300	C
F9	SAAB 340	C
F10	SAAB-340+	C
F11	SAAB-340+	C
F12	SAAB-340+	C
F13	DHC8-300	C
F13A	DHC8-300	C
F13B	B737-800	C
F14	DHC8-300	C
F15	DHC8-300	C
F15A	DHC8-300	C
F15B	SAAB 340	C
F15C	B737-800	C
F16	DHC8-300	C
F16A	DHC8-300	C

Gate	Gates to be Vacant
49	49A, 49B
49A	49, 49B
49B	49, 49A
53	53B
53B	53
55	55B
55B	55
57	57A, 57B
57A	57, 57B
57B	57, 57A
59	59B
59B	59
31	31B
31B	31
33	33B
33B	33
35	35B
35B	35
39	39B
39B	39
52	52A
52A	52
54	54A
54A	54
56	56A
56A	56

Gate	Gates to be Vacant
32	32A
32A	32
34	34A
34A	34
36	36A
36A	36
38	38A
38A	38
40	40A
40A	40
F3	F3A
F3A	F3
F4	F4A, F4B
F4A	F4, F4B
F4B	F4, F4A
F5	F5A
F5A	F5
F6	F6A
F6A	F6
F7	F7A
F7A	F7
F13(DHC8-3)	F13A, F13B, F14
F13(S340)	F13A, F13B
F13A	F13, F13B, F14, F15
F13B	F13, F13A, F14, F15
F14	F13(DHC8), F15A, F15B, F15, F13A, F16A
F15	F13B, F14, F15A, F15B, F16A
F15A	F14, F15, F15B, F15C
F15B	F15, F15A, F15C
F15C F15C(F16-8)	F13B(S340), F14, F15, F15A, F15B, F16, F16A F16(S340), F15C, F16A
F16(S340)	F15C, F16A
F16A	F15C, F16

Rules:
Gate 49A: When is required for B747-2/300 aircraft, B53 is available for B767 or B737 aircraft with winglets
Gate 34: short parking of B737-700 only
Gate 36: short parking up to B737-700 is available
Gate 38&40: short parking up to B737-800 is available
Gate F3A: for layovers only
Gate F13(F13A&13B), F15(F15A,15B&15C) and F16(F16A): Primary position is not available if associated secondary position is occupied.
Gate F13A,F15A and F16A: reverse positions are to be used only when prevailing wind conditions.
Gate F13: restricted to S340 for Gate F14 arrival and departure
Gate F14,:
•not available when secondary position F13A used.
•Can be occupied but cannot departure when aircraft on Bay F15 and F15A.
Gate F13B and F15C: For layover aircraft only

Figure 3.3 – Existing Terminal 2 gate configuration

Terminal 3

Existing: 16 Contact Gates (2E7D7C)

Gate	Capacity	Code
1	B737	C
2	B767-300	D
3	B767-300	D
4	B767-300	D
5	B767-300	D
6	B767-300	D
7	B737	C
7A	B747-400	E
8	B737	C
9	B737	C
10	B747-400	E
11	A330-300	E
13	B767-300	D
16	B737	C
16A	DHC8-400	C
16B	DHC8-400	C
17	B767-300	D
17A	DHC8-400	C
17B	DHC8-400	C
18	DHC8-400	C
18A	DHC8-400	C
19	DHC8-400	C
19A	DHC8-400	C
19B	DHC8-400	C

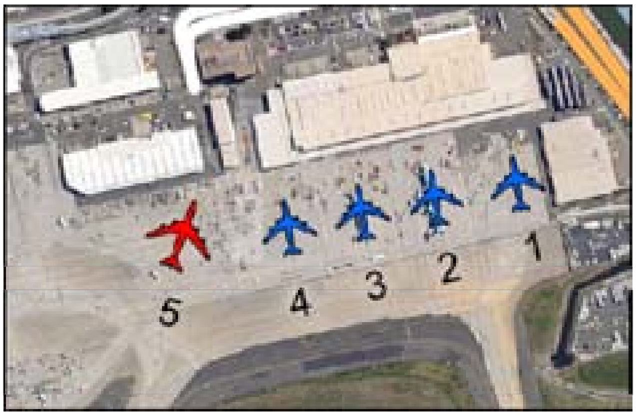
Gate	Gates to be Vacant
6	7A
7	7A
7A	6,7
16	16A, 16B
16A	16, 16B
16B	16, 16A
17	17A, 17B
17A	17, 17B
17B	17, 17A
18	18A, 19A, 19B
18A	18, 19A, 19B
19	19A, 19B
19A	19B
19B	19A

Rules:
Gate 19A and Gate 19B: cater for an overflow condition only
Gate 10: when B747-3/400 occupies the bay arriving or departing on Bay 9 are restricted to maximum B737-400

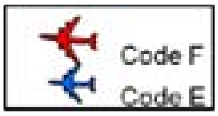
Figure 3.4 – Existing Terminal 3 gate configuration

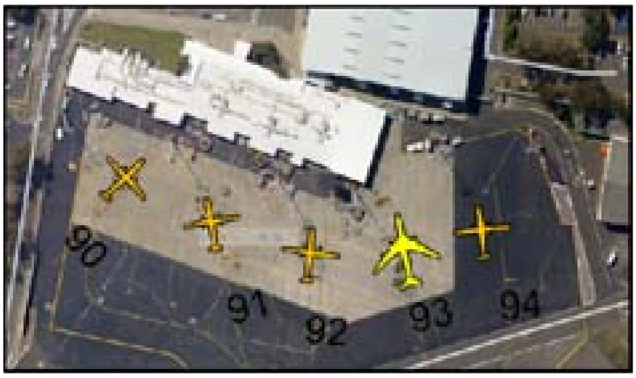
Freight Apron

Existing: 10 Gates (1F4E5C)

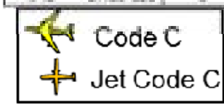


Gate	Capacity	Code
1	B747-400	E
2	B747-400	E
2A	AN 124	F
3	B747-400	E
4	B747-400	F
4A	A380-800	F
5	AN-124	F
5A	B747-400	F
5B	B737/A320	C





Gate	Capacity	Code
90	DHC8-300	C
90A	B737-700	C
90B	DHC8-300	C
91	DHC8-300	C
91A	B737-800	C
91B	DHC8-300	C
92	DHC8-300	C
92A	B737-800	C
92B	DHC8-300	C
93	B737-800	C
93A	B747	E
93B	SAAB-340	C
93C	SAAB-340	C
94	Q400	C
94B	DHC8-300	C



Gate	Gates to be Vacant
90	90A, 90B, 91A
90A	90, 90B
90B	90, 90A, 91A
91	90A, 91A, 91B, 92A
91A	91, 91B
91B	90A, 91, 91A, 92A
92	92A, 92B
92A	92, 92B
92B	92, 92A
93	93A, 93B, 93C
93A	92, 93A, 93B, 93, 93B, 93C, 94, 94B
93B	93, 93A, 93C
93C	93, 93A, 93B
94	93A, 93B
94B	93A, 94

Rules:
Gate 1: Limited to aircraft to B767 and smaller when Gate 2A is occupied
Gate 2: Not available when Gate 2A is occupied
Gate 2 and 3:
Only used for turnaround operation of freight aircraft, or parking of passenger and or freight aircraft.
Gate 4A: for A380 only, and not available when Gate A is occupied
Gate 5:
•Not available when Gate 5A is occupied
•Limited to A300 and smaller when Gate 5B is occupied
Gate 5B: Not available when Gate 5 is occupied by aircraft larger than A300
Priority:
Gate 2 and 3:
1.Qantas handled international cargo only aircraft
2.Other company handled International cargo only aircraft
3.Parking Qantas aircraft
4.Parking other company aircraft
Gate 90 (90A/90B), 91 (91A/91B), 92 (92A, 92B), 93(93A/93B/93C) and 94(94B):
Primary position is not available if associated secondary position is occupied and vice versa
Gate 90B, 91B, 92B, 93C and 94B: Reverse positions are to be used only when prevailing wind conditions
Gate 93A:
•For Aircraft up to B747-400, subject to restriction from airport operations
•Gate 93, 93B, 93C, 94 and 94B not available if Gate 93A is occupied and vice versa

Figure 3.5 – Existing Freight apron gate configuration

3.1.2 Taxiways

The existing taxiway network is shown in the diagram below. Currently the busiest areas of the taxiways are located on the northeast (TWY B, TWY C) adjacent the domestic and regional apron areas of T2 and T3. The two parallel taxiways on the east not only serve as an in/out system for the domestic aprons but also as a route to the second parallel Runway 16L/34R which is used primarily for domestic aircraft movements. When the Airport mode operates a south flow (Mode 10) the taxiways serving Runway 16R are often congested such as TWY A, TWY B and TWY C and subsequently their entry points onto the runway (TWY A1, B1, B2, F, B3, B4).

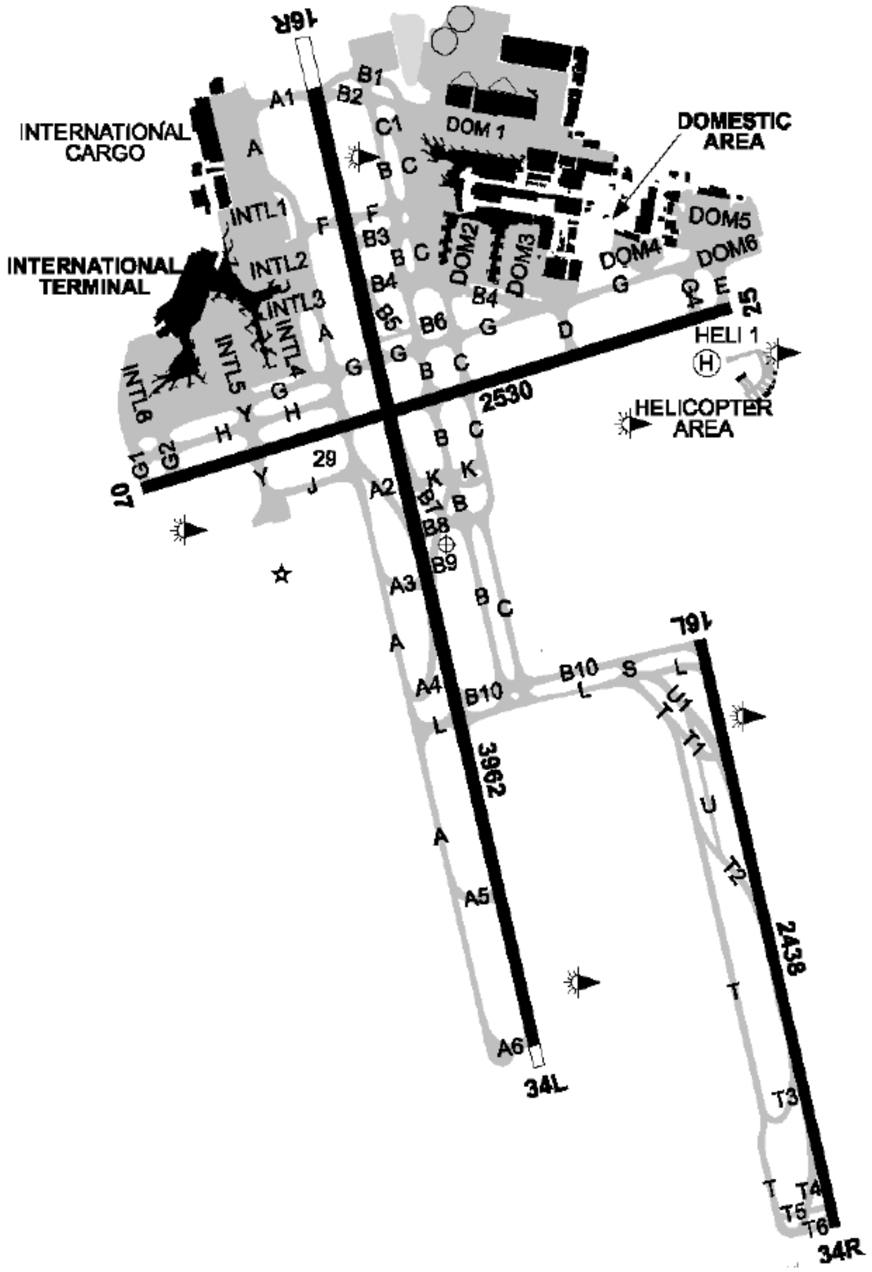


Figure 3.6 – Existing airfield taxiway network

3.2 Current Taxiway Enhancement Work

Sydney (Kingsford-Smith) Airport is currently undertaking a taxiway enhancement in the north eastern sector of the Airport near Terminal 2. This taxiway enhancement, specifically TWY B4, is designed to enable two way flows around the entry to the cul-de-sac apron of TWY DOM2, currently serving Jetstar, Tiger Airways and Virgin Blue services.

The diagram below illustrates the changes in centreline for TWY C, TWY B4 and TWY DOM 2. The current construction of this taxiway enhancement was discussed with ASA and it was decided to include the completed alignment shown below within the base/existing and future TAAM models.

Figure 3.7 – Current Taxiway Enhancement Changes (TWY C, B4, DOM 2)

(Source: Aerial photo from website: www.nearmap.com)

3.3 2029 Master Plan Concept Layout

The Master Plan Concept layout for 2029 shows extensions and changes to all three key passenger terminals within the existing airfield layout in addition to the development of a new remote aircraft parking apron to the south east corner of the cross Runway 07/25. Significant development of Terminal 1 provides 32 contact gates with a new cul-de-sac built to the far northwest corner of the Airport site. The 2029 layout shows Terminal 1 serving passenger aircraft, with all freight operations moving to the northeast corner, adjacent to Terminal 3, whilst extensions to Terminal 2 and Terminal 3 are also included. The progressive implementation of the additional and reconfigured apron infrastructure is set out in Section 15 Implementation of the Master Plan 2009. This is included for reference at Appendix A.

3.3.1 Aprons/Gates

The following diagrams outline the provision of contact or remote stands for each of the apron areas within the existing airfield. The diagrams also provide an overview of the size of aircraft which can use each gate and the associated rules in which they must be operated under.

Figure 3.8 – Master Plan Concept for 2029 - aircraft gate configuration

AC Type	Passenger						Freight	General Aviation
	T1		T2		T3			
	Contact	Remote	Contact	Remote	Contact	Remote		
B1900								
B737-800	2		38	3				
B767-300	1		2					
B747-400	14	3		10	12		9	
A380-800	15	3				2	3	
Total	32	6	40	13	12	2	12	

Figure 3.9 – Master Plan Concept aircraft gate configuration table

The provision of general aviation gates is unclear from the Master Plan Concept and has not been identified for the table above.

Terminal 1

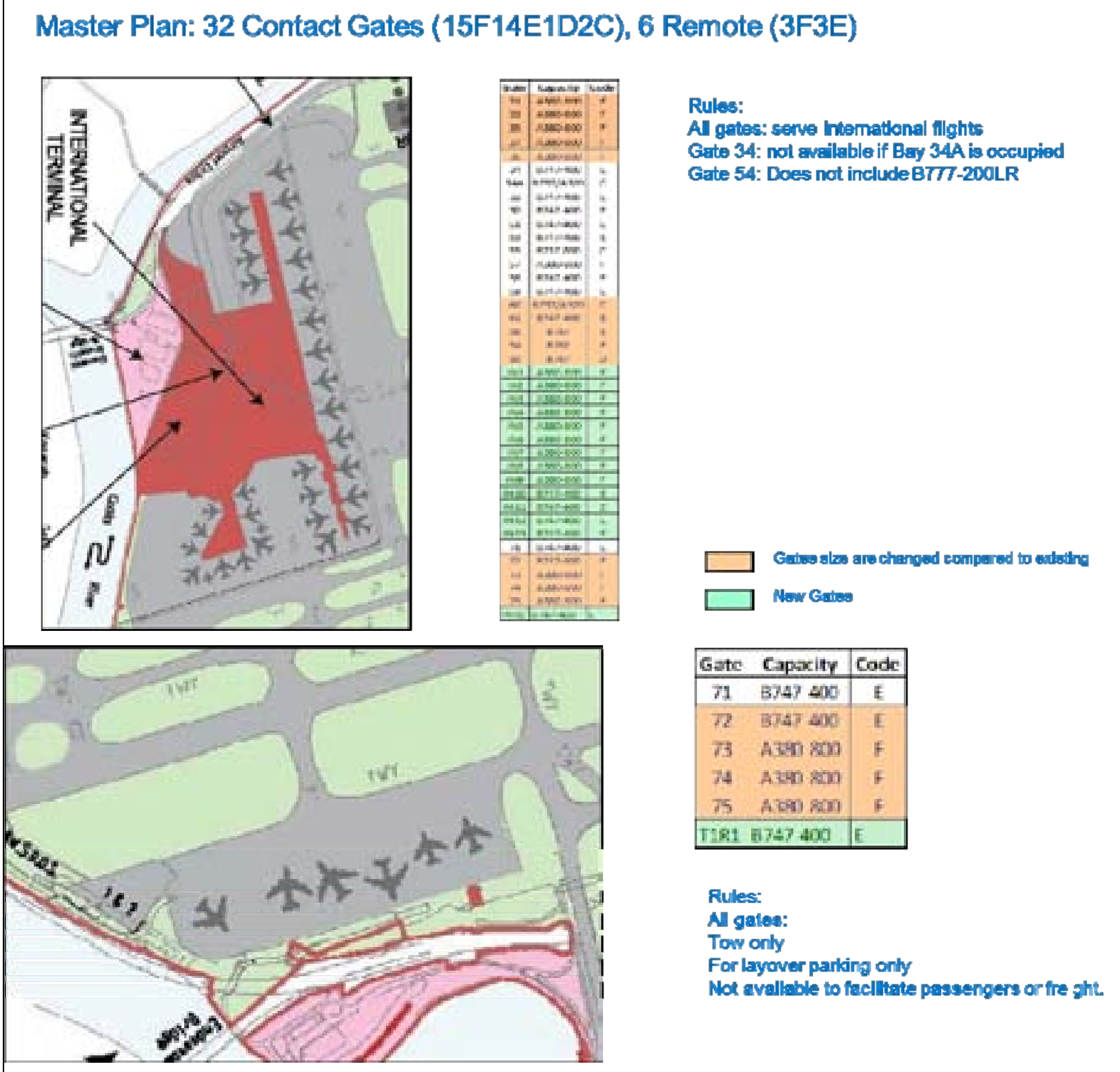
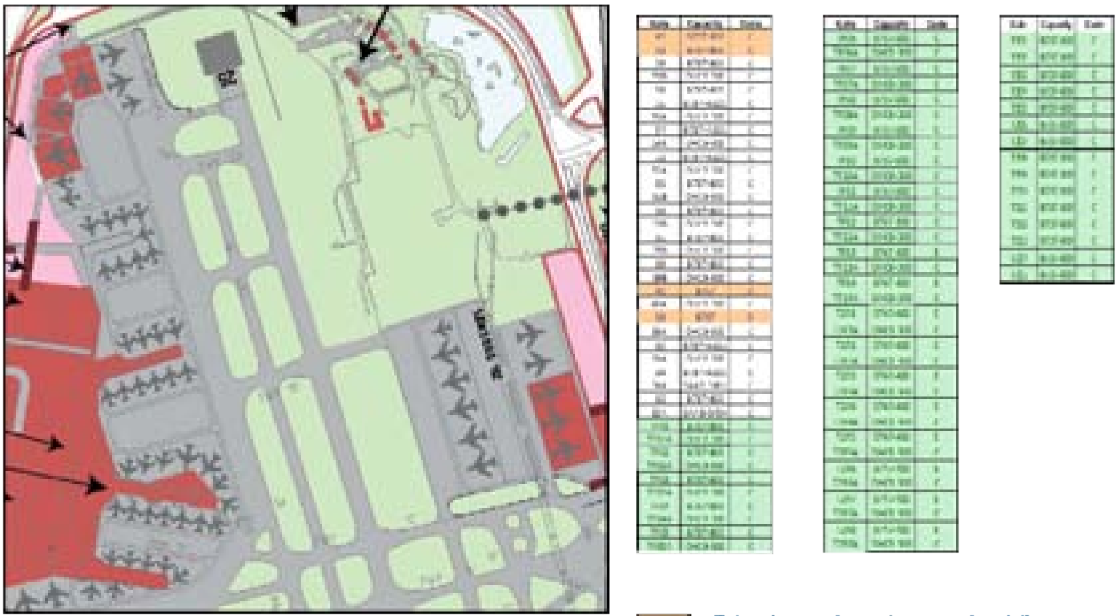


Figure 3.10 – Master Plan Concept - Terminal 1 gate configuration

Terminal 2

Master Plan: 40 Contact Gates (2D38C), 13 Remote (10E3C)



Gates size are changed compare to existing

New Gates

Hush Hangar Area, gates are not been counted

Gate	Gates to be Vacant
31	31B
31B	31
33	33B
33B	33
35	35B
35B	35
39	39B
39B	39
52	52A
52A	52
54	54A
54A	54
56	56A
56A	56
32	32A
32A	32
34	34A
34A	34
36	36A
36A	36
38	38A
38A	38
40	40A
40A	40

Gate	Gates to be Vacant
TF01	TF01A
TF01A	TF01
TF02	TF02A
TF02A	TF02
TF03	TF03A
TF03A	TF03
TF04	TF04A
TF04A	TF04
TF05	TF05A
TF05A	TF05
TF06	TF06A
TF06A	TF06
TF07	TF07A
TF07A	TF07
TF08	TF08A
TF08A	TF08
TF09	TF09A
TF09A	TF09
TF10	TF10A
TF10A	TF10
TF11	TF11A
TF11A	TF11
TF12	TF12A
TF12A	TF12
TF13	TF13A
TF13A	TF13
TF14	TF14A
TF14A	TF14
TF13	TF15A
TF15A	TF15
TF15	TF15A
TF15A	TF15
T2R1	T2R1A
T2R1A	T2R1
T2R2	T2R2A
T2R2A	T2R2
T2R3	T2R3A
T2R3A	T2R3
T2R4	T2R4A
T2R4A	T2R4
T2R5	T2R5A
T2R5A	T2R5
T2R6	T2R6A
T2R6A	T2R6

Rules:
Gate 34: short parking of B737-700 only
Gate 36: short parking up to B737-700 is available
Gate 38&40: short parking up to B737-800 is available
Gate TF10(TF10A), TF11(TF11A) and TF12(F12A): Primary position is not available if associated secondary position is occupied.
Gate TF10A,TF11A and TF12A: reverse positions are to be used only when prevailing wind conditions.
Gate TF10 and TF12: For layover aircraft only

Figure 3.11 – Master Plan Concept - Terminal 2 gate configuration

Terminal 3

Master Plan: 12 Contact Gates (12E), 2 Remote(2F)

Gate	Capacity	Code
2	B747-400	E
3	B747-400	E
4	B747-400	E
5	B747-400	E
6	B747-400	E
7	B747-400	E
8	B747-400	E
9	B747-400	F
10	B747-400	F
11	B747-400	E
13	B747-400	E
16	B747-400	E
T3R1	A380	F
T3R2	A380	F

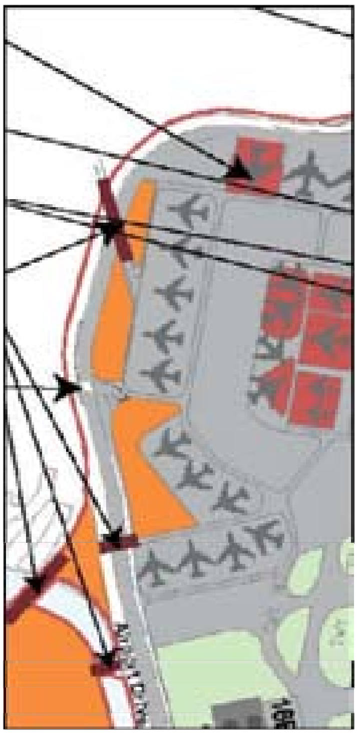
Gates size are changed compare to ex st ng

New Gates

Figure 3.12 – Master Plan Concept - Terminal 3 gate configuration

Freight Apron

Master Plan: 12 Gates (3F9E)



Gate	Capacity	Code
1	B747 400	E
2	A380-800	F
3	A380-800	F
4	A380-800	F
5	B747 400	E

Gate	Capacity	Code
FR1	B747-400	E
FR1A	DHC8-300	C
FR1B	DHC8-300	C
FR2	B747-400	E
FR2A	DHC8-300	C
FR2B	DHC8-300	C
FR3	B747-400	E
FR3A	DHC8-300	C
FR3B	DHC8-300	C
FR4	B747-400	E
FR4A	DHC8-300	C
FR4B	DHC8-300	C
FR5	B747-400	E
FR5A	DHC8-300	C
FR5B	DHC8-300	C
FR6	B747-400	E
FR6A	DHC8-300	C
FR6B	DHC8-300	C
FR7	B747-400	E
FR7A	DHC8-300	C
FR7B	DHC8-300	C

Gates size are changed compare to existing

New Gates

Figure 3.13 – Master Plan Concept - Freight apron gate configuration

Gate	Gates to be Vacant
FR1	FR1A,FR1B
FR1A	FR1,FR1B
FR1B	FR1,FR1A
FR2	FR2A,FR2B
FR2A	FR2,FR2B
FR2B	FR2,FR2A
FR3	FR3A,FR3B
FR3A	FR3,FR3B
FR3B	FR3,FR3A
FR4	FR4A,FR4B
FR4A	FR4,FR4B
FR4B	FR4,FR4A
FR5	FR5A,FR5B
FR5A	FR5,FR5B
FR5B	FR5,FR5A
FR6	FR6A,FR6B
FR6A	FR6,FR6B
FR6B	FR6,FR6A
FR7	FR7A,FR7B
FR7A	FR7,FR7B
FR7B	FR7,FR7A

Rules:
Gate 1: Limited to aircraft to B767 and smaller when Gate 2A s occup ed
Gate 2: Not available when Gate 2A is occupied
Gate 2 and 3:
•Only used for turnaround operat on of freight aircraft, or parking of passenger and or fre ght aircraft.
Gate 4A: for A380 only, and not available when Gate A s occupied
Prior ty:
Gate 2 and 3:
1.Qantas handled International cargo only a rcraft
2.Other company handled International cargo only aircraft
3.Park ng Qantas aircraft
4.Park ng other company aircraft
Gate FR1 (FR1A/FR1B),FR2 (FR2A/FR2B), FR3 (FR3A,FR3B), FR4(FR4A/FR4B) and FR5(FR5A/FR5B):
Primary pos tion is not available f associated secondary pos tion is occup ed and vice versa
Gate FR1B, FR2B, FR3B, FR4B andFR5B:
Reverse positions are to be used only when prevailing wind condit ons

Figure 3.14 – Master Plan Concept - Freight apron gate configuration cont.

3.3.2 Taxiways

The future Master Plan Concept layout taxiway network is shown in the diagram below. Highlighted in yellow are the key infrastructure changes to the taxiway network:

- Extension of TWY H to the east end of Runway 07/25
- Realignment of TWY B4
- Realignment of TWY A and adjacent TWY INTL 1
- Extension of TWY J to both the east and west
- Duplication of TWY A1 at the north end of Runway 16R/34L
- Intersection departure TWY south of TWY L onto Runway 16R/34L
- Additional realignments throughout the domestic and international terminal aprons.

These infrastructure improvements have been included in the future scenario TAAM analysis with variations on the inclusion of key changes such as TWY H extension to test the impacts of these changes/improvements.

Figure 3.15 – Master Plan Concept for 2029 - airfield taxiway network

4.0 Baseline (Existing) Gate Demand

4.1 ATC Tower Visit – Observations

L&B visited the Sydney (Kingsford-Smith) Airport ATC tower on Thursday 24 March (19:30 – 21:00) and Friday 25 March (06:30 – 14:00) 2011 to observe actual aircraft operations.

In terms of apron and gate utilisation the following observations were made, including some anecdotal input from air traffic controllers:

- All apron areas held a healthy level of activity in terms of gate utilisation throughout the day.
- Towing aircraft off to remote stands, particularly from the international terminal, was necessary for several aircraft in order to free up gate availability.
- Aircraft tows crossing the main runway to remote stands such as Northern Pond, Jet Base and DOM6 causes congestion, delays and flow complications on the taxiways, especially A, A1, F, G, B and C. This is particularly the case with large Code E aircraft such as A380, A340-600, A340-500, B747-400 etc.
- DOM2 and DOM3 aprons (serving T2) were very busy throughout the day in terms of gates occupied. Being single taxi lane cul-de-sacs, access to these gates was regularly delayed by aircraft push-backs and engine start-up.
- DOM3A apron for turbo-prop aircraft also sustained a strong level of utilisation during the day.
- DOM1 apron (Qantas) was difficult to observe from the ATC Tower but was consistently well utilised, especially in the early morning and evening peaks when it was effectively full.
- International remote stands (#71 - #75) south of Rwy 07/25 were fully occupied by towed aircraft by early morning (approx. 08:00).
- International freight apron stands also used for towing long-stay passenger aircraft.
- Overnight Virgin Blue aircraft parked at DOM5 before being towed back to gate after morning peak. Air Traffic Controllers commented that not uncommon for 4 – 5 Virgin Blue and Jetstar aircraft to be towed out to DOM5 apron overnight to free up contact gates.

During the AM peak period there were a number of traffic issues observed, particularly around the domestic T2 terminal when aircraft were being towed. Access to the T2 cul-de-sac apron was an issue and the following photos were taken highlighting key issues during the AM peak period.

Figure 4.1 –Domestic taxiway observation 1

4 Virgin Blue arriving aircraft taxiing on RWY 07/25 to TWY D to access TWY G and DOM 2 apron area. There was some queuing of aircraft on the inactive runway for a short period of time. This route was used as TWY C and TWY B4 were utilized for departing aircraft from the DOM 2 apron area.

Figure 4.2 –Domestic taxiway observation 2

Virgin A340 tow is stationary and waiting to access the Northern Pond which blocks TWY B northbound flows. Pushback aircraft onto TWY C block departing aircraft from T3 Qantas apron. 3 Departure aircraft positioned on TWY F and TWY B waiting for a gap in arrivals on RWY 16R/34L.

The observations and anecdotal comments provided by air traffic controllers during this visit identified that available apron and gate capacity is heavily utilised at present. This assisted verification of the existing gate demand model and consideration of future gate capacity development needs.

4.2 2010 Baseline Stand Demand - GMS Analysis

4.2.1 Current Aircraft Stand Provision

A single day (12th November 2010) actual aircraft schedule was adopted by Booz & Co. as a typical busy day for use in establishing a baseline for the forecasts. This same schedule was modeled as a baseline stand allocation exercise using L&B's Gate Management System (GMS) software.

The available stand capacity (outlined in Section 3.1.1) associated with each terminal is illustrated in Figure 4.3 and noted as follows:

- T1 = 34 stands (25 contact, 9 remote)
- T2 = 34 stands (18 contact, 16 remote)
- T3 = 16 contact stands (assuming no utilisation of Jet Base stands)

Some additional stands for towing long stay aircraft are available on remote aprons such as DOM6.

Code	Passenger						Freight		General Aviation
	T1		T2		T3		Int'l	Dom	
	Contact	Remote	Contact	Remote	Contact	Remote			
A									
B				2					6
C	3	1	15	14	7			5	2
D		1	3		7				
E	17	6			2		4		2
F	5	1					1		
Total	25	9	18	16	16		5	5	10

Figure 4.3 – Existing Aircraft Stand Provision

In terms of stand demand/utilisation modelling, available stand occupancy and timing rules were taken from the Sydney Airport Corporation Limited Operations Manual.

For T1 (International) there are some specific rules in terms of aircraft gate occupancy dwell time, relating to aircraft that will be on the ground for several hours:

- Aircraft scheduled to depart within 3 hours of arrival can remain on gate or the international aprons.
- Aircraft scheduled to depart more than 3 hours after arrival are to be towed off to a remote stand, whilst preserving the following gate dwell times for aircraft servicing:
  - Terminating aircraft must vacate a bay 75 minutes after arrival.
  - Originating aircraft cannot access a bay until 90 minutes before departure.

- Sydney (Kingsford-Smith) Airport gate controller has discretion to allow long stay aircraft to remain on a bay for longer than the 3hr dwell time allowance.
- Inter-gate time (buffer time between successive departures and arrivals at a gate) is 15 minutes for International gates.

The size of aircraft type and utilisation of each gate were outlined in Section 3.1.1.

Also, some additional necessary assumptions were made as inputs for the GMS model where sufficient guidance information was not available in the Sydney Airport Corporation Limited Operations Manual:

- Inter-gate (buffer) time of 10 minutes for Domestic gates.
- Allowances for T2 & T3 gate dwell time prior to towing are assumed as per T1, based on Operations Manual guidance that "the principals established...are similar to those applied to T1".
- T2 layover aircraft (arrival only flights) arriving before 3pm towed from gate to prevent layover of 9hrs+ and excessive gate occupancy.

It is important to note that for each terminal the stand dwell time rules/assumptions prior to towing, do not change the flight turnaround and total time on the ground which is dictated by the flight schedule (Arr / Dep times).

4.2.2 Baseline Stand Allocation Exercise

The actual day aircraft schedule used for the baseline stand allocation model was from 12th November 2010 in accordance with the basis for the forecasts prepared by Booz & Co. The full stand allocation chart modeled by GMS is contained at Appendix B.

A sample of the GMS output in the form of a ramp chart extract (refer Figure 4.4) shows the nominal allocation of flights across the 12 November 2010 day at T1.

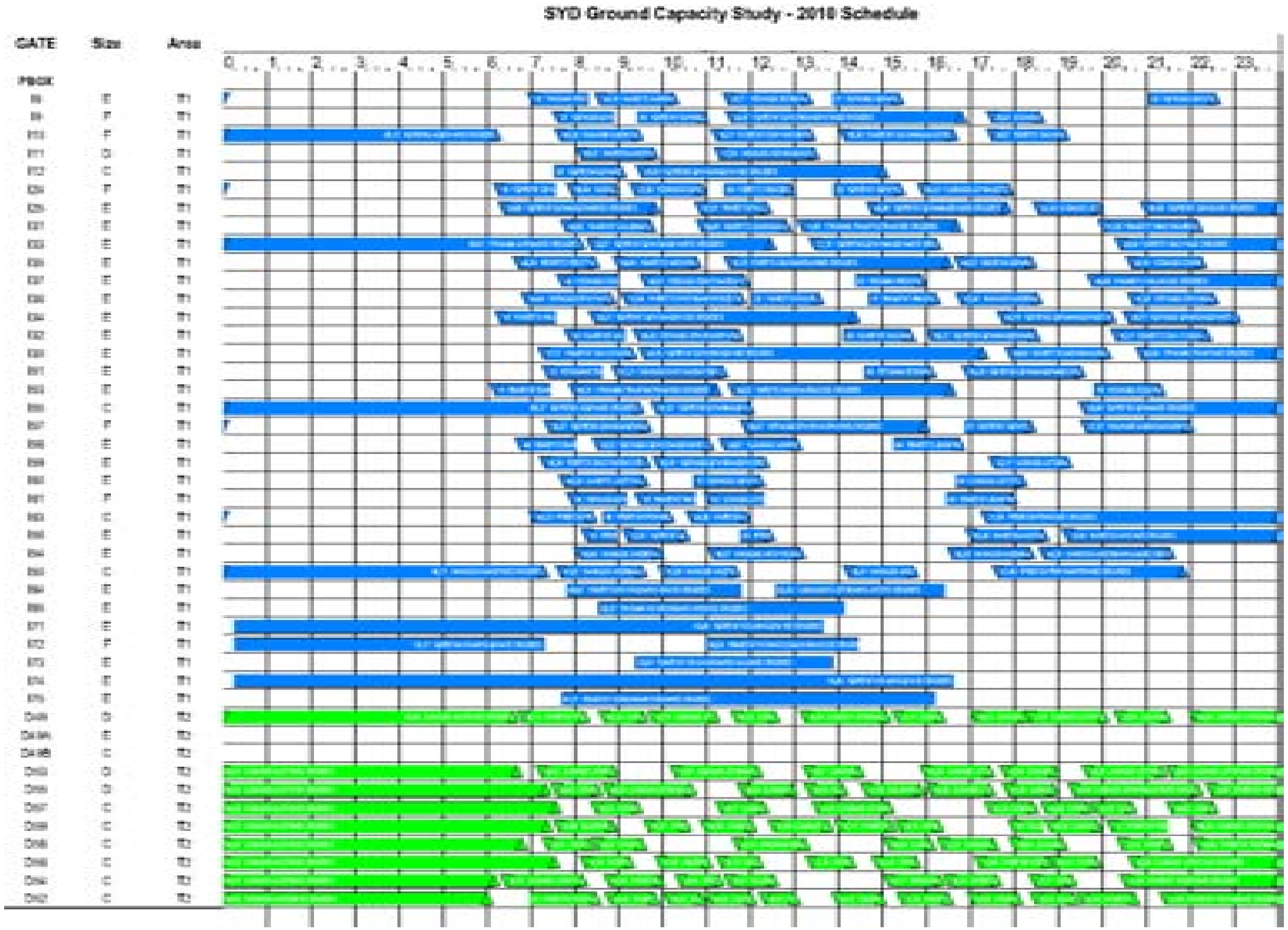


Figure 4.4 – Terminal 1 (International) Stand Allocation Chart Extract from GMS Model

Table 4.1 shows some key statistics from the model with respect to observed activity levels and utilization measured in "turns per day" (an aircraft arriving and departing on a stand is one turn and two daily movements) at each Terminal:

Table 4.1 – 2010 Stand Allocation and Usage Outcomes

	Ave. Flight Turnaround Time (1)	Ave. Turns per Stand (2)	Max Turns per Stand (2)
T1	3hr 19mins	4	6
T2	1hr 18mins	6	11
T3	1hr 24 mins	7	9
Tot	n/a	n/a	n/a

Notes: (1) Turnaround (paired) flights only. Does not include Arrival Only or Departure Only flights.
(2) Does not include remote stands for aircraft tow-off.

The average turns per day achievable on stands is dependent on a number of factors including but not limited to route / sector schedule demand and airline turnaround policies including refuelling / servicing time for aircraft. Domestic aircraft are typically smaller and require less servicing and turnaround time than International aircraft. Similarly, long haul International flight times are often dictated by operating windows (due to curfews, slot constraints or matching transfer timetables) which results in longer turnaround and therefore ground times for aircraft.

These factors drive more turns a day per gate for Domestic versus International, with 1 turn per hour and 1 turn per 3 hours being typical rules of thumb respectively. However, as can be seen in Figure 4.4 and Appendix B the characteristics of the flight schedule in terms of gaps between flights as well as difference between arrival and departure times, combine to reduce this theoretically achievable utilisation over the course of a day. Whilst there are gaps available, particularly in non-peak hours, to absorb more flights, the stands at the international (T1) and domestic terminals (T2 and T3) are strongly utilised in terms of turns per day.

The particular characteristics of each aircraft stand utilisation at each terminal apron are explored here.

4.2.3 T1 (International) Peak Stand Utilisation

Figure 4.5 shows the morning stand utilisation activity for T1 stands. Inspection of the chart shows few gaps between the flights (blue bars) which highlights that the existing stands are heavily occupied throughout the morning.

The gaps that do exist are too small to allow for the typical 3 hr flight turnaround time, or even for minimum 70 minute occupancy time before an arrival aircraft can be towed off to remote stand.

In particular, between 07:30 to 10:00, there is no room available to accommodate extra arrivals on the contact stands.

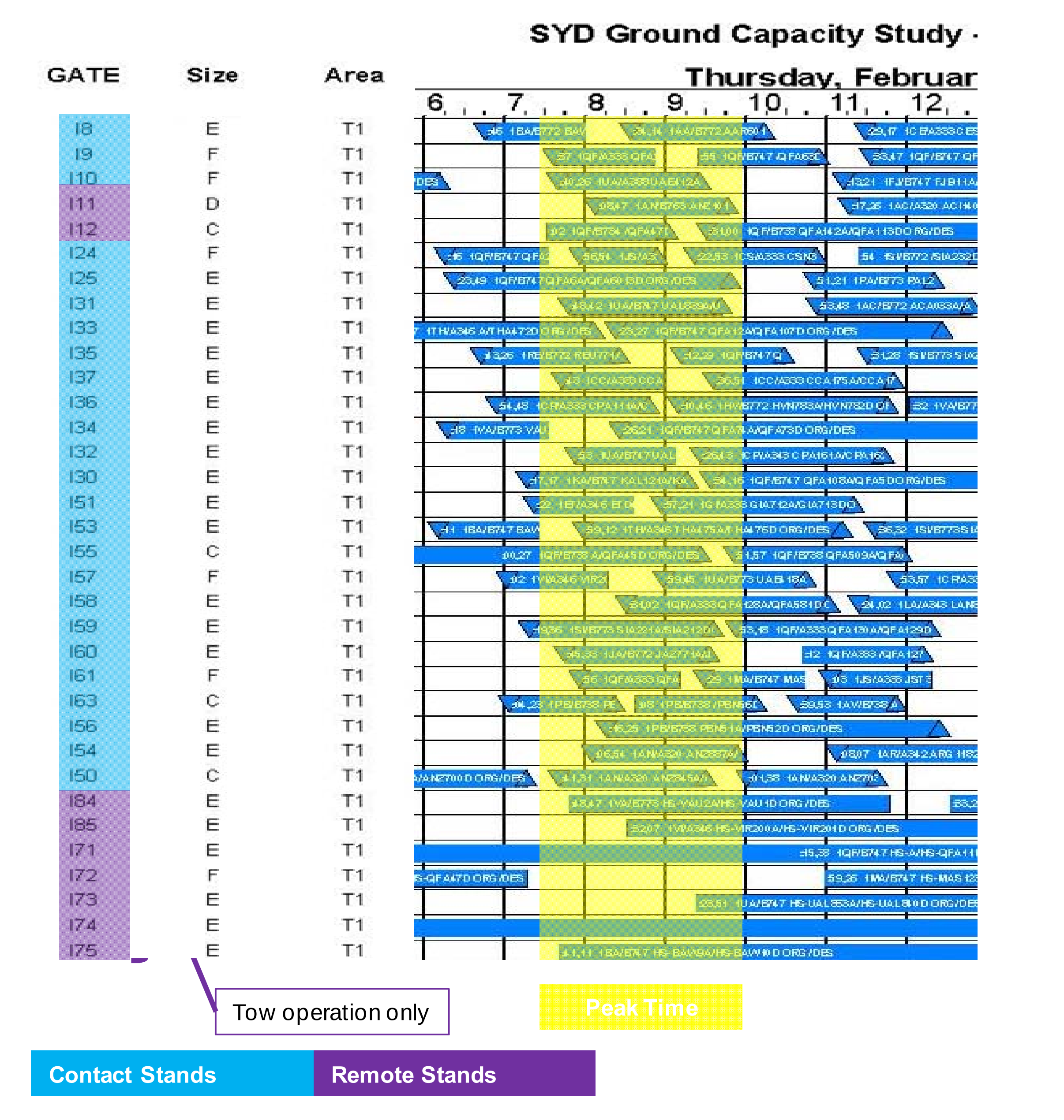


Figure 4.5 – T1 (International) 2010 Stand Allocation Chart Extract

4.2.4 T2 (Domestic / Regional) Peak Stand Utilisation

Figure 4.6 shows the aircraft stand utilisation activity for T2 stands. Inspection of the chart in the peak morning and evening periods (10:00-12:00 and 17:00-20:00) shows some gaps available to accommodate extra demand. However, these are mostly on 'walk-out' (regional aircraft) stands (F1 – F16).

It is noted that some of these stands have multiple parking lines depending on aircraft size. For example D49 = Code D; D49A = Code E; D49B = Code C. Similarly this occurs for stands F13, F15 and F16). However, it should be noted that only one of these parking lines can be occupied at any one time, which is why there are gaps on some of these lines in the chart.

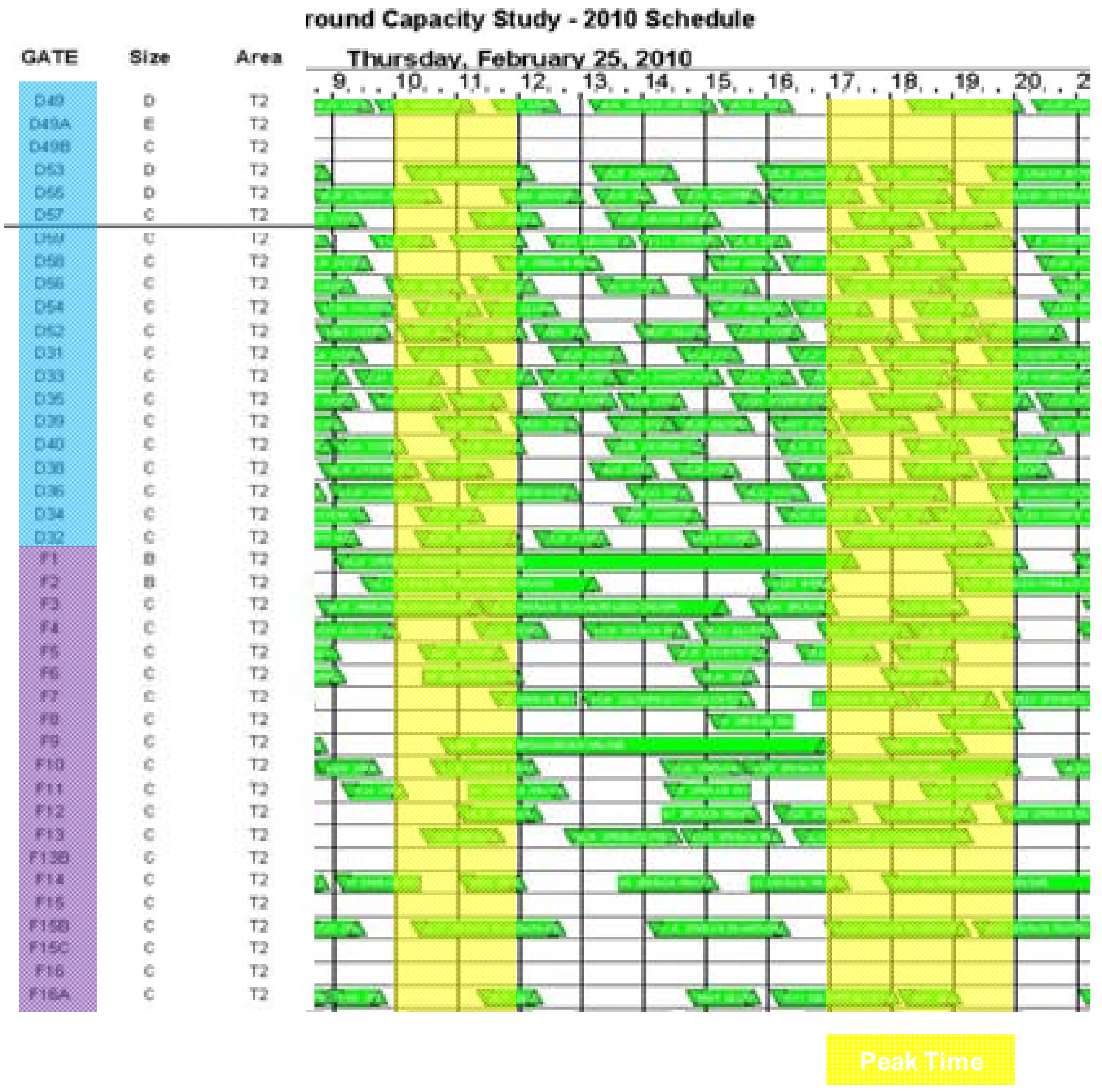


Figure 4.6 – T2 (Domestic / Regional) 2010 Stand Allocation Chart Extract

4.2.5 T3 (Qantas Domestic) Peak Stand Utilisation

Figure 4.7 shows the aircraft stand utilisation activity for T3 stands. The chart clearly demonstrates a consistently high level of stand utilisation throughout the day, with few gaps for accommodating additional demand. This is particularly the case during morning and evening peak times (08:00-10:00 and 17:00-20:00) where all stands are occupied.

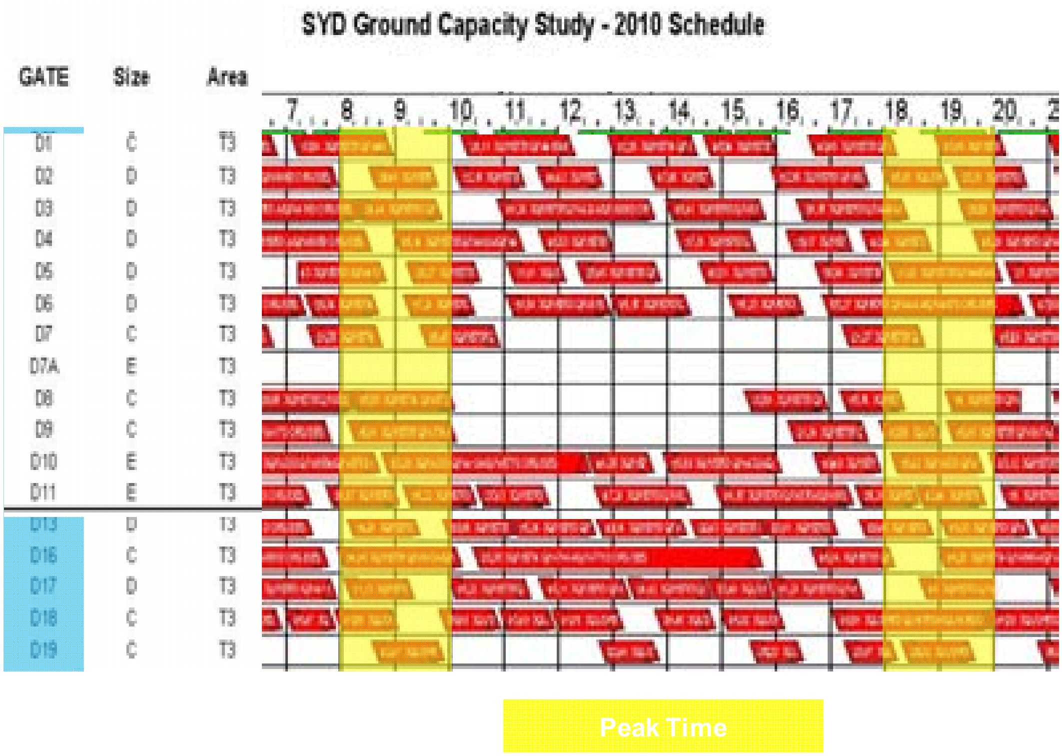


Figure 4.7 – T3 (Qantas Domestic) 2010 Stand Allocation Chart Extract

4.3 Conclusions

As can be seen from the GMS ramp charts in this section:

- All available T1 contact gates are utilised during the early morning peak (07:30 – 10:00).
- All available T2 contact gates (18 no.) are utilised at various times during the day but some stand capacity is available, though much of this is limited to turbo-prop aircraft at 'walk-out' stands.
- T3 contact gates are consistently utilised throughout the day.

This assessment of existing demand versus supply highlights that the individual terminal apron areas are already virtually at capacity in terms of aircraft stand utilisation during peak times, though additional aircraft can certainly be accommodated at other times during the day. The implication of the observed levels of aircraft stand utilisation is that additional aircraft schedule growth in the coming years, particularly any occurring in the morning and evening busy hours at each terminal, will require additional aircraft gate capacity in the near to mid-term future.

5.0 Forecast Aircraft Schedules

5.1 Introduction

An initial set of forecasts and design day aircraft schedules for the years 2015, 2020 and 2035 were produced by Booz & Co. based on a selected planning day schedule (25th February 2010). Following a review by DOIT of this and initial gate demand versus capacity analysis undertaken by L&B, Booz & Co. recast the forecasts based on new actual day data from 12th November 2010. Revised design day forecast aircraft schedules for the years 2015, 2020 and 2035 were provided to L&B between 14-21 July 2011.

The forecast schedules consist of and are based on the following:

- Design day movement schedule times to the nearest minute;
- Flight arrival/departure times that dictate the flight turnaround time (or time on ground) for each aircraft;
- Projected traffic movement volumes categorised by market, sub-markets, aerodrome code, arrival and departure;
- Peak spreading of existing movements (spreading into the shoulder); and
- Up-gauging of aircraft type of existing movements.
- Allocation of mock airlines, flight numbers and tail numbers to movements;
- Movement-by-movement schedules and aircraft movement pair tables; and
- Capacity constraints (e.g. 80 movements/hr runway cap) and operational controls applied to developed schedules.

At the time of writing, L&B did not have a copy of the latest Booz & Co. forecast report.

5.2 Overview and Comparison of forecast schedules

The graph in Figure 5.1 shows the total daily movements for each of the schedules received. The total movement increases between the existing 2010 schedule and the 3 forecast schedules are:

- 2010-2015 (5yrs) = 9.5% increase. CAGR = 1.8%.
- 2015-2020 (5yrs) = 9.1% increase. CAGR = 1.8%.
- 2020-2035 (15yrs) = 22.3% increase. CAGR = 1.3%.

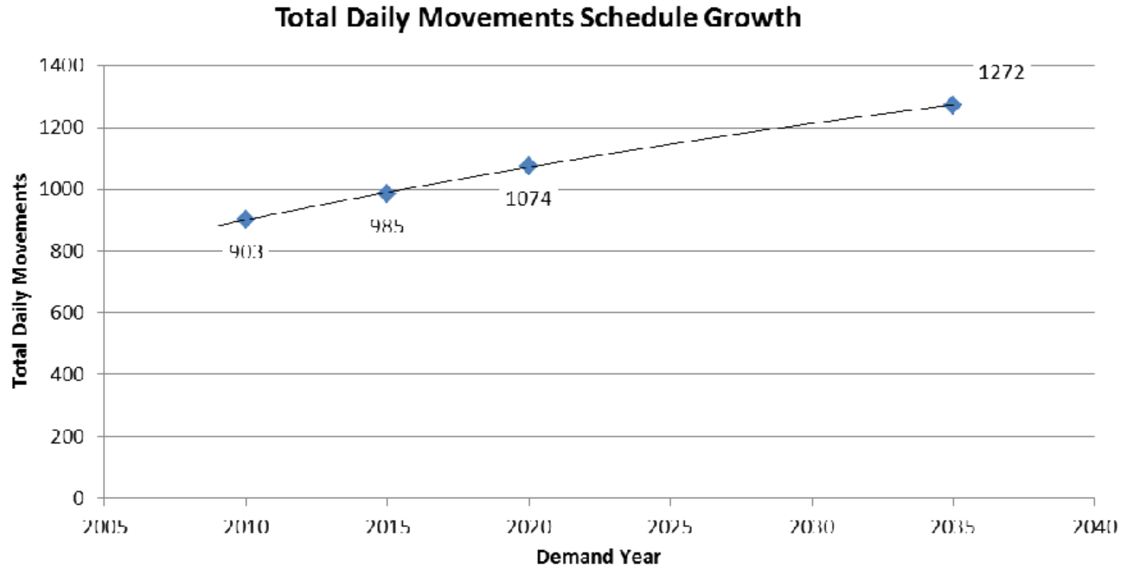


Figure 5.1 – Daily Movements Schedule growth

A comparison of the daily profile of each schedule enabled an understanding of the magnitude of the spreading of demand into the shoulders of the peak periods with respect to the operational restriction of 80 movements per hour.

Figure 5.2 illustrates the growth and spread of the future forecast schedules against the existing 2010 schedule using clock hour (e.g. 10:00 to 11:00).

- The 2015 schedule indicates the forecast daily peak hour is in the morning at 0800.
- Both the 2020 and 2035 schedules reach the peak 80mvts/hour in both the morning and evening peak hours.
- The hourly activity profile of the 2035 schedule is very flat as the growth in aircraft movements consistently reaches Sydney (Kingsford-Smith) Airport's 80 movements per hour runway cap for nearly 12 hours of the operating day.

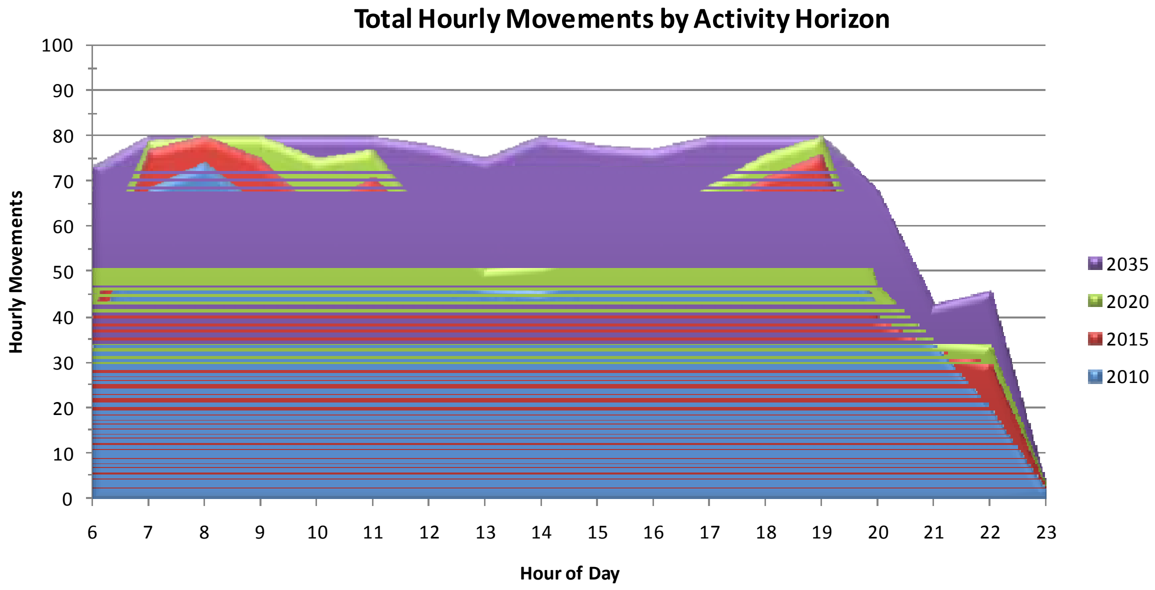


Figure 5.2 – Forecast Horizon - Comparison of Hourly Movements

Table 5.1 provides a summary comparison of the change in hourly movements between each activity horizon.

Table 5.1 – Comparison of Hourly Movement Forecasts

Hour	2010	2015	change	2020	change	2035	change
0-5	7	7	0	7	0	11	4
6	33	40	7	51	11	73	22
7	68	77	9	79	2	**80**	1
8	74	**80**	6	**80**	0	**80**	0
9	64	75	11	**80**	5	**80**	0
10	49	63	14	75	12	**80**	5
11	62	71	9	77	6	**80**	3
12	51	58	7	61	3	78	17
13	47	45	-2	51	6	75	24
14	46	48	2	52	4	**80**	28
15	53	52	-1	56	4	78	22
16	58	54	-4	61	7	77	16
17	63	63	0	69	6	**80**	11
18	67	71	4	76	5	**80**	4
19	63	76	13	**80**	4	**80**	0
20	42	40	-2	47	7	68	21
21	34	33	-1	35	2	43	8
22	20	30	10	34	4	46	12
23	2	2	0	3	1	3	0
Total	**903**	**985**	**82**	**1074**	**89**	**1272**	**198**

The 2010 stand allocation outcomes summarised in Section 4 identified that the available stands at each terminal were virtually all occupied during morning peak hours. It is therefore worth noting from Table 5.1, that an additional 40 aircraft movements have been added to the 07:00 – 10:59 morning peak period when 2010 aircraft stand utilisation is already extremely high and in the case of T1 and T3, at capacity. The implications in terms of stand demand versus proposed capacity at each forecast horizon will be explored in Section 6.

6.0 Future Apron / Stand Demand

6.1 Introduction

6.1.1 Approach

L&B utilised the forecast aircraft schedules provided by Booz & Co to model the aircraft stand utilisation with our proprietary Gate Management System (GMS) software. This is a sophisticated software package developed in conjunction with and tested operationally at some major airports (e.g. Chicago and Los Angeles). GMS incorporates operational rules and dependencies governing aircraft stand usage, e.g. aircraft size capabilities, multiple lead-in line flexibilities and airline allocation preferences, as it allocates flights to available stands.

To give an indication of the impact on stand utilisation of growth for each forecast schedule, results will be shown for average flight turnaround time as well as average and maximum number of turns a day per stand. Where there are not enough stands available to accommodate the schedule demand, any shortfall will be identified along with the number of unaccommodated aircraft turnarounds (flights). The allocation charts generated by GMS are also included in this report as they clearly demonstrate visually the level of activity occurring across the day. An example and explanation of the presented output from GMS is shown in Figure 6.1.

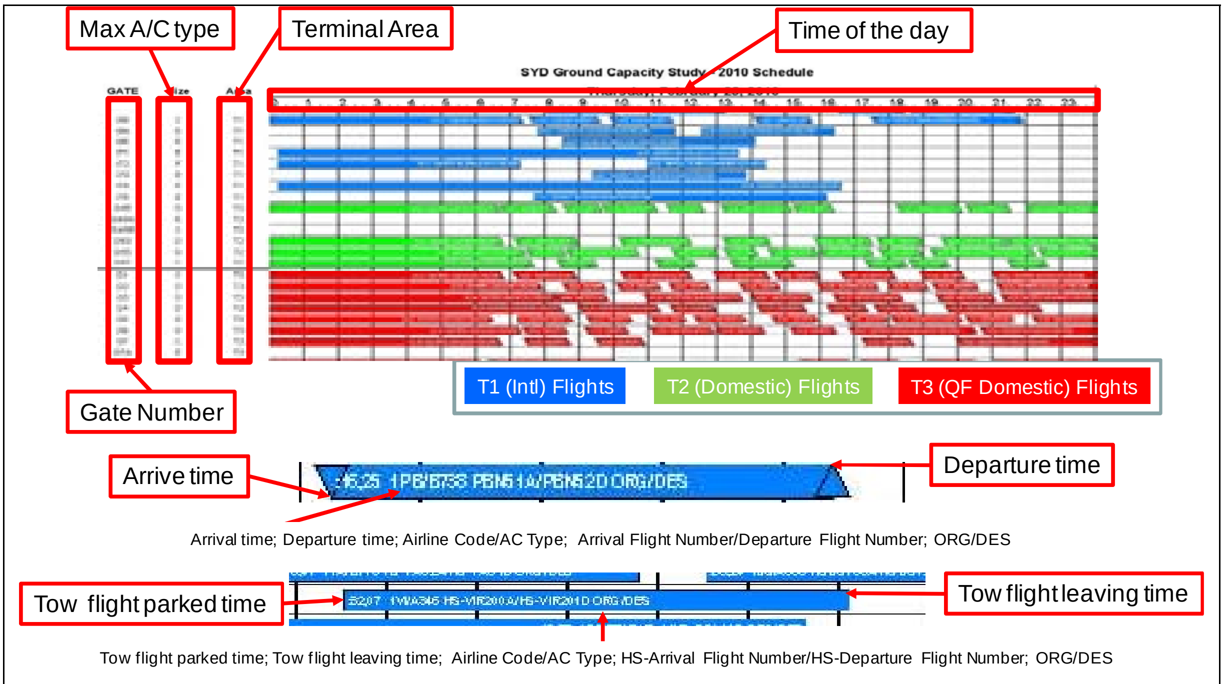


Figure 6.1 – Explanation of GMS Output Chart Appearance

The flight turnaround times modelled in 2015, 2020 and 2035 are dictated by the arrival and departure times as per the forecast schedules provided by Booz & Co.

Finally, it is noted that all outcomes are a function of the level of demand in the forecast schedules as well as the assumed availability and utilisation characteristics of aircraft stands based on interpretation of high level guidance in the Master Plan 2009.

6.1.2 Aircraft Turns per Stand

In terms of achievable stand utilisation, it is noted that 1 aircraft turn per stand per hour is quite typical for a Domestic terminal. This assumes a typical Domestic jet aircraft turnaround of say 40 – 45 minutes plus 10 minute Inter-Gate Time (I.G.T) which is a buffer time to allow for off-schedule departures or arrivals. Depending on aircraft size and servicing requirements, this rate can increase or decrease. Theoretically, if 1 turn per hour was maintained throughout the operating day at Sydney (Kingsford-Smith) Airport, up to 17 turns per day could be achieved, assuming that there was sufficient, equally spaced flight schedule demand to drive this.

In practise however, achieving in the order of 8 - 10 turns a day per stand (not including remote, tow-off stands) represents a strong to high practical level of activity at a domestic terminal. This is due to the characteristics of the flight schedule in terms of gaps between flights as well as difference between arrival and departure times, which combine to reduce this theoretically achievable utilisation over the course of a day.

For an International terminal the average flight turnaround time is typically longer than Domestic, due to factors including longer aircraft servicing for larger aircraft and longer flight sectors. As a rule of thumb it is typically common to see International flight turnaround (time on ground) duration of 2 – 4 hours though this can easily be extended as a result of flight schedule characteristics. In some airports, particularly those with slot constraints, the arrival and departure time pattern of flights is dictated by available operating windows at the home port and also origin / destination airports. These operating windows and flight times for long haul flights commonly result in long layovers (ground time) as is the case for a number of flights at Sydney (Kingsford-Smith) Airport that arrive in the early morning. This extended stand occupancy (ground) time for International flights due to the nature of the flight schedule and aircraft servicing requirements, reduces the practically achievable turns per gate (to say 4 – 6 per day) when compared to Domestic terminals.

L&B has recently observed similar ranges of turns per gate per day for Domestic and International facilities at other airports:

- Shanghai Pudong International Airport: Domestic gates = 9 – 10 turns per day. International = 5 – 6 turns per day.
- Guangzhou International Airport: Domestic gates = 8 - 9 turns per day. International = 4 - 5 turns per day.
- JFK International Airport (New York): 3 – 4 turns per day for a predominantly long haul international based schedule.
- La Guardia Airport (New York): 8 – 9 turns per day for predominantly short-haul international and domestic operations. Though Regional Jet aircraft gates achieve 10 – 11 per day due to lower passenger loads and quicker aircraft servicing turnarounds.

The results from modelling the 2010 aircraft schedule (refer Section 4) showed that T1 gates are already accommodating an average of 4 turns per day, which is already a good level of utilisation particularly considering the characteristics of the International flight schedule. The domestic terminals T2 and T3 are accommodating an average of 6 and 7 turns per gate per day respectively. This suggests that some more flights in underutilised time periods can be accommodated, though with some gates already achieving up to 8 – 10 turns per day, this potential is somewhat limited particularly in peak morning and evening periods.

6.2 2015 Apron / Stand Demand

6.2.1 Stand Availability and Allocation Assumptions

The publically available Master Plan 2009 does not define interim staging, and therefore any planned development of apron/gate provision by 2015 is not known. One exception is the addition of 5 Code C capable positions south of the main T2 pier used primarily by Virgin Blue. This expanded apron area can alternatively accommodate 2 Code E and 1 Code C aircraft and is facilitated by current re-alignment work to Twy B4, due for completion by mid-2011. Figure 6.1 illustrate the area of change and the total stand provision for 2015 is summarised in Table 6.1.

Figure 6.1 – Re-aligned Twy B and Indicative Additional T2 Pier A Stands

(Source: Aerial photo from website: www.nearmap.com)

Table 6.1 – 2015 Aircraft Stand Provision

AC Type	Passenger						Freight		General Aviation	
	T1		T2		T3		Int'l	Dom		
	Contact	Remote	Contact	Remote	Contact	Remote				
B1900				2					6	
B737-800	3	1	20	14	7			5	2	
B767-300		1	3		7					
B747-400	17	6			2		4		2	
A380-800	5	1					1			
Total	**25**	**9**	**23**	**16**	**16**		**5**	**5**	**10**	
		34		39		16		10	10	99 (excl. GA)

L&B have assumed that current rules and procedures relating to gate use will remain in place for year 2015. These have been applied to the 2015 GMS runs:

- T1
  - ANZ, QFA and PBN aircraft to/from New Zealand will normally use the T1 western apron gates 50, 54, 56, and 63.
- T2
  - Tiger (TGW) normally use gates 39 and 40
  - Virgin (VOZ) has exclusive use of gates 31, 32, 33, 34, 35, 36 and 38.

- Jetstar (JST) use 49, 53, 55, 57 and 59.
- Rex (HZL) use the F gates (F1 through to F16).
- Bays 52, 54, 56 and 58 are common user - put any of the above companies on those bays if the normally allocated bays are in use. F4 and F5 can also be used for overflow.
- Aeropelican (PEL) use the "F" Gates similar to Rex

- T3
  - QLink will normally use 16, 17, 18 and 19.
  - Qantas jets only on T3 gates 1 through to 13 and will also use 16 and 17 if available

It is noted that no additional stand developments have been included in this stand modeling exercise, which is as per 2014-2019 Implementation section from the Master Plan 2009 (Appendix A).

6.2.2 2015 GMS Stand Allocation Results

Table 6.2 summarises the outcomes of the stand allocation exercise. The GMS model could not allocate all flights in the 2015 forecast schedule to available stands. Flight turnaround times are dictated by arrival and departure times in the Booz & Co. forecast schedule. In total 59 turns cannot be accommodated at T1, T2 and T3 which would require an additional 25 stands. Virtually all of these un-accommodated flights occur in the morning and evening peak periods when existing stands are fully utilized by 2015.

Table 6.2 – 2015 Stand Allocation and Usage Outcomes

	Ave. Flight Turnaround Time (1)	Ave. Turns per Stand (2)	Max Turns per Stand (2)	Aircraft Turns not accommodated	Add. Stands Required
T1	3hr 13min	4	6	12	8
T2	1hr 20min	7	11	19	9
T3	1hr 32min	6	8	28	8
Tot	n/a	n/a	n/a	59	25

Notes: (1) Turnaround (paired) flights only. Does not include Arrival Only or Departure Only flights.
(2) Does not include remote stands for aircraft tow-off.

It is noted that the individual requirements for each terminal do not necessarily occur at the same time. But due to the specific airline and traffic allocation to each terminal, i.e. no ability to cross-utilise stands, these individual requirements are additive and deliver the result of 25 stands.

Figure 6.2 shows an extract from the GMS model the gate allocation chart showing the 'Penalty Box', i.e. those aircraft that cannot be accommodated on the available stands. The full GMS ramp chart is contained in Appendix C.

Observations from this GMS modelling exercise can be summarised as follows:

- An additional 25 stands (in GMS 'Penalty Box' in Figure 6.2) would be required to accommodate the 2015 forecast schedule demand.
- The shortfall of stands is the result of excess demand during peak periods. For example, the International flights (blue bars) in the Penalty Box are all morning arrivals (approx. 06:45 – 09:15). Looking down the chart to the T1 stands in the corresponding period, there are no contact stands available at T1 to accept any additional flights. The same situation is occurring at T2 (green bars) and T3 (red bars) during their respective busy periods. So whilst there is capacity available at other times of the day in terms of gaps at stands to accept more flights, the stands are fully utilized during peak hours which are driving the shortfall result.
- Of the QF aircraft (red bars) and T2 aircraft in the Penalty Box, the majority are Code E aircraft. There are insufficient Code E stands to accommodate these aircraft at T3 and T2:
  - At the same time there are some Code C stands that are available and not being utilized;
  - If these Domestic Code E aircraft were downgraded to Code C's, then greater utilization of available gates could occur and the Penalty Box shortfall would reduce from 25 to 20 stands;
  - At T3, gates D2 – D6, D13 and D17 are Code D maximum and therefore cannot accommodate the Code E aircraft demand; and
  - Whilst gate D7A is Code E capable, when this is in use the adjacent D6 cannot be used (as per Sydney Airport Corporation Limited Operations Manual).
- Compared to 2010 the average flight turnaround time for T3 has increased which is possibly due to additional larger Code E's with longer servicing time joining the mix.
- The average turns per stand has increased for each terminal compared to the 2010 level of activity.

Drivers behind the stand shortfalls can best be examined by focussing on each terminal apron area in turn.

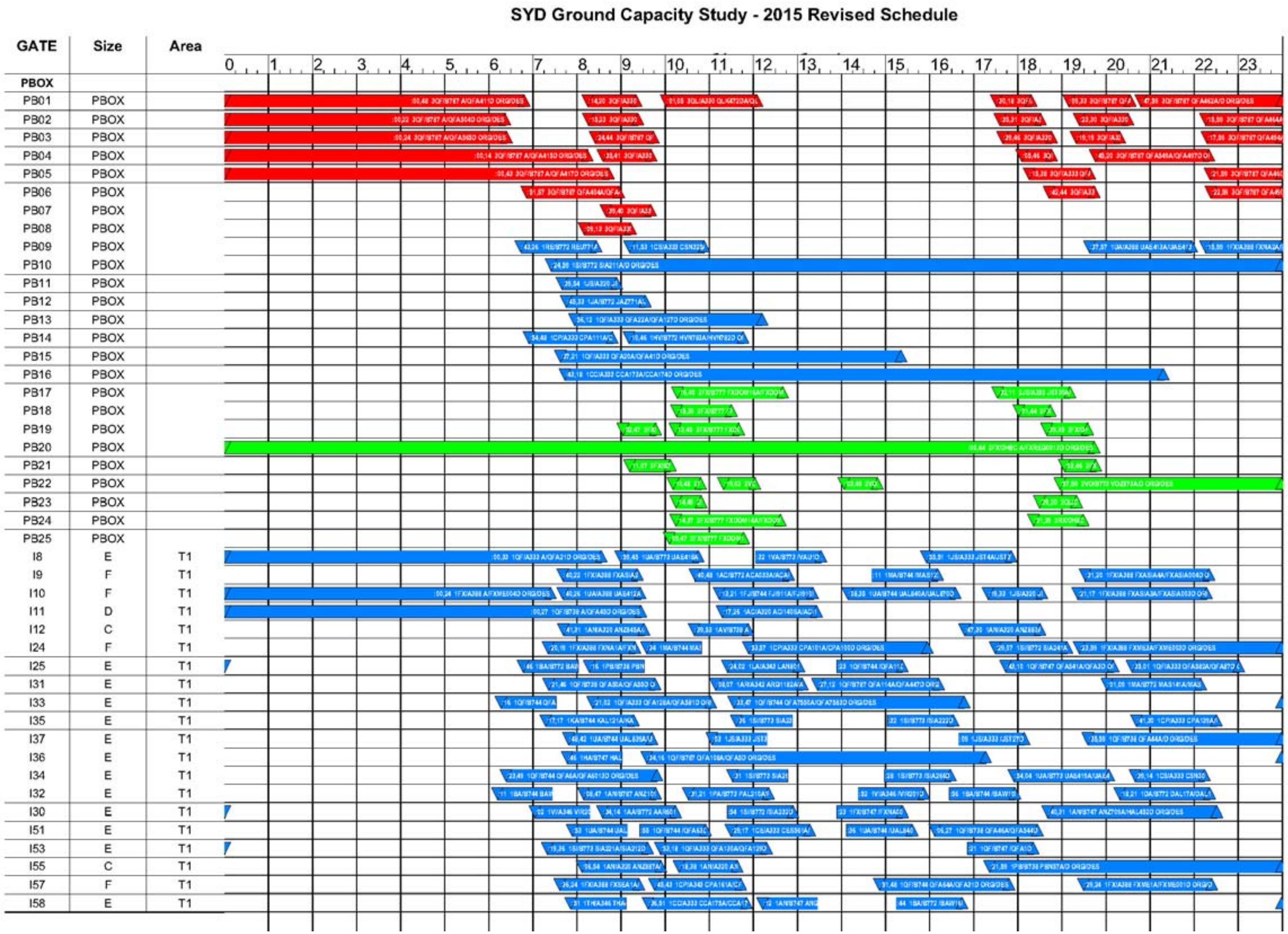


Figure 6.2 – 2015 GMS result - Penalty Box

6.2.3 T1 (International) Peak Stand Utilisation

Figure 6.3 shows the morning stand utilisation activity for T1 stands and identifies a shortfall of 8 stands (tagged as 'PBOX' rows at the top of the chart).

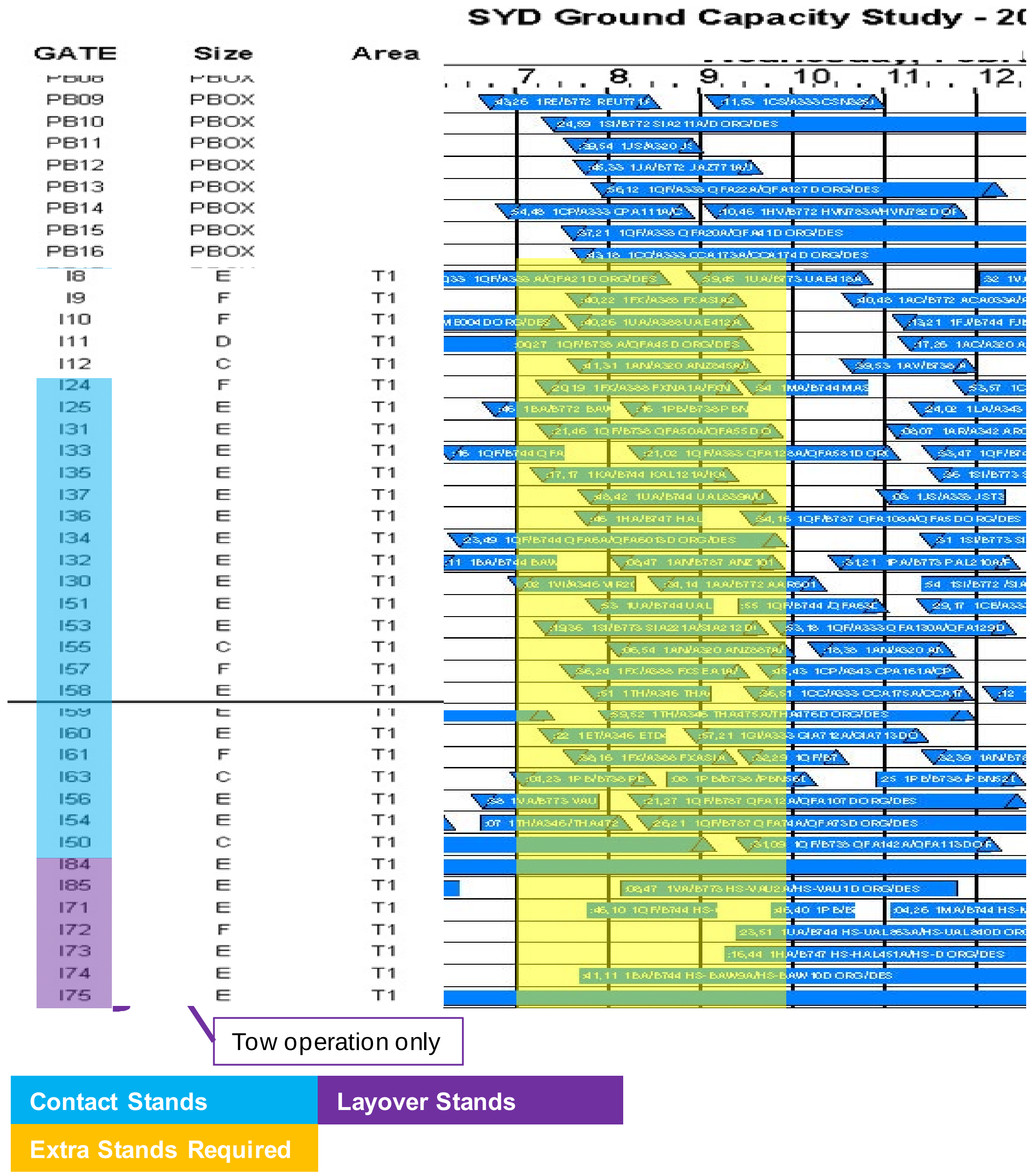


Figure 6.3 – T1 (International) 2015 Stand Allocation Chart Extract

The principal factor behind the stand shortfall result is that the 2015 forecast demand has an extra 12 aircraft movements added into the 07:00 – 10:00 period when compared to 2010 demand as shown in Table 6.3. This extra demand is being added to the schedule but there is no proposed increase in stand capacity by 2015. Given that the 2010 allocation chart (refer Figure 4.5) already showed all contact stands being utilised in this same period, the combination of these elements results in the shortfall of stands in the 2015 allocation exercise.

Table 6.3 – T1 2015 vs. 2010 Hourly Aircraft Movements

Hour	T1 2010 Total	T1 2015 Total	Increase
6	8	8	0
7	**17**	**25**	**8**
8	**14**	**15**	**1**
9	**22**	**25**	**3**
10	9	9	0
11	19	19	0
12	8	10	2
13	8	8	0
14	4	4	0
15	7	8	1
16	15	14	-1
17	10	9	-1
18	11	9	-2
19	7	10	3
20	10	8	-2
21	3	2	-1
22	6	12	6
23	1	1	0
Total	**179**	**196**	**17**

6.2.4 T2 (Domestic / Regional) Peak Stand Utilisation

Figure 6.4 shows the aircraft stand utilisation activity for T2 stands.

The shortfall of up to 9 stands for T2 flight activity occurs in the morning and evening peak periods. This is despite the addition of 5 Code C stands (or alternatively 2 Code E plus 1 Code C) as a result of Pier A expansion and Taxiway B4 reconfiguration.

Reasons for the un-accommodated flights in the 'Penalty Box' in Figure 6.4 are the addition of extra demand in the 2015 forecast and also the up-gauging of several aircraft from Code C to Code E.

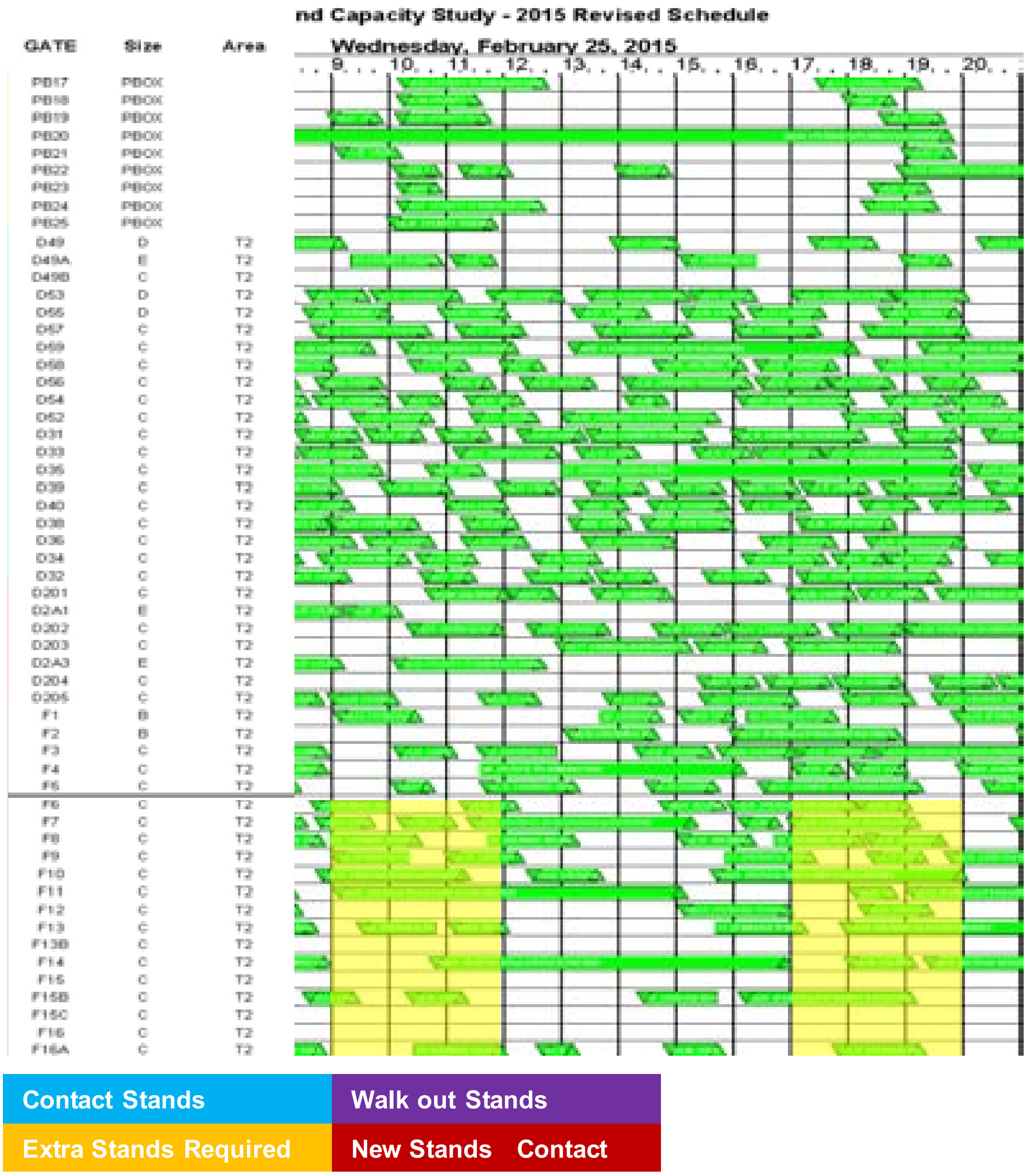


Figure 6.4 – T2 (Domestic / Regional) 2015 Stand Allocation Chart Extract

The growth in flight activity in the 2015 forecast is driving greater utilisation of T2 stands. Table 6.4 compares the 2010 hourly movements against the 2015 forecast.

The Penalty Box flights in the peak morning period of 10:00 - 12:00 is partly due to the increased demand. The 2015 forecast adds an extra 22 domestic / regional movements into this period, which already experiences high stand utilisation as per the 2010 chart (refer Figure 4.6)

Similarly, in the peak evening period of 17:00 - 20:00 an extra 11 domestic/regional flights are added to 2015 forecast schedule in a period when stands were already heavily occupied.

Table 6.4 – T2 2015 vs. 2010 Hourly Aircraft Movements

Hour	T2 2010 Total	T2 2015 Total	Increase
6	16	18	2
7	37	43	6
8	41	43	2
9	28	31	3
10	**26**	**41**	**15**
11	28	35	7
12	27	32	5
13	24	27	3
14	26	27	1
15	30	30	0
16	26	30	4
17	36	37	1
18	40	46	6
19	38	42	4
20	17	18	1
21	18	23	5
22	9	9	0
23	0	0	0
Total	**467**	**532**	**65**

The other factor behind the stand shortfall is aircraft up-gauging. As can be seen from the highlighted peak periods in Figure 6.4, there are some gaps on stands associated with T2. Some flights in the Penalty Box could slot into these gaps but the aircraft are up-gauged Code E and cannot fit onto the predominantly Code C stands.

If the un-gated code E flights in the morning peak period were down-graded to code C, then the stand shortfall would reduce from 9 to only 3 extra gates required. In the evening peak period the shortfall would reduce from 8 to 6 stands.

6.2.5 T3 (Qantas Domestic) Peak Stand Utilisation

Figure 6.5 shows the aircraft stand utilisation activity for T3 stands.

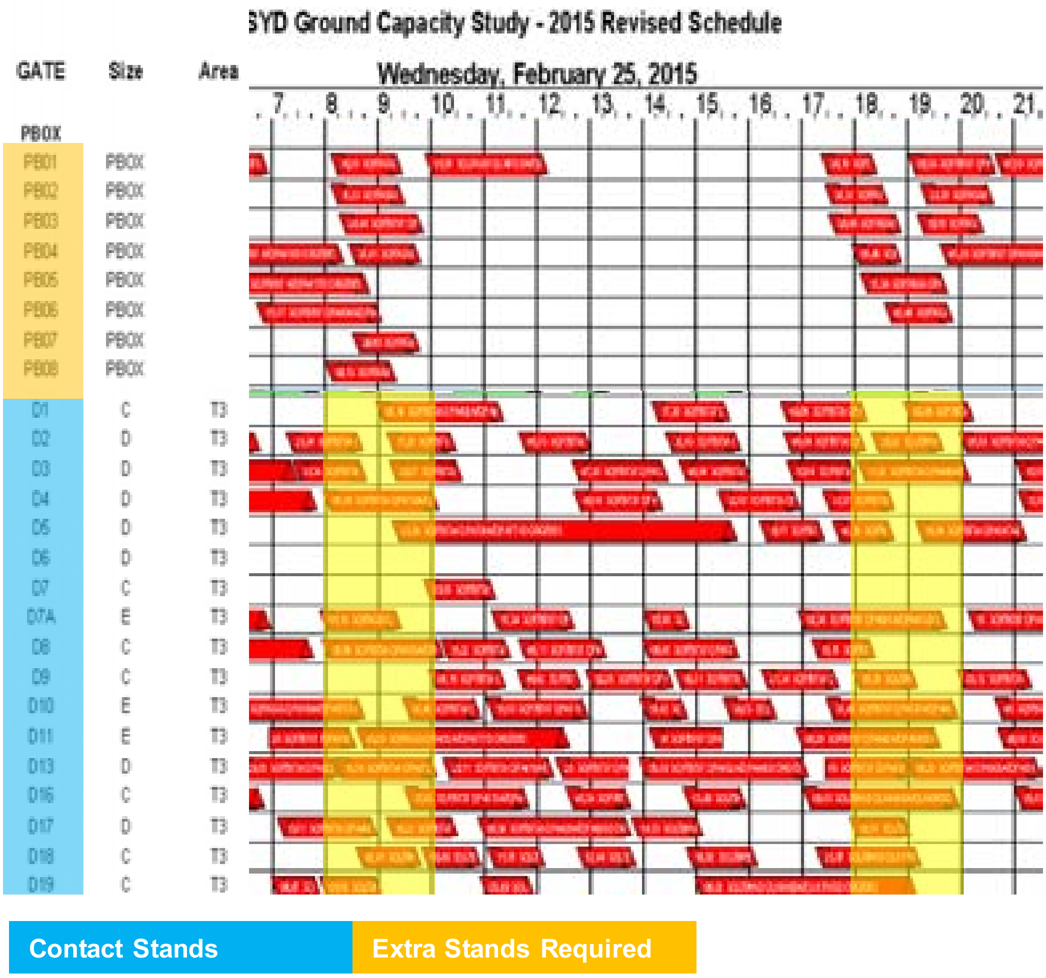


Figure 6.5 – T3 (Qantas Domestic) 2015 Stand Allocation Chart Extract

There are two factors behind the apparent shortfall of 8 stands.

The first is that the 2015 forecast demand has an extra 8 aircraft movements added into the 08:00 – 10:00 period when compared to 2010 demand as shown in Table 6.5. This extra demand is being added to the schedule but there is no proposed increase in stand capacity by 2015.

Table 6.5 – T3 2015 vs. 2010 Hourly Aircraft Movements

Hour	T3 2010 Total	T3 2015 Total	Increase
6	8	13	5
7	13	8	-5
8	**18**	**21**	**3**
9	**14**	**19**	**5**
10	13	12	-1
11	14	14	0
12	13	13	0
13	11	6	-5
14	14	15	1
15	13	11	-2
16	15	7	-8
17	15	15	0
18	16	16	0
19	14	19	5
20	13	11	-2
21	11	7	-4
22	3	7	4
23	0	0	0
Total	**218**	**214**	**-4**

Secondly, the 2010 chart for T1 (refer Figure 4.7) showed all stands being occupied during busy morning and evening periods. In comparison, Figure 6.3 shows gaps on some of the stands in the same highlighted peak periods as flights allocated to the Penalty Box. This is the result of aircraft up-gauging in the 2015 demand, without a corresponding increase in the capability of aircraft stands to accommodate larger aircraft.

In the 2015 demand several flights (notably all Code D aircraft) have been up-gauged to Code E aircraft and all of these cannot fit onto the existing 3 Code E capable stands. Additionally, when stand D7A (Code E capable) is occupied by a Code E aircraft, this larger aircraft means the adjacent stand D6 (Code C) cannot be used, as per the Sydney Airport Corporation Limited Operations Manual. This means that available stand capacity is reduced by 1 stand at times when all 3 Code E stands are occupied.

If the un-gated code E flights were down-sized to code C, then the total shortfall would drop from 8 to 5 extra gates required in the 08:00 – 09:00 and 18:00 – 20:00 hours.

6.2.6 2015 Stand Allocation Summary

This section has identified a total stand shortfall of 25 stands based on the received 2015 forecast demand and aircraft stand provision.

However, part of this shortfall is the result of domestic aircraft up-gauging from Code C to Code E aircraft when there is not a similar increase in the size of aircraft stands. This results in some smaller (Code D and C) stands at T2 and T3 not being fully utilized during busy periods. As a sensitivity test, if the Code E aircraft in the GMS Penalty Box were down-graded to Code C aircraft then the shortfall of stands would reduce from 25 to 20. If some other Code E aircraft in the schedule were similarly down-graded (or not up-gauged) from 2010, further reductions in the stand shortfall may be possible.

Other factors behind the stand shortfall result include the exclusive use nature of each terminal. The excess demand for T2 and T3 actually occur at different times in the morning and theoretically speaking these flights could use the same stands if they could be shared use for different airlines. Further to this is that the analysis has not assumed bussing operations for passenger flights to remote aprons, which have only been used for towing long layover aircraft. This may allow some additional aircraft to be accommodated.

The other issues are the extent of demand growth to 2015 and the turnaround (ground) time duration of flights. The park morning hour (08:00 – 09:00) increases from 74 total aircraft movements in 2010 up to the 80 movement airport cap in 2015. Because of this, the adjacent hours have bigger increases in movements due to peak spreading. In total an extra 47 aircraft movements are added airport wide between 06:00 – 11:00 in the 2015 forecast. In terms of infrastructure only 5 additional Code C stands at T2 (or alternatively 2 Code E and 1 Code C) are added to the apron capacity. The average flight turnaround times are 3hr 20min for International and approximately 1hr 20min for T2 and T3 flights means that flights are not arriving and vacating from stands within each hour of activity. This is reflected in the average turns per stand across the day at each terminal and simply the lack of gaps between flights that can be seen on the allocation chart.

The addition of so many movements in adjacent busy period hours when existing (2010) stand utilization is already very high to full, combined with aircraft up-gauging and minimal provision of additional stand capacity, is resulting in not all 2015 forecast flights being accommodated on available stands.

6.3 2020 Apron / Gate Demand

6.3.1 Stand Availability and Allocation Assumptions

The apron / stand provision modelled against the forecast 2020 aircraft schedule demand is summarised here and the additional apron / stands (giving a total of 107 stands) are shown over the existing layout in Figure 6.6:

- Availability of apron/stand developments as per 2014 – 2019 Implementation section in Master Plan 2009 (refer Appendix A).
- Some sharing of T2 Pier A between JetStar and Virgin; plus some Virgin use of Pier C.
- 2 x western gates of T2 Pier B assumed to also be available for QF Domestic use.

15.1.2 2014 to 2019

1 T1 expansion to the north including development of Pier A. Development will facilitate additional terminal processing capacity and provide additional aerobridge positions for aircraft parking, including improved flexibility of handling Code F aircraft.

2 T2 expansion to the east including development of Pier C. Development to facilitate additional terminal processing capacity and provide additional aerobridge positions for aircraft parking, including improved flexibility of handling Code E aircraft.

3 Apron expansion and associated taxiway works for aircraft parking in the south-east sector of the airport.

(Source: Sydney Airport 2009 Master Plan; Section 15 Implementation)

4 Intl Freight must relocate from existing location to facilitate T1 expansion. Assumed that these first 7 common use freight/remote stands are provided (redevelopment of Qantas Jet Base area is noted separately in 2019 – 2024 timeframe).

AC Type	Passenger						Freight		General Aviation
	T1		T2		T3		Int'l	Dom	
	Active	Layover	Active	Layover	Active	Layover			
Code B									6
Code C	3	1	30	1	7			5	2
Code D		1	3	7	7				
Code E	17	5			2		7		2
Code F	10	1							
Total	30	8	33	8	16		7	5	10
		38		41		16		12	10

107 (excl. GA)

Figure 6.6 – 2020 Additional Apron / Stand Provision

Much of the added stand capacity shown in Figure 6.6 is reconfiguration and relocation of existing stands, which does not yield a significant increase in overall stand capacity. For example, development of T2 Pier C does provide additional contact stands but these displace a greater number of turbo-prop stands thereby actually reducing the overall stand provision at T2. Whilst new remote stands in the south-east sector offset this, these are for use by towed-off aircraft as opposed to the current walk-out stands at T2. Similarly, T1 gains 5 additional contact stands by these displace current International Freight stands which in turn replace the remote stands at Northern Pond and maintenance base. Therefore the volume of work shown in Figure 6.6 only yields a net gain of 8 stands over 2015.

It is noted that as per Section 15 Implementation of the Master Plan 2009 (ref Appendix A) full development of T1 Pier A, redevelopment of Qantas Jet Base, relocation of GA from North-East to expanded South-East Sector and further eastern expansion of T2 aprons, all occur beyond 2020.

6.3.2 2020 GMS Stand Allocation Results

The 2020 forecast demand adds 89 movements over the 2015 forecast. By 2020 the 07:00, 08:00, 09:00 and 19:00 hours have all reached the 80 movements cap and the adjacent hours are absorbing additional movements due to peak spreading. The hourly growth in forecast aircraft movement demand from 2015 to 2020 is shown for each terminal in Table 6.6.

Table 6.6 – 2020 Hourly Aircraft Movement Growth

Hour	T1 2015 Total	T1 2020 Total	Increase
6	8	10	2
7	25	27	2
8	15	15	0
9	**25**	**27**	**2**
10	**9**	**11**	**2**
11	**19**	**23**	**4**
12	10	11	1
13	8	10	2
14	4	4	0
15	8	9	1
16	14	16	2
17	9	11	2
18	9	9	0
19	10	10	0
20	8	11	3
21	2	2	0
22	12	13	1
23	1	2	1
Total	**196**	**221**	**25**

Hour	T2 2015 Total	T2 2020 Total	Increase
6	18	25	7
7	43	44	1
8	**43**	**47**	**4**
9	**31**	**39**	**8**
10	41	42	1
11	35	33	-2
12	32	34	2
13	27	28	1
14	**27**	**35**	**8**
15	30	35	5
16	30	32	2
17	**37**	**42**	**5**
18	**46**	**50**	**4**
19	**42**	**51**	**9**
20	**18**	**23**	**5**
21	23	19	-4
22	9	16	7
23	0	0	0
Total	**532**	**595**	**63**

Hour	T3 2015 Total	T3 2020 Total	Increase
6	13	14	1
7	8	8	0
8	21	17	-4
9	19	14	-5
10	**12**	**21**	**9**
11	**14**	**18**	**4**
12	13	15	2
13	6	8	2
14	15	11	-4
15	11	9	-2
16	7	10	3
17	15	15	0
18	16	17	1
19	19	14	-5
20	11	12	1
21	7	12	5
22	7	3	-4
23	0	0	0
Total	**214**	**218**	**4**

Given the aircraft stand shortfalls identified in the 2015 analysis, continued aircraft movement growth in the 2020 peak and adjacent hours once again more than offsets the additional stand provisions.

The GMS modelling analysis of the 2020 forecast schedule yielded the following results as summarised in Table 6.7. Flight turnaround times are dictated by arrival and departure times in the Booz & Co. forecast schedule. In total 30 turns cannot be accommodated at T1, T2 and T3 which would require an additional 19 stands. Factoring in the additional schedule growth above 2015 (an extra 89 aircraft movements) this result is a significant improvement over the 2015 outcome and shows the additional apron / stand capacity provided in this timeframe is delivering some capacity benefits.

Table 6.7 – 2020 Stand Allocation and Usage Outcomes

	Ave. Flight Turnaround Time (1)	Ave. Turns per Stand (2)	Max Turns per Stand (2)	Aircraft Turns not accommodated	Add. Stands Required
T1	3hr 10min	4	5	7	7
T2	1hr 12min	8	11	14	8
T3	1hr 45min	6	8	9	4
Tot	n/a	n/a	n/a	30	19

Notes: (1) Turnaround (paired) flights only. Does not include Arrival Only or Departure Only flights.
(2) Does not include remote stands for aircraft tow-off.

Figure 6.7 shows an extract from the GMS model stand allocation chart showing the 'Penalty Box', i.e. those aircraft that cannot be accommodated on the available stands. The full GMS ramp chart is contained in Appendix D.

Observations from this GMS modelling exercise can be summarised as follows:

- An additional 19 stands (in GMS 'Penalty Box' in Figure 6.7) would be required to accommodate the 2020 forecast schedule demand.
  - 14 of these stands only have 1 flight (turn) per day which are in the peak periods and therefore cannot make use of gaps on stands during non-peak periods. Note that building these stands for 1 turn per day is not considered commercially justifiable and slight changes in future growth patterns, i.e. slower growth or alternative aircraft up-gauging, could remove many of these flights.

  - Arrival times of flights in the Penalty Box are occurring during busy hours when stands are utilized. For example, for T1 International flights (blue bars) between 07:00 – 09:00 there are no gaps on stands to accommodate the seven arrivals that are left in the Penalty Box.
- The un-accommodated aircraft at T3 and T2 are predominantly Code E aircraft:
  - If Domestic Code E aircraft in the Penalty Box were downgraded to Code C's, then only two T2 and one T1 aircraft turns could be accommodated on stands due to the lack of gaps between traffic being accommodated. The Penalty Box shortfall would therefore only slightly reduce to 18 stands;
- Other factors that could help alleviate the shortfall of stands include:
  - Increasing integration of the domestic terminal / apron facilities to allow more shared use of available stands;
  - Running bussing operations to remote stands for some passenger flights.
- The average flight turnaround time has reduced for T1 and T2, which can be expected as more flight activity is added and peak spreading occurs. Conversely, T3 aircraft turnaround time has increased which is possibly due to additional larger Code E's with longer servicing time joining the mix. These turnaround times were inherent characteristics of the forecast aircraft schedule provided by Booz & Co.
- The average turns per gate has increased for T2 and T3 compared to the 2015 level of activity demonstrating greater usage of available assets as more flights are added throughout the day.

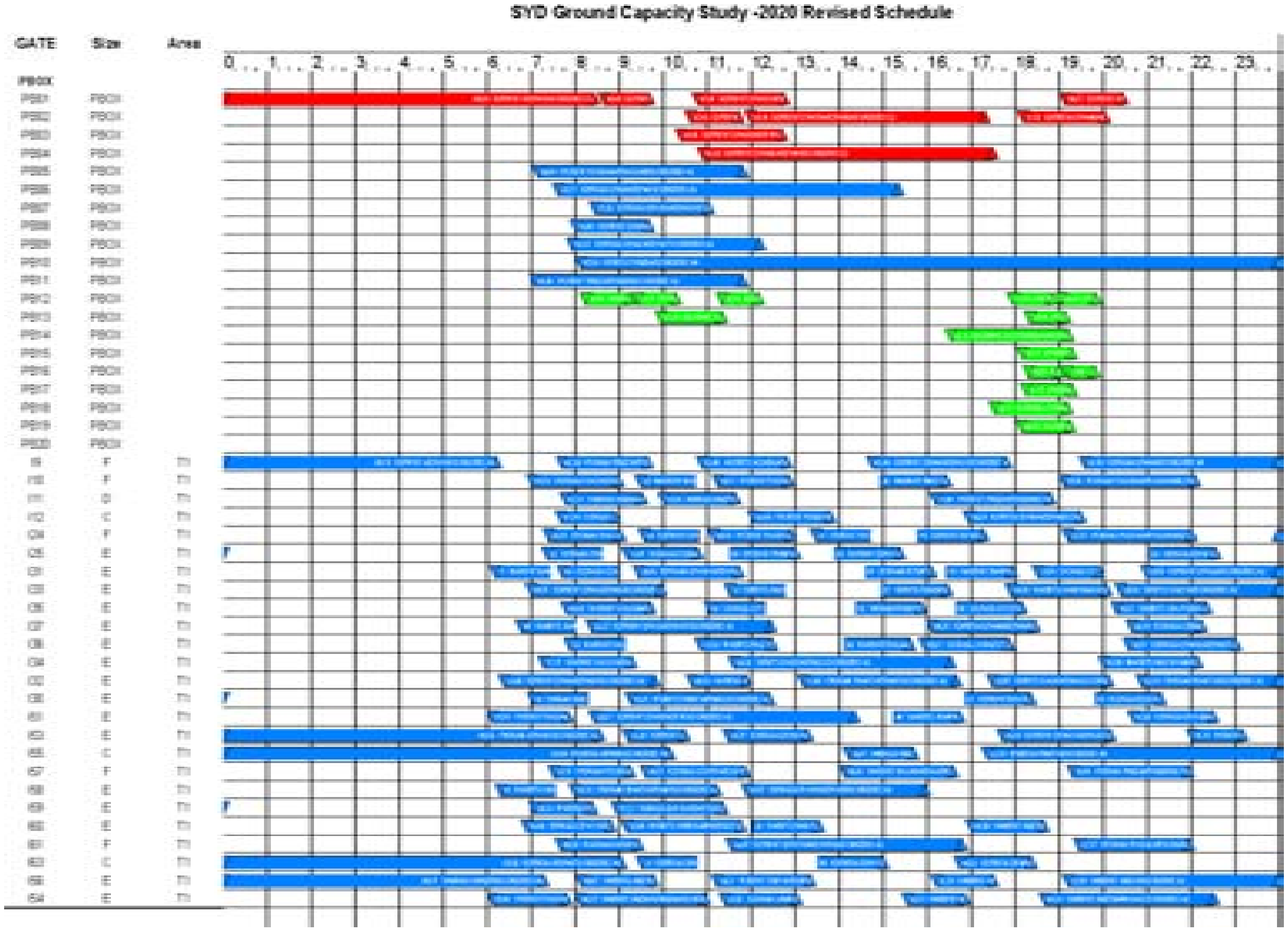


Figure 6.7 – 2020 GMS result - Penalty Box

6.4 2035 Apron / Gate Demand

For this long term gate demand analysis, L&B have utilised the full apron / stand provision of the Master Plan Concept layout. Other assumptions include:

- Existing operational assumptions for international and domestic flights including time on gate prior to towing, inter-gate (buffer) time etc. have been applied.
- Common use of T2 between JetStar, Virgin, etc., but not QF mainline Domestic.
- Western gates of T2 Pier B assumed also available for QF Domestic use as part of "integration between the two terminals" as per Implementation section in Master Plan 2009 (refer Appendix A).

By 2035 half (9) of the Airport's operating hours have reached the 80 movements cap and another four hours are at 75 movements or higher. Driven by peak spreading, this consistent level of movement activity still creates stand capacity implications because the average turnaround time for domestic flights exceeds 1hour and international flights is 3hours.

The hourly growth in forecast aircraft movement demand from 2020 to 2035 is shown for each terminal in Table 6.8. In particular, this demonstrates significant growth in T2 domestic/regional movements.

Table 6.8 – 2035 Hourly Aircraft Movement Growth

Hour	T1 2020 Total	T1 2035 Total	Increase
6	**10**	**13**	**3**
7	**27**	**30**	**3**
8	15	15	0
9	27	29	2
10	11	12	1
11	23	26	3
12	11	13	2
13	10	13	3
14	4	5	1
15	9	11	2
16	16	20	4
17	11	12	1
18	9	8	-1
19	10	13	3
20	11	15	4
21	2	2	0
22	**13**	**22**	**9**
23	2	2	0
Total	**221**	**261**	**40**

Hour	T2 2020 Total	T2 2035 Total	Increase
6	**25**	**51**	**26**
7	44	36	-8
8	47	46	-1
9	39	37	-2
10	42	53	11
11	33	39	6
12	**34**	**51**	**17**
13	**28**	**46**	**18**
14	**35**	**58**	**23**
15	35	49	14
16	32	40	8
17	42	52	10
18	50	56	6
19	51	49	-2
20	23	38	15
21	19	28	9
22	16	19	3
23	0	0	0
Total	**595**	**748**	**153**

Hour	T3 2020 Total	T3 2035 Total	Increase
6	14	8	-6
7	**8**	**13**	**5**
8	17	18	1
9	14	14	0
10	21	14	-7
11	18	14	-4
12	15	12	-3
13	8	11	3
14	11	14	3
15	**9**	**14**	**5**
16	10	14	4
17	15	15	0
18	17	16	-1
19	14	14	0
20	12	13	1
21	12	11	-1
22	3	3	0
23	0	0	0
Total	**218**	**218**	**0**

The GMS modelling analysis of the 2035 forecast schedule yielded the following results as summarised in Table 6.9. Flight turnaround times are dictated by arrival and departure times in the Booz & Co. forecast schedule. In total 39 turns cannot be accommodated at T1, T2 and T3 which would require an additional 16 stands. Given that the 2035 forecast horizon is 6 years beyond the 2029 planning horizon in the Master Plan 2009 it is therefore not surprising that there is a discrepancy between stand demand and planned supply.

Table 6.9 – 2035 Stand Allocation and Usage Outcomes

	Ave. Flight Turnaround Time (1)	Ave. Turns per Stand (2)	Max Turns per Stand (2)	Aircraft Turns not accommodated	Add. Stands Required
T1	**2hr 58min**	**4**	**7**	**7**	**6**
T2	**1hr 11min**	**9**	**12**	**27**	**8**
T3	**1hr 24min**	**9**	**10**	**5**	**2**
Tot	**n/a**	**n/a**	**n/a**	**39**	**16**

Notes: (1) Turnaround (paired) flights only. Does not include Arrival Only or Departure Only flights.
(2) Does not include remote stands for aircraft tow-off.

Figure 6.8 shows an extract from the GMS model the gate allocation chart showing the 'Penalty Box', i.e. those aircraft that cannot be accommodated on the available gates. The full GMS ramp chart is contained in Appendix E.

Observations from this GMS modelling exercise can be summarised as follows:

- An additional 16 stands (in GMS 'Penalty Box' in Figure 6.8) would be required to accommodate the 2035 forecast schedule demand.
- Many un-accommodated aircraft at T2 are Code E aircraft.
- If Penalty Box Code E (Domestic) aircraft were downgraded to Code C's, then greater utilization of available gates could occur and the Penalty Box shortfall would reduce from 16 to 11 stands.
- The average flight turnaround time has reduced for aircraft at all three terminals due to additional peak spreading and flights filling available gaps in the schedule.
- The average turns per gate has increased for T2 and T3 compared to the 2015 level of activity demonstrating greater usage of available assets as more flights are added throughout the day.

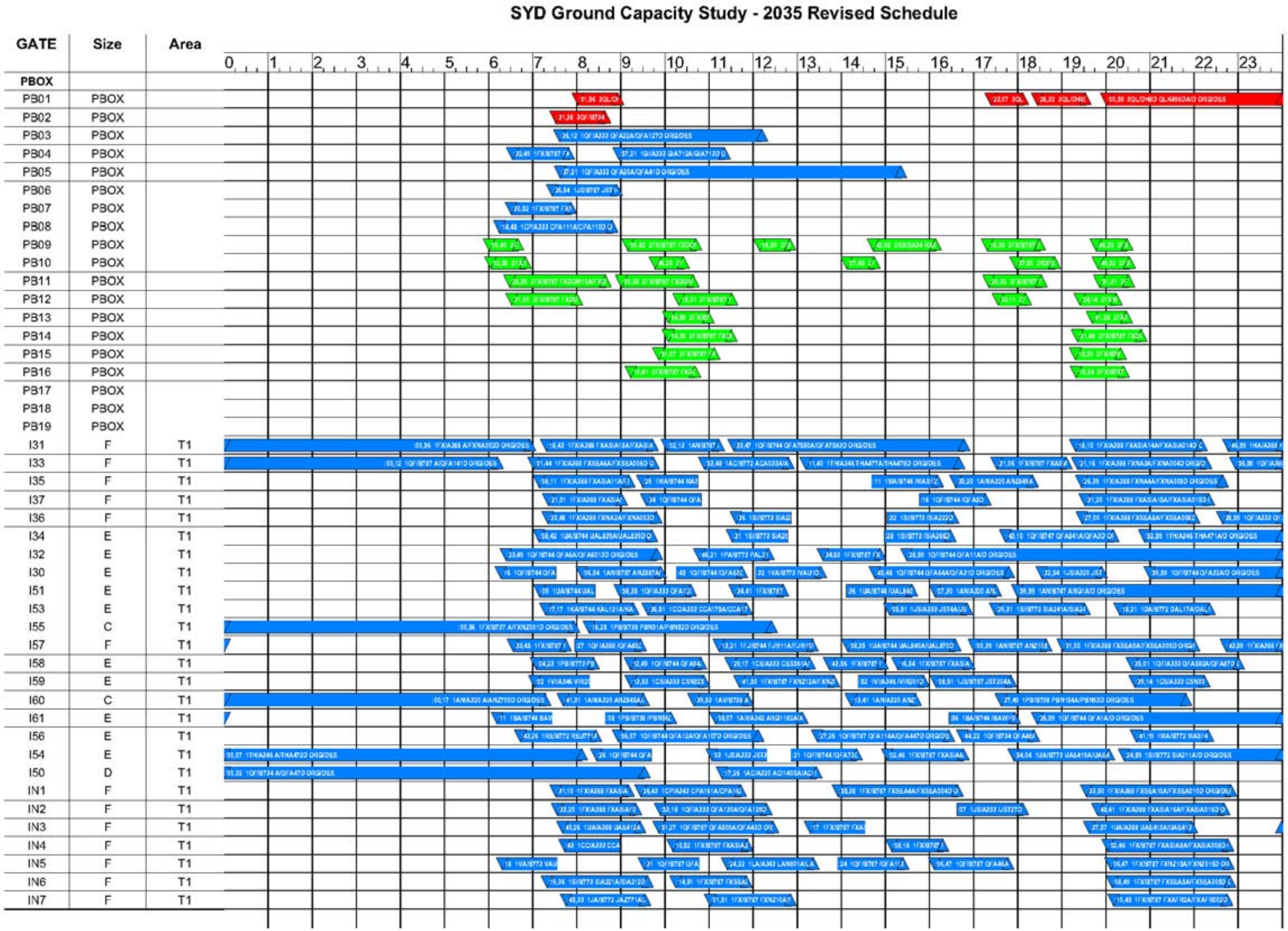


Figure 6.8 – 2035 GMS results - Penalty Box

6.5 Apron / Stand Demand vs. Capacity Summary

Key outcomes of allocating forecast aircraft movement demand versus stand provision at each demand level horizon can be summarised as follows.

2010:

- The existing aircraft stands are already heavily utilised at each terminal in peak periods.
- T1 contact stands are all occupied between 07:30 – 10:00.
- T2 stands have some gaps to absorb additional aircraft movements during busy periods of 10:00 – 12:00 and 17:00 – 20:00.
- T3 contact stands are all occupied between 08:00 – 10:00 and 17:00 – 20:00.
- Average turnaround times for T1 flights are 3hrs 20mins, 1hr 18mins for T2 and 1hr 24mins for T3.
- The average turns per stand across the day are quite strong due to the level of activity:
    - T1 = 4 turns per stand average (maximum = 6 turns)
    - T2 = 6 turns per stand (maximum = 11 turns)
    - T3 = 7 turns per stand (maximum = 9 turns)

2015:

- The forecast 2015 flight demand adds 47 movements above 2010 demand into the peak morning period (06:00 – 11:00), when existing aircraft stand utilisation is already very high to full.
    - T1 = 12 additional movements between 07:00 – 10:00.
    - T2 = 22 additional movements between 10:00 – 12:00.
    - T3 = 8 additional movements between 08:00 – 10:00.
- Up-gauging of domestic aircraft is introducing extra Code E aircraft into the mix without a corresponding increase in Code E capable stands.
- There is minimal provision of additional stand capacity planned by 2015 with only 5 x Code C stands (or alternatively 2 x E plus 1 x C) provided at T2 in the short term following completion of current Twy B4 realignment works.
- The average turns per stand across the day remains the same as 2010.
- A shortfall of 25 total stands was identified in the stand allocation exercise.
    - 10 of these stands only have 1 turn per day including a couple of ultra-long stay flights.

    - If un-accommodated Code E aircraft were downsized to Code C, the shortfall would reduce from 25 to 20.
    - The additional stands are required at different times at each terminal but due to airline use segregation, there is no opportunity for potential optimisation through common use.
- Average flight turnaround times are similar to 2010 meaning that on average flights are not vacating stands in less than an hour. These turnaround times are defined by arrival and departure times in the Booz & Co. forecast aircraft schedule. So, additional flight growth in each hour plus adjacent hours is combining to increase stand demand.
- The peak period growth in forecast aircraft movements is exceeding available stand capacity. Hence, additional aircraft stands are required to accommodate the forecast aircraft schedule demand T1, T2 and T3.

2020:

Development of aircraft stand capacity is assumed as per Section 15 Implementation, of the Master Plan 2009.

- The forecast 2020 scheduled day has a total of 89 movements above 2015 with many of these occurring in the morning and evening peak periods.
    - T1 receives an additional 8 movements between 09:00 – 12:00.
    - T2 receives an additional 12 movements between 08:00 – 09:00 plus 23 movements between 17:00 – 21:00.
    - T3 receives an additional 13 movements between 10:00 – 12:00.
- The allocation exercise identified a shortfall of 19 stands needed to accommodate forecast demand.
    - However, 14 of these stands only have 1 aircraft turn per day. It is considered unlikely that additional stands could justifiably be built for 1 turn per day.
    - If un-accommodated Code E aircraft were downsized to Code C, the shortfall would only marginally reduce from 19 to 18 stands.
    - If the forecast aircraft movement activity was slightly trimmed and/or different aircraft up-gauging assumptions were used, then the un-accommodated flights and aircraft stands shortfall may be reduced.
- The addition of extra stand capacity at T2 has helped to accommodate more flights when compared to the 2015 result.

- The extent of continued aircraft up-gauging to Code E flights for Qantas domestic (T3) still exceeds the provision and redevelopment of existing stands to Code E capability.
- The average turns per stand at T2 and T3 across the day increases over 2015, indicating better utilisation of available stands due to peak spreading.
- At T1 the addition of contact stands helps to absorb some forecast growth. However, the additional flight demand in the peak morning period still outweighs the extra capacity.

2035:

- The stand demand driven by the 2035 forecast aircraft schedule exceeds the capacity provided by the 2029 long-term apron/gate layout.
- A total shortfall of 16 stands was identified in the peak morning period, though 6 of these only accommodate one aircraft turn.
- The average turns per stand at T2 and T3 across the day increases over 2020, indicating better utilisation of available stands due to peak spreading.
- Given the 6 year discrepancy between the forecast and 2029 layout, a shortfall of stands in peak periods is not unexpected.

In summary, additional aircraft stand capacity is required by 2015 to accommodate forecast demand. Substantial aircraft movement growth is occurring airport wide in the peak morning period and this is not being matched by additional aircraft stand capacity.

The forecast aircraft schedules show up-gauging of aircraft at 2015 and 2020 horizons. Conversely, whilst the 2029 layout plan does provide many up-sized aircraft stands, these are predominantly delivered after 2020 leading to a gap between capacity and forecast demand.

Beyond this, as much of the Master Plan Concept layout for 2029 as possible is required to be developed by 2020 to accommodate the forecast schedule demand, especially during peak morning, evening and overnight periods. This will allow further, incremental activity growth by further peak spreading in the aircraft schedule to continue out to the Master Plan 2009 20 year planning horizon.

This analysis of the provided forecast aircraft schedules has shown that provision of available stand capacity will be an issue and potential constraint on peak period growth of aircraft activity at Sydney (Kingsford-Smith) Airport in the near and long term. Additional stand capacity is required by 2015 to avoid constraining short term peak period growth. If stand capacity as per the Master Plan Concept layout for 2029 can be provided in a timely and continuous manner over the next decade, then the airport will be able to grow towards its Master Plan 2009 design horizon, albeit at a somewhat constrained rate.

7.0 Baseline (Existing) Taxiway Activity

7.1 Runway Operating Modes and Taxiway Flows

The two runway operating modes which L&B have been tasked with analysing are Mode 9 (North flow) and Mode 10 (South flow). Both modes utilise both parallel runways with the crosswind runway 07/25 used as an alternative taxiway when required.

The existing taxiway network is shown in the airfield diagrams below and highlight the common flows for arrival and departure movements in both Mode 9 (North flow) and Mode 10 (South Flow). The diagrams indicate the common runway entry and exit taxiways and possible points of conflict and single lane access to gates.

These flows can vary depending on the location of taxiway traffic and the way the air traffic controller determines the best way forward. However, the flows shown are considered to be the most likely and logical based on the L&B site visit to the Sydney (Kingsford-Smith) Airport ATC tower and discussions held with ASA.

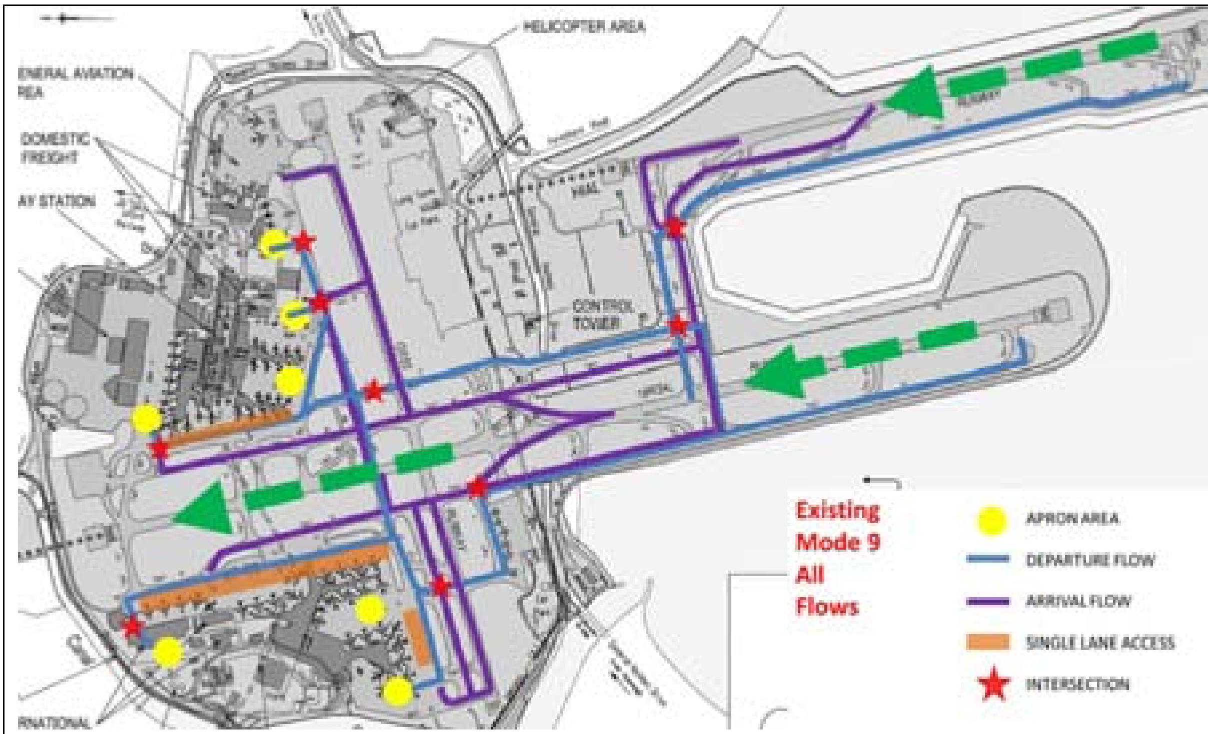


Figure 7.1 – Existing Mode 9 taxiway flows

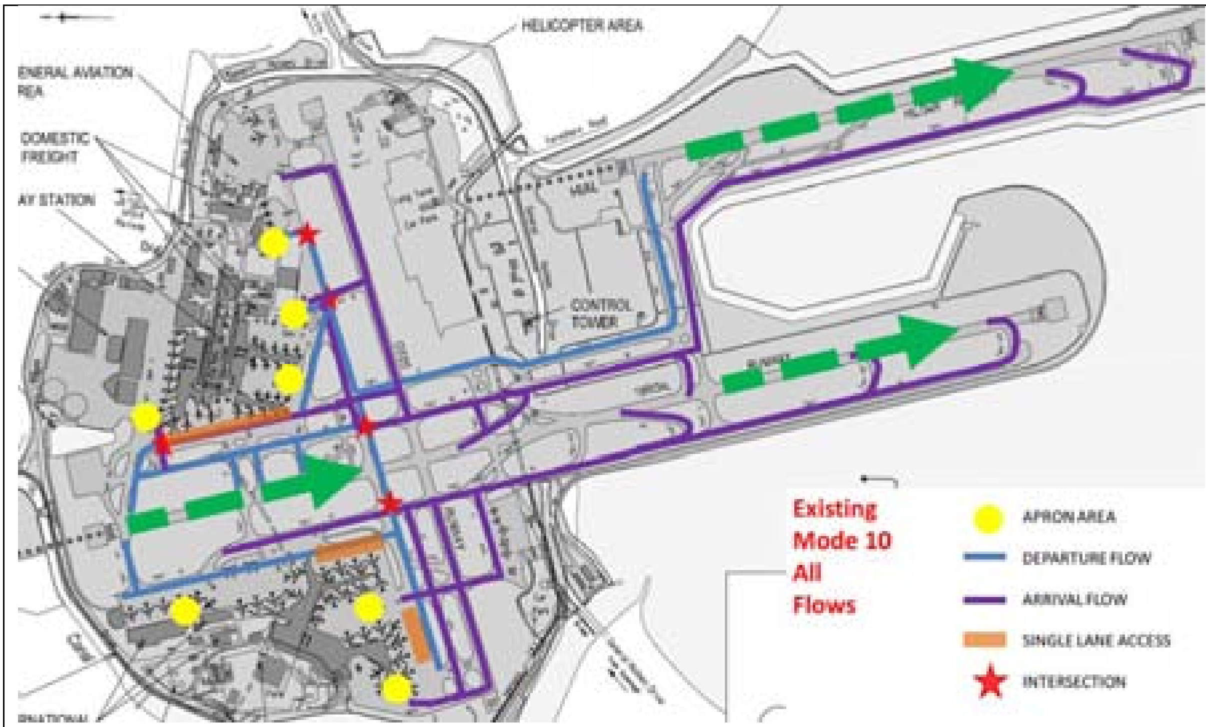


Figure 7.2 – Existing Mode 10 taxiway flows

7.2 ATC Tower Visit – Observations

Airfield operations were observed from the Sydney (Kingsford-Smith) Airport ATC tower on the 24th and 25th March 2011 where both mode 9 and mode 10 operations were observed. L&B received a taxiway dataset recording movements during the tower visit and examined it to produce key statistics highlighted with the following chart. This taxiway data provided a useful input for TAAM modelling where L&B were able to specify an average taxi time for each runway in both modes of operation.

Figure 7.3 – Existing average taxi time analysis

7.3 TAAM Operating Parameters and Modelling Assumptions

7.3.1 Airspace

The base models provided by AsA included SIDs (Standard Instrument Departure) and STARs (Standard Terminal Arrival Route) for Sydney (Kingsford-Smith) Airport. This data was compared with the published flight procedures and modified when necessary. After discussions with AsA, it is understood that Sydney (Kingsford-Smith) Airport will not have significant airspace improvements within the Master Plan 2009 planning horizon, i.e. the departure/arrival procedures, flight routes, as well as separation requirements will remain unchanged throughout the time periods modelled.

For arriving flights, the flight route is assumed to be straight from the origin airport to an arrival fix, and then follows a STAR to the landing runway. The desired air speed on the final approach was assumed to be 150 knots, as in the base model.

For departing flights, the flight route is assumed to first follow SID to a departure fix, and then straight to the destination airport. When necessary, jet and turbo-prop will use different routes (departure fix) as in actual practices. In some instance, when different departure fixes are used to the same destination from different runways, a fictitious common "departure fix" is created so that there is one unique route between each city-pair to satisfy TAAM modelling requirement.

Below figures depict the SIDs and STARs for Mode 9 and Mode 10 operations, respectively.

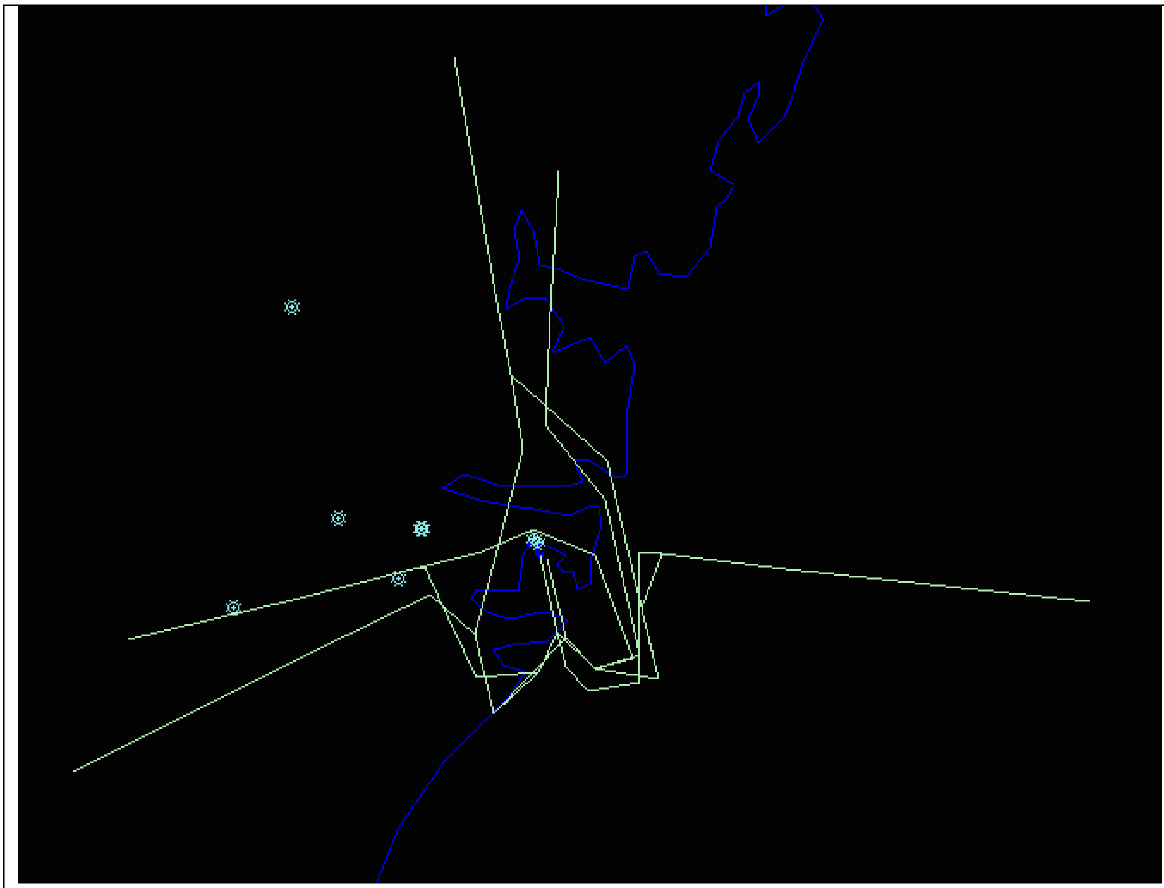


Figure 7.4 –Mode 9 STARs

Mode 9 STARs used:

- YSSY_34L_BOREE_1vmc.sta
- YSSY_34L_CAA_1b.sta
- YSSY_34L_MARLN_1vmc.sta
- YSSY_34L_ODALE_1vmc.sta
- YSSY_34L_RIVET_1vmc.sta
- YSSY_34R_BOREE_1vmc.sta
- YSSY_34R_CAA_1vmc.sta
- YSSY_34R_MARLN_1vmc.sta
- YSSY_34R_ODALE_1vmc.sta
- YSSY_34R_RIVET_1vmc.sta

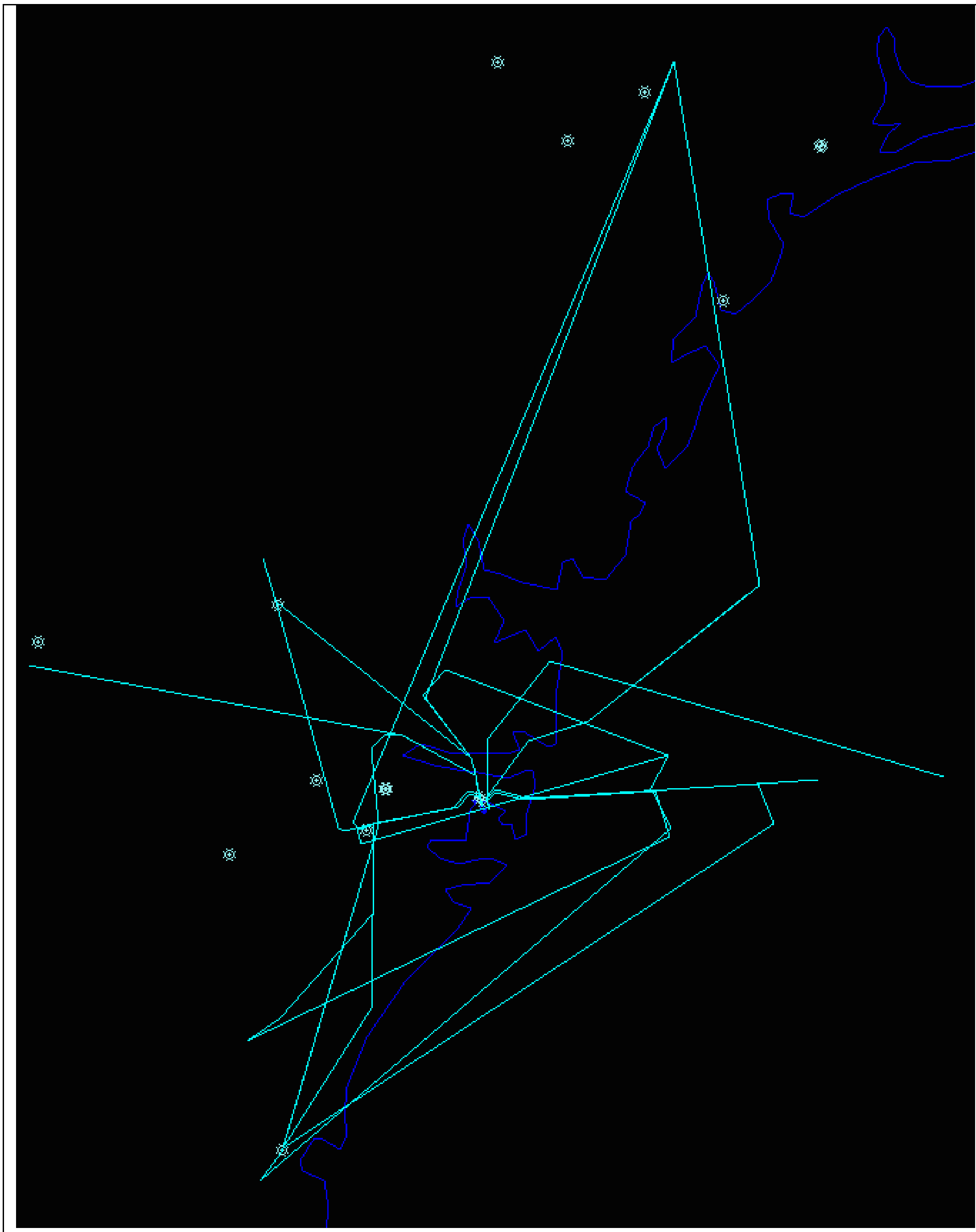


Figure 7.5 –Mode 9 SIDs

Mode 9 SIDs used (exclude the factious one created to meet TAAM requirements):

- YSSY_34L_RIC_1.sid
- YSSY_34L_RIC_2.sid
- YSSY_34L_WOL_1.sid
- YSSY_34L_WOL_2.sid
- YSSY_34R_ENTRA_1.sid

- YSSY_34R_MARUB_1.sid
- YSSY_34R_WOL_1.sid
- YSSY_34L_KAT_1.sid
- YSSY_34L_CORDO_2.sid
- YSSY_34R_DIPSO_2.sid
- YSSY_34L_RICA_1.sid
- YSSY_34L_S2412_1.sid

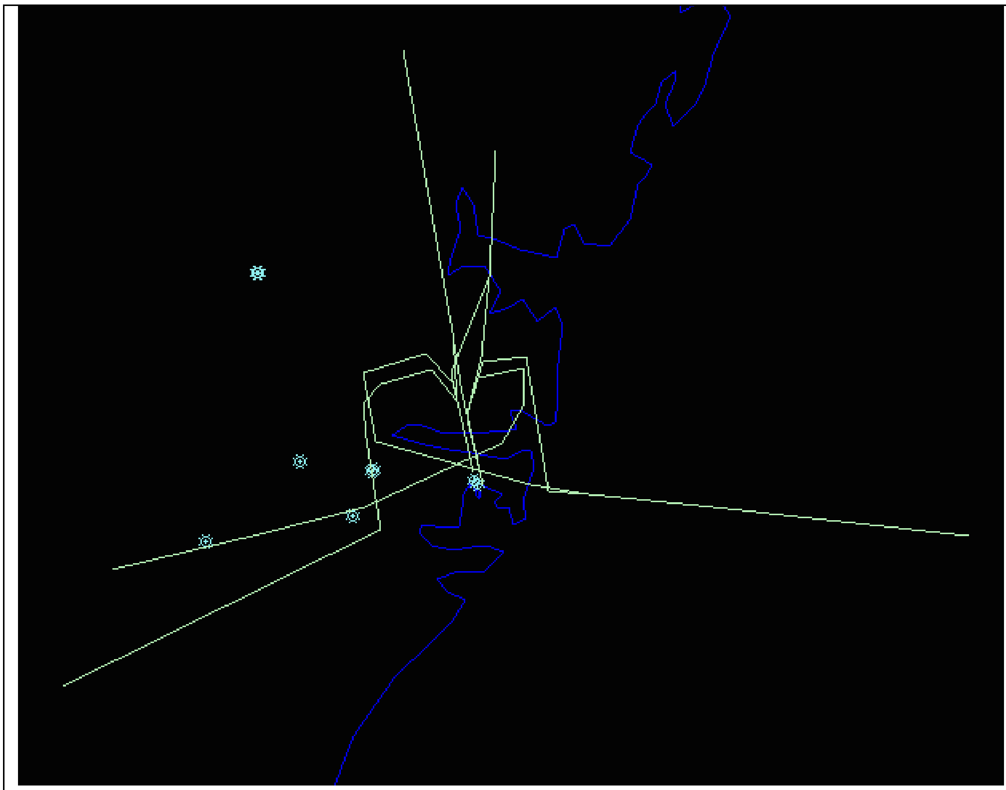


Figure 7.6 –Mode 10 STARs

Mode 10 STARs used:

- YSSY_16L_BOREE_1.sta
- YSSY_16L_CAA_1.sta
- YSSY_16L_MARLN_1.sta
- YSSY_16L_ODALE_1.sta
- YSSY_16R_BOREE_1.sta
- YSSY_16R_CAA_1vmc.sta
- YSSY_16R_MARLN_1vmc.sta
- YSSY_16R_RIVET_1vmc.sta

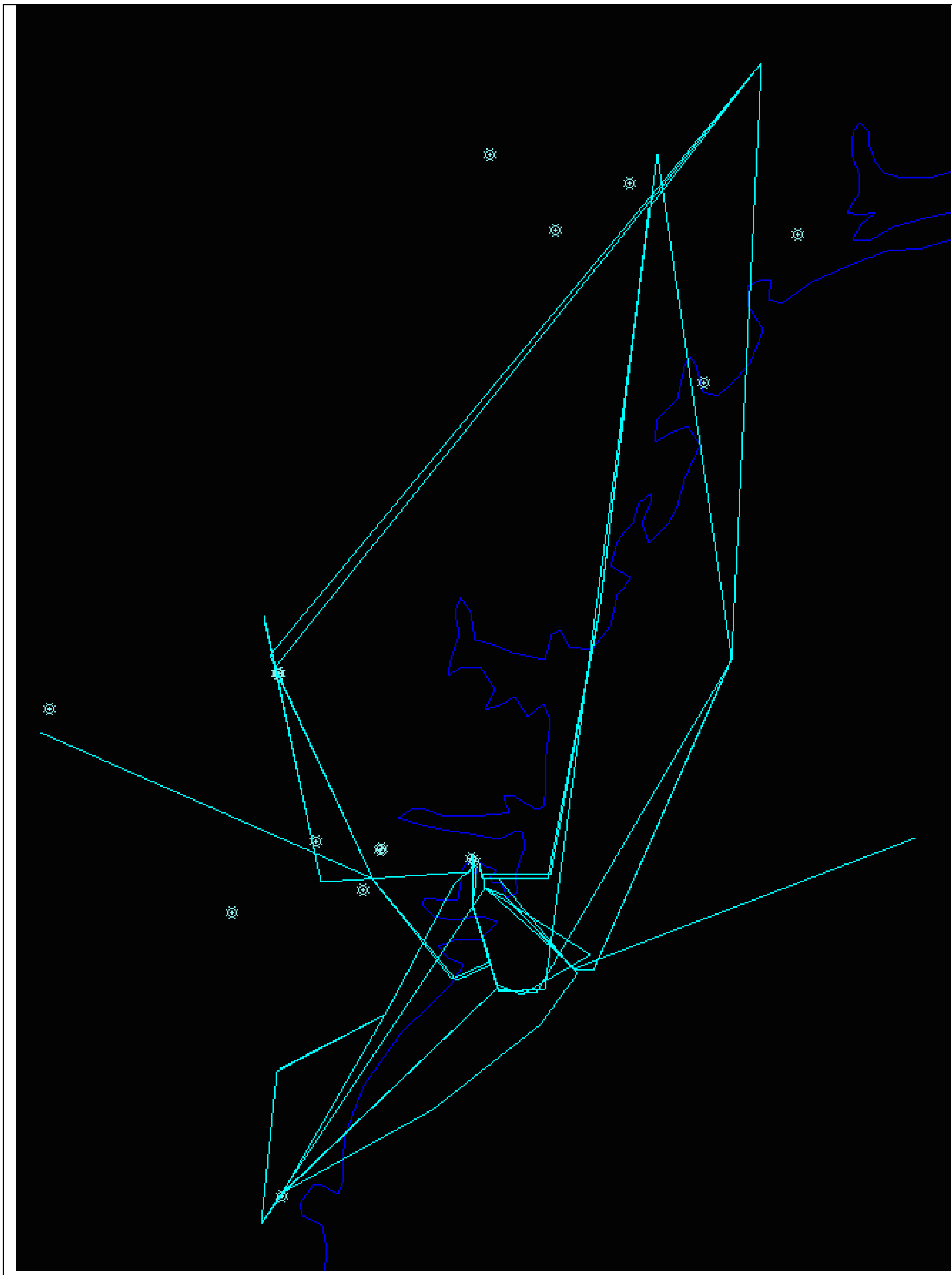


Figure 7.7 –Mode 10 SIDs

Mode 10 SIDs used (exclude the factious one created to meet TAAM requirements):

- YSSY_16L_ENTRA_1.sid
- YSSY_16L_KAMBA_1.sid
- YSSY_16L_KEVIN_1.sid
- YSSY_16L_WMD_1.sid

- YSSY_16L_WOL_1.sid
- YSSY_16R_CORDO_1.sid
- YSSY_16R_ENTRA_1.sid
- YSSY_16R_KAMPI_1.sid
- YSSY_16R_RIC_1.sid
- YSSY_16R_WOL_1.sid
- YSSY_16R_WOL_2.sid
- YSSY_16R_KAT_1.sid
- YSSY_16L_DIPSO_2.sid
- YSSY_16R_RIC_2.sid

7.3.2 Runway Operations

Under Mode 9 (north flow) and Mode 10 (south flow), Sydney (Kingsford-Smith) Airport is utilizing mixed mode operations, i.e. both runways are used for take-off and landings. There is sufficient spacing between the two runways (34L/16R and 34R/16L) enabling independent runway operations. The following runway use restrictions exist at Sydney (Kingsford-Smith) Airport and were modelled accordingly in the simulations:

- On Runway 34R there is an environmental restriction on aircraft greater than B767 or A330;
- On Runway 34R/16L the fillet design does not cater for long wheel base aircraft such as B777-300. This infrastructure is assumed not to change and the restriction to landing these aircraft on the runway will continue for the future scenario.

For landing aircraft, rapid exits are used predominantly with rare occurrences of aircraft using exits further down RWY 16R/34L. For some domestic B767's, exiting at TWY B10 or L, especially when wet is not unusual.

7.3.3 Separation Requirements

7.3.3.1 Wake Turbulence Separation Requirements

For safety reasons associated with wake vertex, an aircraft cannot fly too close to the preceding aircraft on the same route. The separation between consecutive aircraft for safe operation depends on the leading and trailing aircraft types. Air traffic controllers use standard minimum separations depending on the leading and trailing aircraft. The separations are specified independently for arrival and departure operations in either minutes or distance in the TAAM simulations.

In Table 7.1 arrival separation standards indicate an approximate 5% buffer, the resulting separation buffer produced by the TAAM model is about 10%. This 10% buffer was added to reflect real world operations. The 4.3 nautical miles (NMI) separations for a Super Heavy following either a Heavy-Plus or Heavy is based on input from A380 pilots L&B interviewed as part of other studies.

Table 7.1 –Minimum Arrival Wake Turbulence Separation Standards (nmi)

		Trailing					
		Super Heavy	Heavy-Plus	Heavy	Medium	Medium-Light	Light
Leading	Super Heavy	4.3	6.4	6.5	7.5	7.5	8.5
	Heavy-Plus	4.3	4.3	4.3	5.4	5.4	6.5
	Heavy	4.3	4.3	4.3	5.4	5.4	6.5
	Medium	3.3	3.3	3.3	3.3	3.3	5.4
	Medium-Light	3.3	3.3	3.3	3.3	3.3	5.4
	Light	3.3	3.3	3.3	3.3	3.3	3.3

Table 7.2 are the minimum wake turbulence separation requirements for departing flights.

Table 7.2: Minimum Departure Wake Turbulence Separation Standards (minutes)

		Trailing					
		Super Heavy	Heavy-Plus	Heavy	Medium	Medium-Light	Light
Leading	Super Heavy		2	2	3	3	3
	Heavy-Plus				2	2	2
	Heavy				2	2	2
	Medium						2
	Medium-Light						2
	Light						

Additionally, according to ICAO Doc 4444 "A separation minimum of 3 minutes shall be applied between a LIGHT or MEDIUM aircraft when taking off behind a HEAVY aircraft or a LIGHT aircraft when taking off behind a MEDIUM aircraft from: (a) an intermediate part of the same runway". Intersection departures are frequently used on Runway 34L/16R at Sydney (Kingsford-Smith) Airport; this intersection departure separation requirement is enforced in the TAAM simulations.

7.3.3.2 Other Separation Requirements

Sydney (Kingsford-Smith) Airport also follows the following separation requirements according to its SOP (Standard Operation Procedure):

- Same Runway Arrival:
  - Mode 9 – 5 nautical miles
  - Mode 10 – 4 nautical miles
- Same Runway Departure – non-jets:
  - Mode 9 – 3 nautical miles
  - Mode 10 – 3 nautical miles
- Same Runway Departure – jets:
  - Mode 9 – 5 nautical miles (not applicable between ENTRA – MARUB departures)
  - Mode 10 – 5 nautical miles

These separations requirements were applied in the TAAM models.

7.3.4 Airport Ground Operation Assumptions

The following assumptions were used in the simulations regarding aircraft taxiing and ramp movement operations:

Table 7.3: Ground Taxiing Operations Assumptions

Parameter	Value
Default Taxi Speed	**15 knots**
Taxi Speed on taxiway T & A towards the departure end of the runways	**20 knots**
Apron Taxi Speed	**5 knots**
Towing Speed	**5-8 knots**
Pushback Speed	**3 knots**
2 Engine Pushback Pause	**150 seconds**
4 Engine Pushback Pause	**210 seconds**

As seen in Table 7.3, L&B assumed that towing speed is in the range between 5 to 8 knots. During the visit to the Sydney (Kingsford-Smith) Airport ATC tower variations in towing speed were observed, though 8 knots was a typical towing speed. In supporting this, tow tractors currently on the market can produce a top speed greater than 15 knots and capable of towing aircraft as large as an A380. Hence, L&B used 8 knots as the towing speed in the simulations.

When aircraft are signalled to cross runways, it takes time for the aircraft to begin accelerating. This study uses the following time delays before the aircraft begin accelerating:

Table 7.4: Time delay before acceleration

Aircraft Type	Time (seconds)
Super Heavy	10
Heavy Plus	10
Heavy	10
Medium	6
Medium-Light	6
Light	2

Sydney (Kingsford-Smith) Airport airfield layout has certain restrictions which prevent aircraft movement in certain areas. Specifically, large aircraft such as A380, B777, and A340 have specific taxi routes as depicted in the figures below.

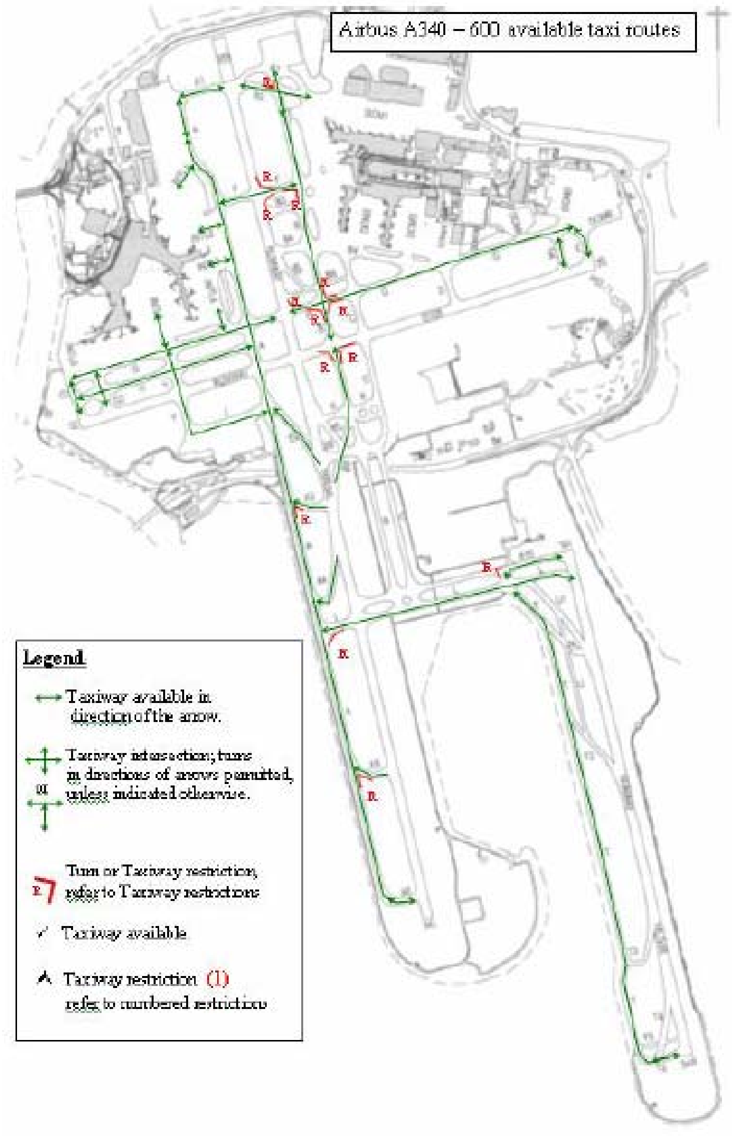


Figure 7.8 - A340 Available Taxi Route

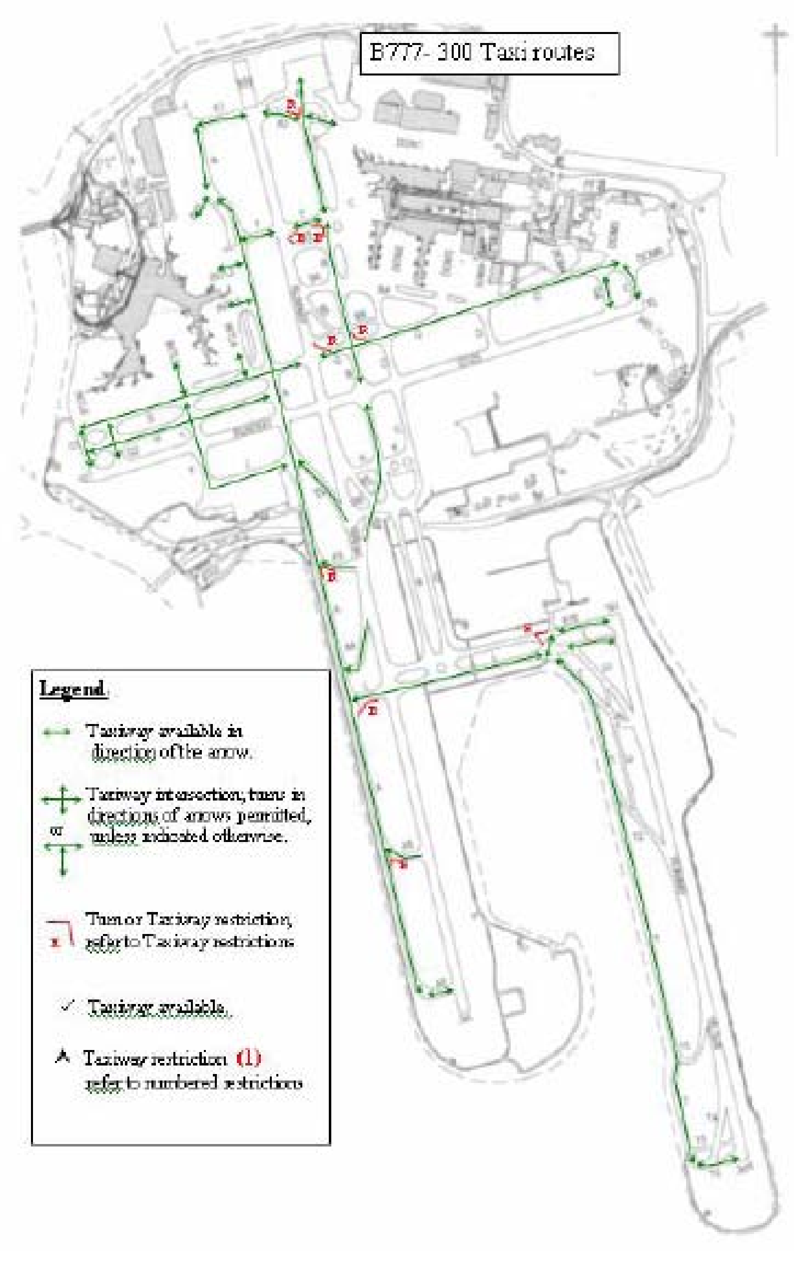


Figure 7.9 - B777 Available Taxi Route

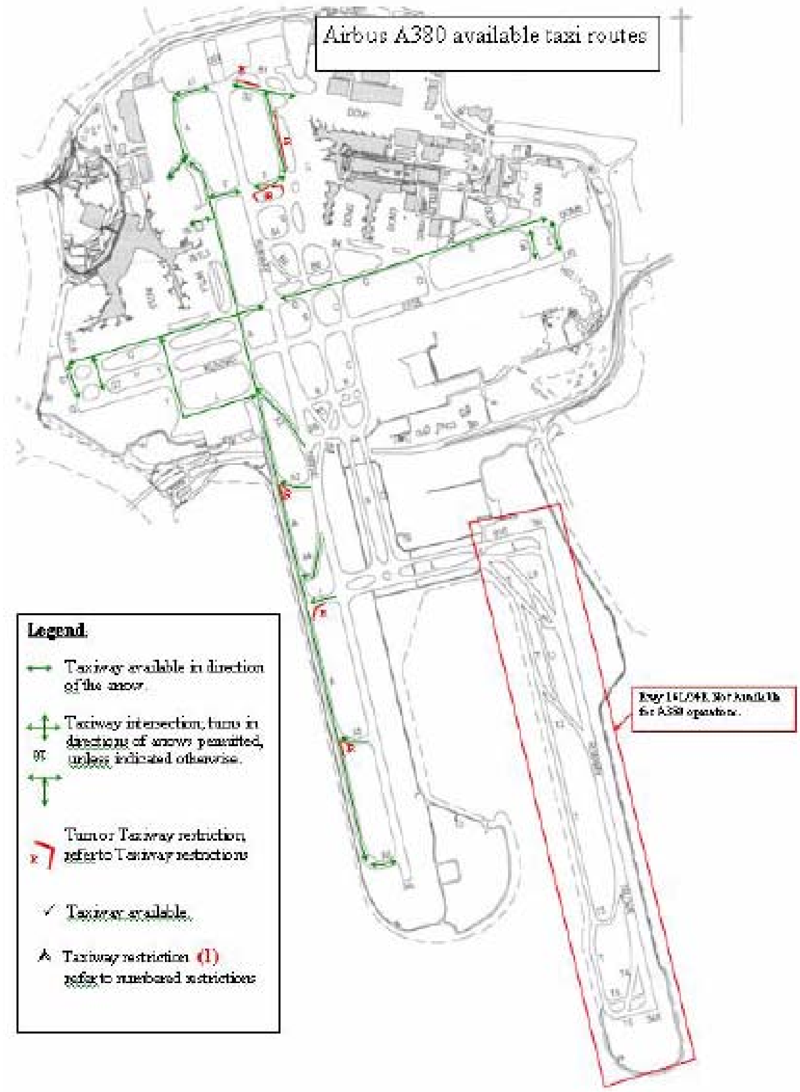


Figure 7.10 - A380 Available Taxi Route

In addition to these, there are a number of restrictions for aircraft movement on the taxiways due to clearance issues caused by geometric and aircraft size constraints. The AsA En-Route Supplement Australia (ERSA) pilot information document lists the taxiway movement restrictions under the 'Local Traffic Regulations' section. Some examples of key restrictions are:

- Pilots of Code D, E and F aircraft (B777/B747/B767/A380/A340/A330) to exercise caution when taxiing on Twy A or Twy B from Twy B3 to Runway 07/25 at intersections of all taxiways. When Code D, E or F type aircraft are holding short of the associated Runway, no Code D, E or F type aircraft should taxi behind due to insufficient wingtip clearance.
- When aircraft exiting Runway 34L on Twy A2, aircraft northbound on Twy A must hold short of Twy A2 at intermediate holding position marking and aircraft southbound on Twy A must hold short of Twy J or north of Runway 07/25.
- Twy C between Twy F and Twy B4 speed restriction to a maximum of 20 knots applies to all aircraft above a 52 metre wingspan.
- Twy C between Twy F and Twy G, Twy B4 between Twy B and DOM2 restricted to 60.4 metre maximum wingspan.

The movement restrictions (illustrated graphically in Appendix F) were incorporated into the TAAM simulation model.

7.3.5 Acceptable Level of Delay

Both peak and average delay are important measures of airport performance. Airfield capacity is typically defined based on the level of demand at which average delays begin to exceed tolerable or acceptable levels.There is no single accepted industry delay threshold in this regard. In the past, the Federal Aviation Administration (FAA) has defined acceptable average delay as 4 to 8 minutes per aircraft. However, higher thresholds (8 to 15 minutes) are often applied at many major hub airports.

In many cases, a better indicator of the performance of an airfield is the ability of the airlines to maintain the integrity of their flight schedules without significant disruption. While average delays can remain relatively modest, there may be multiple hours throughout the day when delay levels are excessive, to the point where (1) passengers miss connections, (2) airline crews miss their connecting flight assignments, (3) the delay to an arriving aircraft results in a significant delay to the corresponding departure that can then cascade delays throughout the airspace system, or, (4) in extreme cases, arriving aircraft are diverted to other airports because they do not have sufficient fuel reserves to hold in the airspace.

Each airport is different; however the common level of acceptable delay is one in which the schedule integrity can be maintained, and that the operation can recover from periods of high delays quickly, usually within an hour. This way, an airport can provide an acceptable level-of-service for passengers and airlines.

As an example, average peak period delays of 16 minutes per arrival has been considered a standard used at John F. Kennedy International Airport in New York for "normal" operations in a large international arrival peak.

Based on experience, and taking into consideration Sydney (Kingsford-Smith) Airport operation characteristics, the following delay levels (total delay including airborne holding and ground delay) were assumed to be acceptable metrics for this analysis:

- average delay in the peak hour of less than 16 minutes per movement;
- no more than two contiguous hours of average departure delay or arrival delay greater than 12 minutes per movement; and
- 24 hour average delay of less than 8 minutes per movement.

At these delay levels, small increases in demand can quickly result in excessive peak period delays.

After examining the simulation results, it was found that under the assumed operating condition and demands, the 24 hour average delay levels for all scenarios tested were never very high as to cause concerns. Therefore, when presenting simulation results this report will concentrate on the peak hour average delay and peak hour average departure delay and arrival delay.

7.3.6 Experiment Design

After careful consideration, L&B designed a number of experiments targeted to address the objectives of the study. Table 7.5 lists these experiments. Operations of two flow directions, Mode 9 (North Flow) and Mode 10 (South Flow), were simulated with various airfield configurations (i.e., Existing Airfield, 2015 incremental Master Plan Concept airfield, etc.), under 2009, or the forecast 2015, 2035, or 90% of 2035 demand levels. Simulation results were than analyzed to evaluate the operation performances.

Table 7.5: Simulation Experiment Design

	MODE 9				MODE 10			
	Demand Level				Demand Level			
Airfield Configuration	2009	2015	2035	2035 Reduce 10%	2009	2015	2035	2035 Reduce 10%
Existing Airfield	√				√			
2015 Incremental Master Plan Concept		√				√		
Master Plan Concept			√				√	
Master Plan Concept w/o Stub Taxiway South of Taxiway "L"			√				√	
Master Plan Concept w/o Taxiway "J" Extension			√				√	
Master Plan Concept w/o Taxiway "H" Extension			√				√	
Master Plan Concept w/o Taxiway "C1" Extension			√				√	
Master Plan Concept w/o Stub Taxiway South of Taxiway "L", Taxiways "J", "H", and "C1" Extensions			√	√			√	√
Master Plan Concept w/o Stub Taxiway South of Taxiway "L", Taxiways "J", and "H" Extensions			√				√	
Master Plan Concept w/o Stub Taxiway South of Taxiway "L", Taxiways "J", and "C1" Extensions			√				√	
Master Plan Concept w/o Stub Taxiway South of Taxiway "L", and Taxiways "J" Extensions			√				√	

7.4 Current Airfield Taxiway Demand – TAAM Analysis

To establish a baseline for this study, L&B simulated the existing airfield operations using an actual flight schedule of November 6, 2009. In the simulations, L&B applied the assumptions discussed in Section 6.3 and assigned runway usage according to the operation record of that day. A comparison of the TAAM modelled schedule activity against the actual schedule recorded activity was undertaken to calibrate the model, as shown in Appendix G.

7.4.1 Simulation Results

Table 7.6 compares the peak hour average delays for these current airfield taxiway demand experiments. Simulated peak hour average delays for both scenarios were under 8 minutes.

Table 7.6 - Delay Comparison for Current Airfield Taxiway Simulations

	MODE 9	MODE 10
Demand Level	**2009**	**2009**
Daily arrival and departure operations	**888**	**888**
Existing Airfield	**6.9** 36% 5.7 / 12.0	**7.2** 24% 5.4 / 11.1

6.9	Average Peak Hour Delay
36%	% of flights above Average Delay
5.7 / 12.0	Average Peak Hour Arrival / Departure Delay

Peak hour delay below 10 minutes with less than 8 minutes of delay for contiguous hours
Peak hour delay greater than 10 minutes OR greater than 8 minutes of delay for contiguous hours
Peak hour delay greater than 12 minutes OR greater than 10 minutes of delay for contiguous hours
Peak hour delay greater than 16 minutes OR greater than 12 minutes of delay for contiguous hours

Figure 7.9 depicts the average delay by hour, while Figures 7.10 depicts the aircraft delay distribution for Mode 9 (North Flow) and Mode 10 (South Flow) under the 2009 demand level.

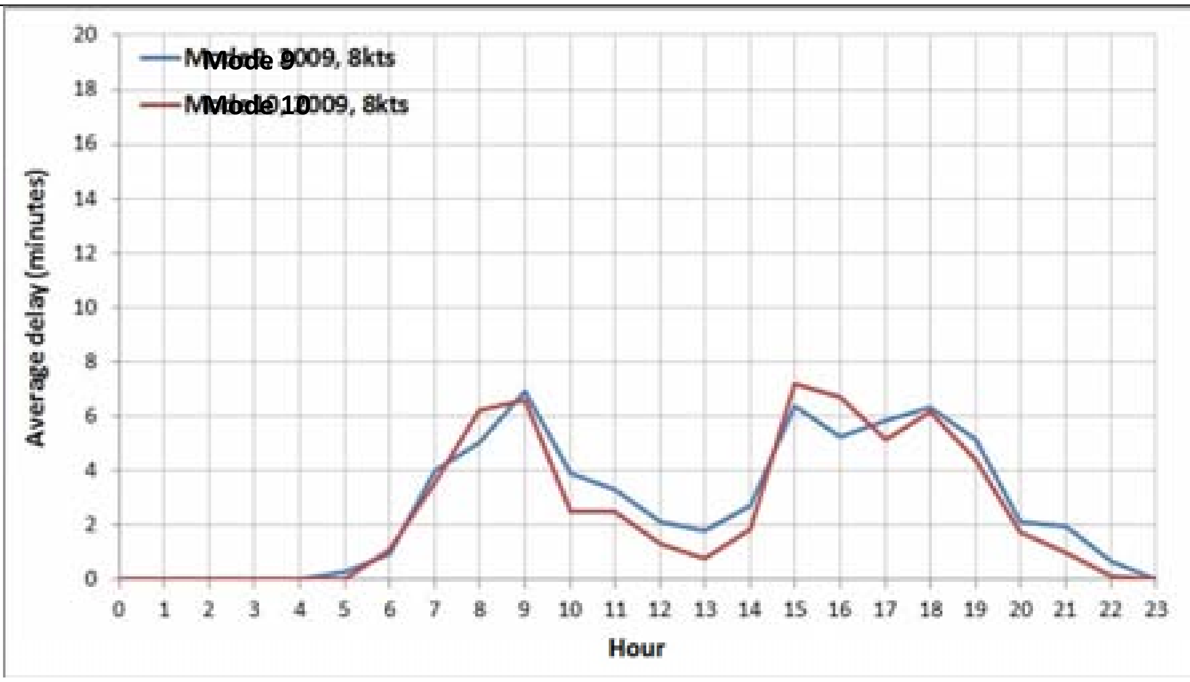


Figure 7.9 Existing Airfield Simulations Average Delay by Hour - Mode 9 vs. Mode 10

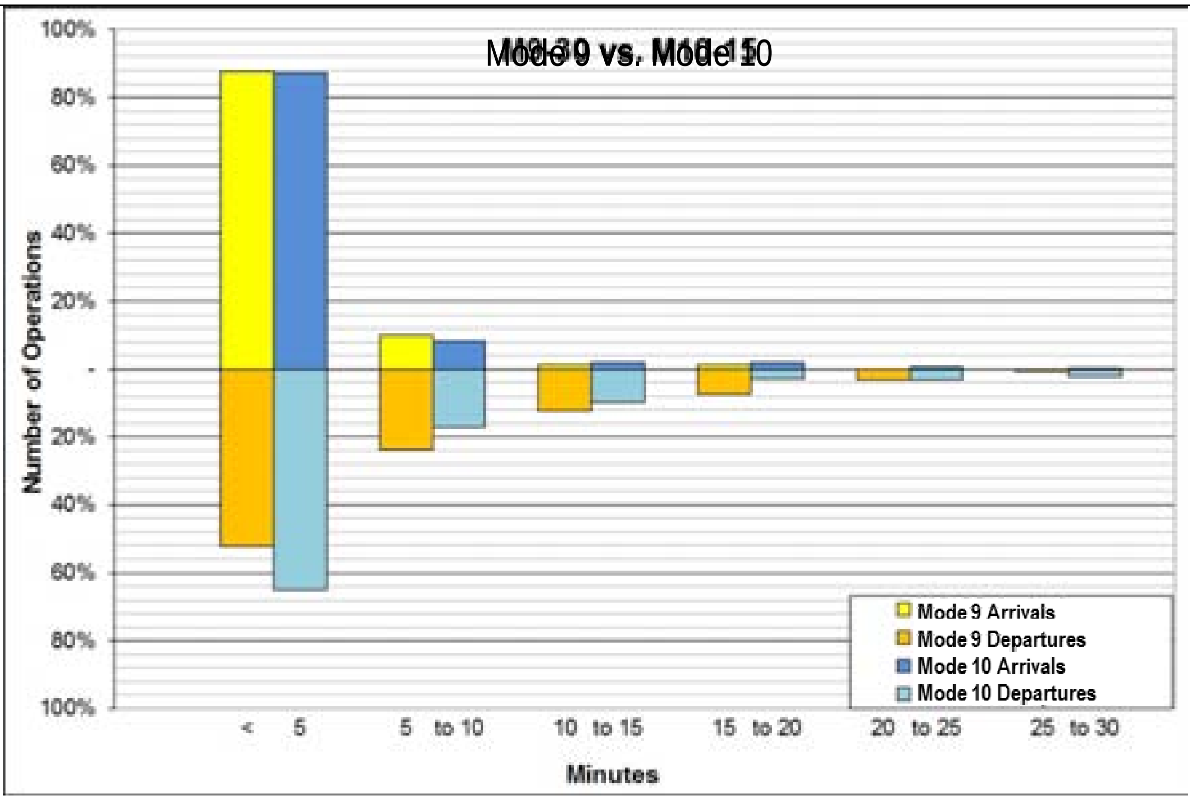


Figure 7.10 - Existing Airfield Simulations Delay Distribution – Mode 9 vs. Mode 10

The peak throughputs achieved in the simulations were 74 for Mode 9 and 73 for Mode 10, below the 80 movements per hour limit. This agrees well with the flight schedule input which was developed based on the operational record of November 6, 2009. Performance report from AsA indicates that the actual arrival rate was 37 movements in an hour for that day—the simulation results matched this rate. This gives us confidence that our baseline models are trustworthy.

7.4.2 Discussions

Observations of the simulations revealed the following:

- Runway assignments in the simulations were obtained from the actual operation record of November 6, 2009. The operation of that day showed about 66% of all flights landed or departed from the west runway. This created long departure queue for the west runway during both north flow (See Figure 7.11) and south flow (see Figure 7.12) during departure push periods, whilst the other runway was "starved" of operations. More balanced runway use, especially with increasing demand level should be considered for maintaining the high standard service to users.

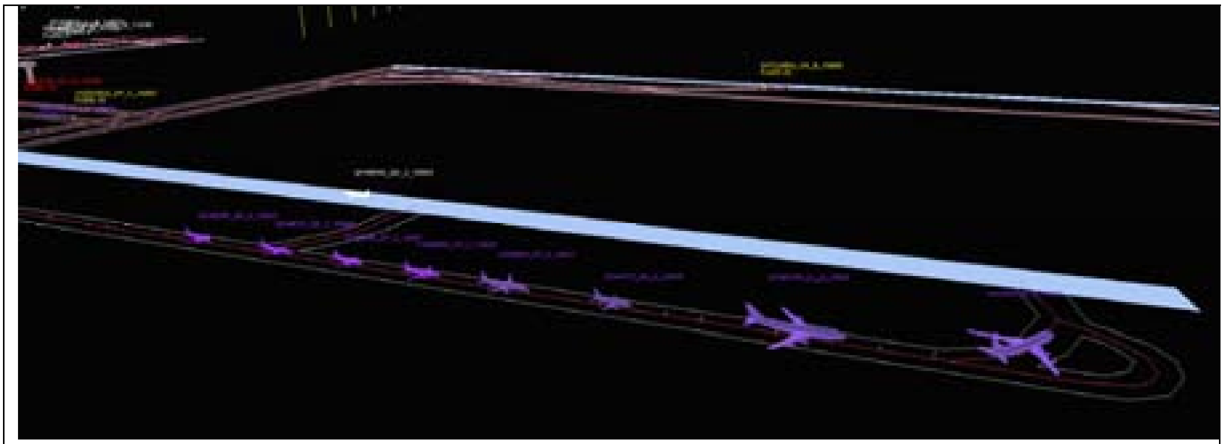


Figure 7.11 - Long Departure Queue for Runway 34L

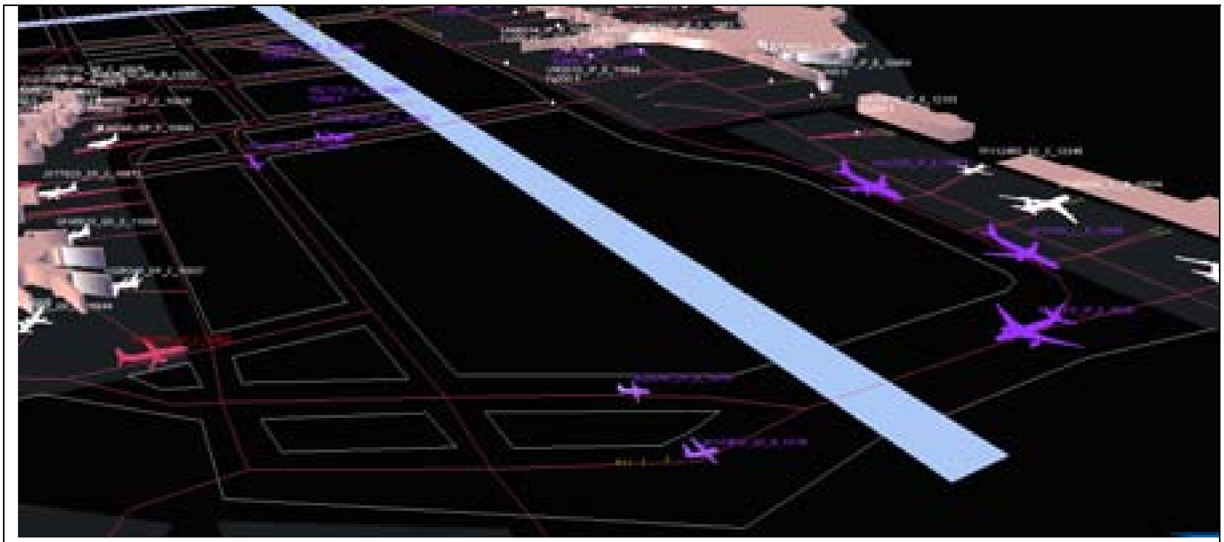


Figure 7.12 - Long Departure Queue for Runway 16R

- The long departure queue resulted in operational issues, especially during south flow. When a long queue is developed on Taxiway A, arriving aircraft (in yellow and white) may be "stuck" behind departing aircraft and suffer delay due to single taxiway access to the apron (see Figure 7.13). Similar situation may also occur on Taxiway B.

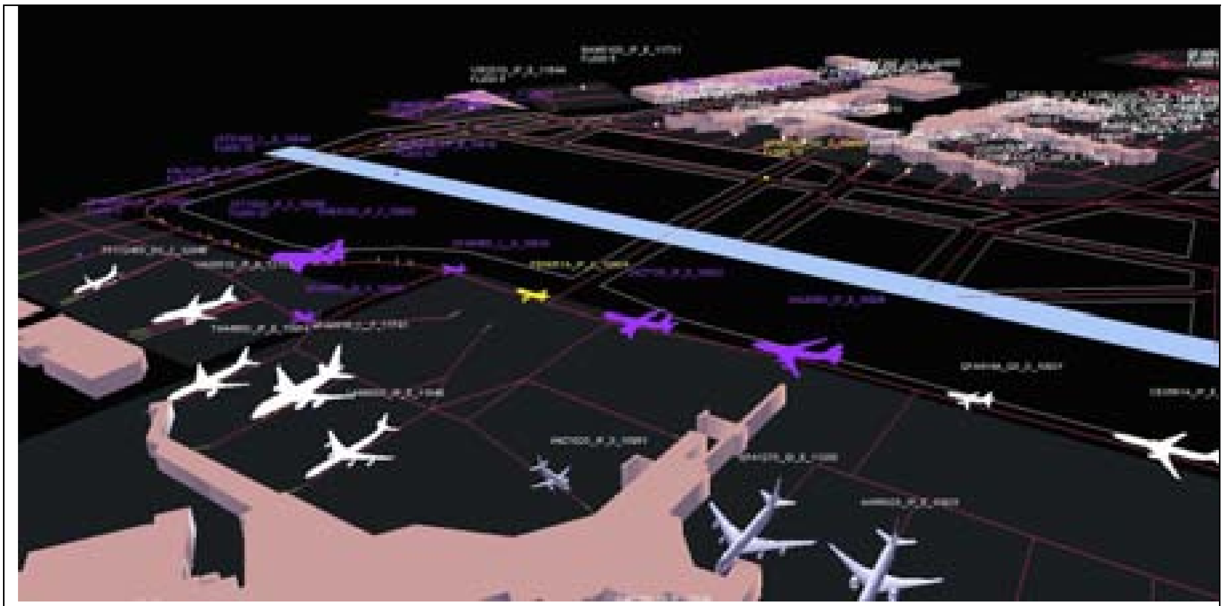


Figure 7.13 - Long Departure Queue for Runway 16R on Taxiway A Blocking Arriving Aircraft

- Intersection departure from Taxiways B3, B4, and F may relieve some of the pressure of the departure queue problem during South flow. However, this needs to be carefully managed so that the intersection departure separation requirement (i.e., 3 minutes separation requirement between a LIGHT or MEDIUM aircraft when taking off behind a HEAVY aircraft or a LIGHT aircraft when taking off behind a MEDIUM aircraft from an intermediate part of the same runway) will not reduce the operational rate.

- During north flow, large number of departing aircraft taxiing to Runway 34L for departure may result in congestion at intersections of Taxiway B10, L, B, and C. When many prop aircraft are holding to take-off from Taxiway B10, or domestic jets crossing Runway 34L at Taxiway L for full-length departure, can affect the through arriving traffic from 34R (travelling from Taxiway L to Taxiway B) and also domestic departure to Runway 34L for take-off (see Figures 7.14, 7.15).

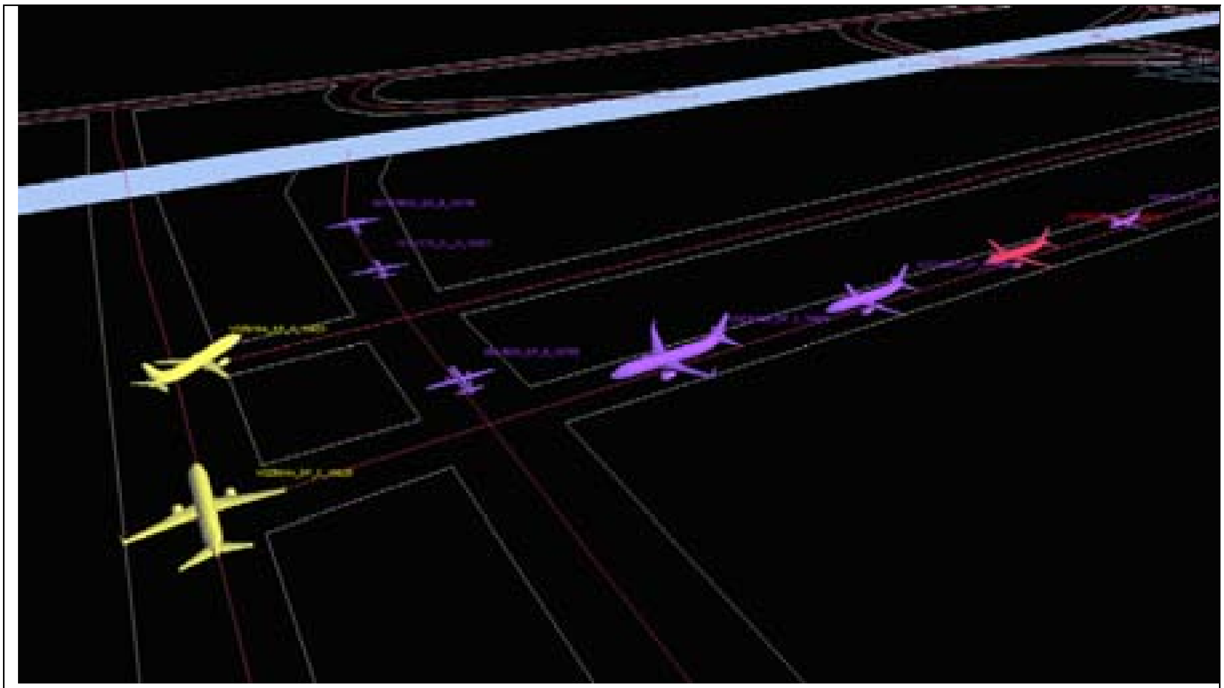


Figure 7.14 - Intersection Departure from Taxiway B10 Blocking

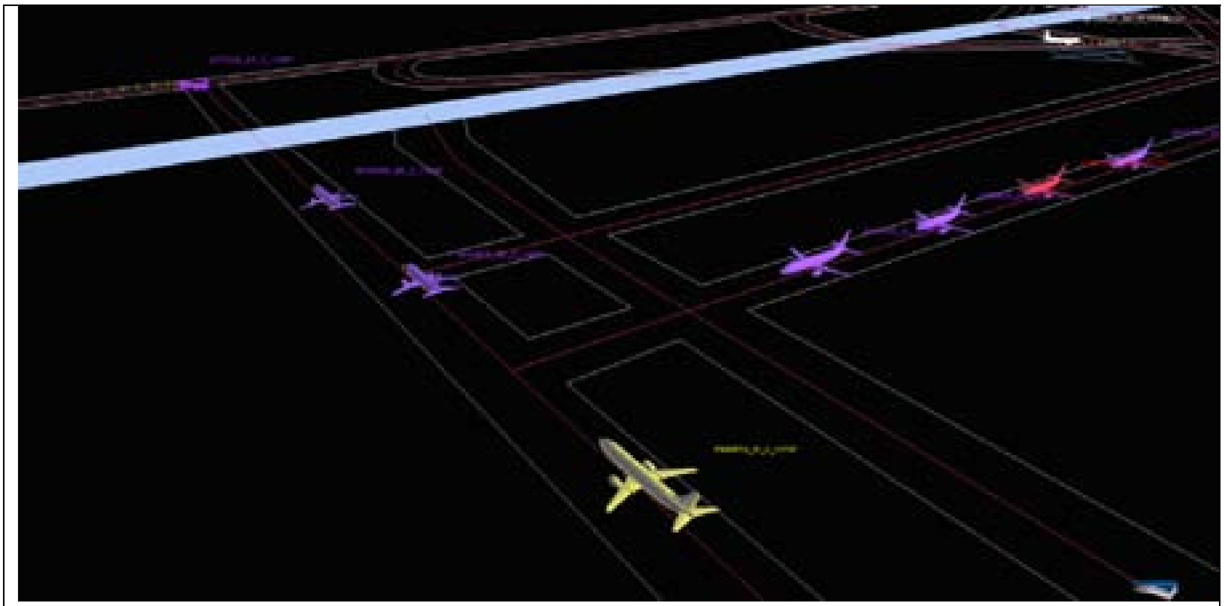


Figure 7.15 - 34L Full-Length Departure Crossing from Taxiway L Blocking

- In addition to safety issues, such as potential runway incursion, runway crossing can also negatively affect operation efficiency. A towed aircraft is generally slower than taxiing aircraft, and may require longer time crossing runway and in the process blocking other aircraft and cause congestion (see Figure 7.16).

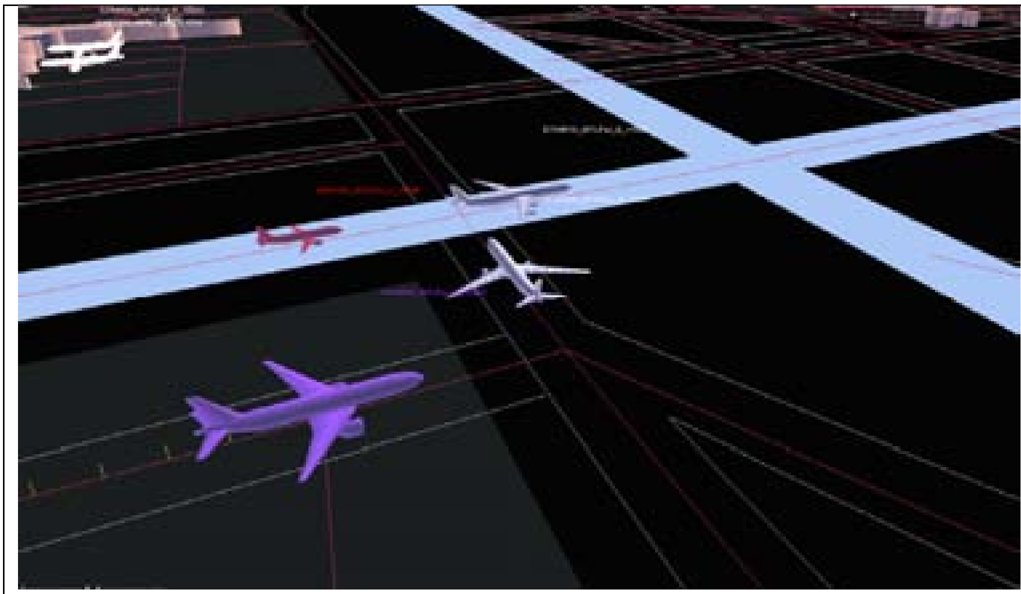


Figure 7.16 - 34L Full-Length Departure Crossing from Taxiway L Blocking

- When planning for towing operations, it is beneficial to schedule them in the off-peak hours (L&B learned during visit to the tower that a lot of towing will occur during the curfew to free up space on T1). During busy operation periods, controller will make strategic decisions to hold towed aircraft and make way for departure/arrival traffic flow, or open a gap in the arrival stream and hold the departures to allow crossing. During our visit to the Sydney (Kingsford-Smith) Airport Control Tower, L&B learned that a runway crossing generally takes one slot. When demand increases in the future, it is certainly advantageous to reduce the number of runway crossing during peak operation periods, especially by towed aircraft.

- It is noted that during setup of the simulation and modelling process of the existing airfield operations, L&B observed that low average towing speeds below 8 knots created issues in the form of towed aircraft blocking arriving or departing aircraft flows on Taxiways A and B while waiting to cross the runway. The lower towing speed caused towed aircraft to miss available gaps to cross the runway and blocked Taxiways A and B due to insufficient clearance behind the towed aircraft. Whereas a controller may see this issue emerging and take pre-emptive action, such as holding the tow movement back to let other aircraft pass first, programming such decision making into the simulations is very difficult. To avoid additional congestion in future, this reinforces the need for tow operations to maintain good speed on the taxiways as per the 8 knots observed during our tower visit and assumed in these simulations.

7.5 Conclusions

Under the 2009 demand level, Sydney (Kingsford-Smith) Airport operating efficiency is fair with the existing airfield. Major considerations for the future include balancing runway utilization to reduce the length of departure queue to the west runway. The lack of queuing space for Runway 16R and departure queue caused congestion on north sections of Taxiways A and B is a concern. Runway crossings and towing operations during peak operating periods negatively affect the operation performance. During north flow, interaction of several traffic streams at the intersections of Taxiways B10, L, B, and C sometimes create bottlenecks.

The intersections marked in the taxi flow charts where taxi paths cross may also cause problems; this is discussed in Section 9.1.2.

8.0 TAAM Simulation Forecast Aircraft Schedules

8.1 Introduction

The original set of forecasts for this study for the years 2015 and 2035 were produced by Booz & Co. and received by L&B on the 31st March 2011. These were used as the basis for the TAAM simulation modelling of taxiway infrastructure at 2015 and 2035 horizons.

It is important to note that these forecasts behind the TAAM simulation differ from those that were re-cast in July and used as the basis for the GMS stand allocation versus demand exercise covered in Sections 3 to 5 of this report.

Further details outlining the approach undertaken by Booz & Co. to develop the original set of future forecasts are contained within the Booz & Co. document *Planning Day Schedules – 11 March 2011- Draft Working Paper 3.*

Figure 8.1 shows the increase of total daily movements for each forecast horizon. The percentage of total movement increases between the existing 2009 schedule and the 3 forecast schedules are:

- 2009-2015 (6yrs) = 15.7%
- 2015-2020 (5yrs) = 9.8%
- 2020-2035 (15yrs) = 14.4%

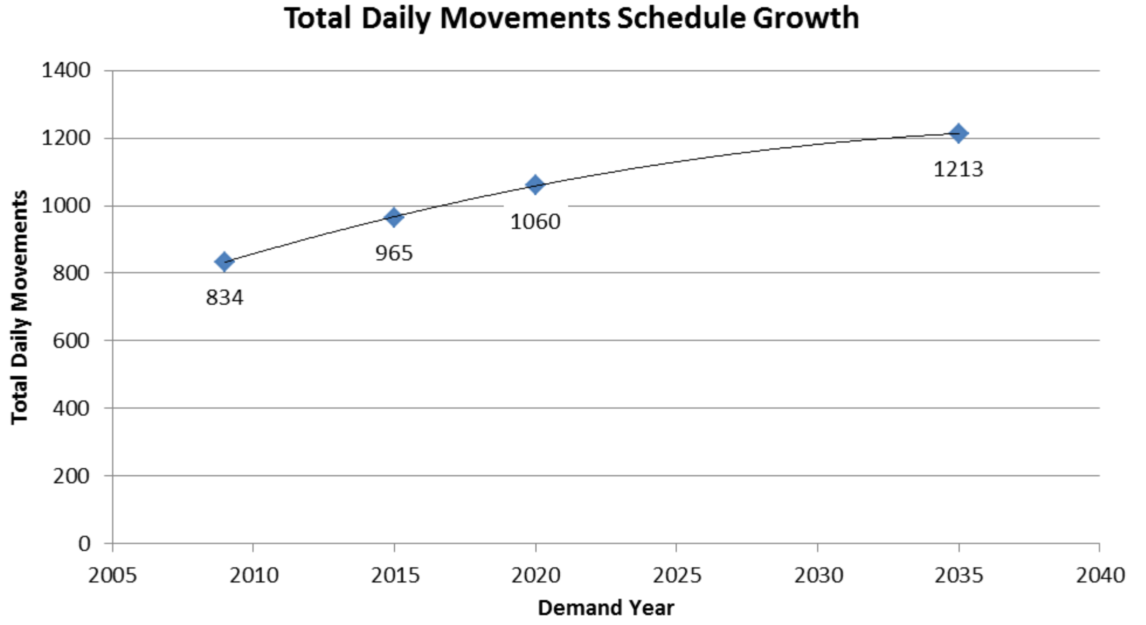


Figure 8.1 – Daily Movements Schedule growth

The growth and percentage of market share in the various markets between 2015 and 2035 are summarised below:

- Regional growth is **4.3%** with the market share **reducing** by **4%**
- Domestic growth is **25.1%** with the market share **reducing** by **0.4%**
- International growth is **62%** with the market share **increasing** by **5%**
- GA & Military growth is **minimal**. Market share remains at less than **4%**

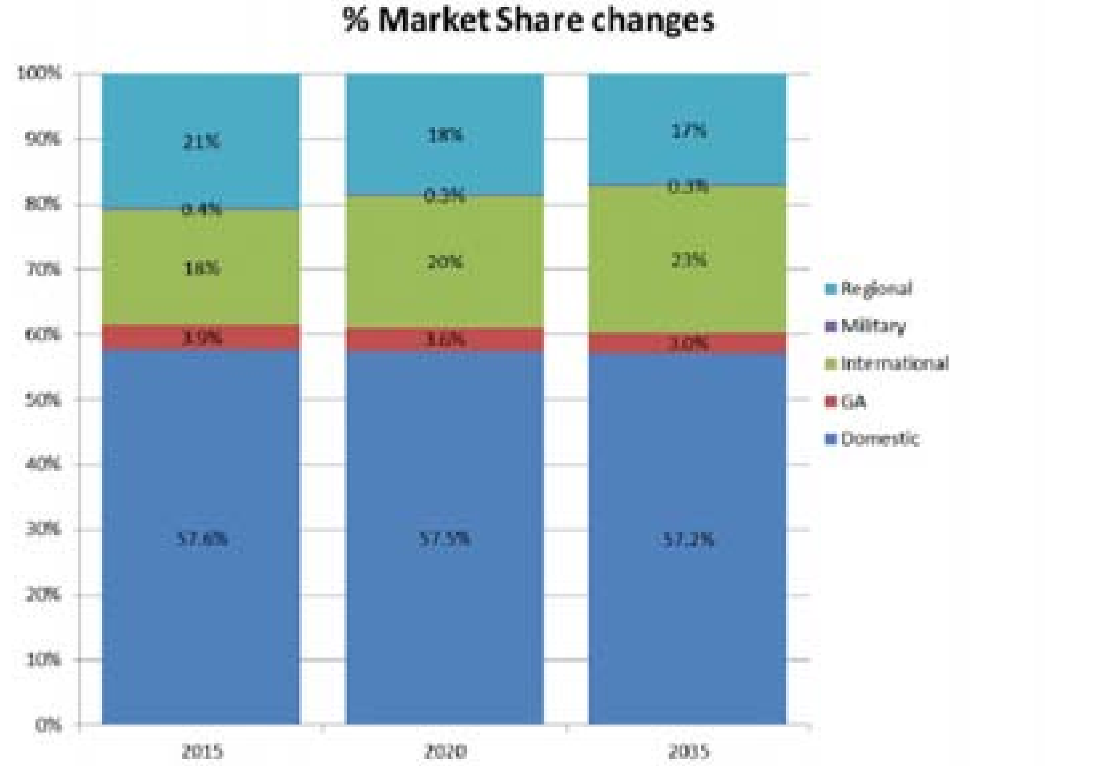
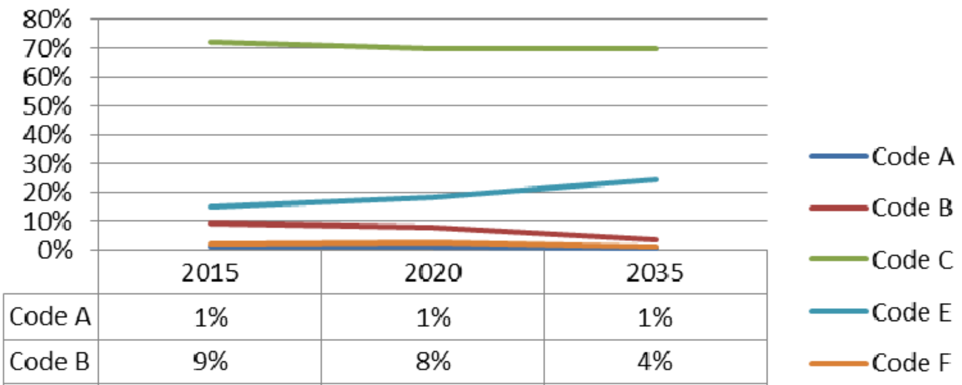


Figure 8.2 – Market share percentage changes

- Increased market share in Code E aircraft due to up-gauging of domestic fleets and a general increase in international market share.



	2015	2020	2035
Code A	1%	1%	1%
Code B	9%	8%	4%
Code C	72%	70%	70%
Code E	15%	18%	25%
Code F	2%	3%	1%

Note: No Code D aircraft were forecast

Figure 8.3 – Aircraft size percentage changes

A comparison of the daily profile of each schedule shows the magnitude of the spreading of demand into the shoulders of the peak periods with respect to the operational restriction of 80 movements per hour.

Figure 8.4 illustrates the growth and spread of the future forecast schedules against the simulation baseline 2009 schedule.

- The 2015 schedule indicates the forecast daily peak hour is in the evening at 1800, differing from the existing 2009, where the peak hour is in the morning peak at 8am.
- Both the 2020 and 2035 schedules reach the peak 80mvts/hour in both the morning and evening peak hours.

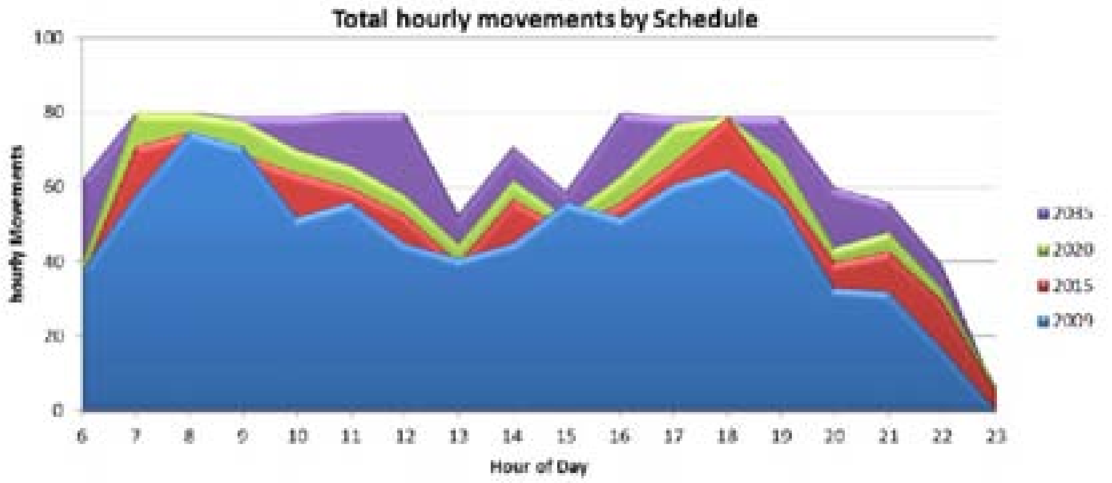


Figure 8.4 – Forecast schedule comparison of hourly movements

The 2035 daily profile shows significant spreading of demand across both the AM and PM peak periods, with approximately 5 hours of peak flow (80mvts/hr) in the AM peak period and 3 hours in the PM peak period.

9.0 Taxiway Capacity Modelling (TAAM Analysis)

9.1 2015 Demand – Impact on Existing Taxiways

The taxiways are influenced by apron access/egress (and therefore any congestion on the aprons), runway usage and the movement of aircraft to/from runways. In this regard, these three elements form an integrated and dependent system that was modelled in the airfield simulation.

The existing airfield layout was modified to reflect the 2015 Master Plan ALP; specifically the second finger of Terminal 2 was extended to add five additional gates (D201 to D205), this was accomplished by the realignment of Taxiway B4 (Figure 9.1).

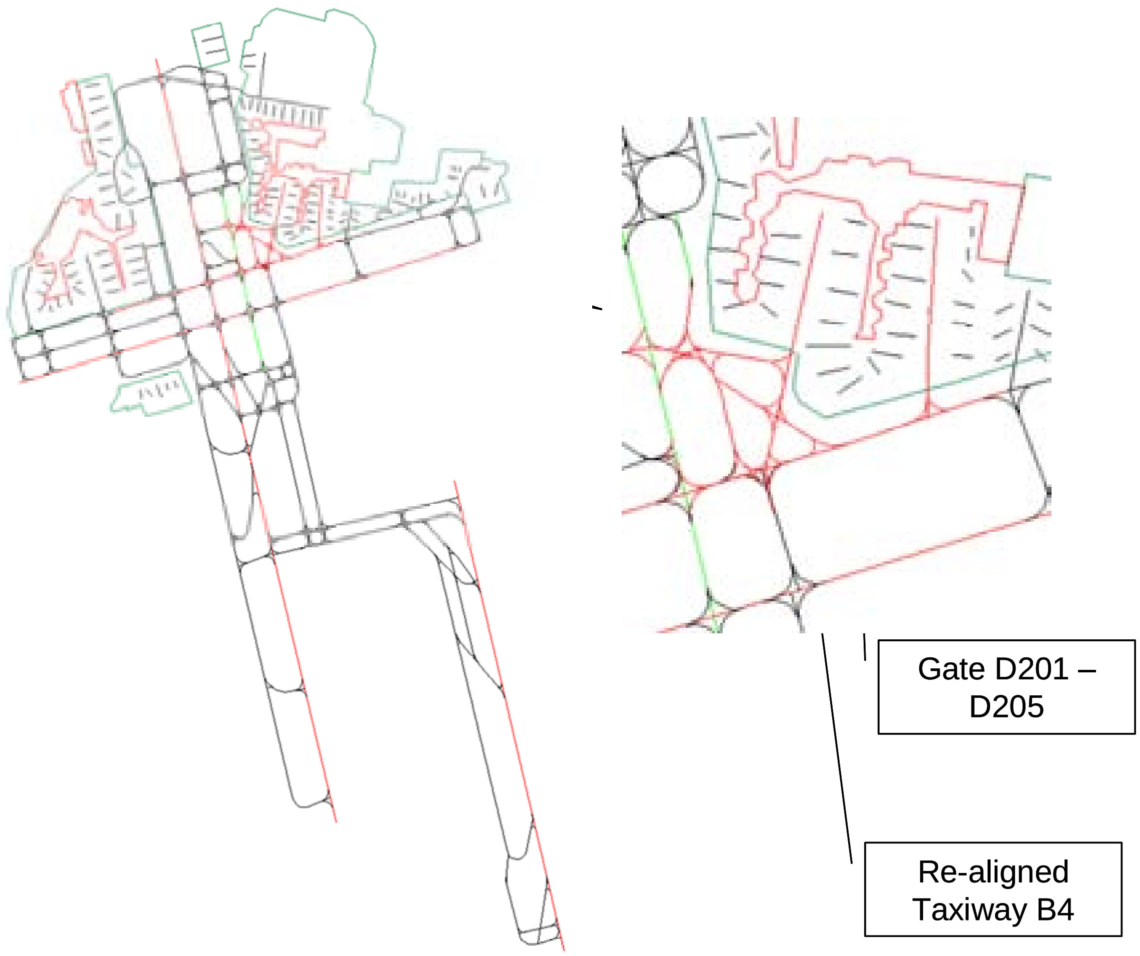


Figure 9.1 - 2015 incremental Master Plan Concept airfield layout

The forecast 2015 aircraft schedule provided by Booz & Co. was used as the basis for flight demand and movement in the simulation model. The allocation of aircraft to stands was initially modelled with the GMS software to provide a 'gated schedule' as a key input to the simulation modelling of the taxiway system. Where aircraft could not be accommodated on stands ('un-gated flights') these were not modelled in the taxiway simulation. This represents a practical scenario of modelling demand that can be accommodated. The actual aircraft schedule activity that is simulated is lower than the unconstrained forecast aircraft movement demand in the Booz & Co. forecast schedule.

9.1.1 Simulation Results

Table 9.1 compares the peak hour average delays for the 2015 demand simulation experiments.

Table 9.1: Delay Comparison for 2015 Airfield Simulations

	MODE 9	MODE 10
Demand Level	**2015**	**2015**
Daily arrival and departure operations	**911**	**911**
2015 incremental Master Plan Concept	**3.4** 27% 2.2 / 5.1	**3.3** 39% 1.8 / 4.9

3.4	Average Peak Hour Delay
27%	% of flights above Average Delay
2.2 / 5.1	Average Peak Hour Arrival / Departure Delay

Peak hour delay below 10 minutes with less than 8 minutes of delay for contiguous hours
Peak hour delay greater than 10 minutes OR greater than 8 minutes of delay for contiguous hours
Peak hour delay greater than 12 minutes OR greater than 10 minutes of delay for contiguous hours
Peak hour delay greater than 16 minutes OR greater than 12 minutes of delay for contiguous hours

It can be seen that all simulated delays were well below the delay threshold and quite low for both modes (see Figure 9.2). These are even well below the 2009 demand results (refer Table 6.6) which is due to the more balanced runway usage split.

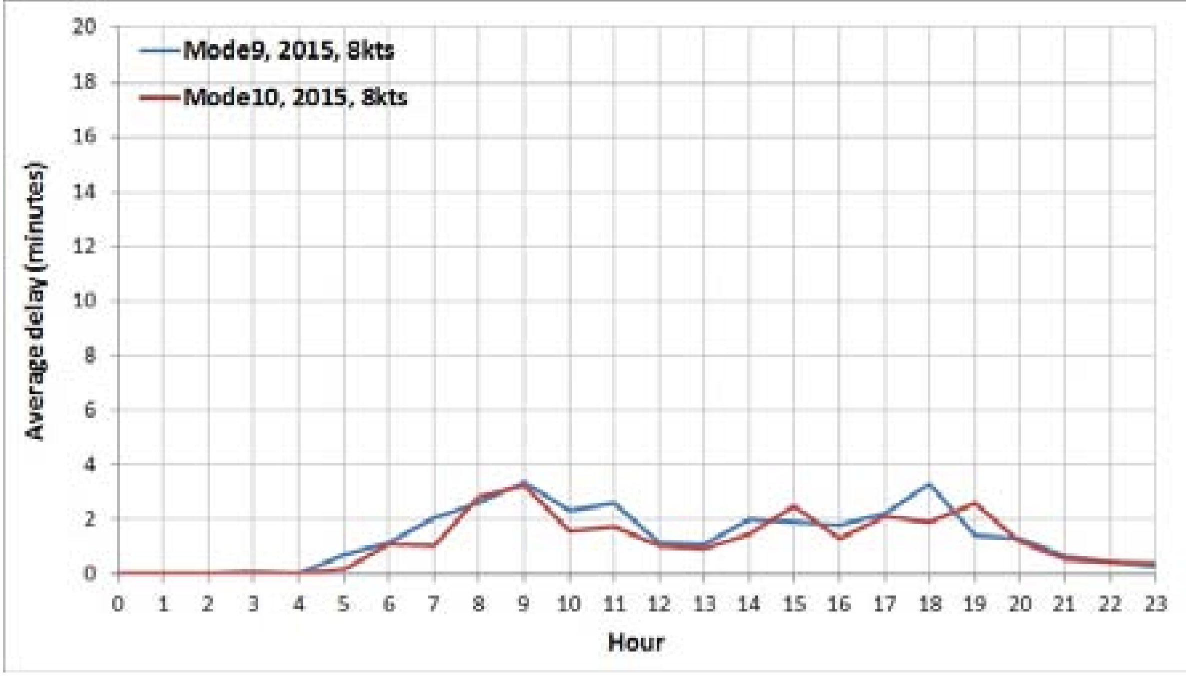


Figure 9.2 - 2015 Incremental Master Plan Simulation Average Delay by Hour

Figure 9.3 depicts the delay distributions; greater than 90% of arrivals and 80% of departures have delay below 5 minutes.

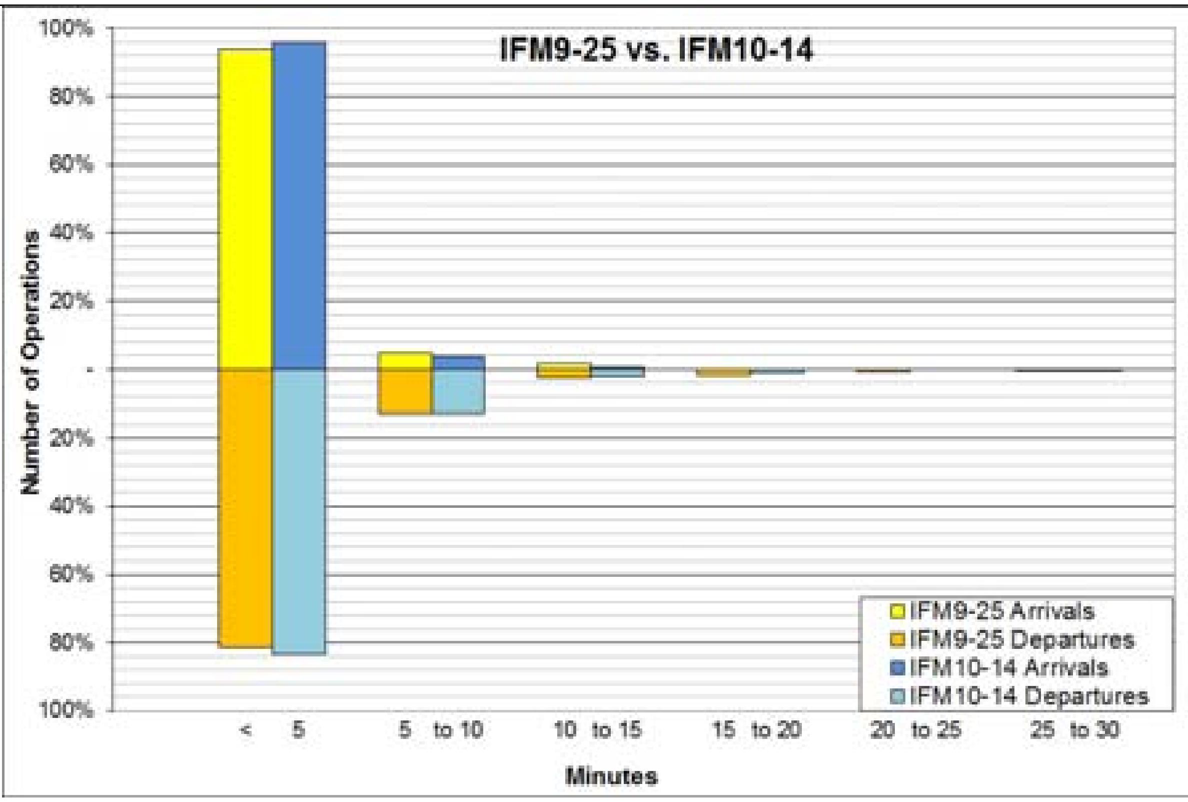
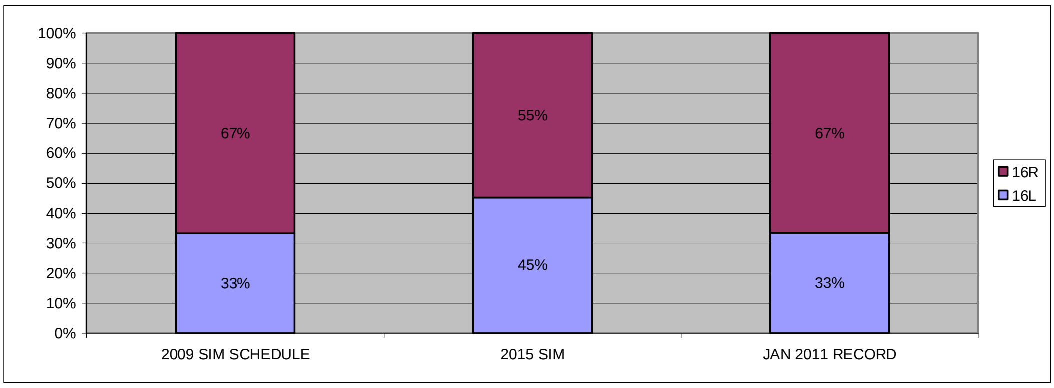


Figure 9.3 - 2015 Incremental Master Plan Airfield Simulation Delay Distribution; Mode 9: IFM9-24; Mode 10: IFM10-14

9.1.2 Discussion

The improved performance of the airfield shown in the 2015 modelling results is due in part to the assumption that traffic can be better balanced across the runway system.

Analysis of the November 6, 2009 flight record shows that at that day the runway usage is skewed in favour of Runway 34L/16R by roughly 2 to 1 ratio which was used for the baseline 2009 simulation analysis. Whilst generally consistent in south flow conditions (RWY 16L / RWY 16R), the split is more balanced in north flow conditions (RWY 34L / RWY 34R) and has historically varied, as far as 58%:42%. The January 2011 runway use record statistics L&B analysed showed more operations on runway 34R, and L&B believe runway use during south flow will also become more balanced in the future. The 2015 incremental Master Plan Concept airfield simulations assumed a more balanced runway usage for both Mode 9 and Mode 10 (see Figure 9-4).



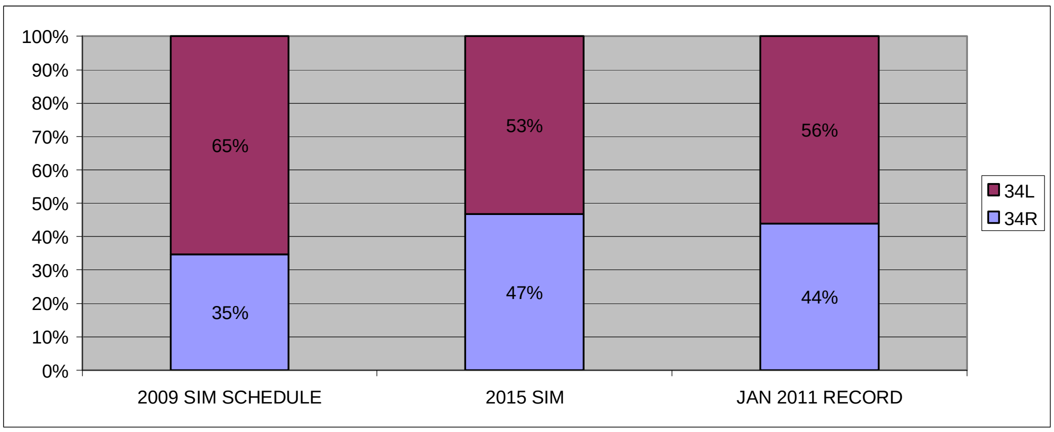


Figure 9.4 - Runway Use Percentage Comparison

It is noted that the short runway (34R/16L) cannot handle heavy, long range flights due to runway length requirements. Aircraft using the shorter parallel runway, RWY 16L/34R, for departure are limited to maximum B767/A330 size aircraft for domestic routes. These restrictions were maintained in the simulation modelling.

The current runway usage imbalance is also due in part to the location of the runways relative to the aircraft parking positions—it is more convenient for the aircraft to use Runway 34L/16R especially during south flow (Mode 10) operations when both departing and arriving aircraft have shorter taxi distances. However, with increased demand this advantage will likely diminish due to increased departure and arrival queue delays when too many aircraft are assigned to one runway. Therefore, from a long term perspective it is more beneficial for the taxiway system to have more balanced runway use.

Though it is a somewhat optimised situation, the 2015 incremental Master Plan Concept airfield simulations assumed a more balanced runway usage for both Mode 9 and Mode 10 with the simulation model attempting to limit delays on the airfield through more balanced traffic flow. There may be challenges to achieving this, particularly in South Flow (RWY 16L / RWY 16R) where current flight path limitations for domestic flights apply. However, it should be noted that this level of split has been demonstrated historically in north Flow conditions (RWY 34L / RWY 34R), for example, through January 2011, and is therefore possible.

With regard to the taxiway change for the 2015 layout, re-alignment of Taxiway B4 does not seem to cause taxi problems; observation of the simulations reveal that the intersections where taxi paths cross remains the cause of taxi delays (see Figure 9-5, where arriving aircraft in white and yellow on Taxiway G have to hold short of Taxiway C and wait for departing aircraft in red), in addition to runway crossings especially by towed aircraft.

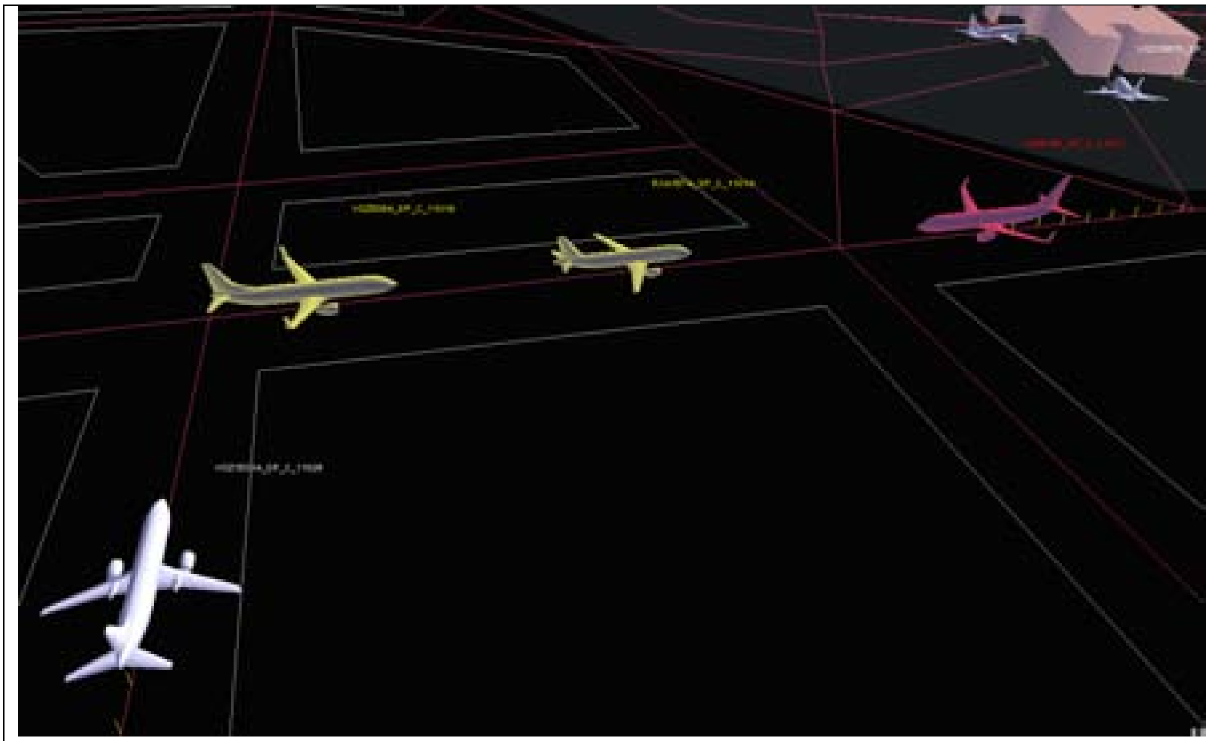


Figure 9.5 - Taxiway G/C Intersection Delay

9.2 Existing Taxiway System Capacity

In order to test capacity of the existing taxiway system, the forecast 2035 aircraft schedule was used. To facilitate the simulation of the existing taxiways with this future demand, additional gates were required to accommodate the extra aircraft. Therefore the Master Plan Concept gate layout for 2029 was adopted but the taxiway enhancements were excluded as illustrated in Figure 9.6.

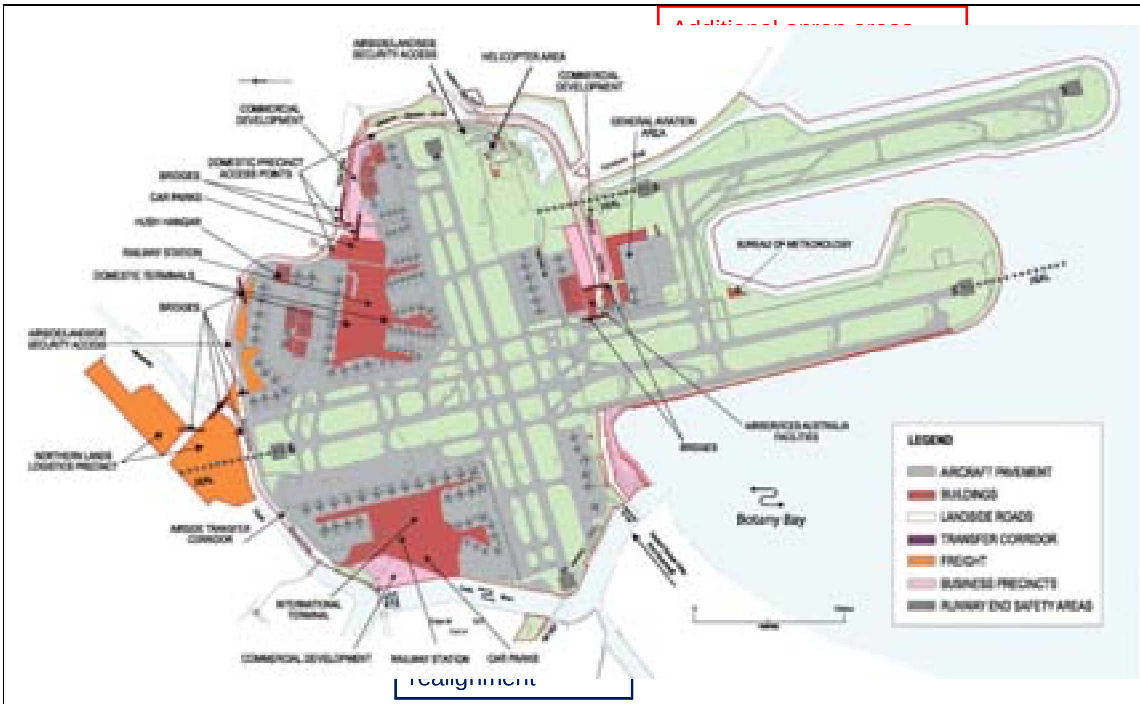


Figure 9.6 - Master Plan Concept Layout minus Taxiway enhancements to test existing Taxiway capacity

Taxiway B4 realignment is being constructed now to facilitate the extension of the second finger of T2 (see Figure 9.1). Taxiway A extension is considered to be part of T1 apron restructuring in order to add necessary Code F contact parking positions. The additional apron area south of Runway 07/25 and east of Runway 34L/16R is for T3 remote stands and relocation of GA apron. These improvements were assumed for the assessment of the existing taxiway system capacity.

Detailed GA apron layout was not given in the 2035 airfield layout; for the purpose of simulation L&B assumed that the number of parking positions and their sizes retain that of the existing GA apron (see Figure 9.7).

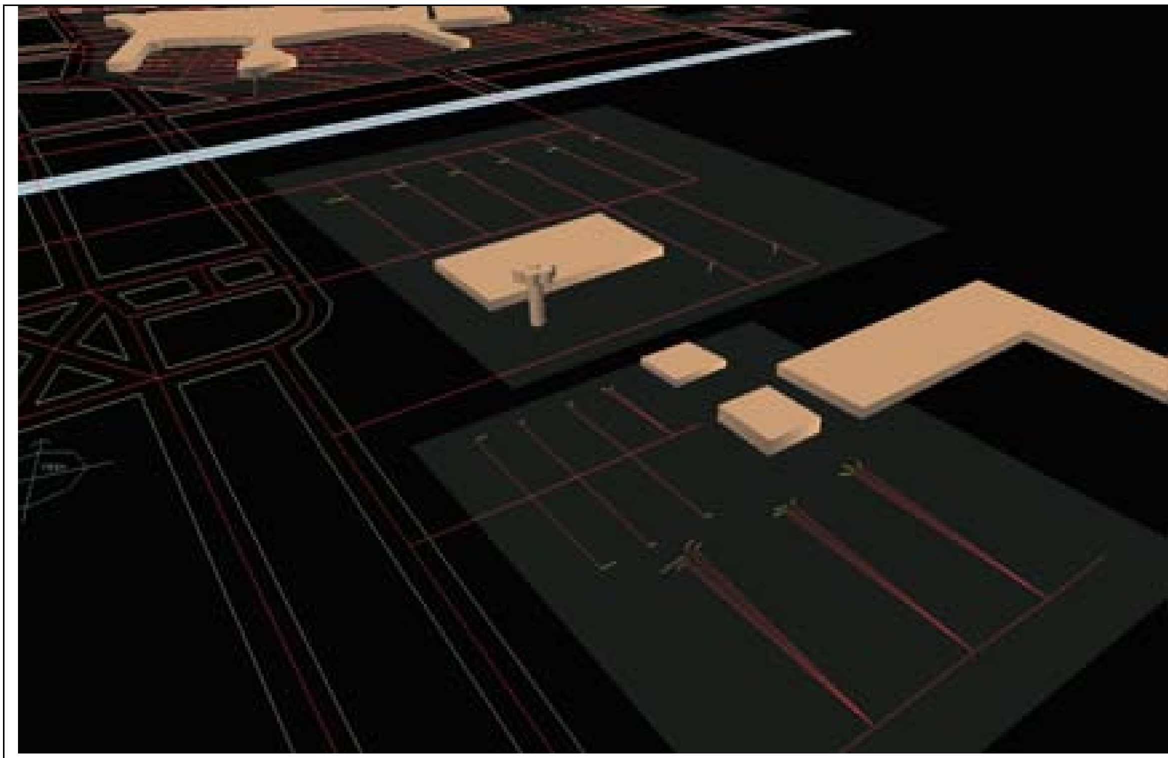


Figure 9.7 - Assumed Future GA Apron

9.2.1 Simulation Results

L&B simulated both the projected 2035 demand level and a 90% 2035 demand level for Mode 9 and Mode 10 operations. The TAAM simulation model adopted a runway usage split of 55%:45% in favour of (RWY 16R/34L) as outlined in Section 9.1.2, though aircraft type restrictions for departing aircraft using the shorter parallel runway, RWY 16L/34R, were maintained.

The forecast 2035 aircraft schedule provided by Booz & Co. was used as the basis for flight demand and developing a 'gated schedule' (using GMS software) for the simulation modelling of the taxiway system. Where aircraft could not be accommodated on available aircraft stand provision ('un-gated flights') these were not modelled in the taxiway simulation. The simulated aircraft schedule activity is therefore slightly lower than the unconstrained forecast schedule from Booz & Co. forecast schedule. If more stands were available to accommodate the full schedule, a higher number of movements would occur on the taxiway system. This and a less balanced runway usage would potentially result in higher delays than the following results.

Table 9-2 compares the peak hour average delays for these experiments.

Table 9.2: Delay comparison for Future Airfield Capacity Simulations

	MODE 9		MODE 10	
Demand Level	**2035**	**2035 Reduce 10%**	**2035**	**2035 Reduce 10%**
Daily arrival and departure operations	**1187**	**911**	**1,187**	**911**
Existing Taxiway System	**10.2** 23% 8.9 / 14.8	**5.3** 45% 4.8 / 6.7	**12.3** 40% 12.2 / 13.2	**5.3** 30% 4.6 / 6.9

10.2	Average Peak Hour Delay
23%	% of flights above Average Delay
8.9 / 14.8	Average Peak Hour Arrival / Departure Delay

Peak hour delay below 10 minutes with less than 8 minutes of delay for contiguous hours
Peak hour delay greater than 10 minutes OR greater than 8 minutes of delay for contiguous hours
Peak hour delay greater than 12 minutes OR greater than 10 minutes of delay for contiguous hours
Peak hour delay greater than 16 minutes OR greater than 12 minutes of delay for contiguous hours

Although all simulated delays were under the defined delay threshold, the peak hour average delays under the 2035 demand level are moderate to marginal—under Mode 10 peak hour average delay exceeds 12 minutes per operation as seen in Figure 9-8. At 90% of the 2035 demand level the peak hour average delay was reduced to below 6 minutes. Mode 9 generally performs better than Mode 10 (see Figure 9-9), with peak hour average delay at the 10 minutes per operation level under the 2035 demand. Figures 9-10 and 9-11 compare the aircraft delay distribution of the 4 scenarios simulated, where histograms of aircraft experiencing delay greater than a certain level are plotted and compared. It can be seen that decrease in demand greatly reduced the number of flights with high level of delay.

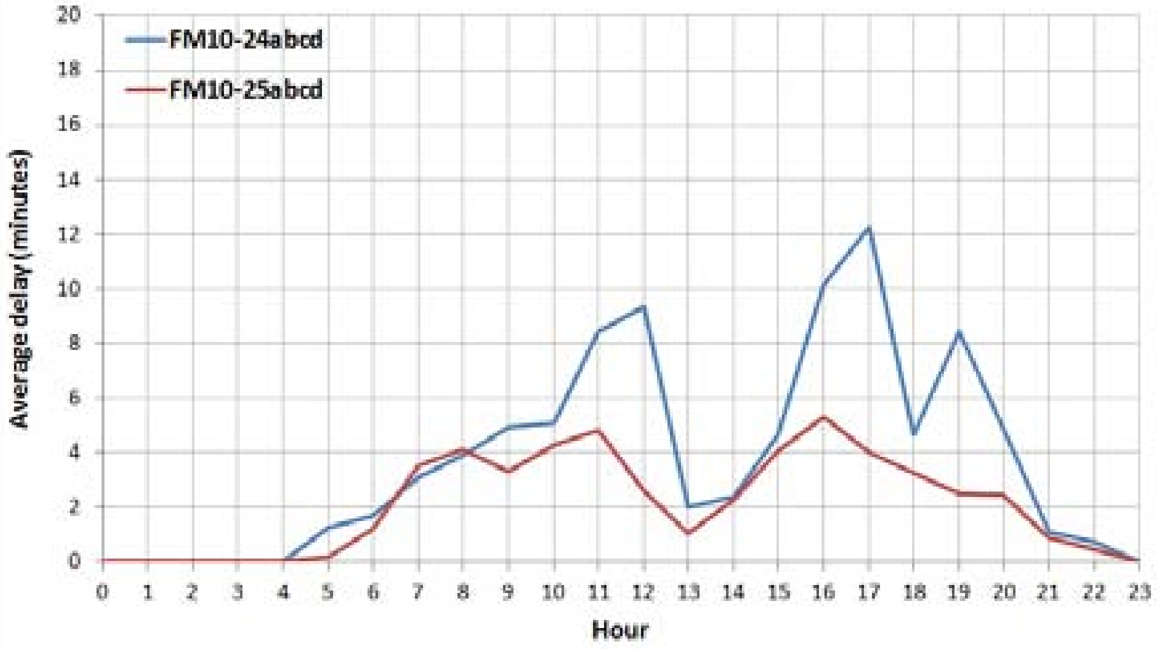


Figure 9.8 - Existing Taxiway Simulations Average Delay by Hour – Mode 10 FM10-24abcd: 2035 demand level; FM10-25abcd: 90% of 2035 demand level

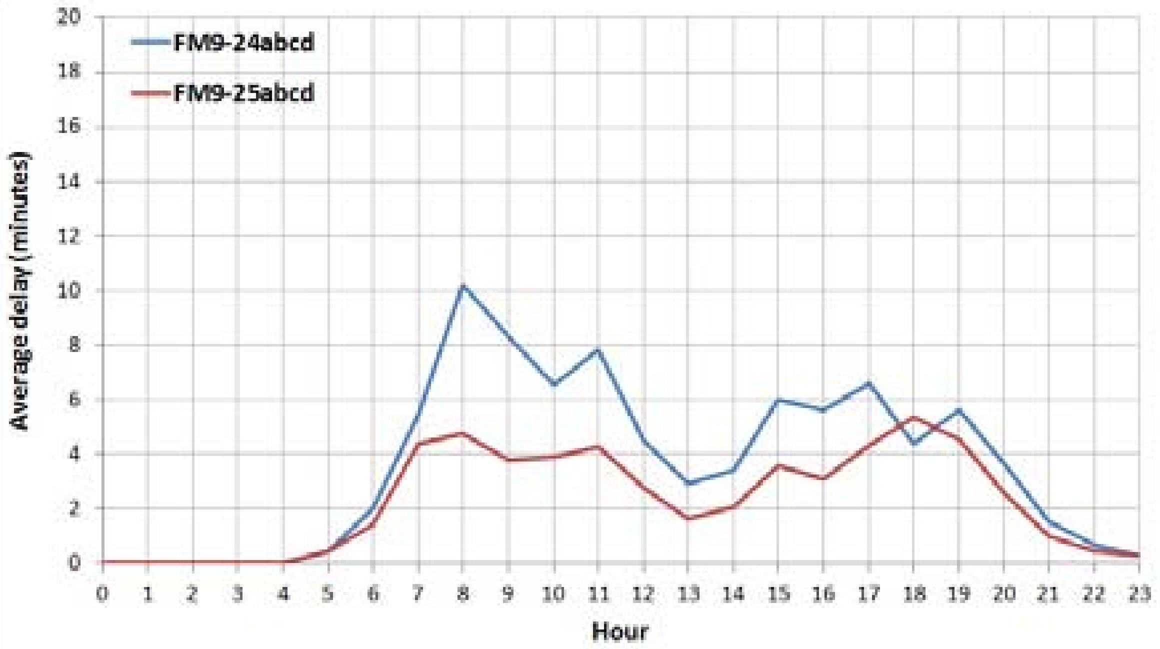


Figure 9.9 - Existing Taxiway Simulations Average Delay by Hour – Mode 9 FM9-24abcd: 2035 demand level; FM9-25abcd: 90% of 2035 demand level

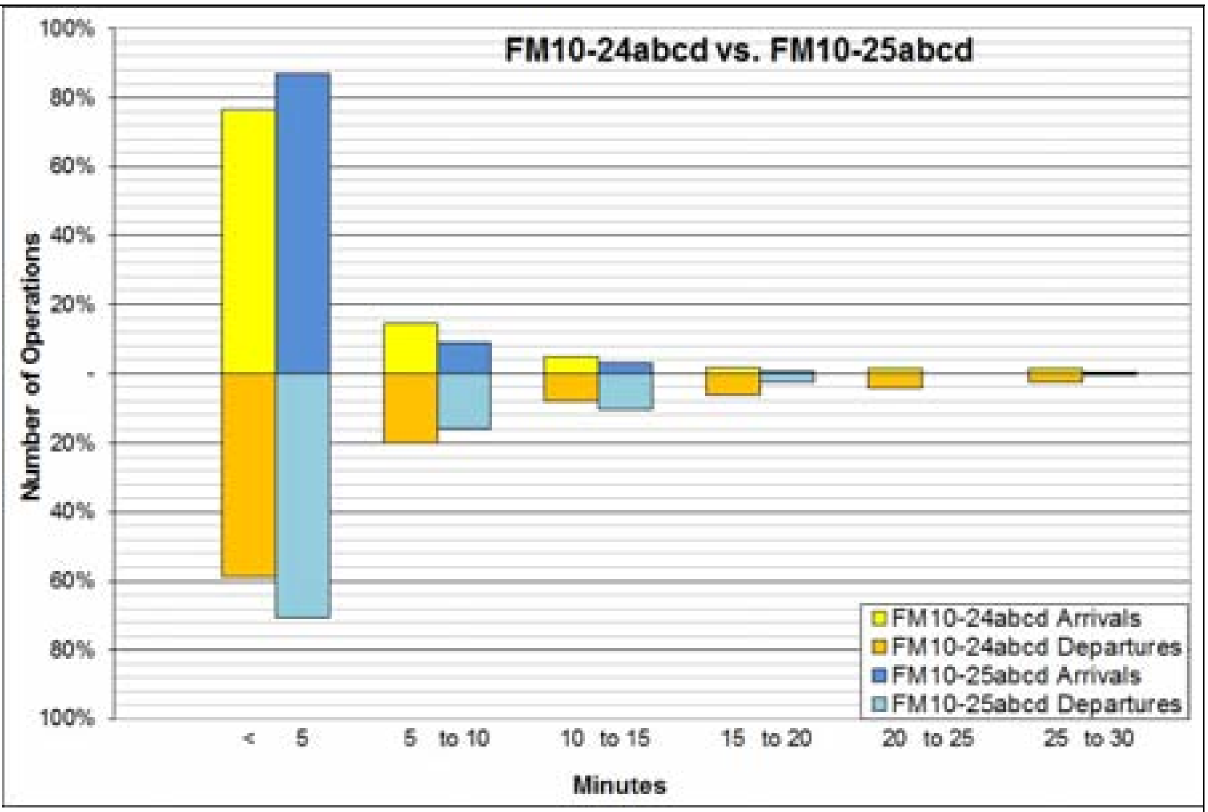


Figure 9.10 - Existing Taxiway Simulations Delay Distribution – Mode 10 FM10-24abcd: 2035 demand level; FM10-25abcd: 90% of 2035 demand level

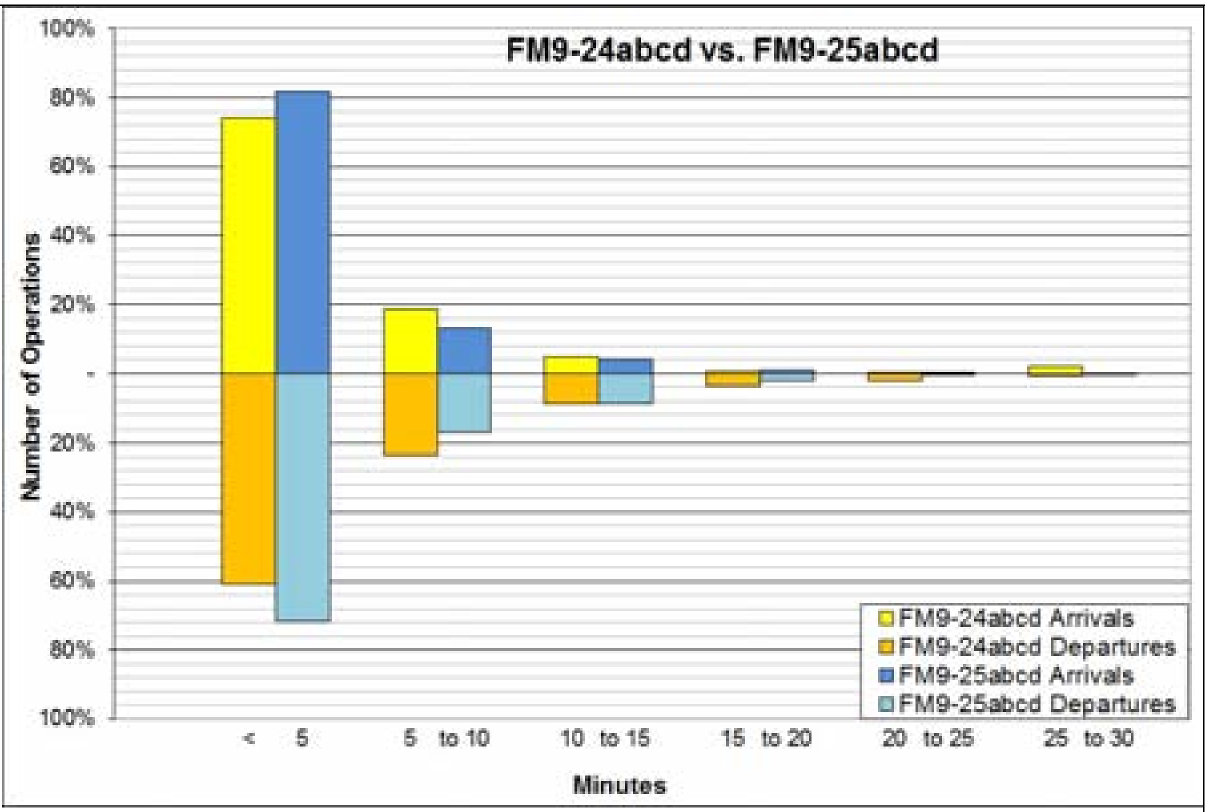


Figure 9.11 - Existing Taxiway Simulations Delay Distribution – Mode 9 FM9-24abcd: 2035 demand level; FM9-25abcd: 90% of 2035 demand level

9.2.2 Discussion

Observations of the simulations exposed several areas of concern:

- During north flow, large departing freight aircraft (e.g. B777) and towed International passenger aircraft (e.g. A380, A346 and B777) assigned to remote parking positions on the eastern side will need to cross Runway 34L via Taxiways A1/B1, F or G (not an option for A380). From here freighters will taxi along Taxiway A south for departure from 34L, whilst International tows will use Taxiway A to access gates. For these large aircraft types it is difficult to use the Taxiway F route because it interferes with the arrival flow, as well as the potential of blocking Taxiway B while waiting. The simulation model preferentially directed them to cross at A1/B1. However, in the process of doing so they may block the alleyway south of the cargo stands and cause delays. See Figure 9-12 for an example. In actual practice this problem can be lessened by holding these A380/A346/B777 aircraft at the gate to wait for appropriate gaps.

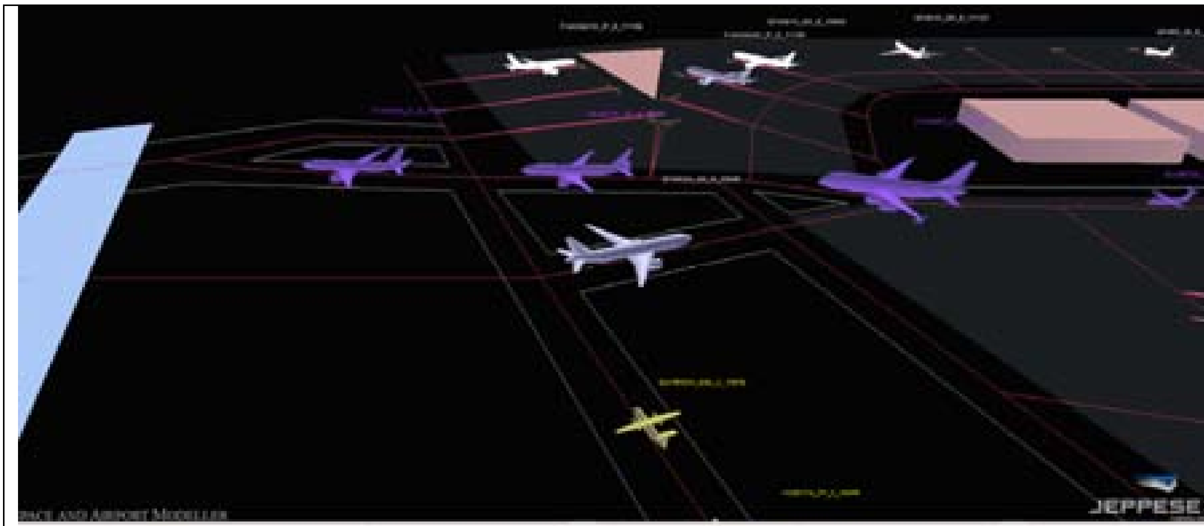


Figure 9.12 - A380/A348/B777 Departures/tows from freight apron – Mode 9

- During south flow, large freight aircraft (e.g. B777) landing on Runway 16R taxi north on Taxiway A and cross the runway at a point north of the crosswind runway 07/25 to access the freight apron. Similarly towed International passenger aircraft (e.g. A380/A346/B777) will cross the main runway at points such as Taxiways A1/B1 and F to access remote stands. L&B learned during the visit to the Sydney (Kingsford-Smith) Airport tower that these crossings will generally take one slot each time, which affects operation rate while driving up delay.

- This problem may also occur between pushback aircraft blocking access of arriving aircraft to their gates (see Figure 9-13). This problem is particularly bad during south flow when these aircraft also interfere with the Runway 16R departure queue.

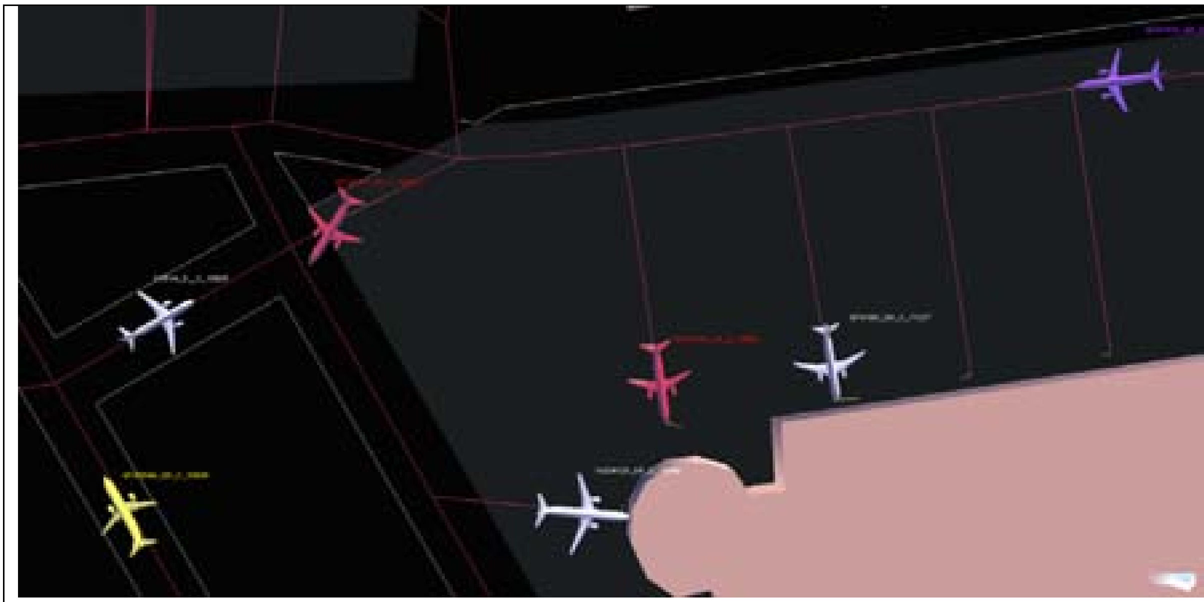


Figure 9.13 - Alleyway Interference between Departing and Arriving Aircraft

9.2.3 Summary – Existing Taxiway Capacity

Similar to the 2015 airfield simulations, the runway usage is more balanced than the November 6, 2009 record and also the January 2011 record (see Figure 9-14).

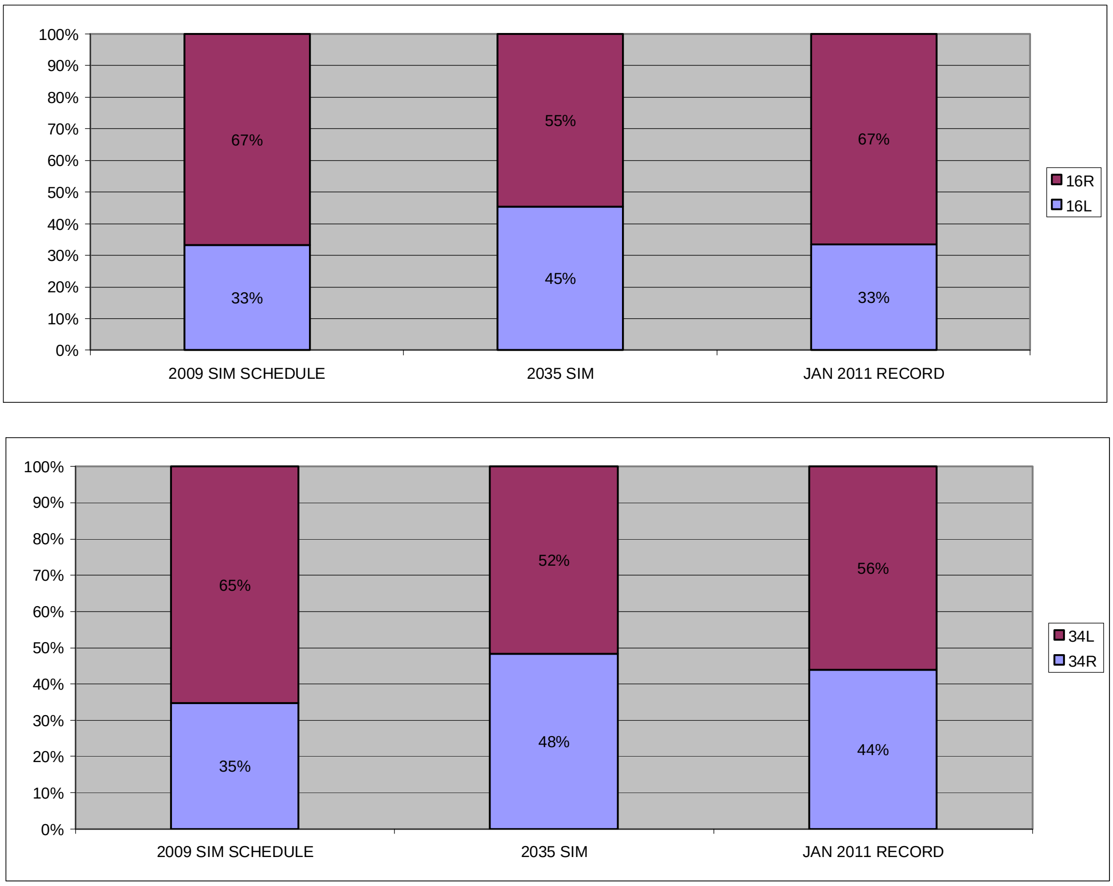


Figure 9.14 - Runway Use Percentage Comparison

As demonstrated in Table 9.2 the average aircraft delay in the peak hour is 12.3 minutes which is significantly higher than existing but remains under the assumed 16 minute average peak hour delay threshold. This assessment indicates that with the modified existing airfield and assuming more balanced runway utilization the taxiway system can handle the 2035 gate constrained demand level of activities. The taxiway improvements associated with the Master Plan Concept will be discussed in the next section.

9.3 2035 Demand – Impact on Master Plan Concept Taxiway Layout

L&B also tested the Master Plan Concept airfield layout with all or some the taxiway system improvements shown in Figure 9.6 under the gate constrained 2035 demand level for both north and south flows.

9.3.1 Simulation Results

Table 9.3 compares the peak hour average delays for the experiments with all proposed Master Plan Concept layout for 2029 taxiway improvements. As previously, the 2035 gated schedule was simulated, with un-gated flights not modelled which delivers a slightly lower demand than the unconstrained Booz & Co. forecast. Also the simulation assumed more balanced usage of the runways with 55%:45% split of 'main runway' to 'parallel runway' in both Modes. These factors represent a somewhat optimised simulation scenario and with different assumptions, e.g. no gate constraints or less balanced runways, more movements could occur on areas of the taxiway system leading to potentially higher delays.

Table 9.3 - Delay Comparison for Master Plan Concept Airfield Simulations

	MODE 9	**MODE 10**
Demand Level	**2035**	**2035**
Daily arrival and departure operations	**1,187**	**1,187**
Master Plan Concept	**7.2** 44% 5.0 / 9.5	**6.9** 29% 4.7 / 10.1

7.2	Average Peak Hour Delay
44%	% of flights above Average Delay
5.0 / 9.5	Average Peak Hour Arrival / Departure Delay

Peak hour delay below 10 minutes with less than 8 minutes of delay for contiguous hours
Peak hour delay greater than 10 minutes OR greater than 8 minutes of delay for contiguous hours
Peak hour delay greater than 12 minutes OR greater than 10 minutes of delay for contiguous hours
Peak hour delay greater than 16 minutes OR greater than 12 minutes of delay for contiguous hours

It can be seen that the delay levels are in the acceptable range. See Figure 9-15 which depicts the average delay by hour, while Figures 9-17 and 9-18 depict the aircraft delay distribution for Mode 9 and Mode 10, respectively.

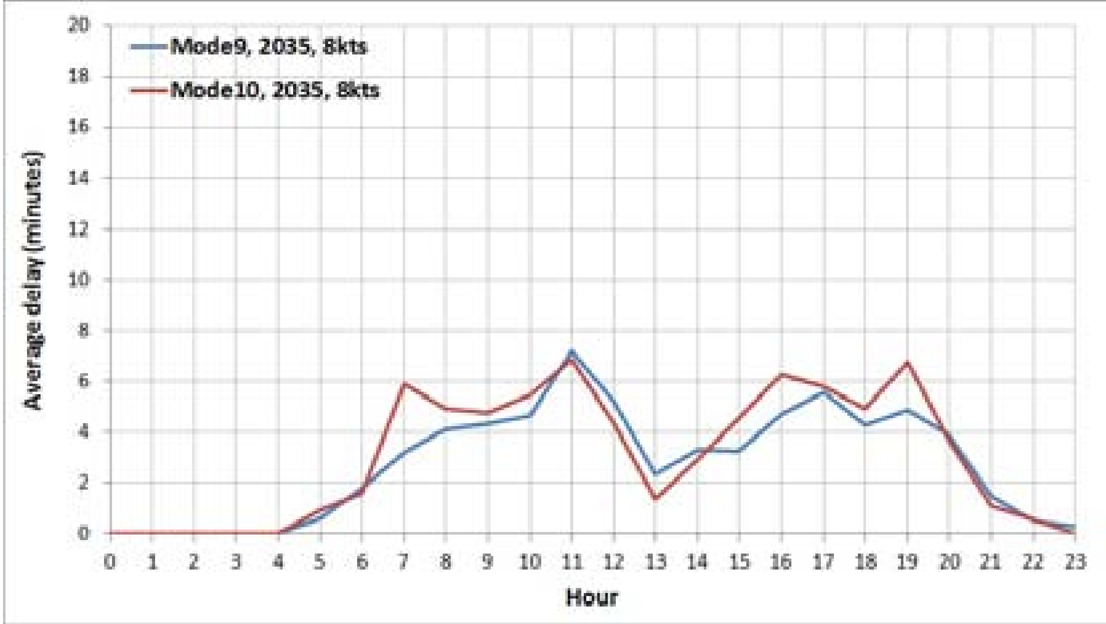


Figure 9.15 - Master Plan Concept Airfield Simulations Average Delay by Hour

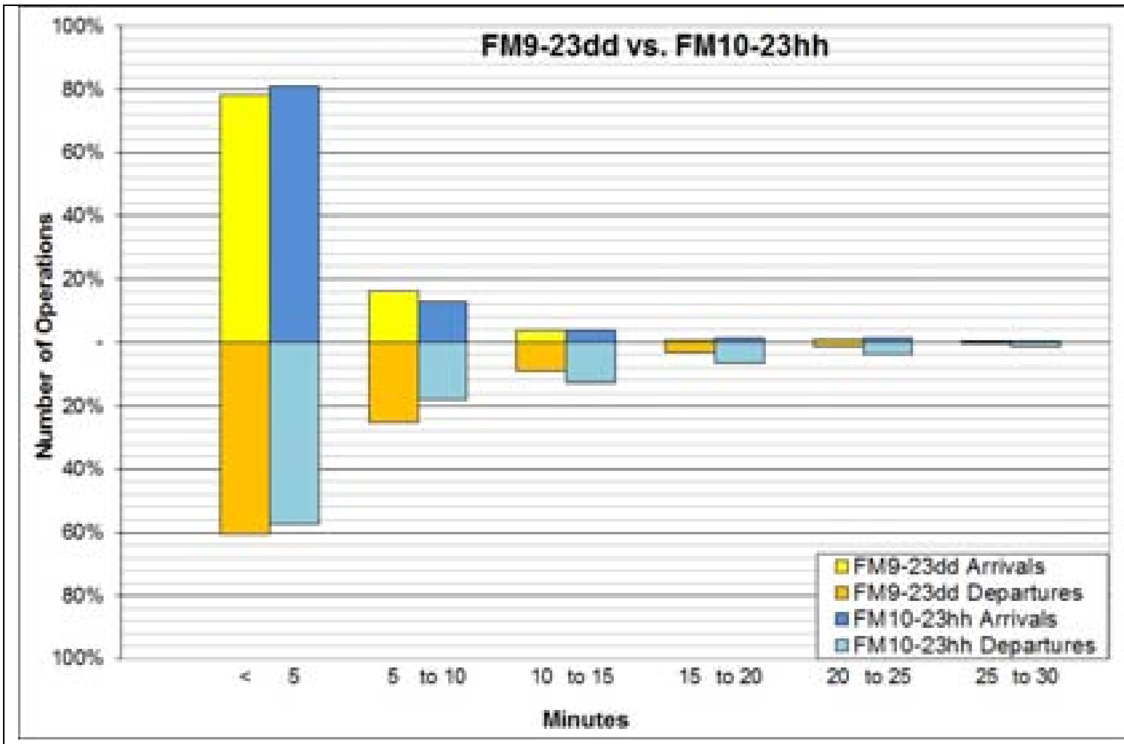


Figure 9.16 - Master Plan Concept Airfield Simulations Delay Distribution Mode 9: FM9-23dd; Mode 10: FM10-23hh

The effects of the various taxiway improvements of the Master Plan Concept airfield on the operational performance can be observed from the following plots—Figures 9-17 and 9-18 compare the average delay by hour with and without these taxiway improvements for north flow and south flow, Figures 9-19 and 9-20 compare the delay distribution with and without these taxiway improvements for north flow and south flow. Generally, these taxiway improvements reduced both the average delay and peak hour delay.

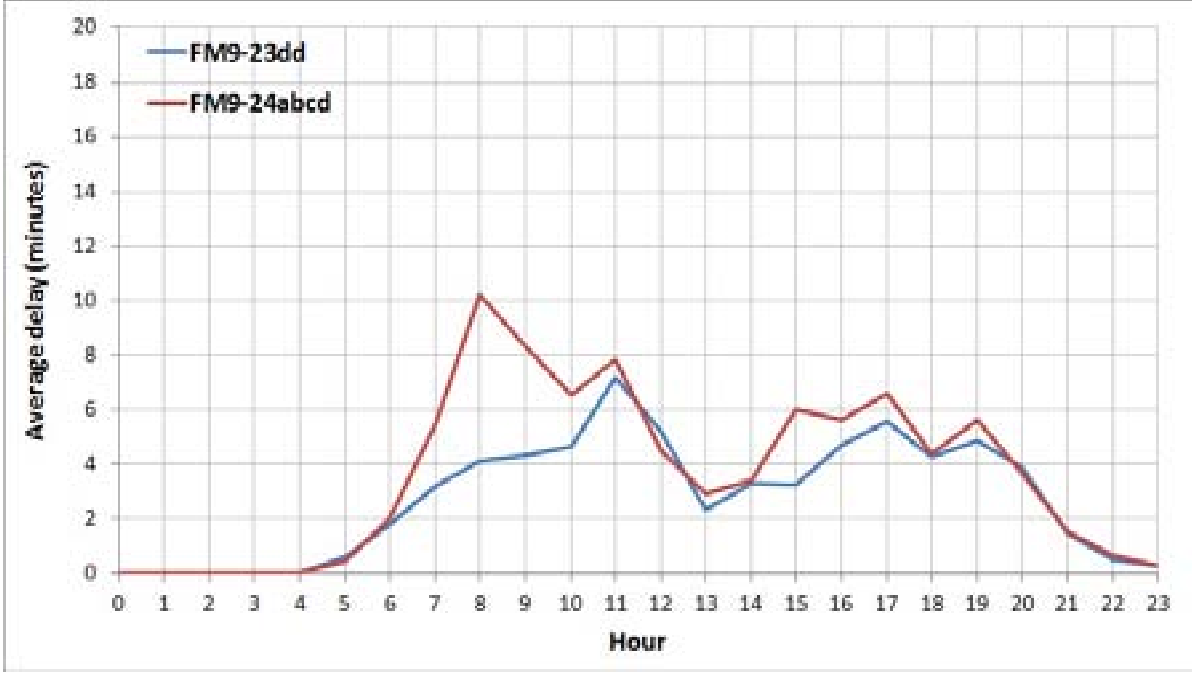


Figure 9.17 - 2035 demand level, Average Delay by Hour Comparison - Mode 9
FM9-23dd: w/ taxiway improvements; FM9-24abcd: w/o taxiway improvements

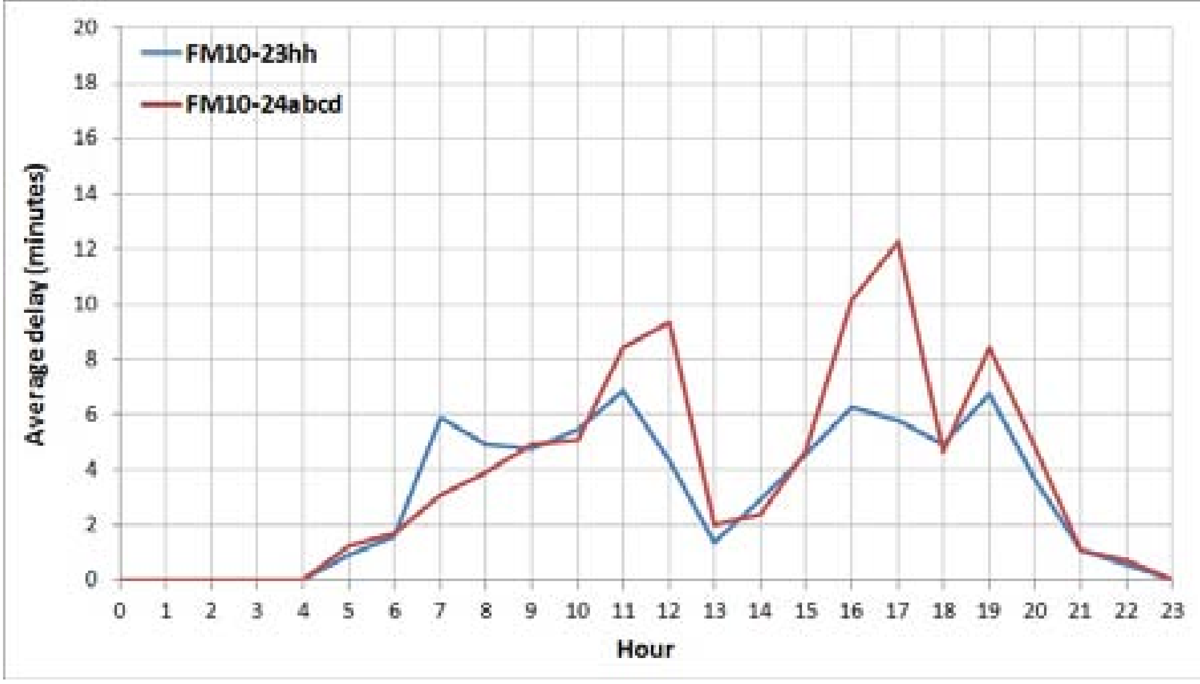


Figure 9.18 - 2035 demand level, Average Delay by Hour Comparison -Mode 10
FM10-23hh: w/ taxiway improvements; FM10-24abcd: w/o taxiway improvements

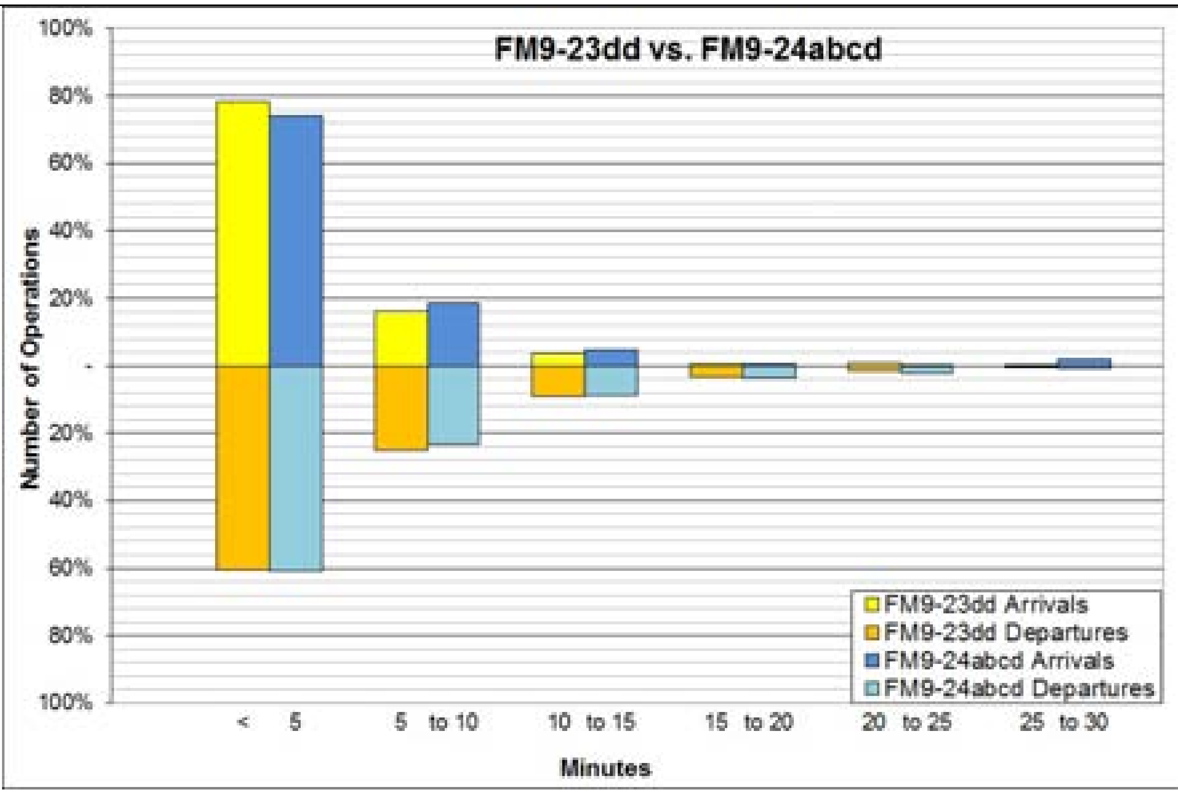


Figure 9.19 - 2035 demand level, Delay Distribution Comparison - Mode 9
FM9-23dd: w/ taxiway improvements; FM9-24abcd: w/o taxiway improvements

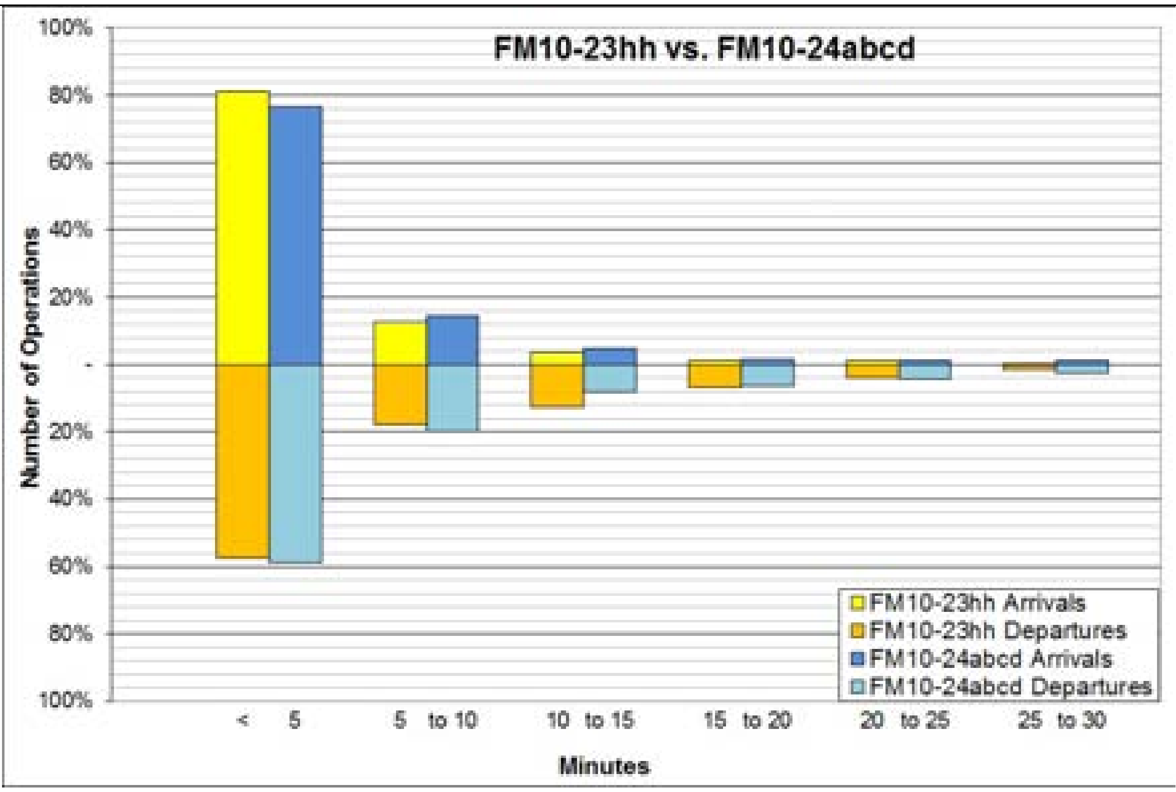


Figure 9.20 - 2035 demand level, Delay Distribution Comparison - Mode 10
FM10-23hh: w/ taxiway improvements; FM10-24abcd: w/o taxiway improvements

To further assess the details on these effects, L&B also conducted experiments using the Master Plan Concept airfield without some of the improvements. Specifically testing:

1. 2035 Airfield Variation "a": without the stub taxiway south of Taxiway L;
2. 2035 Airfield Variation "b": without Taxiway J extension;
3. 2035 Airfield Variation "c": without Taxiway H extension;
4. 2035 Airfield Variation "a": without Taxiway C1 extension;
5. 2035 Airfield Variation "ab": without the stub taxiway south of Taxiway L and Taxiway J extension;
6. 2035 Airfield Variation "abc": without the stub taxiway south of Taxiway L, and Taxiway J, H extensions;
7. 2035 Airfield Variation "abd": without the stub taxiway south of Taxiway L, and Taxiway J, C1 extensions;

The peak hour average delay statistics of these simulations are listed in Table 9.4. The Master Plan Concept (with all taxiway improvements) and Existing Airfield (Variation "abcd") simulation results are also listed in the table for comparison.

Table 9.4 - Delay Comparison for Master Plan Concept Airfield Variation Simulations

		MODE 9	MODE 10
	Demand Level	**2035**	**2035**
	Daily arrival and departure operations	**1,187**	**1,187**
Master Plan Concept (MPC)		**7.2** 44% 5.0 / 9.5	**6.9** 29% 4.7 / 10.1
Variation "a"	MPC w/o Stub TWY	**7.3** 41% 7.2 / 10.5	**6.9** 29% 4.7 / 10.1
Variation "b"	MPC w/o TWY "J" Ext.	**7.2** 41% 5.9 / 9.7	**8.7** 32% 5.1 / 11.7
Variation "c"	MPC w/o TWY "H" Ext.	**7.1** 35% 7.1 / 8.5	**9.2** 43% 7.5 / 14.3
Variation "d"	MPC w/o TWY "C1" Ext.	**7.3** 38% 6.4 / 9.8	**8.9** 37% 3.8 / 16.1
Variation "abcd"	MPC w/o Stub, J, H, C1 Ext.	**10.2** 23% 8.9 / 14.8	**12.3** 40% 12.2 / 13.2
Variation "abc"	MPC w/o Stub, J, H Ext.	**10.0** 36% 12.1 / 11.0	**9.6** 36% 8.3 / 12.0
Variation "abd"	MPC w/o Stub, J, C1 Ext.	**10.2** 23% 9.0 / 14.8	**11.6** 28% 6.0 / 16.4
Variation "ab"	MPC w/o Stub, J Ext.	**8.6** 40% 7.2 / 10.9	**8.7** 32% 5.1 / 11.7

Key	
7.2	Average Peak Hour Delay (minutes)
44%	% of flights above Average Delay
5.0 / 9.5	Average Peak Hour Arrival / Departure Delay

Peak hour delay below 10 minutes with less than 8 minutes of delay for contiguous hours
Peak hour delay greater than 10 minutes OR greater than 8 minutes of delay for contiguous hours
Peak hour delay greater than 12 minutes OR greater than 10 minutes of delay for contiguous hours
Peak hour delay greater than 16 minutes OR greater than 12 minutes of delay for contiguous hours

With only Taxiway H extension, simulated peak hour average delay for both flows increased to moderate level at above 10 minutes per operation. This is also the case for Mode 9 with only the Taxiway C1 extension. Figures 9.21 through 9.24 compare the average delay by hour plots of these simulations; Figures 9.21 and 9.22 are for Mode 9 simulations, Figure 9.23 and 9.24 are for Mode 10 tests.

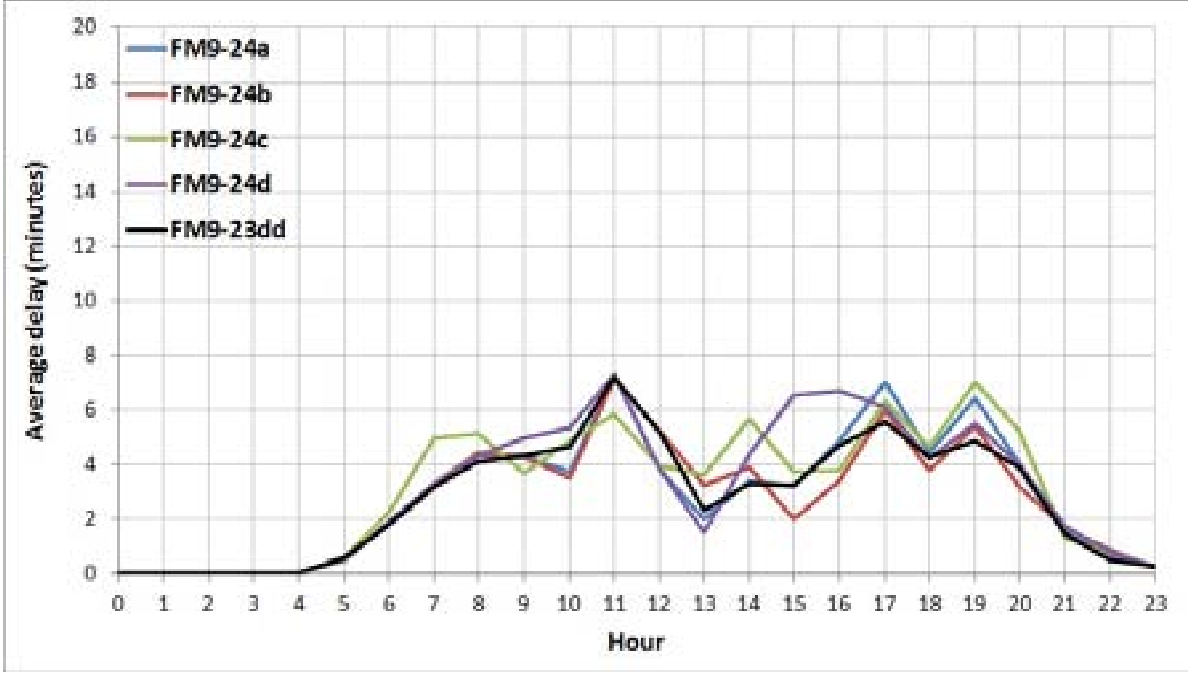


Figure 9.21 - 2035 demand level, Average Delay by Hour Comparison - Mode 9 FM9-23dd: w/ taxiway improvements; FM9-24a, -b, -c, -d: see test descriptions

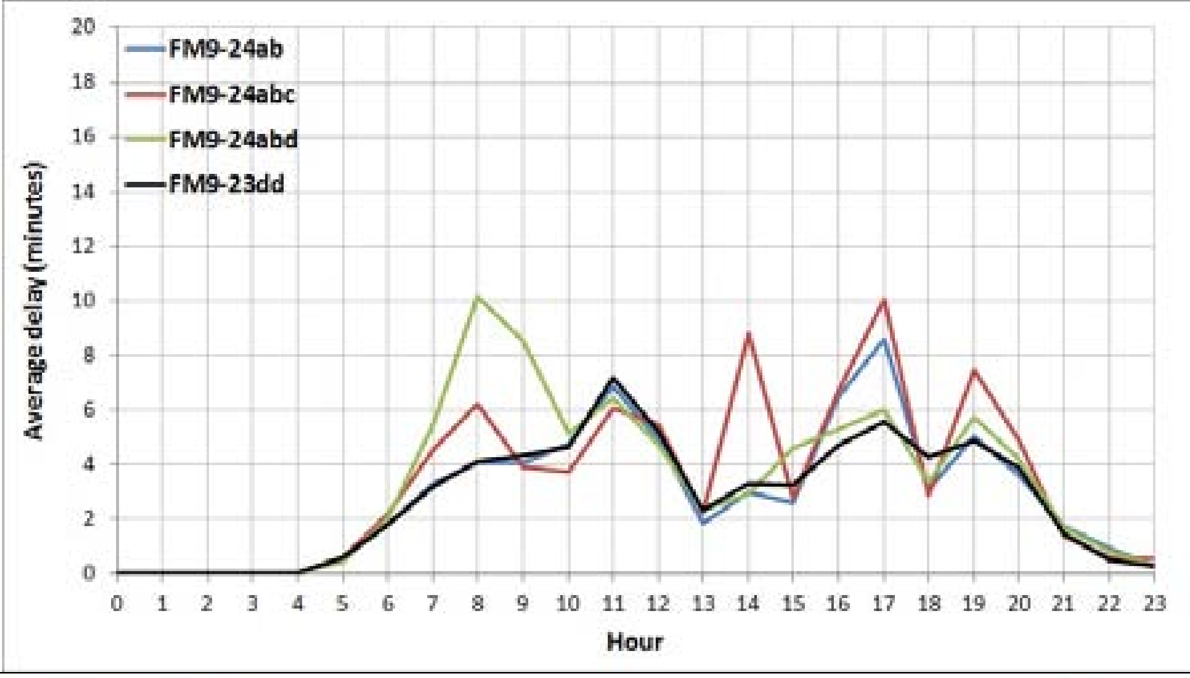


Figure 9.22 - 2035 demand level, Average Delay by Hour Comparison - Mode 9
FM9-23dd: w/ taxiway improvements; FM9-24ab, -abc, -abd: see test descriptions

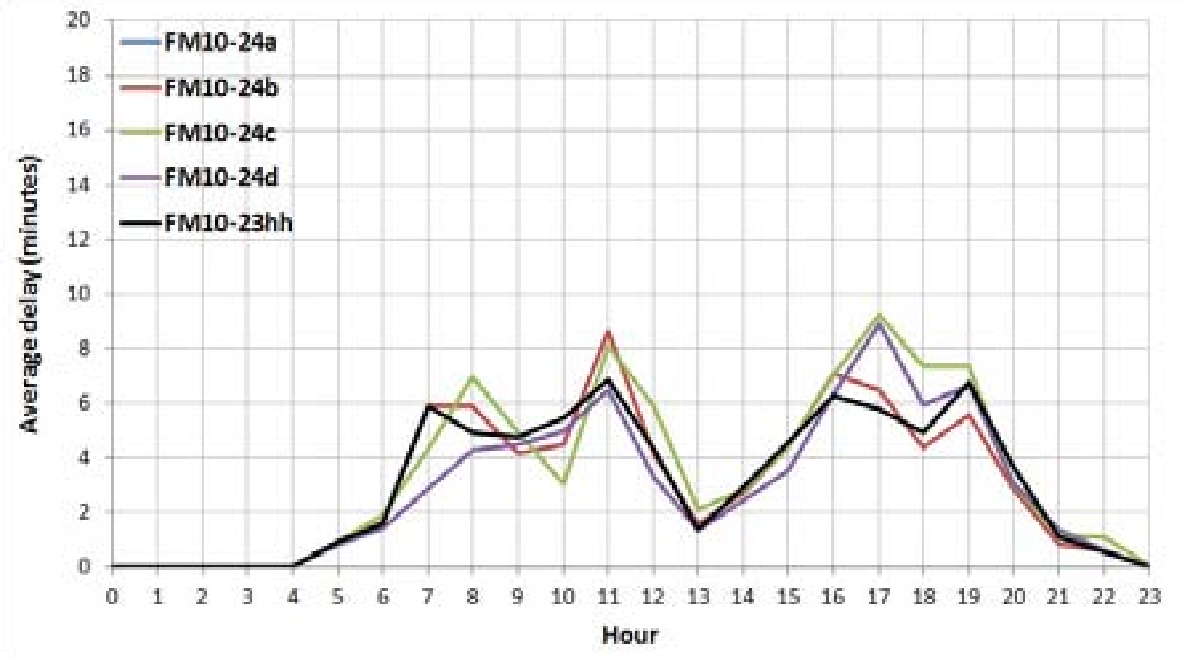


Figure 9.23 - 2035 demand level, Average Delay by Hour Comparison -Mode 10
FM10-23hh: w/ taxiway improvements; FM10-24a, -b, -c, -d: see test descriptions

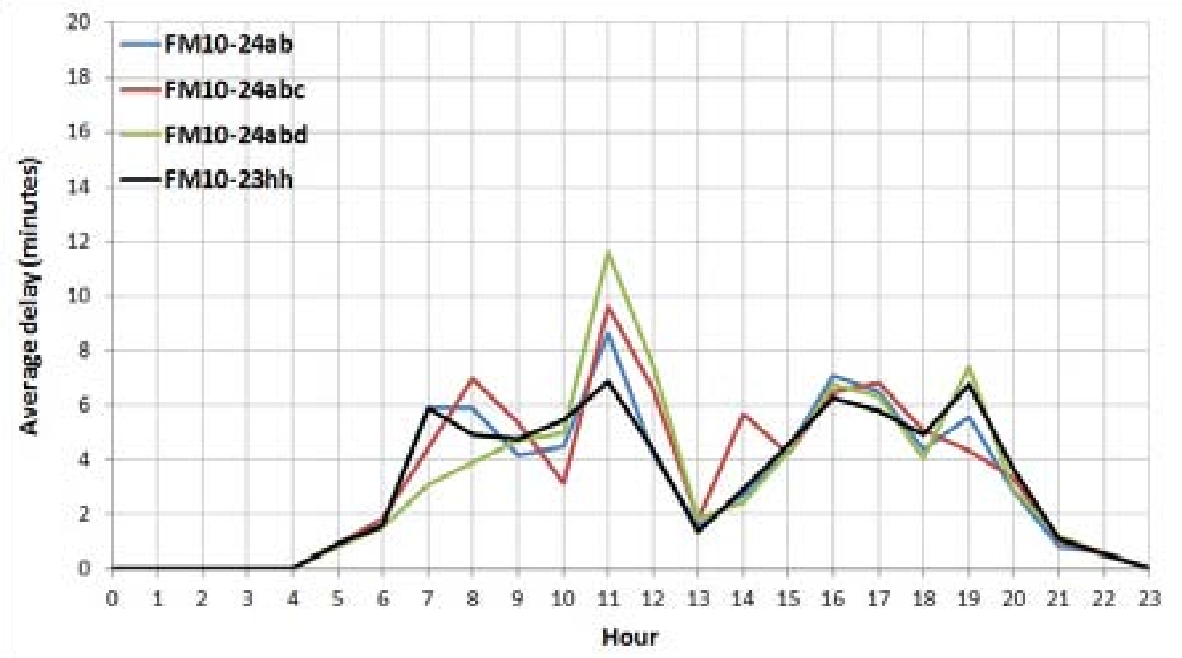


Figure 9.24 - 2035 demand level, Average Delay by Hour Comparison -Mode 10
FM10-23hh: w/ taxiway improvements; FM10-24ab, -abc, -abd: see test descriptions

9.3.2 Discussions

With all of the proposed taxiway enhancements implemented, the results show that the proposed 2029 taxiway system can accommodate simulated 2035 demand within the nominated average delay thresholds. This is based on simulating the 'gated aircraft schedule' and more balanced runway split. Table 9.4 shows that delays are lower on this airfield layout than the existing airfield without enhancements, demonstrating a benefit of the proposed enhancements.

The stub taxiway south of Taxiway L has little use during south flow, except in rare occasions for runway turnoff. Hence the delay statistics with and without this improvement showed no change. The intent of introducing this stub taxiway is to have a better intersection departure point during north flow, not block arriving aircraft taxiing on Taxiway B, and in turn provide a more smooth ground movement for departure flows to both runways and arrival flow from Runway 16L. This effect can be seen from the slight increase of overall delay levels in Variation "a". When used by turbo-prop aircraft, the new stub taxiway can hold up to four aircraft without blocking Taxiway L (see Figure 9.25).

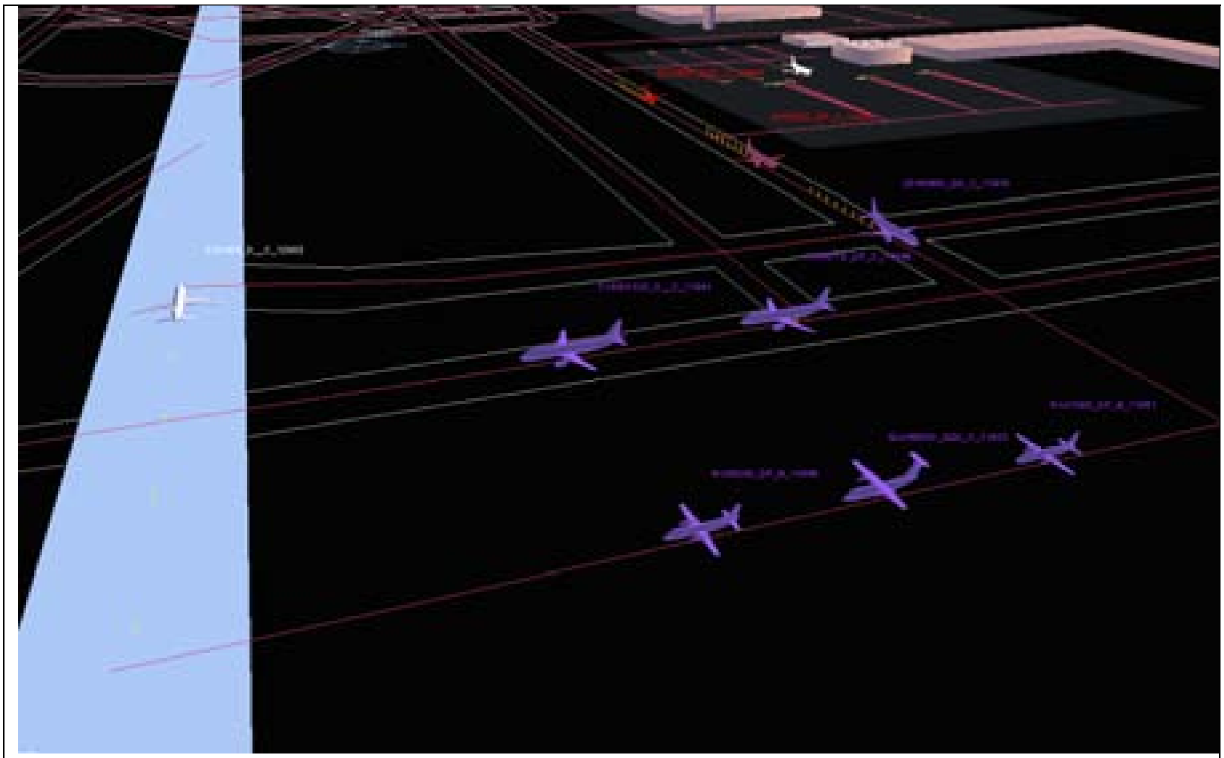


Figure 9.25 - Intersection Departure from New Stub Taxiway during North Flow

Taxiway J extension can provide an additional runway crossing point to facilitate better runway crossing. However due to its proximity to the main high speed exit of Runway 34L its effectiveness is not very high during north flow. Without Taxiway J extension, the peak hour departure delay increased moderately during south flow.

Like Taxiway J extension, Taxiway H extension can provide an additional runway crossing point and this provided significant improvement, especially for south flow because it is closer to the departure end of Runway 16R than Runway 34L yet away from the departure queue. Moreover, the Taxiway H extension also provides a parallel route to/from most area of the T2 apron in addition to Taxiway G, and to reduce the interference between departing and arriving taxi flows in this area as seen in Figure 9.5 (see Figure 9.26 where an aircraft in yellow was taxiing to its gate in the T2 apron after landing on Runway 34L, aircraft in purple and red are departing aircraft to Runway 34R and 34L, respectively). The crosswind Runway 07/25 can also provide some of this function, but can only be used during day time.

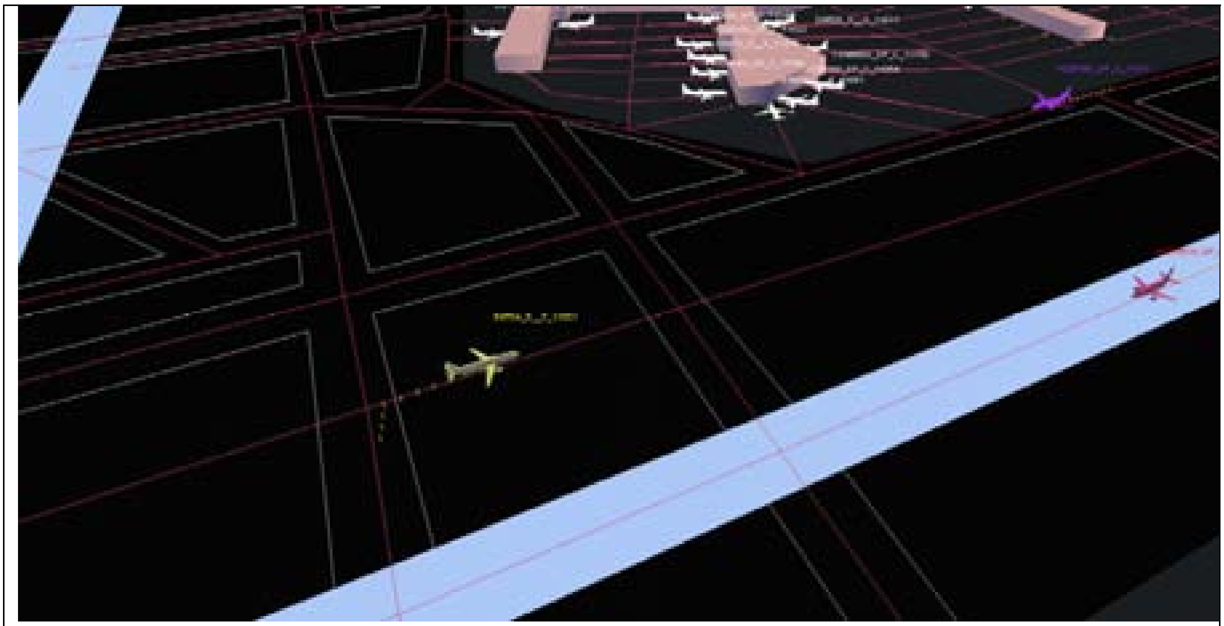


Figure 9.26 - Separated arrival/departure flows on Taxiways G, H, and the Crosswind Runway 07/25

Taxiway C1 extension is very useful during south flow because it provides an alternative departure entry for international flights, especially when arriving large freight aircraft (e.g. B777) cross the runway at A1/B1 to access their parking position in the freight apron as discussed in Section 9.2.2. This is shown in Figure 9.27, where a B777 aircraft landed on Runway 16R (white) is taxiing behind the departing aircraft from runway entry C1 (purple) to its parking position. The A1/B1 taxiway link can also be used for towing large International passenger aircraft (e.g. A380/A340/B777) between the international side and the domestic side remote stands on the freight apron during both flows. Together with the additional apron taxi-lane parallel to taxiway A, the congestions problem on the international side of Runway 16R end is alleviated. Without the Taxiway C1 extension, the peak hour departure delay during south flow jumped to a relatively high level.

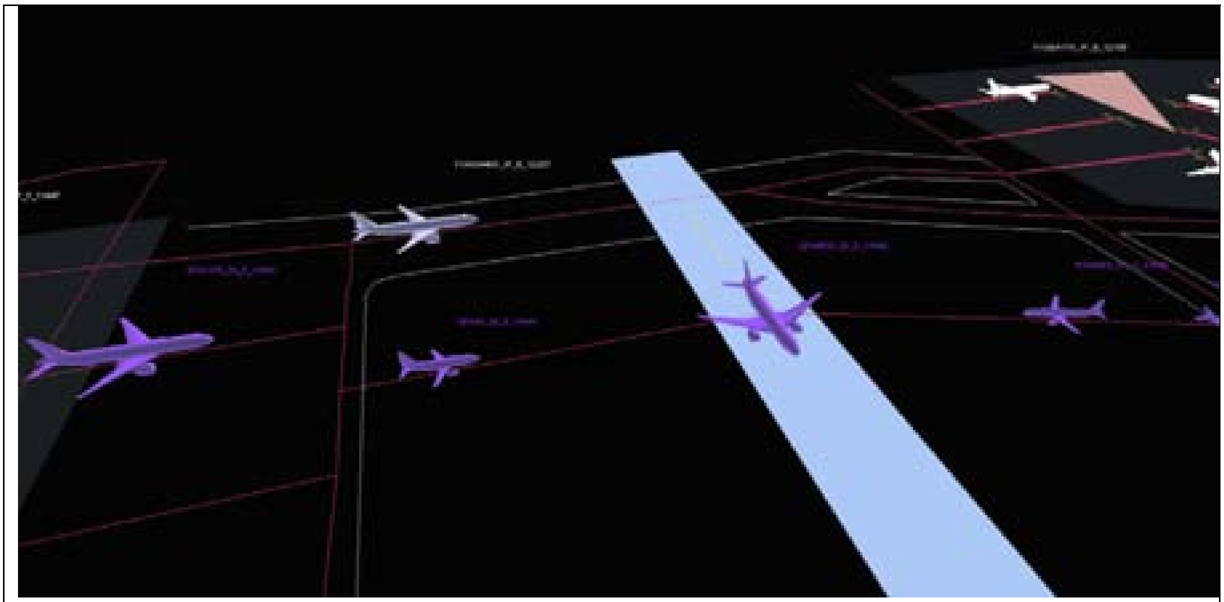


Figure 9.27 - Arriving B777 Taxiing Behind Departing Aircraft from Runway Entry C1

The results showed that none of these improvements are absolutely necessary from an aircraft delay stand point, assuming balanced runway utilization can be achieved and good towing speed maintained. However from the tests of various enhancement combinations, results indicate that Taxiway H and C1 extensions are more beneficial to the operational performance (see Figures 9.28 and 9.29). Peak hour average delay can be reduced by 16% for Mode 9 and 29% for Mode 10 as calculated from the simulation results. More in-depth Cost Benefit Assessment is recommended to further study this issue and provide quantitative decision support.

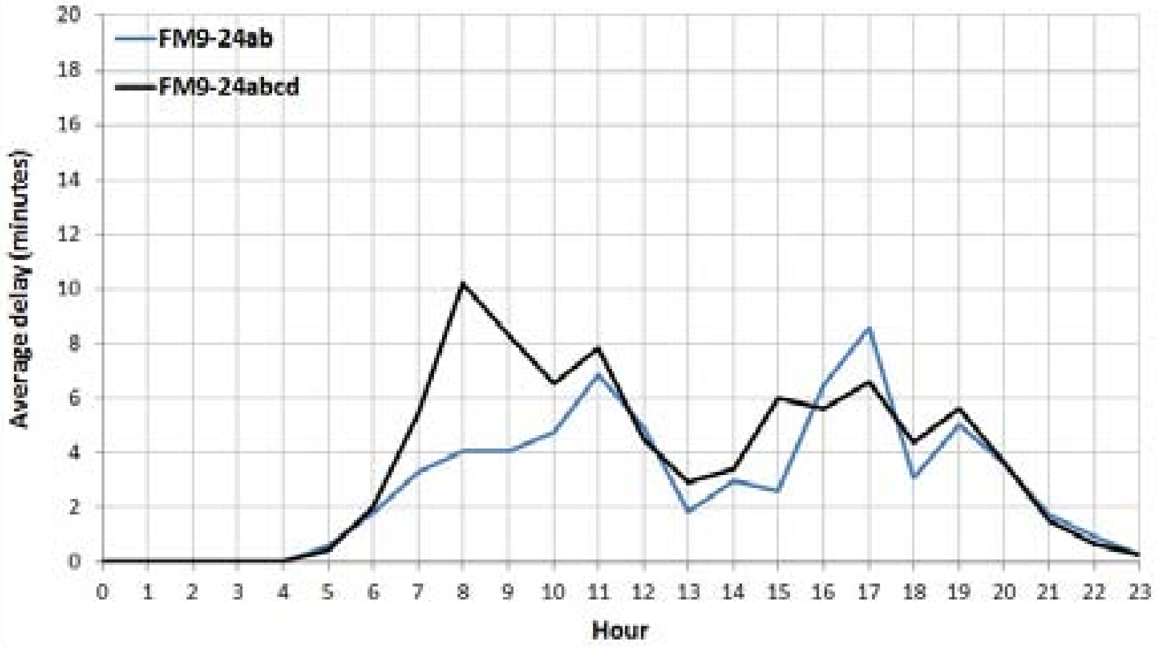


Figure 9.28 - 2035 demand level, Average Delay by Hour Comparison - Mode 9
FM9-24abcd: w/o taxiway improvements; FM9-24ab: w/ Taxiways "H", "C1" extensions

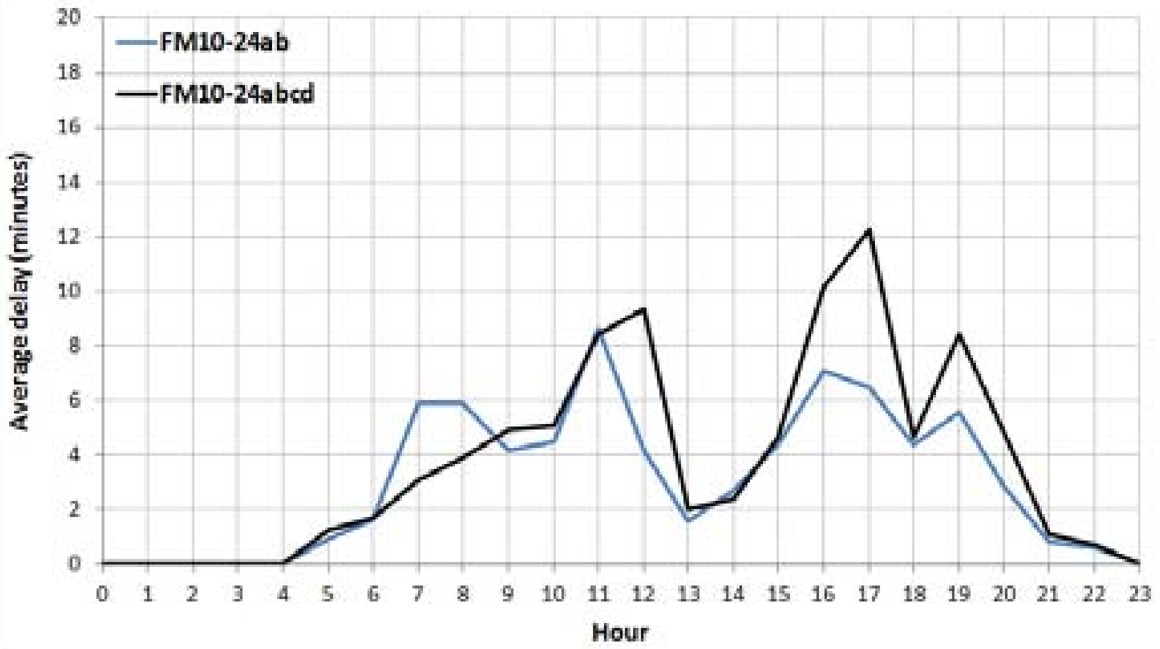


Figure 9.29 - 2035 demand level, Average Delay by Hour Comparison -Mode 10
FM10-24abcd: w/o taxiway improvements; FM10-24ab: w/ Taxiways "H", "C1" extensions

9.4 Taxiway Enhancement Recommendations

1. Extend Taxiway B10 to Taxiway A to facilitate runway crossing.
2. Construct additional remote parking positions for large aircraft west of Runway 16R/34L for international flights, thus reduce the number of runway crossings.
3. Construct additional rapid exit taxiways for Runway 16R to reduce runway occupancy time. For example, if landing aircraft overshoot the A4 exit it may have to taxi a great distance on the runway before turn off from A5, potentially reduce the operational rate.

10.0 Conclusions

10.1 Apron / Gate Capacity

- The modelling predicts that a shortfall in aircraft stands will be the limiting ground factor in terms of accommodating forecast demand at Sydney (Kingsford-Smith) Airport. This is based on flight arrival, departure and turnaround times in the Booz & Co. forecast schedules and planned implementation of aircraft stands in the Master Plan 2009.

- Assuming 2015 layout includes TWY B4 realignment and 5 additional T2 pier gates, the 2015 gate capacity does not accommodate the 2015 demand. 59 aircraft turns remain un-accommodated and will require up to an additional 25 gates to accommodate the entire 2015 forecast schedule demand.

- The current Master Plan Concept ultimate development plan shows significant up-sizing of aircraft stands to accommodate the forecast up-gauging of the aircraft fleet operating at Sydney (Kingsford-Smith) Airport. However, based on the forecast schedules and the staging plans shown in the Master Plan 2009, the rate of up-gauging of stands appears to fall below demand in the period leading up to 2020.

- The 2020 forecast schedule demand cannot be accommodated by the planned aircraft stand provision. There is an overall shortfall of up to 19 stands with 30 un-accommodated aircraft turns.

- The 2029 long-term gate provision is insufficient to accommodate the forecast 2035 schedule demand though it is noted that there is not a correlation in these demand and capacity planning horizons. A total of 39 aircraft turns remain un-accommodated and require the addition of up to 16 aircraft stands.

- The aircraft stand modelling indicates that approximately 1,200 daily aircraft movements (dependent on aircraft schedule characteristics and aircraft turnaround time) appears to be the approximate limit of capacity at Sydney (Kingsford-Smith) Airport governed by available stands in the Master Plan Concept layout for 2029.

It is recommended that the above conclusions and the assumptions behind them be discussed with Sydney Airport Corporation Limited. It is recommended that alternative implementation strategy should be explored with the aim of maximizing and accelerating stand provision to ensure potential aviation growth at Sydney (Kingsford-Smith) Airport is supported to the extent possible.

10.2 Taxiway System Capacity

- Simulation of the taxiway system was based on the 'gated aircraft schedules' from the aircraft stand modelling exercise, i.e. those flights that can be accommodated on aircraft stands. Aircraft tow operations (to/from remote gates) and runway crossings were included in the simulation. Provision of more stands will facilitate additional aircraft movements in the peak periods which could result in higher delays than those simulated.

- The simulation of future demand scenarios also assumed greater runway usage balancing than currently occurs on an annual basis, though it has been achieved over monthly periods in the past. Where possible, pursuing greater runway balancing of runway usage should be a target as this will help facilitate improved ground traffic flow and reduce delays on the taxiways.

- Assuming more balanced runway utilization can be achieved at Sydney (Kingsford-Smith) Airport in the future, the analysis concludes that the current taxiway system can support forecast demand within assumed delay thresholds, though delays increased substantially less than 2035 demand. This is the case for the gate constrained 2015 and 2035 forecast schedules, noting that Master Plan Concept layout gates were assumed available in the latter scenario to facilitate simulation. The simulated peak hour average delays are less than the 16 minutes per operation assumed threshold and there are no more than 2 contiguous hours of delay greater than 12 minutes per operation.

- Simulation of the airfield including enhancements planned in the Master Plan 2009 showed the improved taxiway system can accommodate forecast aircraft movement growth within assumed delay thresholds and with much lower delays than the airfield without enhancements.

- With respect to the Master Plan Concept airfield, simulation results indicate that Taxiways H and C1 extensions are beneficial to the operational performance in terms of reducing peak hour and average delay levels.

- Taxiway H extension provides additional runway crossing points for Rwy 16R/34L which will help with towing operations and aircraft movement. Taxiway H also provides a parallel route to/from T2 apron in addition to Taxiway G which reduces the interference between departing and arriving taxi flows, especially in response to substantial apron expansion in the Master Plan Concept layout for 2029. Extending Taxiway H will also reduce reliance on the use of the crosswind runway as a taxiway which has operational implications and cannot be used during noise sharing modes.

- Taxiway C1 extension provides an alternative entry to Rwy 16R/34L for departure flights during south flow. It also frees up A1/B1 taxiway link to be used for large freighters or towed passenger aircraft (e.g. A380/A340/B777) crossing the runway between the international and the domestic sides.

Appendix A – Proposed Implementation of Airfield Infrastructure

15.0 Implementation

The development concept outlined in this Master Plan represents current views of development expected to be realised in a staged manner, largely as a result of increased passenger and aircraft demand. Major Development Plans are also required for designated major airport developments, as set out in the Airports Act 1996. Such development proposals are the subject of further community consultation, environmental assessment and Ministerial approval.

15.1 Implementation framework

This Master Plan provides a 20 year strategic planning framework for the future development of Sydney Airport. It demonstrates the necessary flexibility to ensure that future aviation industry trends and demands are appropriately met through the provision of new or enhanced infrastructure in a timely manner.

Below is a high level indicative summary of the potential phasing associated with this Master Plan. The actual timing of each of the developments will depend on the realisation of the demand triggers, SACL's assessment of prevailing and forecast market conditions, the carrying out of any necessary environmental assessment and approvals processes and the outcome of stakeholder consultation processes.

15.1.1 Now to 2014

International Terminal (T1) expansion for centralised outbound processing and security screening, additional reclaims, secondary line and primary line reconfiguration and expansion of the outbound baggage handling system.

Domestic Terminal (T2) expansion of Pier A for additional aircraft parking and expansion of terminal processing facilities including the baggage handling system.

Apron expansion and associated taxiway works for aircraft parking in the south-west and north-east sectors of the airport.

Completion of the runway end safety area (RESA).

Domestic precinct road augmentation and ground transport facilities.

Additional multi-storey car parking capacity within the international and domestic precinct.

Commercial developments including things such as aircraft hangars, freight and catering facilities, office, hotel and other commercial facilities in various sectors of the airport.

Timing of developments beyond the initial five year period is of course more indicative with less certainty when a specific demand trigger will be reached. Further, the Act provides for the final Master Plan to remain in force for five years. Consequently, this Master Plan will again be reviewed and updated in 2014.

15.1.2 2014 to 2019

T1 expansion to the north including development of Pier A. Development will facilitate additional terminal processing capacity and provide additional aerobridge positions for aircraft parking, including improved flexibility of handling Code F aircraft.

T2 expansion to the east including development of Pier C. Development to facilitate additional terminal processing capacity and provide additional aerobridge positions for aircraft parking, including improved flexibility of handling Code E aircraft.

Apron expansion and associated taxiway works for aircraft parking in the south-east sector of the airport.

Road improvements to the International and Domestic precincts, including road improvements to Airport/Qantas Drive.

Commercial developments including such things as aircraft hangars, freight facilities, multi-storey car parking modules (international and domestic), office and hotel developments, and other commercial facilities in various sectors of the airport.

15.1.3 2019 to 2024

T1 expansion to the north and west to provide additional terminal processing capacity.

T2 and T3 expansion to the west, including improved integration between the two terminals and expansion of the existing Pier A. Developments will provide additional terminal processing capacity and improve connectivity between the two domestic terminals.

Redevelopment of the current Qantas Jet Base to provide additional common use aircraft parking positions.

Additional expansion of the south-east sector aircraft parking positions.

Development of new taxiways to improve airport operations and improved connectivity to remote aircraft parking positions.

Road developments in the International and Domestic terminal precincts to improve level of service and capacity. This includes development of multi-storey car parks to minimise at grade traffic circulation and airside transfer corridor to improve connectivity between the international and domestic terminals.

Continued relocation of general and corporate aviation facilities to the South south-east sector.

Commercial developments including such things as aircraft hangars, multi-storey car parking modules, office and hotel developments, and other commercial facilities in various sectors of the airport.

15.1.4 2024 to 2029

T1 expansion to the east and widening of Pier A. The development also provide additional aerobridge positions for aircraft parking on the western side of Pier A.

Expansion of T3 to the east to facilitate additional aerobridge positions for aircraft parking and terminal capacity.

Augmentation of the taxiway system in the International precinct to facilitate dual taxiways for improved airfield operation and capacity.

New alignment of road systems in the International precinct due to the development of aircraft parking to the west of Pier A.

Commercial developments including such things as aircraft hangars, multi-storey car parking modules, office and hotel developments, and other commercial facilities in various sectors of the airport.

Appendix B – 2010 GMS Stand Allocation Chart

SYD Ground Capacity Study - 2010 Schedule

GATE	Size	Area
PBOX		
I8	E	T1
I9	F	T1
I10	F	T1
I11	D	T1
I12	C	T1
I24	F	T1
I25	E	T1
I31	E	T1
I33	E	T1
I35	E	T1
I37	E	T1
I36	E	T1
I34	E	T1
I32	E	T1
I30	E	T1
I51	E	T1
I53	E	T1
I55	C	T1
I57	F	T1
I58	E	T1
I59	E	T1
I60	E	T1
I61	F	T1
I63	C	T1
I56	E	T1
I54	E	T1
I50	C	T1
I84	E	T1
I85	E	T1
I71	E	T1
I72	F	T1
I73	E	T1
I74	E	T1
I75	E	T1
D49	D	T2
D49A	E	T2
D49B	C	T2
D53	D	T2
D55	D	T2
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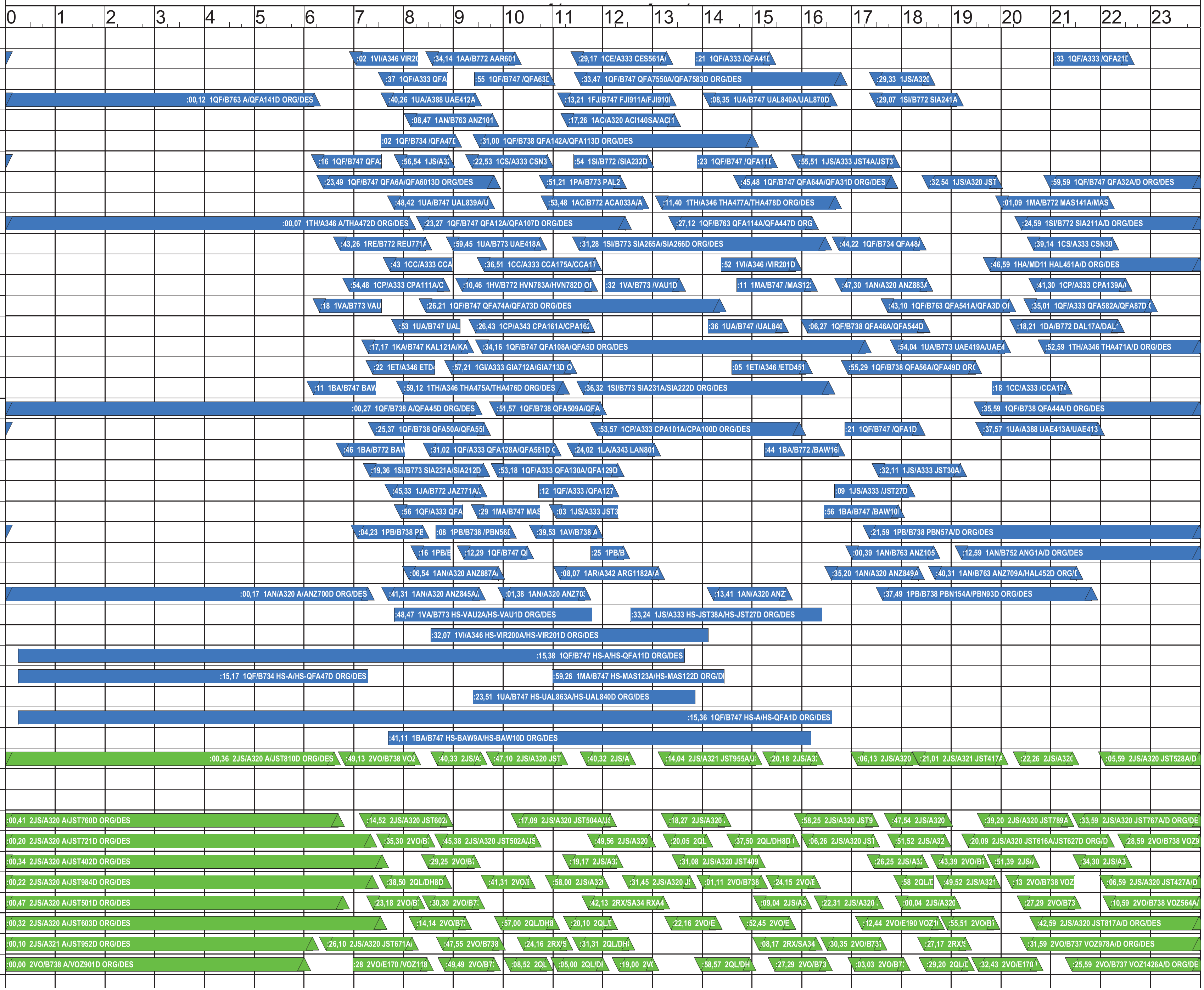
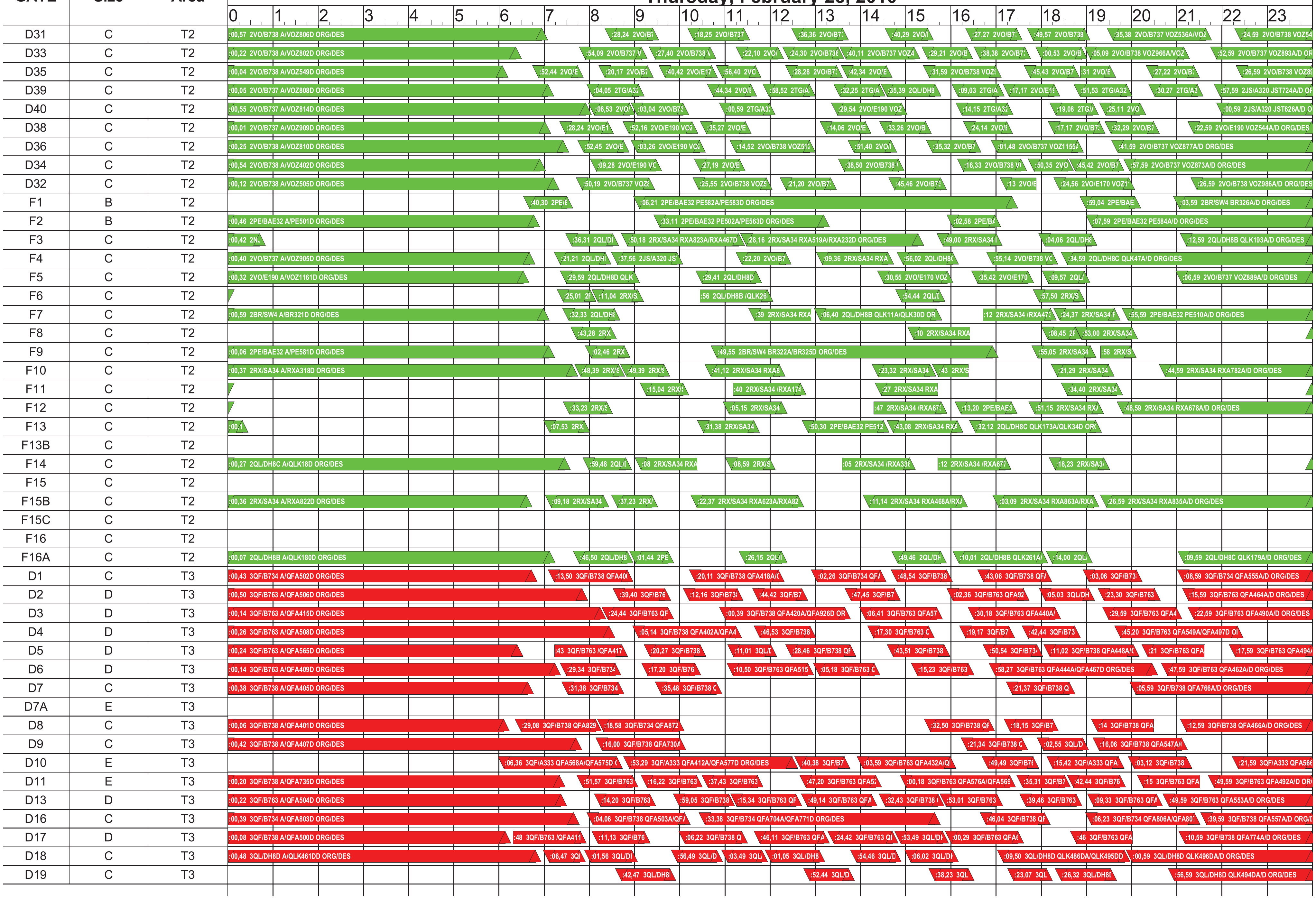
D59	C	T2
D58	C	T2
D56	C	T2
D54	C	T2
D52	C	T2

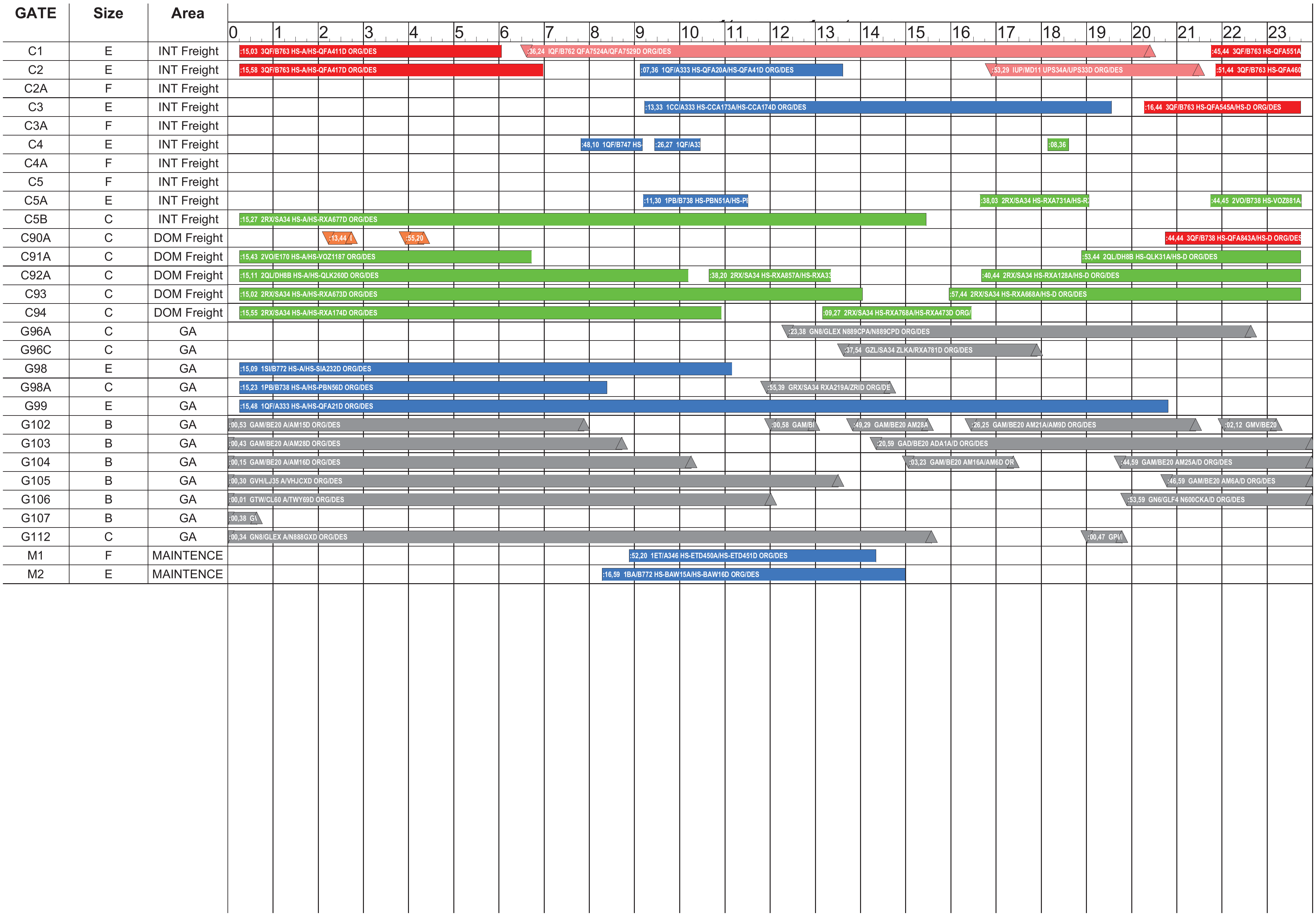


SYD Ground Capacity Study - 2010 Schedule

Thursday, February 25, 2010



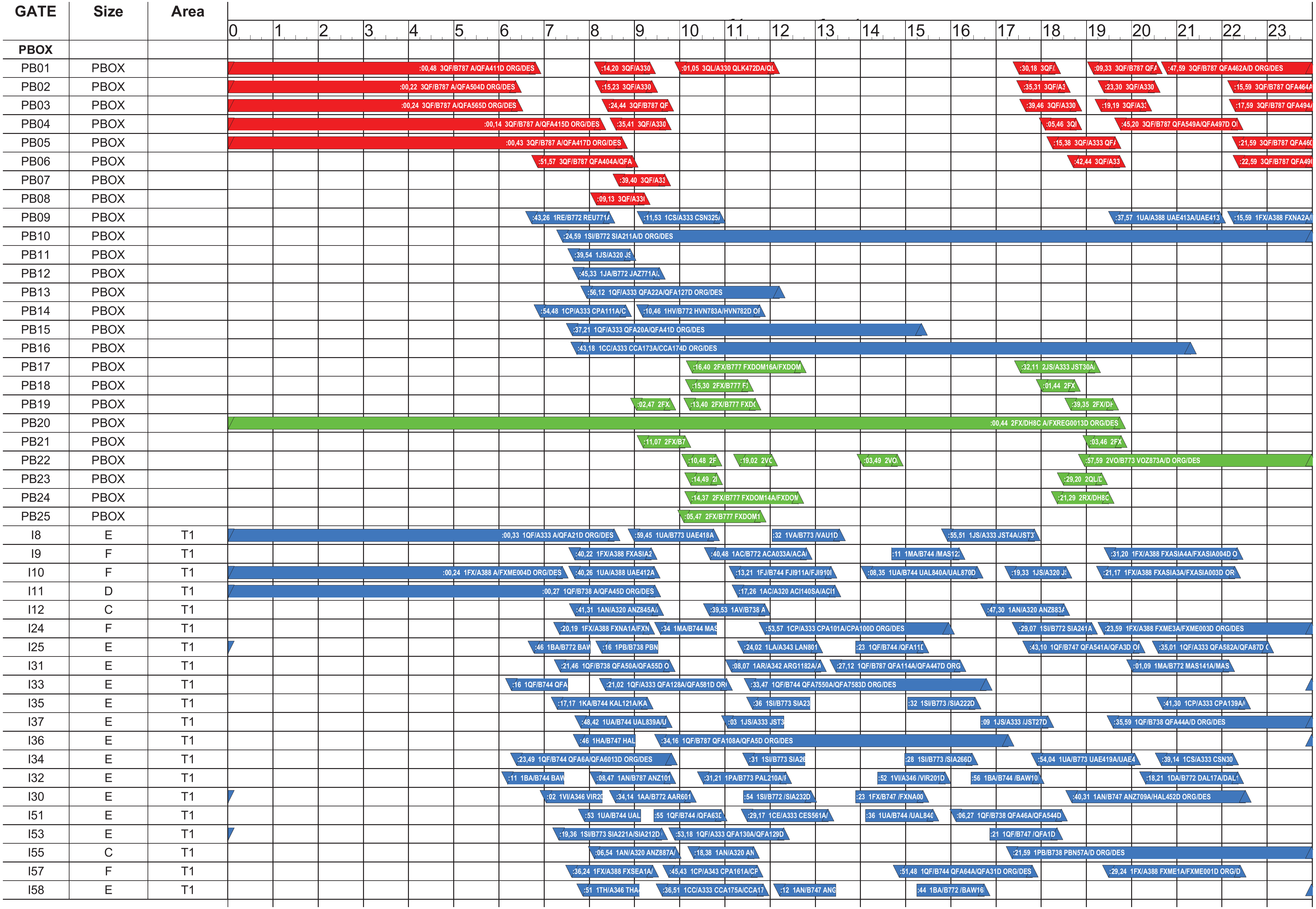
SYD Ground Capacity Study - 2010 Schedule



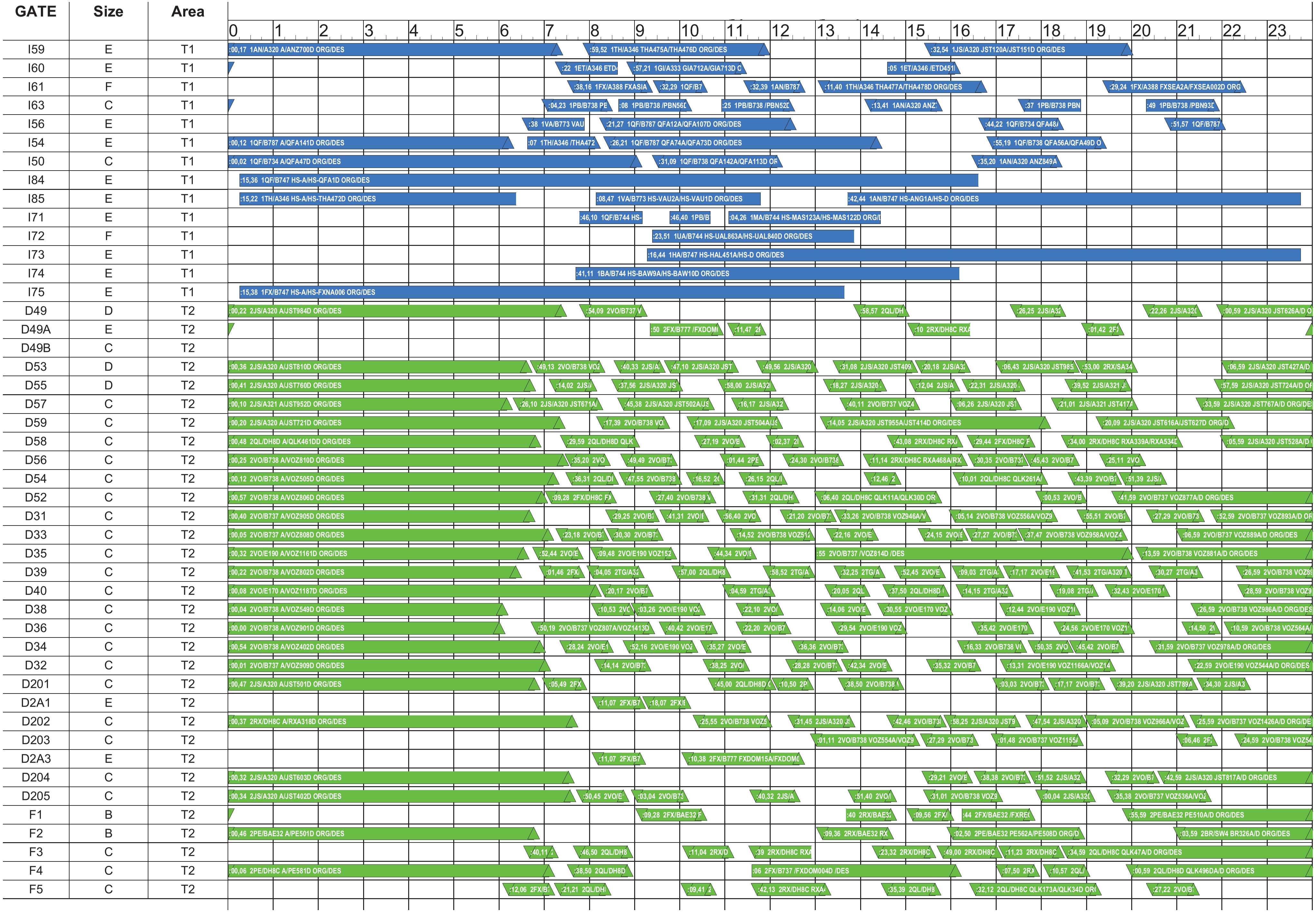
Appendix C – 2015 Forecast Schedule

GMS Stand Allocation Chart

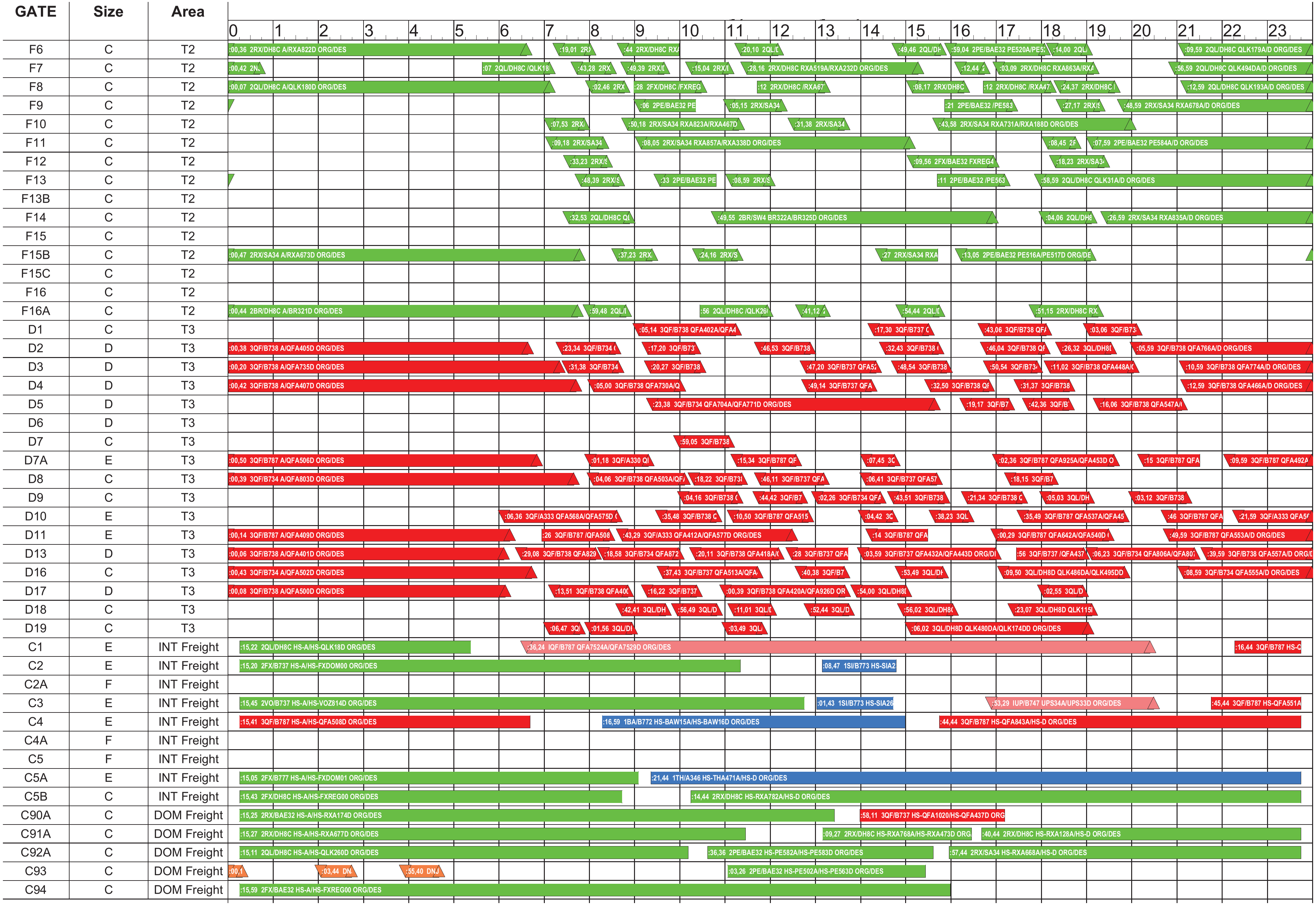
SYD Ground Capacity Study - 2015 Revised Schedule



SYD Ground Capacity Study - 2015 Revised Schedule



SYD Ground Capacity Study - 2015 Revised Schedule



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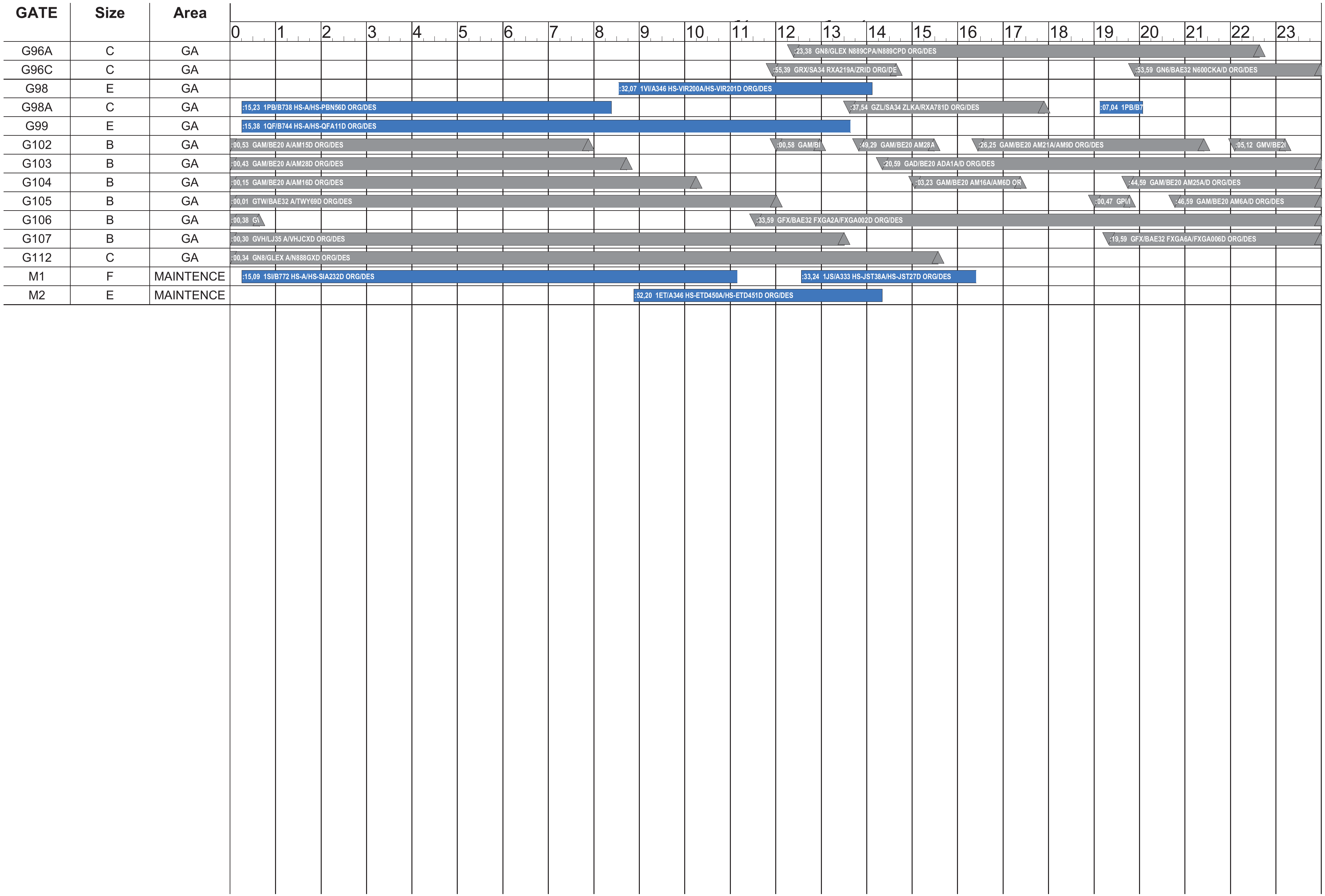
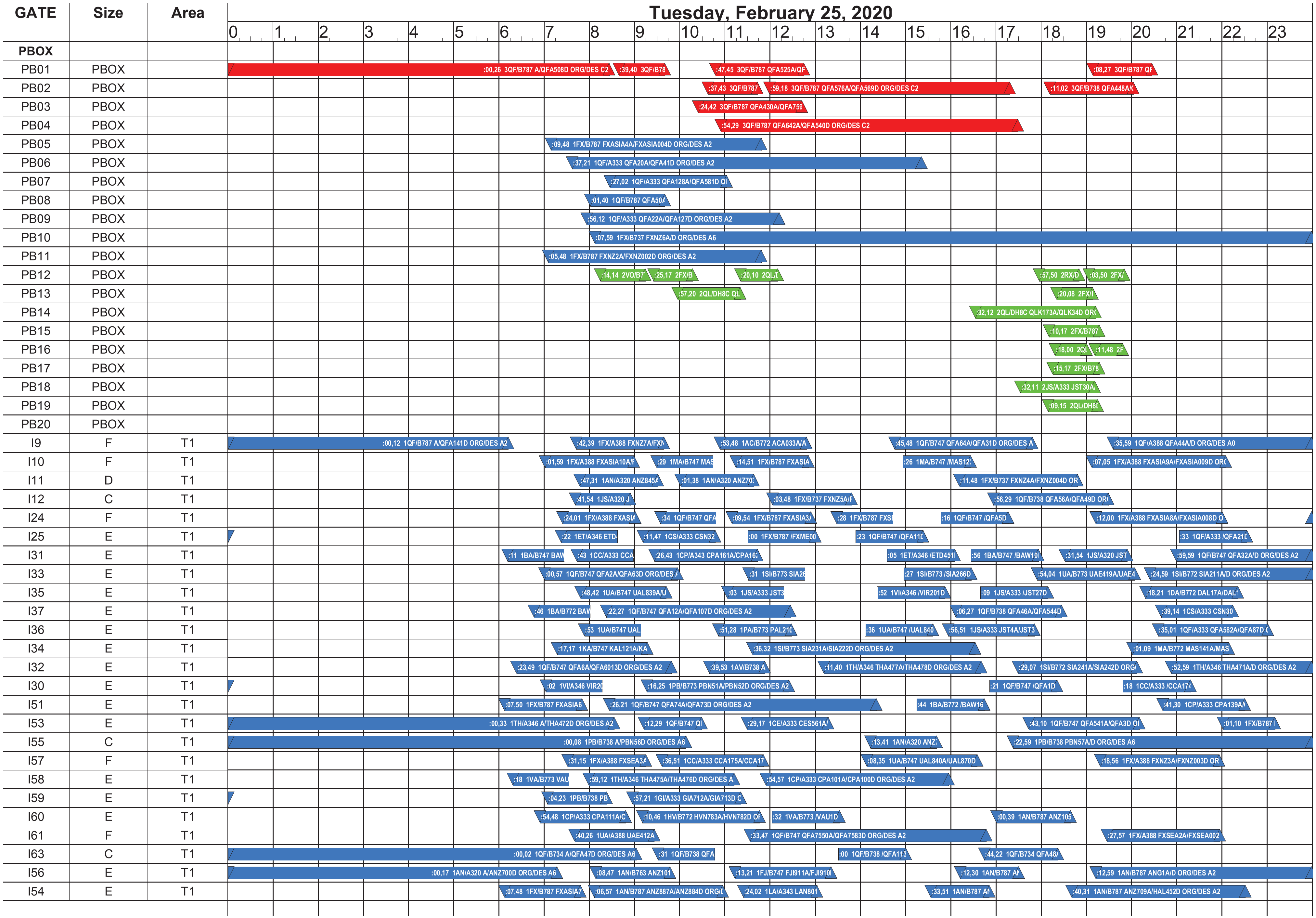
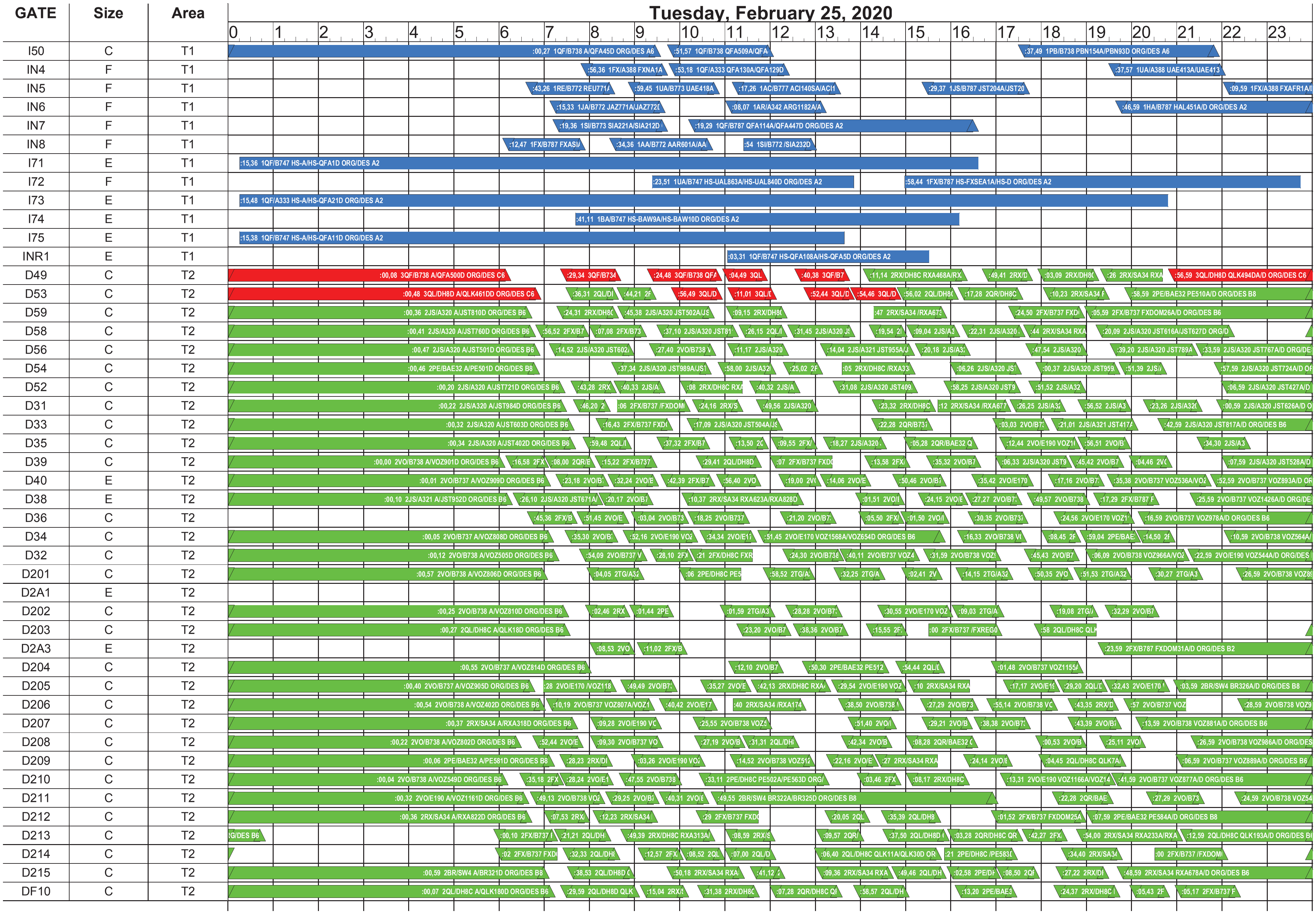


Appendix D – 2020 Forecast Schedule GMS Stand Allocation Chart

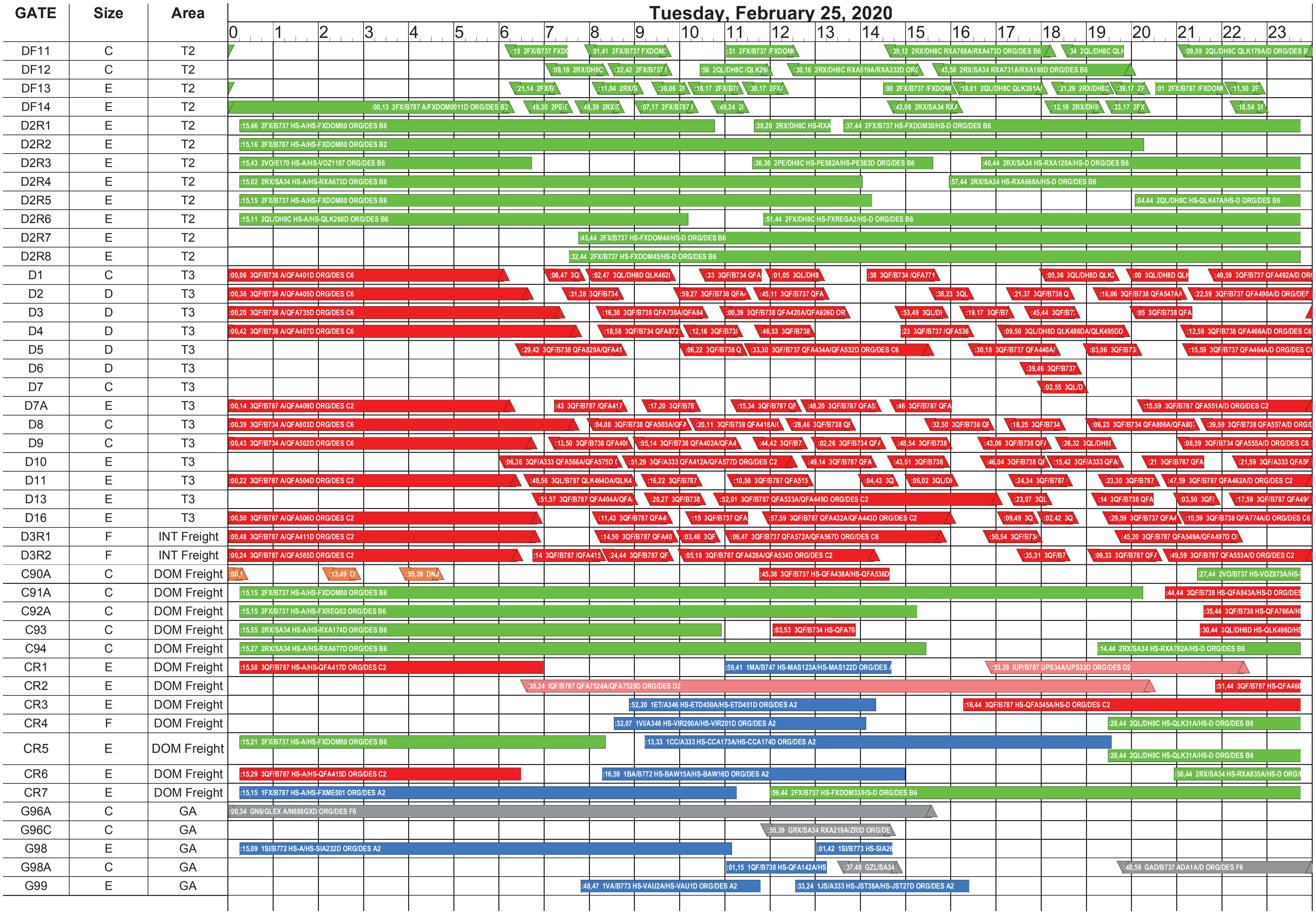
SYD Ground Capacity Study -2020 Revised Schedule



SYD Ground Capacity Study -2020 Revised Schedule



SYD Ground Capacity Study -2020 Revised Schedule



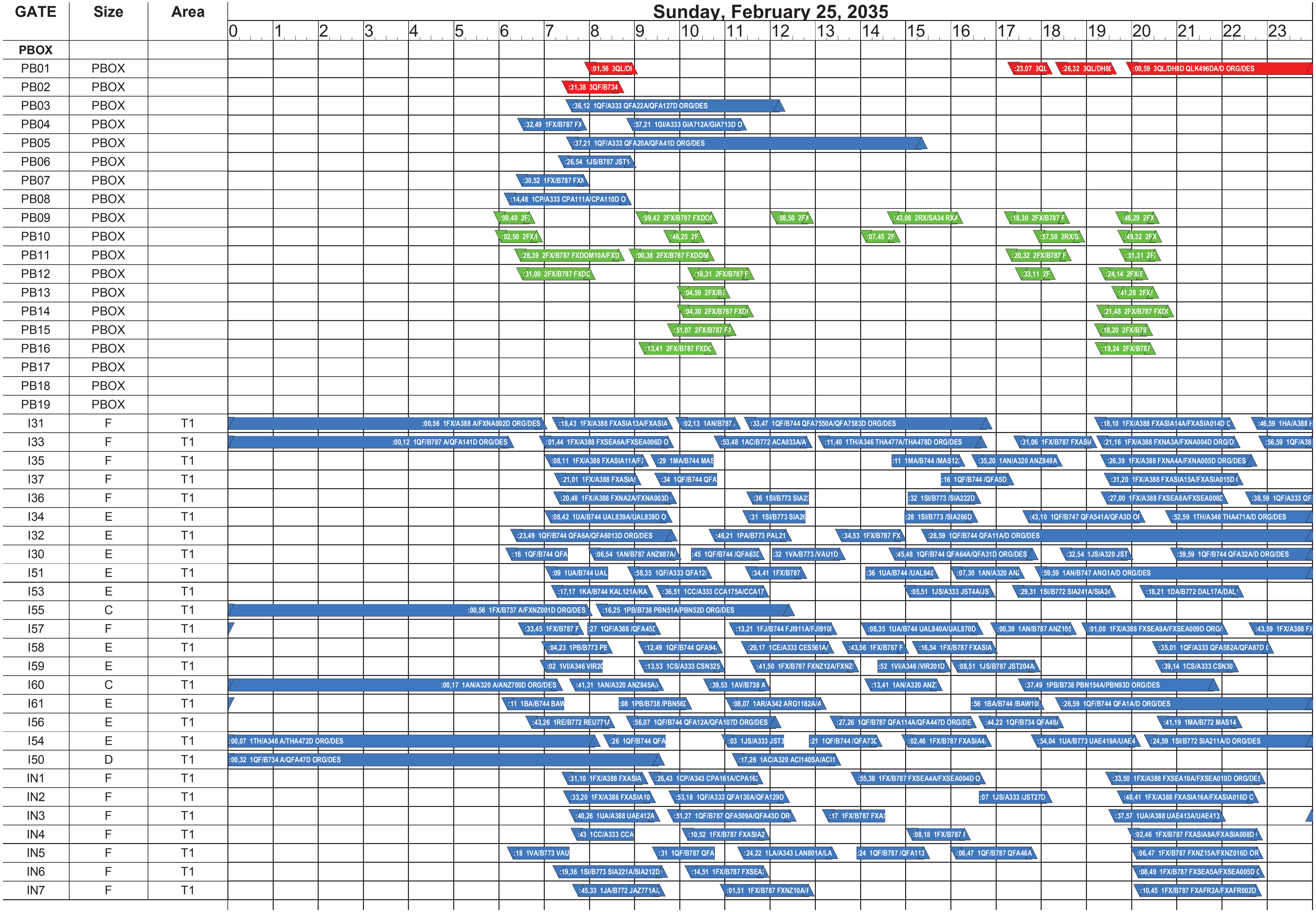
SYD Ground Capacity Study -2020 Revised Schedule

Tuesday, February 25, 2020

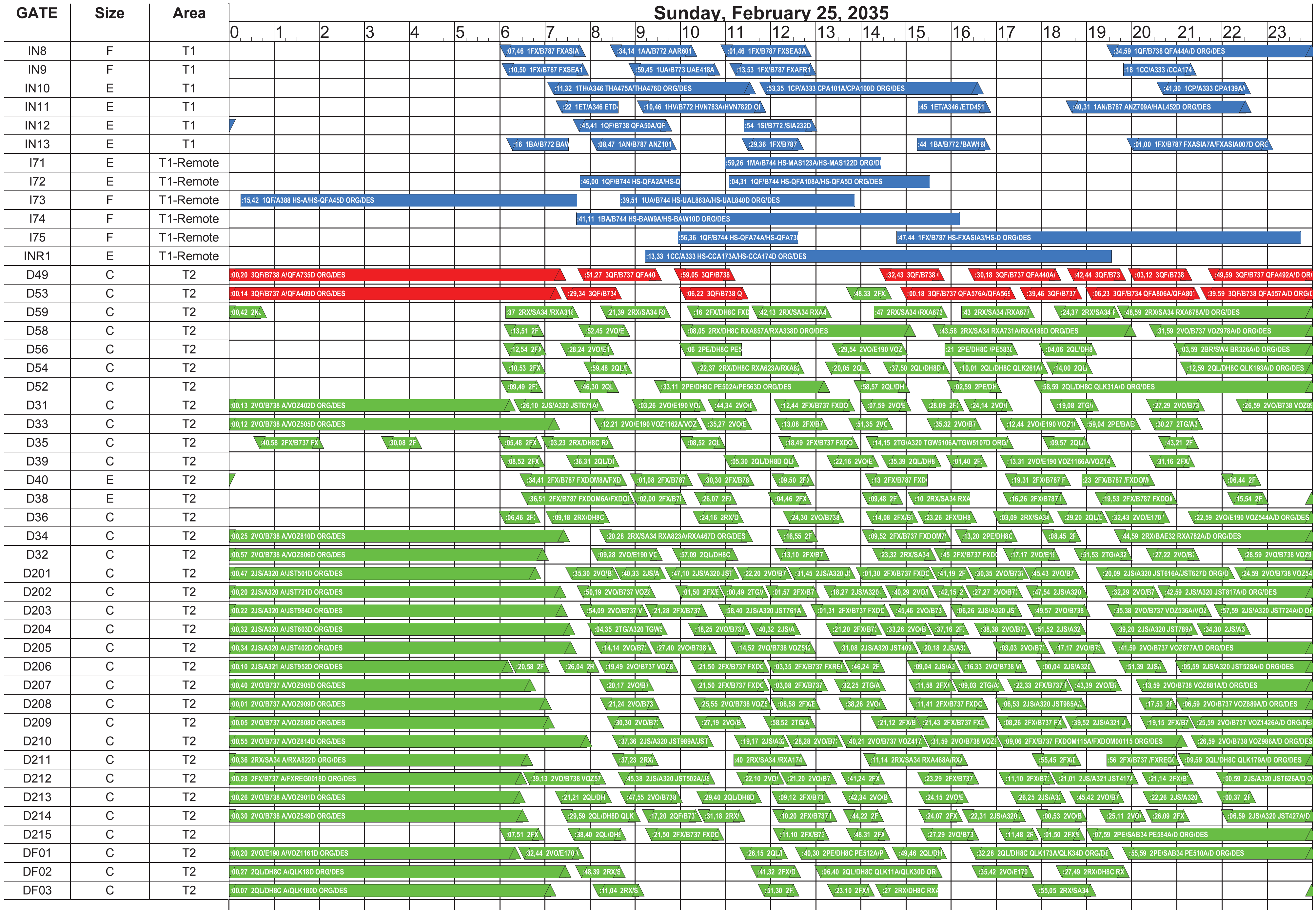
GATE	Size	Area
G102	B	GA
G103	B	GA
G104	B	GA
G105	B	GA
G106	B	GA
G107	B	GA
G112	C	GA

Appendix E – 2035 Forecast Schedule GMS Stand Allocation Chart

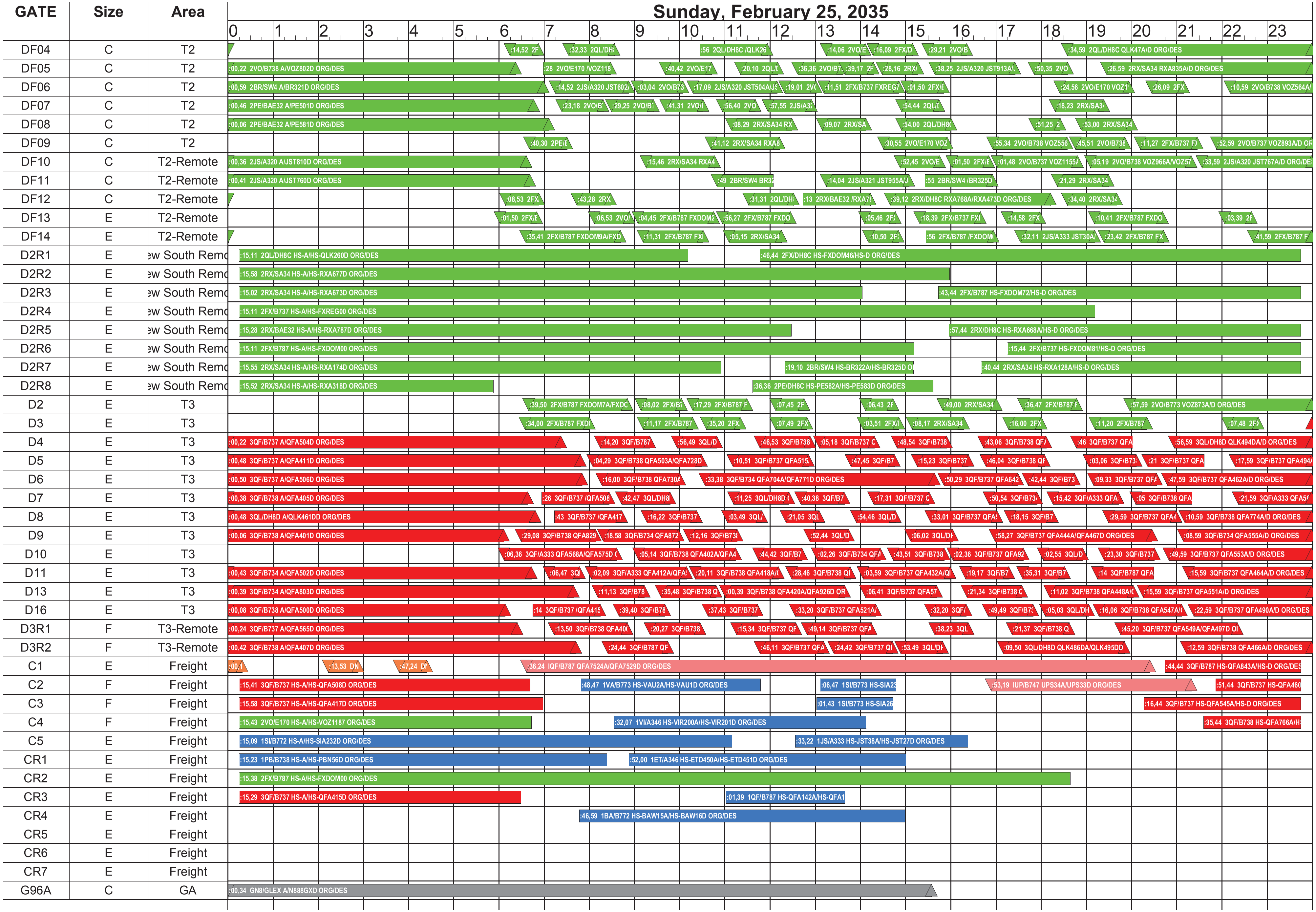
SYD Ground Capacity Study - 2035 Revised Schedule



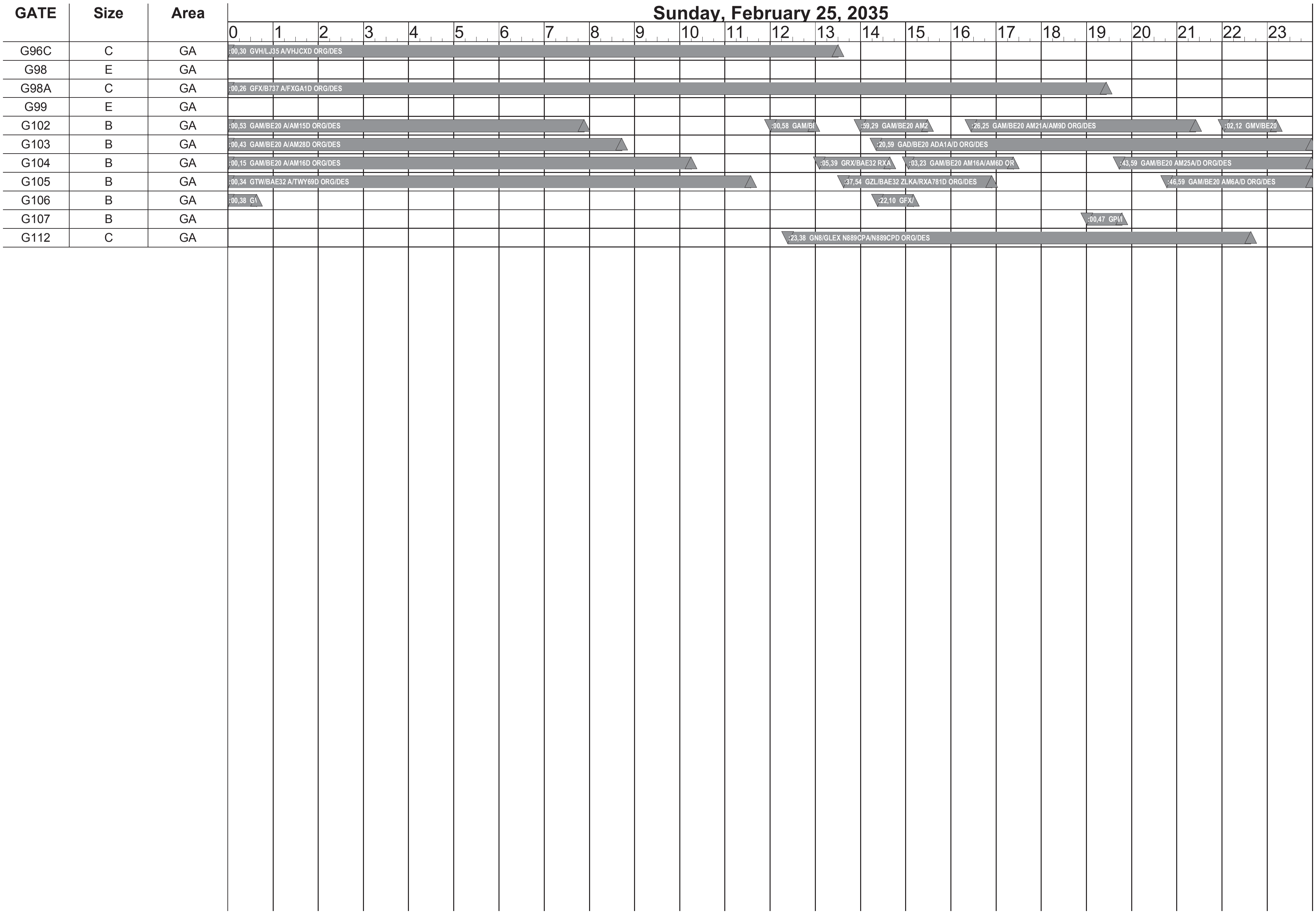
SYD Ground Capacity Study - 2035 Revised Schedule



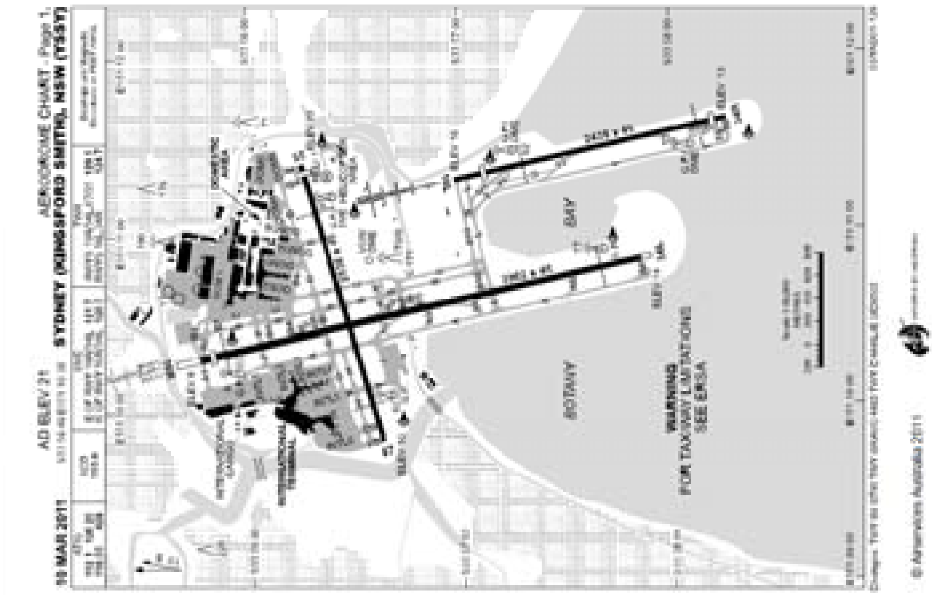
SYD Ground Capacity Study - 2035 Revised Schedule



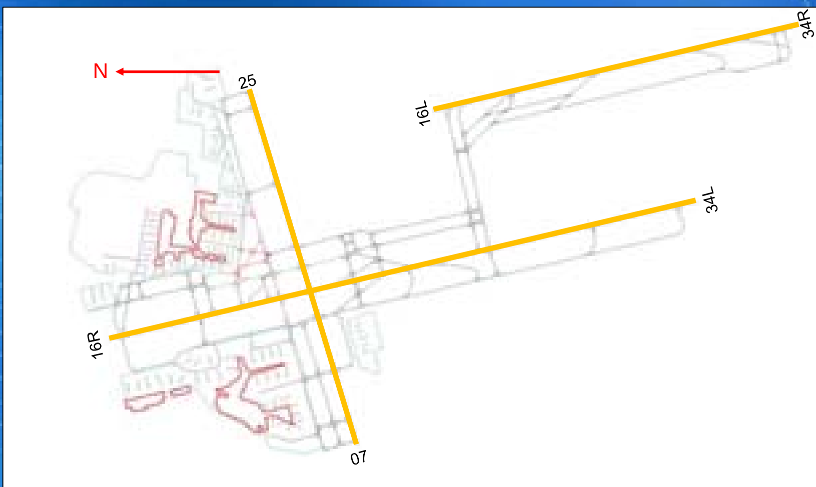
SYD Ground Capacity Study - 2035 Revised Schedule



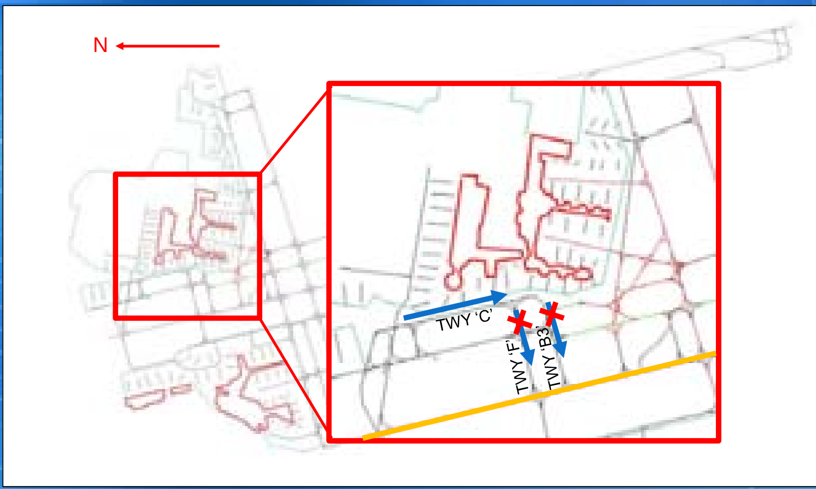
Appendix F – Current Aircraft Taxiing Restrictions (Source: ERSA)



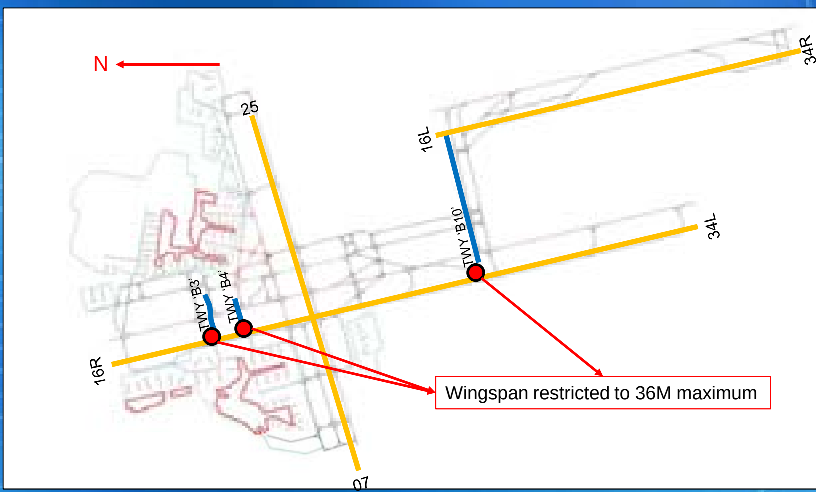
Aviation Planning at the Leading Edge



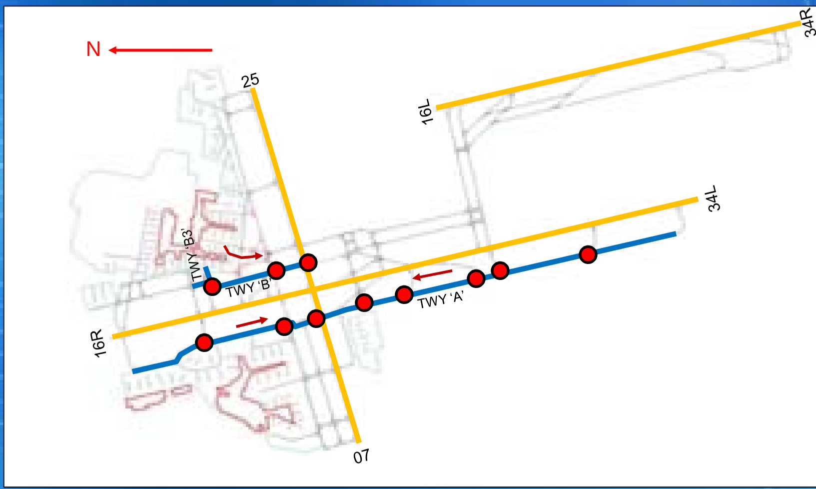
Aviation Planning at the Leading Edge



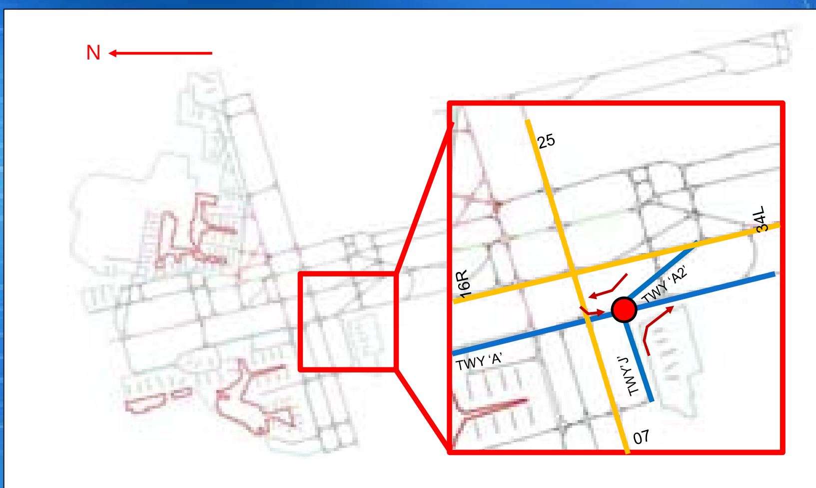
DC10/MD11 type ACFT under PWR not permitted to turn FM TWY C to TWY F or TWY B3 due to jet blast on apron



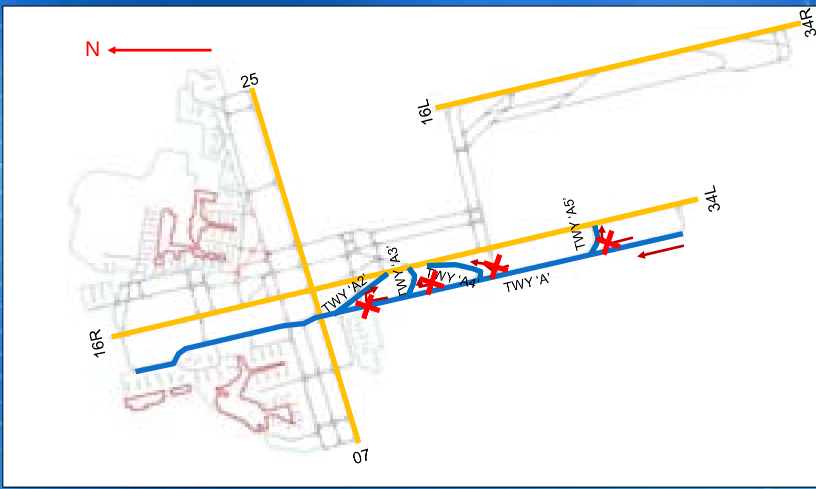
Intersection DEP RWY 16R/34L from TWY B3,B4 and B10 restricted to 36M MAX wingspan (under 36M wingspan : A320/B717/B737/E170/F100/BAe146/DHC8-300/Q400)



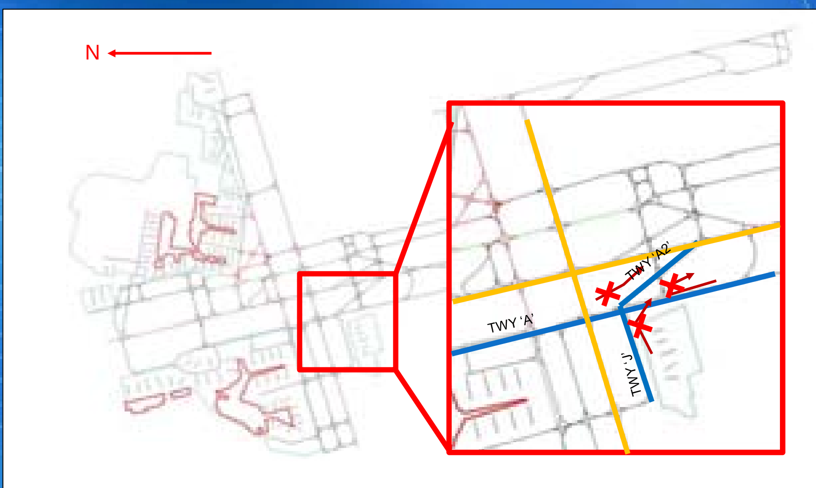
Pilots of Code D, E and F ACFT (B77/B747/B767/A380/A340/A330) to exercise caution when taxiing on TWY A or TWY B FM TWY B3 to RWY 07/25 at intersections of all TWY. When Code D,E or F type ACFT are holding short of associated RWY, no Code D, E or F type ACFT should taxi behind due insufficient wingtip clearance



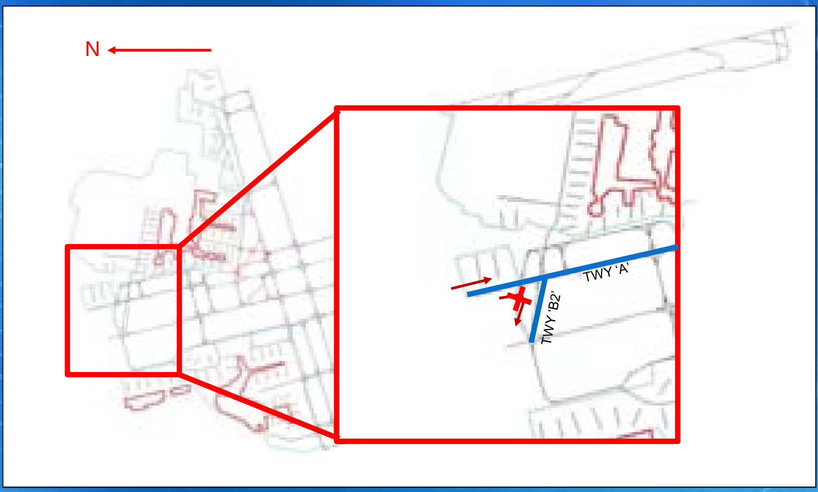
When ACFT exiting RWY 34L on TWY A2, ACFT northbound on TWY A must hold short of TWY A2 at intermediate holding position marking and ACFT southbound on TWY A must hold short of TWY J or N of RWY 07/25



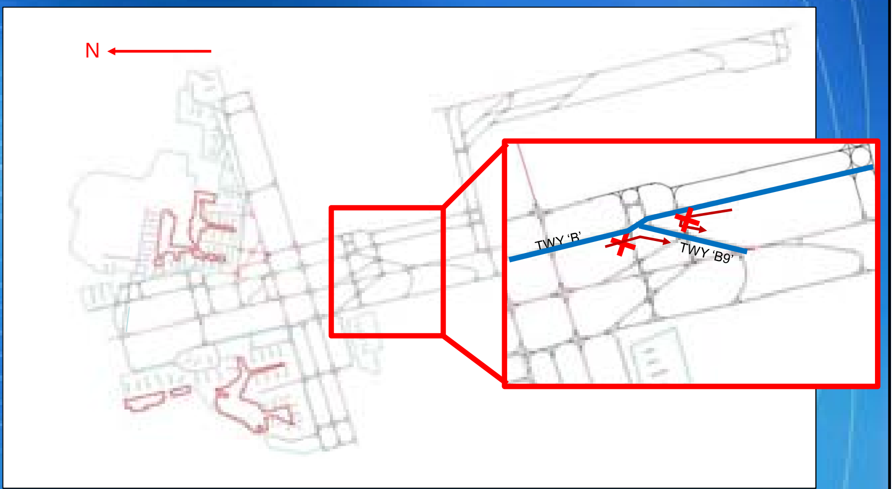
TWY A heading north right turn onto TWY A2, TWY A3, TWY A4, TWY A5 not available and vice versa



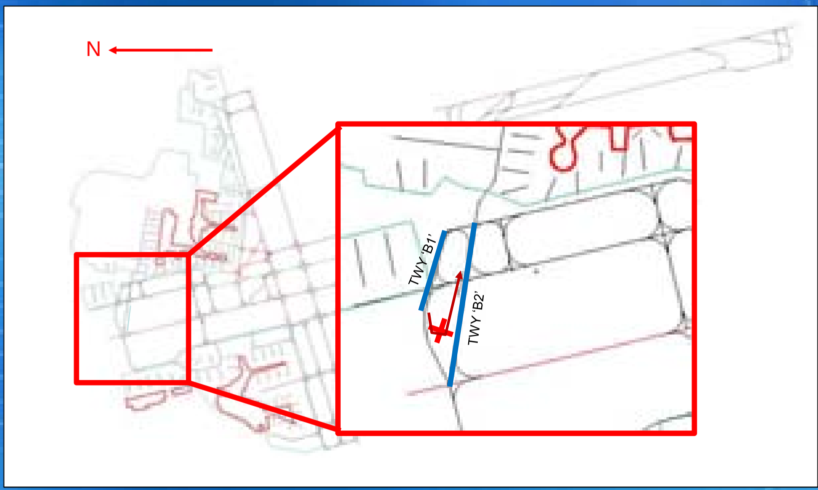
TWY A2 – No entry from FM TWY A or TWY J



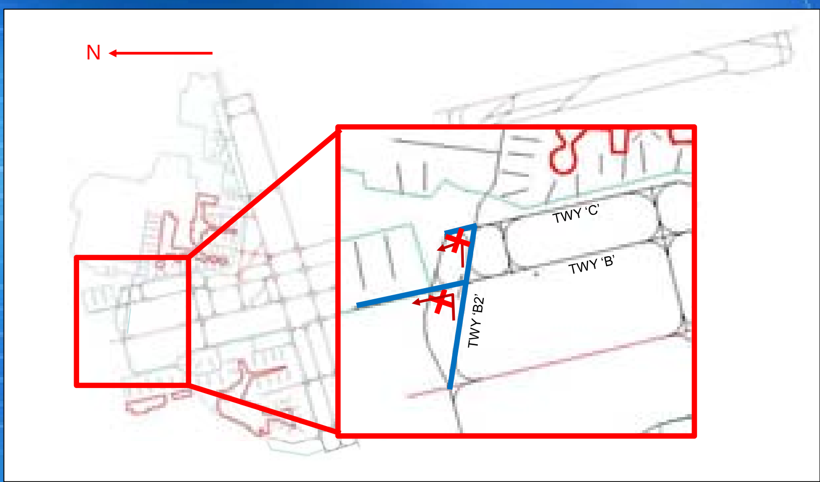
TWY B heading S right turn onto TWY B2 not AVBL



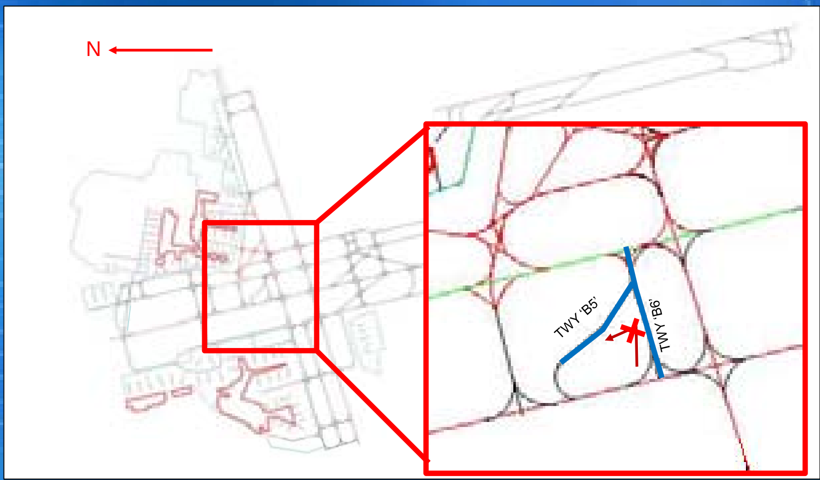
TWY B – turning into TWY B9 not AVBL



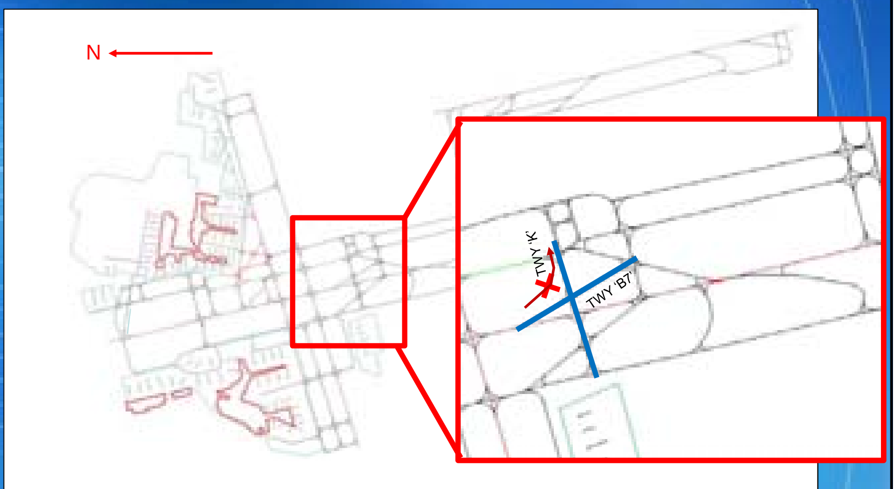
TWY B1 W end – left turn onto TWY B2 not AVBL



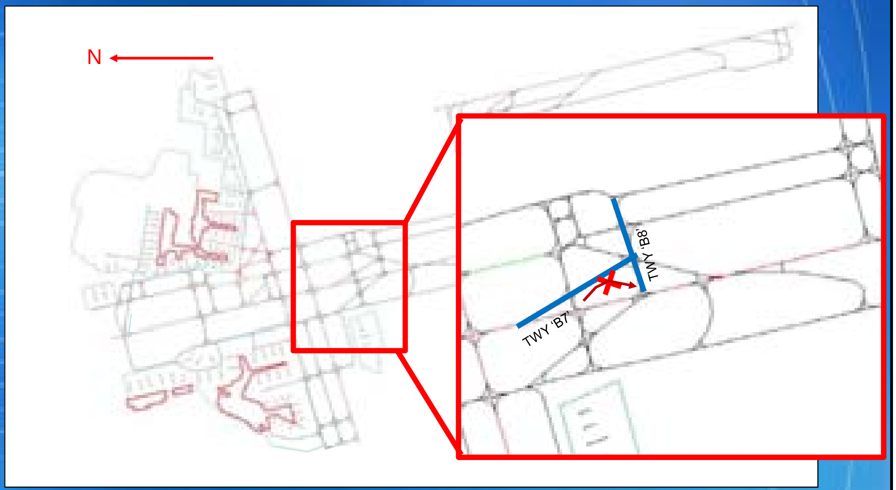
TWY B2 heading E left turns onto TWYs B and C not AVBL



TWY B6 heading E left turns onto TWY B5 not available and vice versa



TWY B7 heading S left turns onto TWY K not AVBL

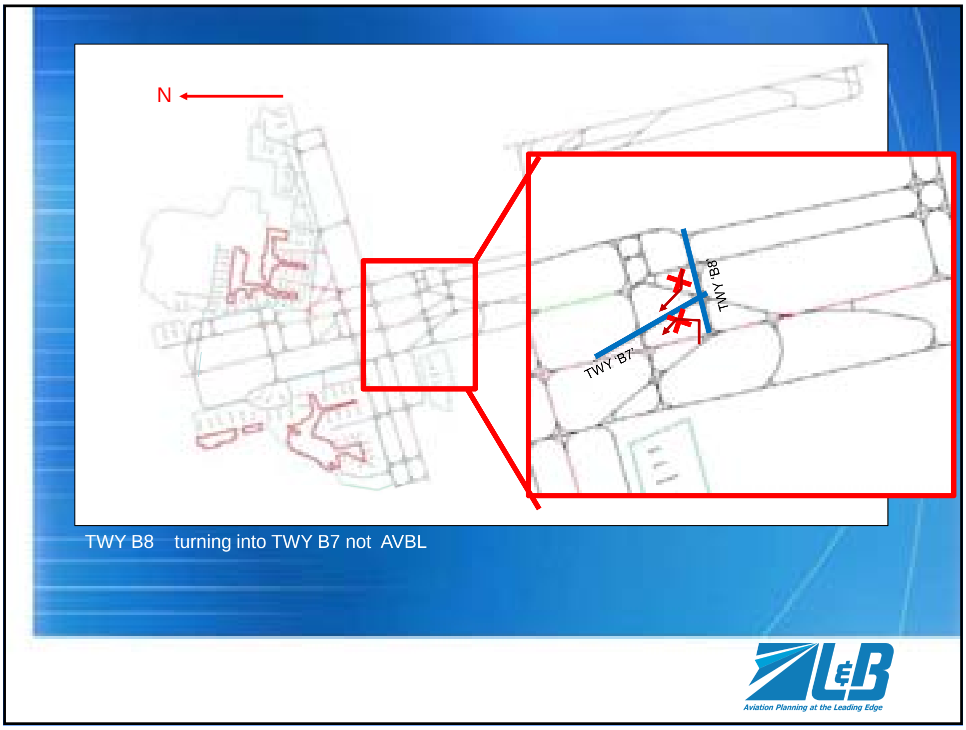


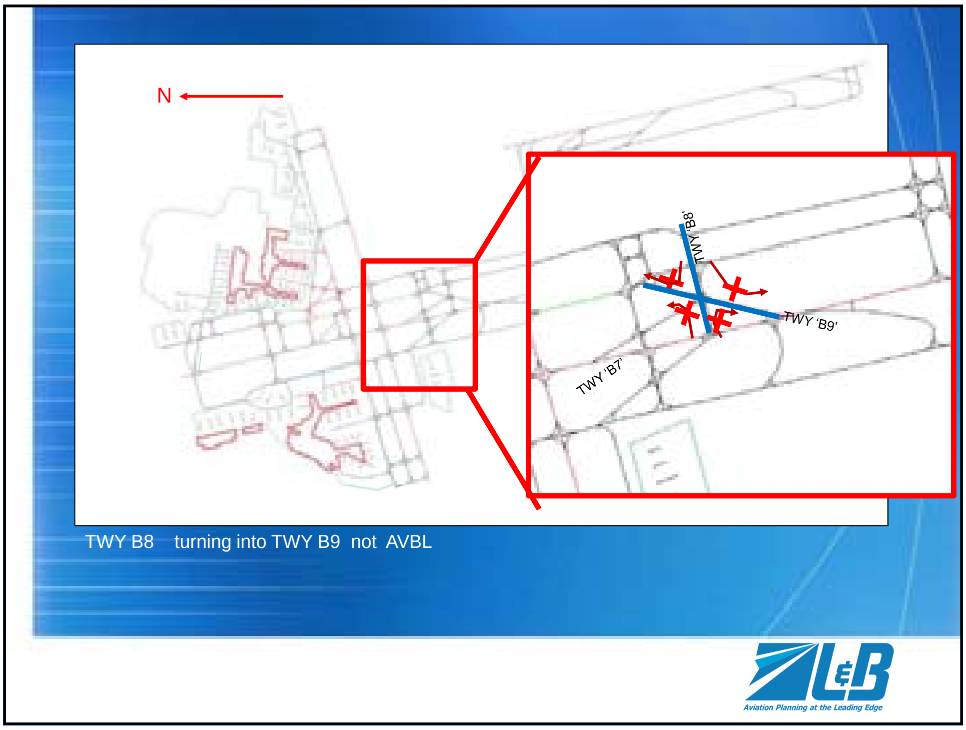
TWY B7 heading S right turns onto TWY B8 not AVBL

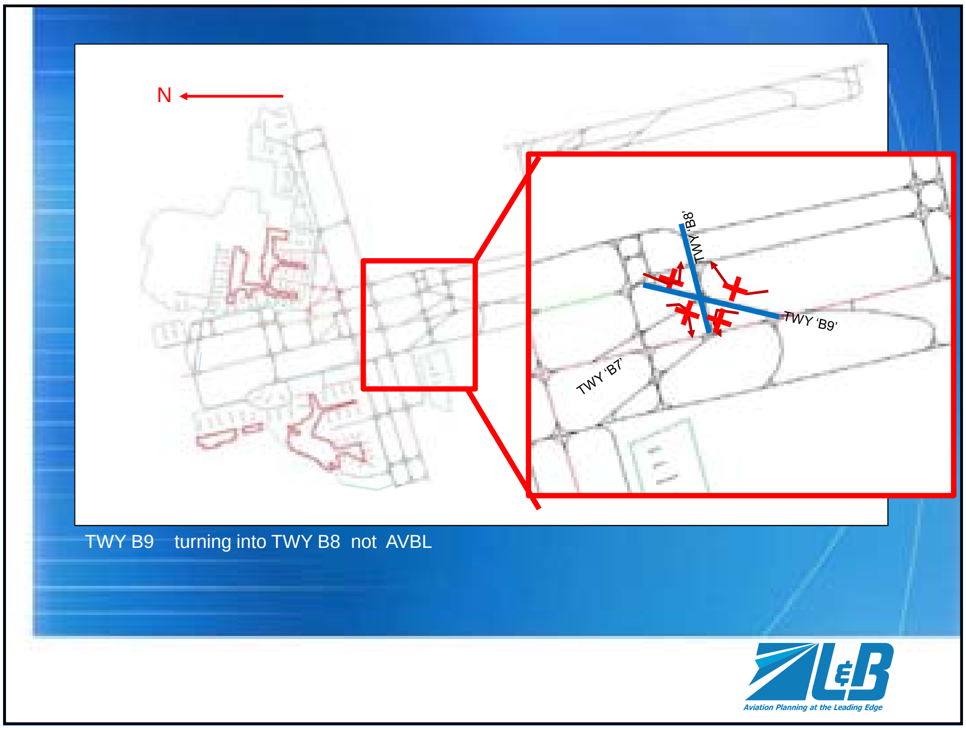
Aviation Planning at the Leading Edge

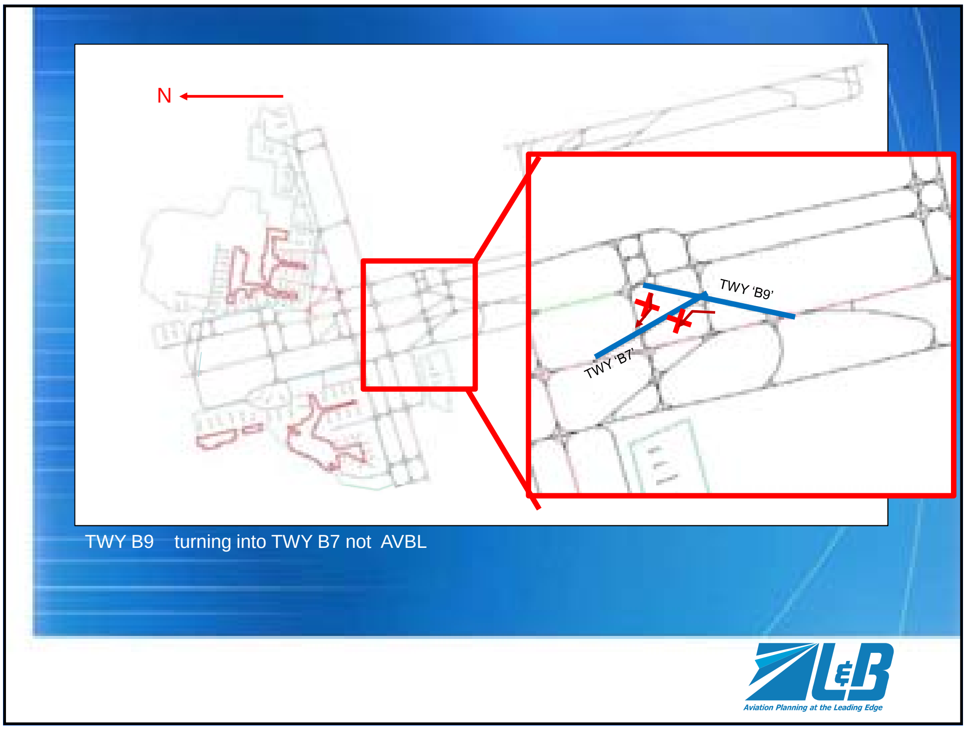
TWY B7 heading S left or right turns onto TWY B9 not AVBL

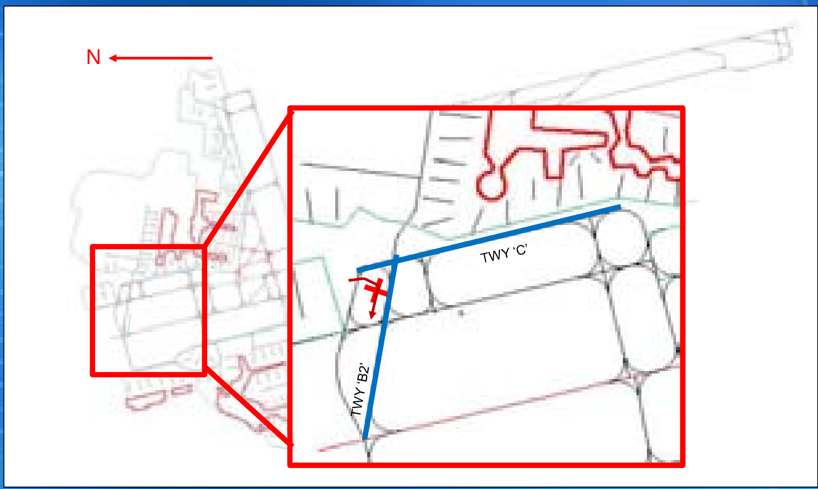
Aviation Planning at the Leading Edge


N
TWY 'B8'
TWY 'B7'
TWY B8 turning into TWY B7 not AVBL
L&B
Aviation Planning at the Leading Edge

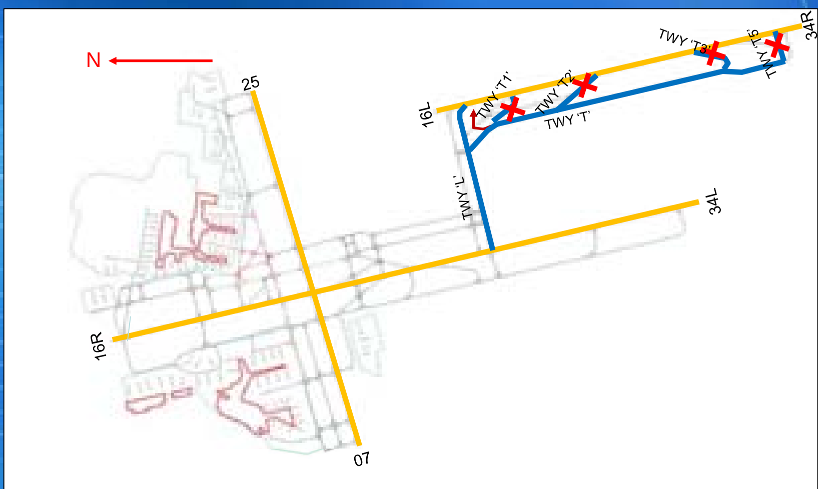

N
TWY 'B8'
TWY 'B9'
TWY 'B7'
TWY B8 turning into TWY B9 not AVBL
L&B
Aviation Planning at the Leading Edge


N
TWY 'B8'
TWY 'B9'
TWY 'B7'
TWY B9 turning into TWY B8 not AVBL
Aviation Planning at the Leading Edge

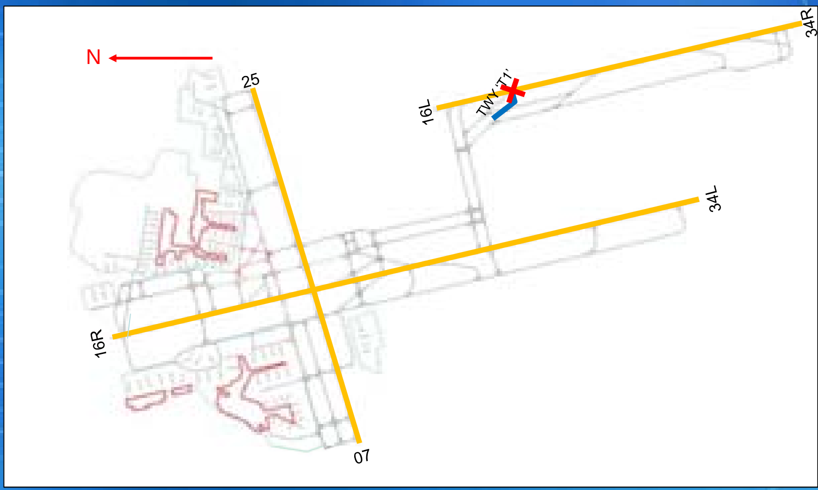

N
TWY 'B9'
TWY 'B7'
TWY B9 turning into TWY B7 not AVBL
Aviation Planning at the Leading Edge



TWY C – heading S – right turn onto TWY B2 not AVBL

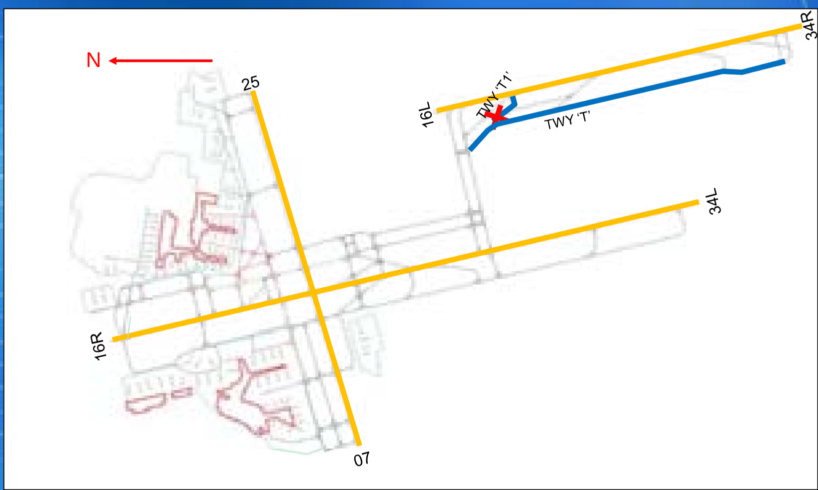


TWY T heading north right turn onto TWY L eastbound, TWY T1, TWY T2, TWY T3 and TWY T5 not available and vice versa



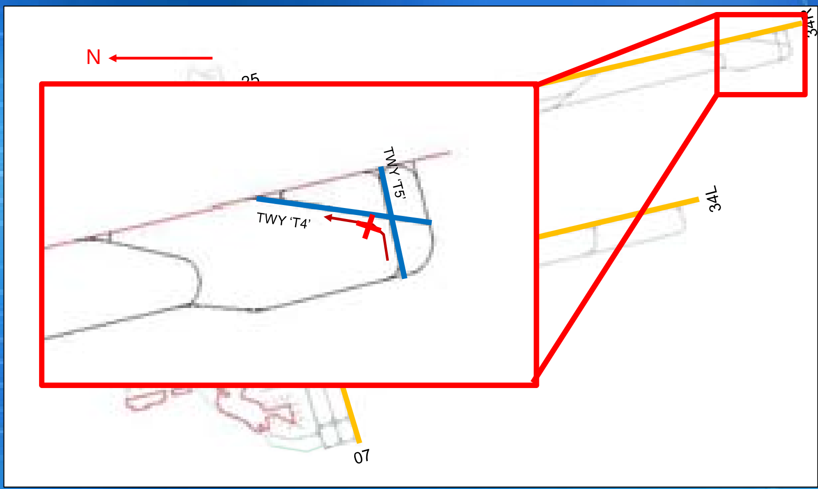
TWY T 1 is not AVBL to ACFT exiting RWY 34R

Aviation Planning at the Leading Edge

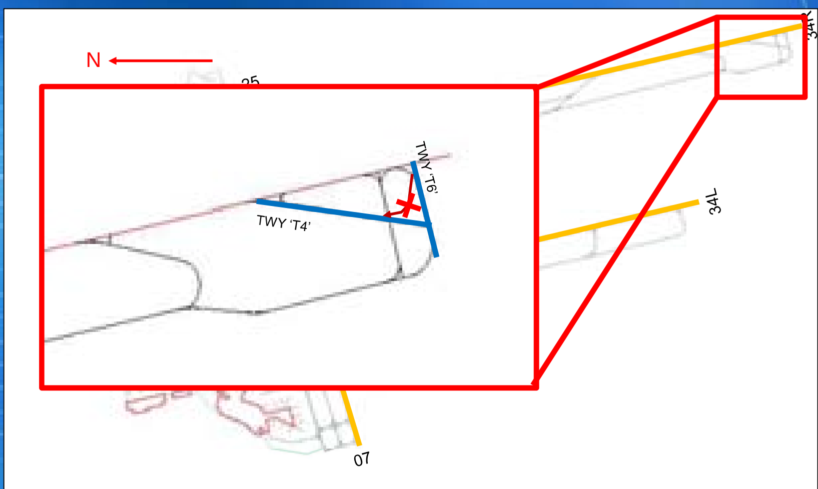


TWY T 1 is not AVBL to ACFT on TWY Tango

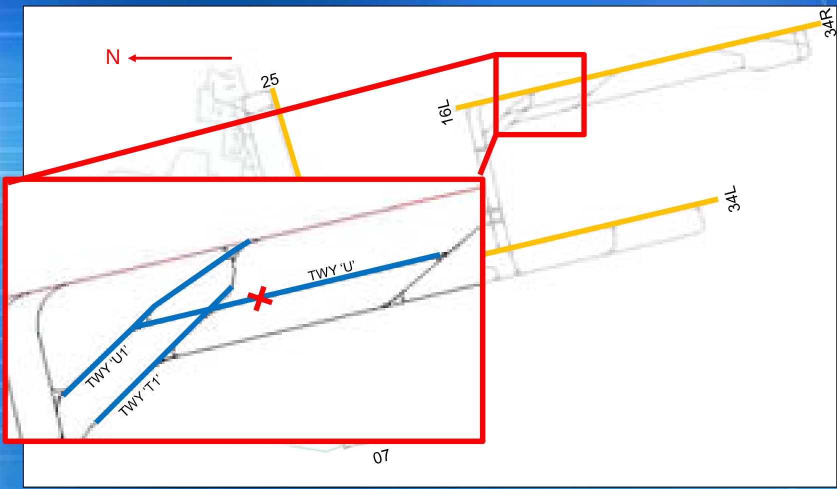
Aviation Planning at the Leading Edge



TWY T5 heading E left turn onto TWY T4 not available and vice versa

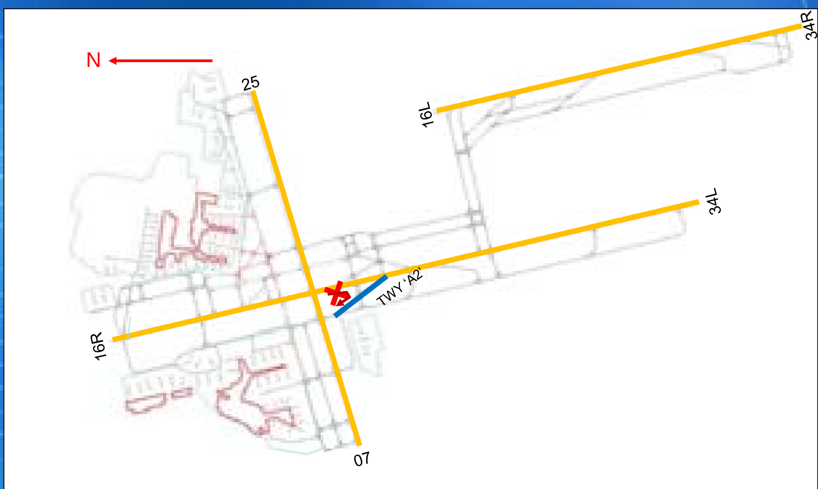


TWY T6 heading W right turn onto TWY T4 not available and vice versa



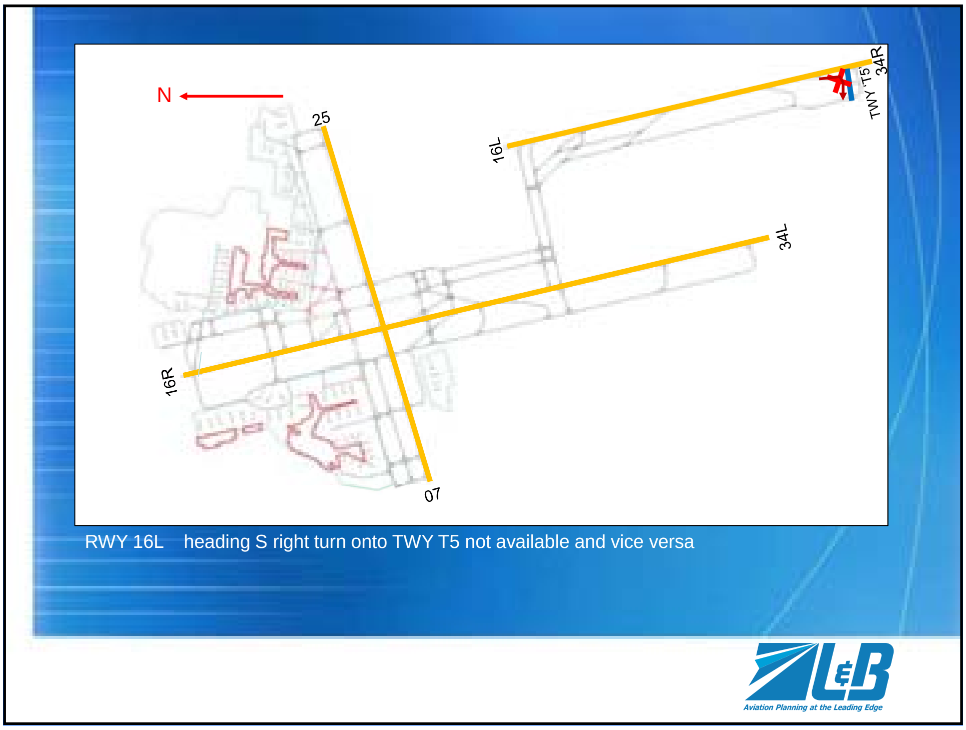
TWY U not AVBL to aircraft on TWY U1 or TWY T1

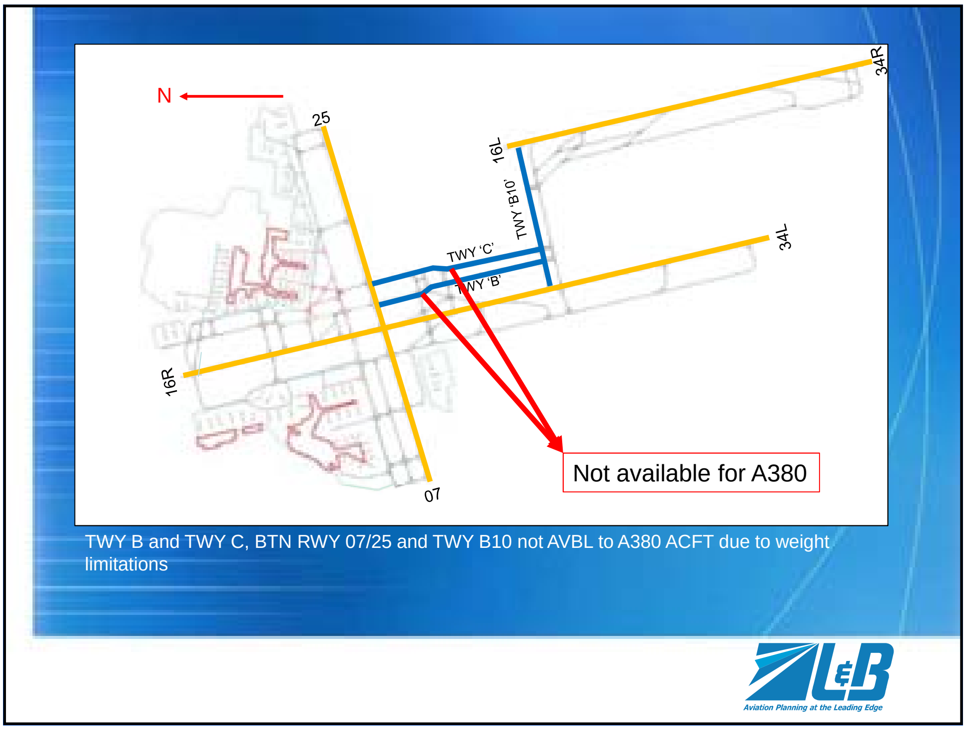
Aviation Planning at the Leading Edge

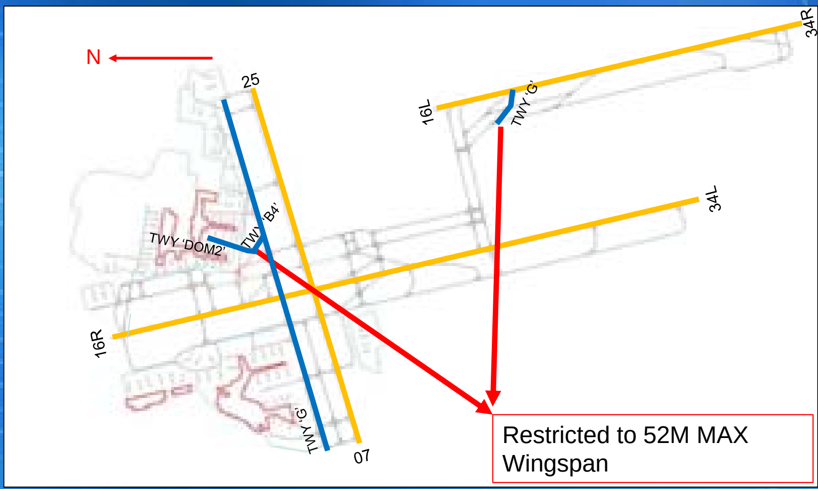


RWY 16R heading S right turn onto TWY A2 not available and vice versa

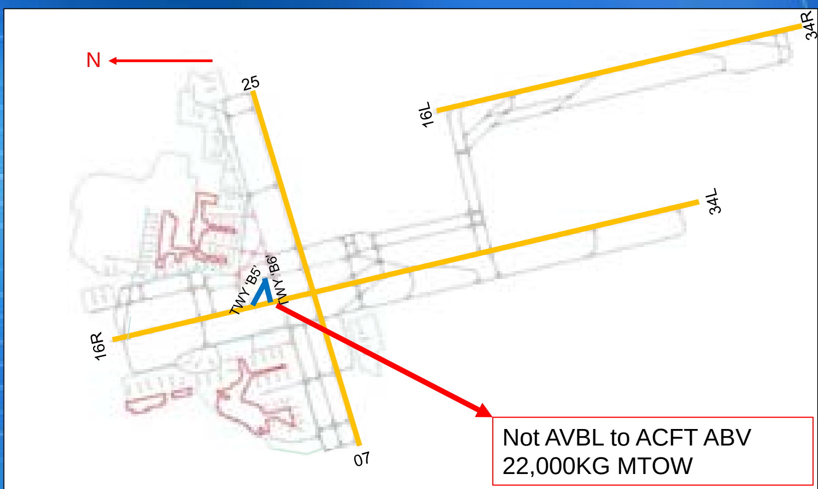
Aviation Planning at the Leading Edge


N
25
16L
34R
TWY 'T5'
34L
16R
07
RWY 16L heading S right turn onto TWY T5 not available and vice versa
Aviation Planning at the Leading Edge

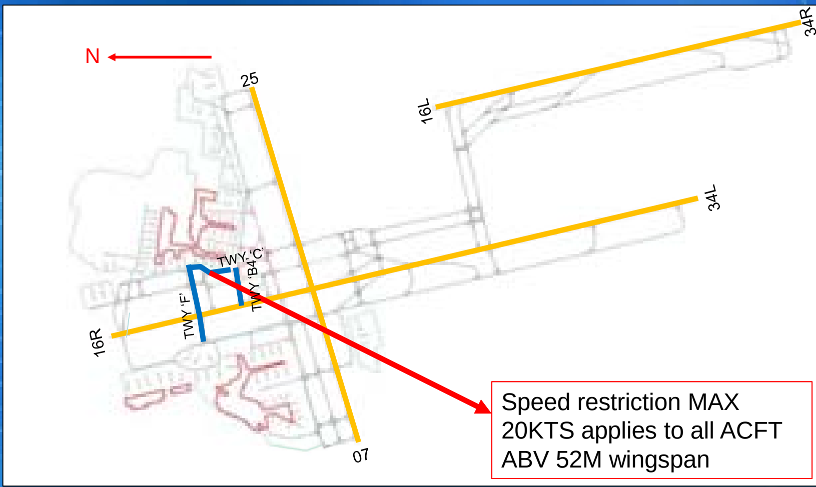

N
25
16L
34R
TWY 'B10'
TWY 'C'
TWY 'B'
34L
16R
07
Not available for A380
TWY B and TWY C, BTN RWY 07/25 and TWY B10 not AVBL to A380 ACFT due to weight limitations
Aviation Planning at the Leading Edge



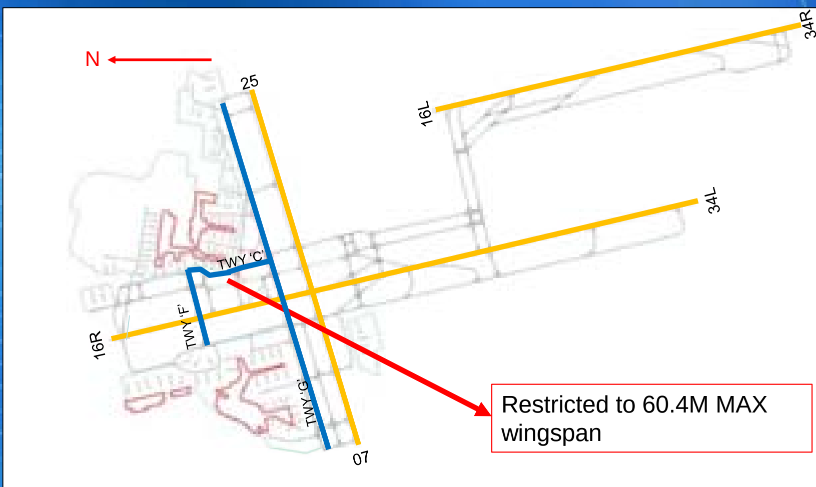
TWY B4 BTN TWY DOM2 and TWY G, T1 restricted to 52M MAX wingspan (under 52M wingspan: A300/A320/B717/B737/B757/B767/E170/F100/BAe146/DHC8-300/Q400)



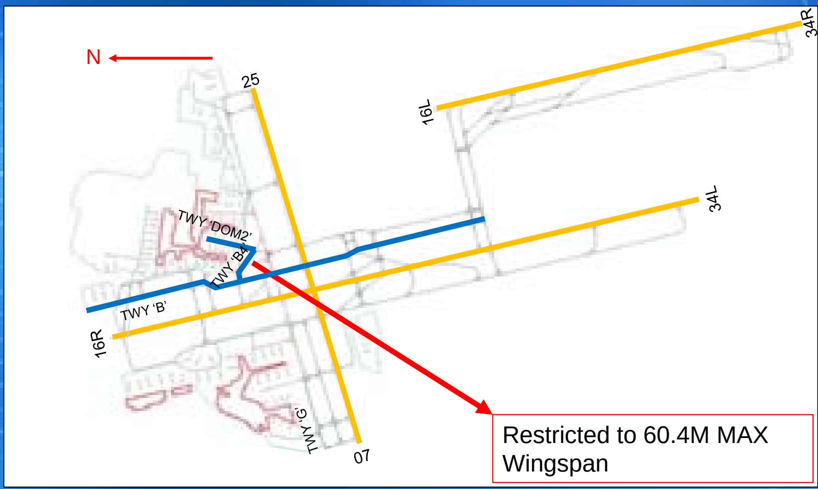
TWY B5 and B6 not AVBL to ACFT ABV 22,000KG MTOW. MAX tyre pressure 1,400KPA (Code A and B aircraft)



TYW C BTN TWY F and TWY B4 speed restriction MAX 20KTS applies to all ACFT ABV 52M wingspan (ABV 52M wingspan: A330/A340/A380/B747/B777/B787)

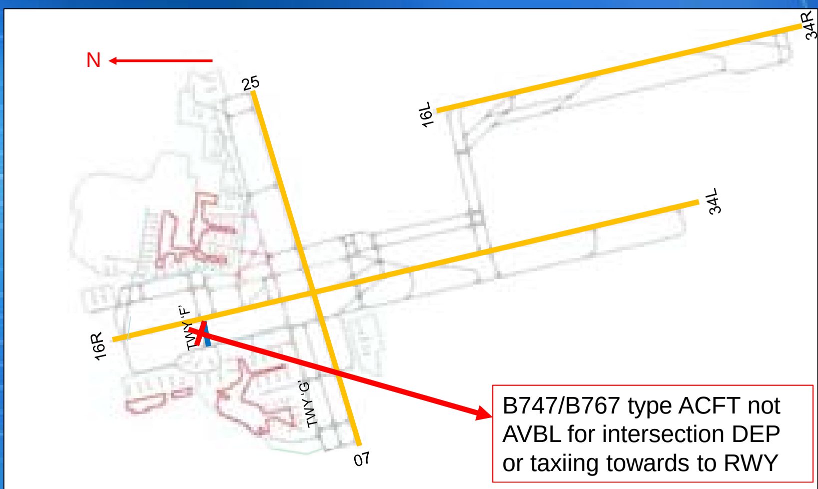


TYW C BTN TWY F and TWY G restricted to 60.4M MAX wingspan (under 60.4M wingspan: A300/A320/A342/A343/B717/B737/B747-100/B747-200/B747-300/B757/B767/B777/E170/F100/BAe146/DHC8-300/Q400)



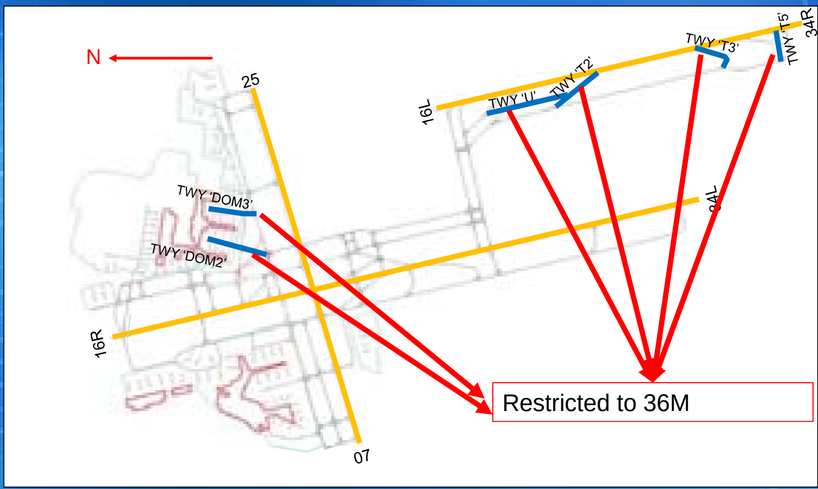
TWY B4 BTN TWY B and DOM2 restricted to 60.4M MAX wingspan under 60.4M wingspan: A300/A320/A342/A343/B717/B737/B747-100/B747-200/B747-300/B757/B767/B777/E170/F100/BAe146/DHC8-300/Q400

Aviation Planning at the Leading Edge



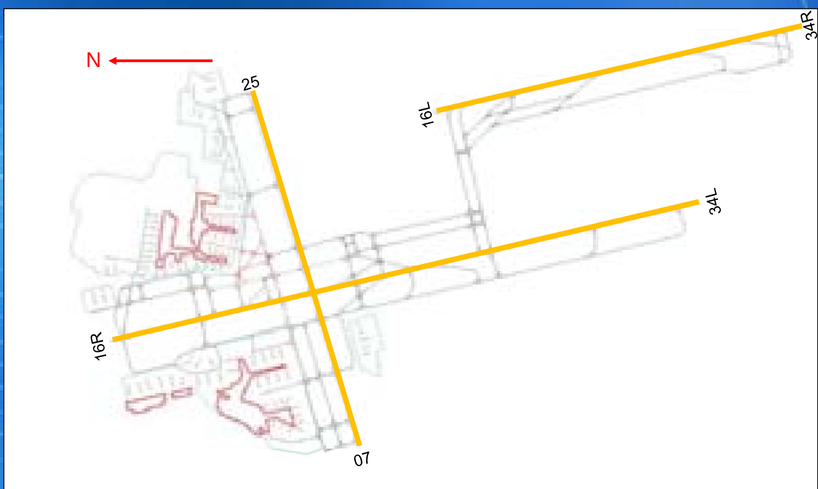
TWY F west restrictions B747/B767 type ACFT TWY not AVBL for intersection DEP or taxiing towards RWY

Aviation Planning at the Leading Edge



TWY T2,T3,T5,U,DOM2 and DOM3 restricted to 36M MAX wingspan (under 36M wingspan: A320/B717/B737/E170/F100/BAe146/DHC8-300/Q400)

Aviation Planning at the Leading Edge



For CASA APV operators, ALL RWYs are capable of supporting take-offs with an RVR/RV of not less than 35M (under 35M wingspan: A320/B717/up to B737-700/E170/F100/BAe146/DHC8-300/Q400)

Aviation Planning at the Leading Edge

(under 36M wingspan:
A320/B717/B737/E170/F100/BAe146/D
HC8-300/Q400)

Appendix G – TAAM Calibration Report

TAAM Calibration

To ascertain the accuracy of the TAAM simulation model, it was calibrated using actual data. In this study, the following three measures were used to calibrate the model:

1. Rolling-hour operation counts

In this analysis, the day is divided into many overlapping hourly intervals. Each hourly interval is referred to as a rolling-hour. The duration between the start times of two consecutive hourly intervals, indicates the time-bin used for the computation, and determines the number of rolling-hours in the simulation period. This study used a 5 minute time-bin, and therefore, had 288 rolling-hours in a 24-hour period. The rolling-hour operation counts for the input design day schedule were compared to the simulation output. Figure 1&2 show the rolling hour operation counts for the Mode 9 and Mode 10 operations, respectively.

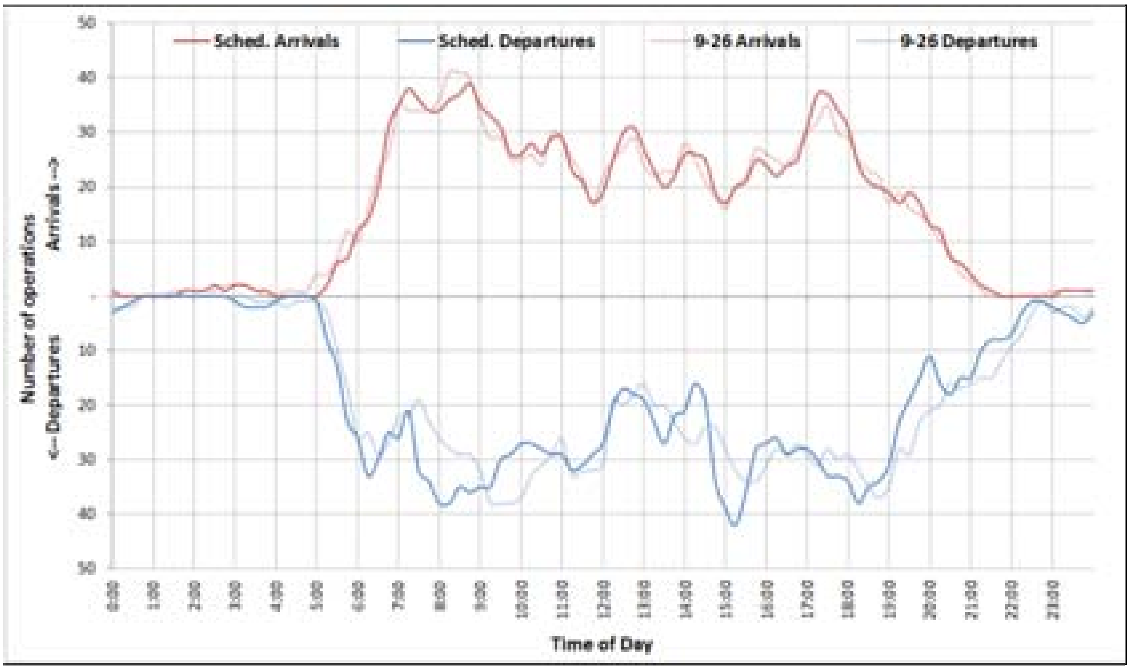


Figure 1: Mode 9 Rolling-hour comparison

Figure 2: Mode 10 Rolling-hour comparison

2. *Fixed interval throughput counts*

In this analysis, the simulation period is divided into several equal-duration non-overlapping intervals called time-bins. The required number of time-bins determines the duration of each time-bin. This study used 24 hourly time-bins. The actual tower data provided by Airservices Australia (AsA) was compared to the simulation output.Figure 3& Figure 4 show the fixed-hour throughput counts for Modes 9 and 10, respectively.

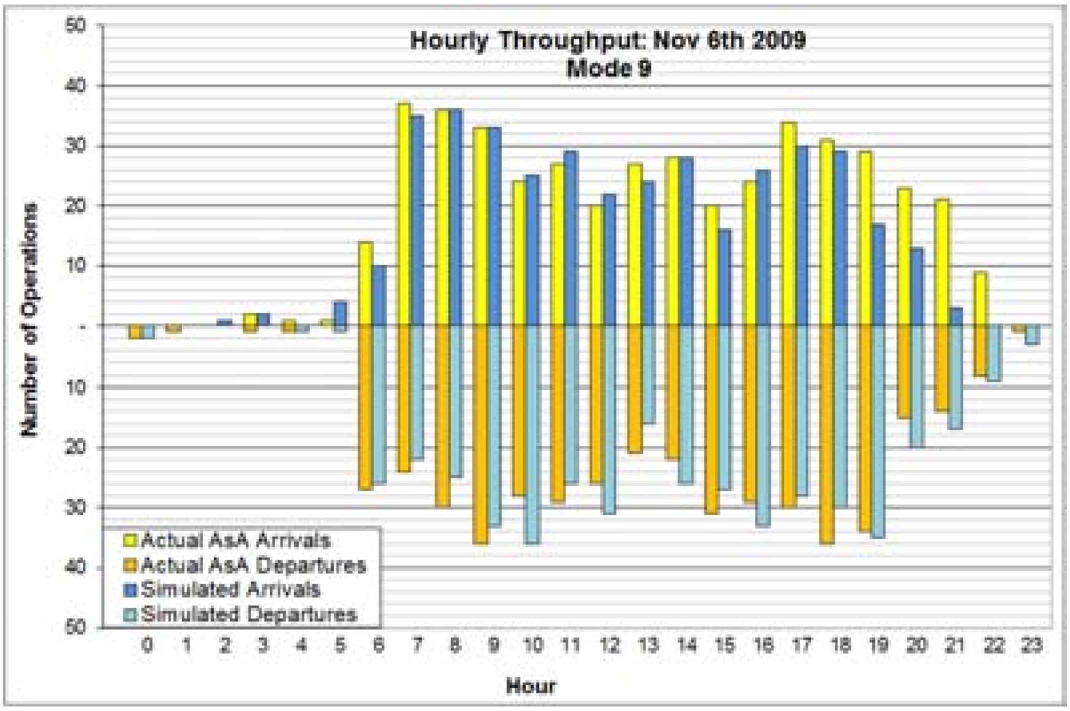


Figure 3: Mode 9 hourly throughput comparison

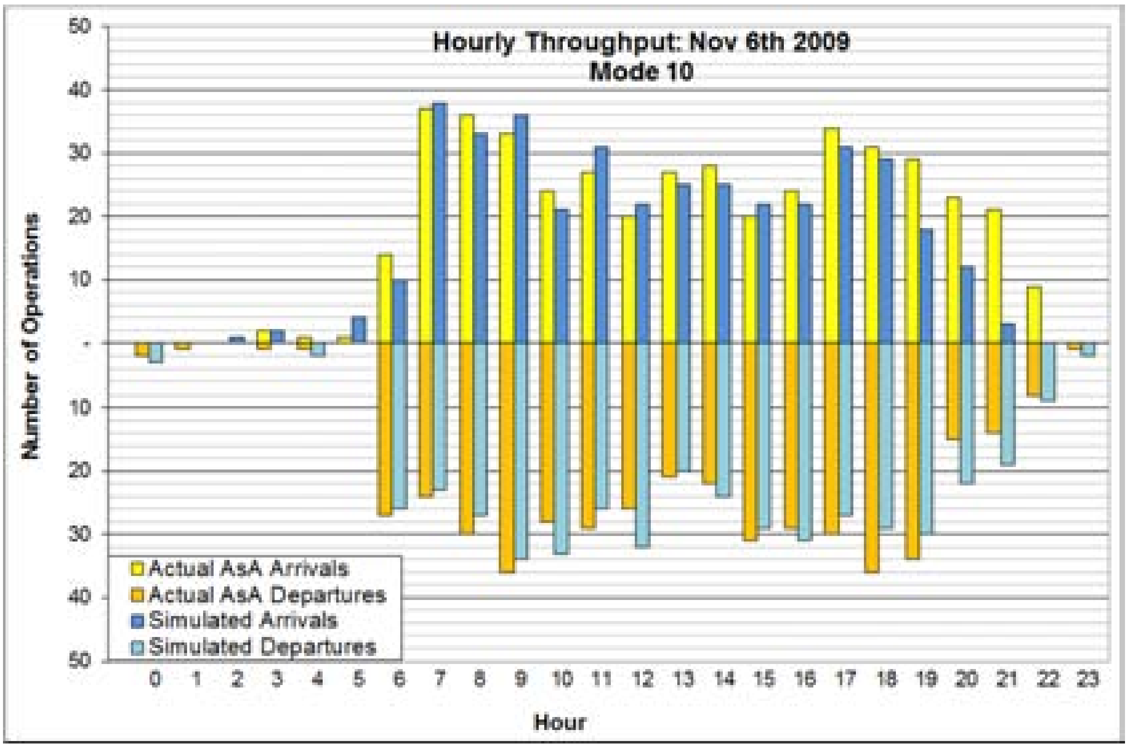


Figure 4: Mode 10 hourly throughput comparison

3. *Throughput heat map*

This analysis plots the number of hourly arrivals against the number of hourly departures. A heat index is used to illustrate the frequency of occurrence of a particular hourly arrival-departure combination. The purpose of this plot is to illustrate the most commonly occurring throughput values at the Airport. This study comparedthe hourly arrival-departure combinations that occurred more than 5 times in the year 2010 (according to the Airport's tower log, provided by AsA) against the simulation model's output. Figure 5 & Figure 6 compare the simulation outputs for Modes 9 and 10 against the actual data, respectively.

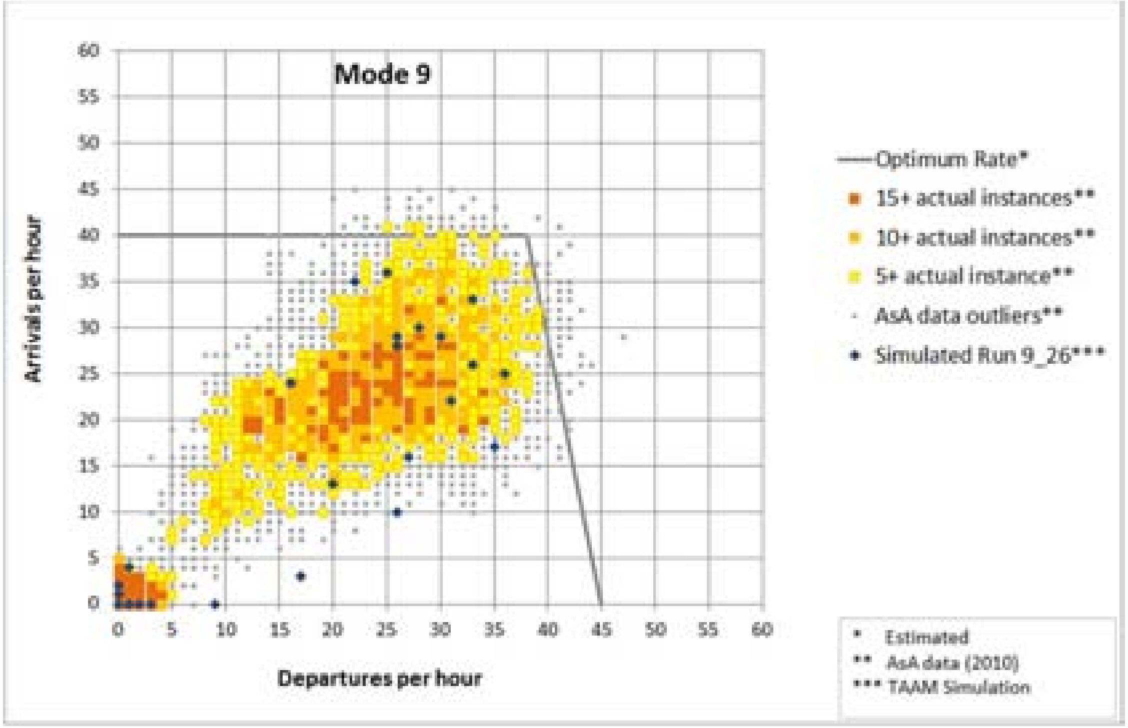


Figure 5: Mode 9 throughput heat-map

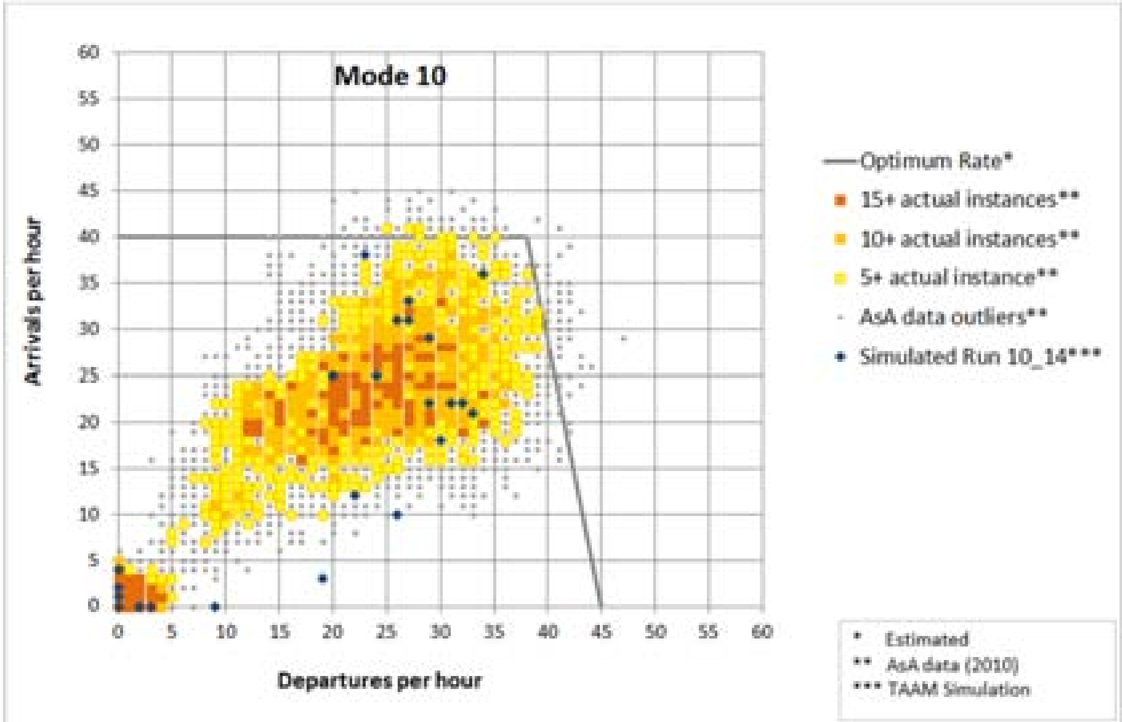


Figure 6: Mode 10 throughput heat-map

Sydney (Kingsford-Smith) Airport additional demand and runway capacity analysis

B2

JOINT STUDY ON AVIATION CAPACITY FOR THE SYDNEY REGION

ADDITIONAL DEMAND ANALYSIS SYDNEY (KSA)

FINAL REPORT

EXECUTIVE SUMMARY

As part of a joint Commonwealth and NSW State Government initiative to develop an Aviation Strategic Plan for the Sydney region, Airservices Australia has been requested to undertake analysis in relation to aviation capacity in the Sydney region. The task undertaken in this report is an analysis of theoretical changes to the legislated movement cap; specifically 85, 90 and 95 movements per hour. The report examines the following effects of those movement figures on airspace capacity, runway capacity and gate capacity.

This report is not intended for circulation beyond the Department of Infrastructure and Transport and the Commonwealth Government.

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Readers should rely on their own enquiries and seek independent advice.

Airservices makes no representation, warranty or guarantee concerning any findings in this report.

Any findings are to be treated as indicative only, and based on Airservices limited role in the overall study.

This report represents the view of Airservices and not the view of any individual person.

The report draws upon runway capacity analysis previously undertaken by Airservices, a qualitative analysis of airspace capacity, taxiway capacity modelling and sensitivity analysis of gate capacity. Airservices recommends that further detailed analysis is conducted on airspace and runway capacities.

The analysis takes an integrated approach, whereby the upper limit movement rates for each system component (gates, taxiways, runways and airspace) is assessed against overall system performance - the effect of an overload on one component on other system components.

Key Findings

Airspace Capacity
Airspace capacity is qualitative, based on past operational outcomes. It is considered that the airspace has demonstrated capacity to sustain a movement rate of 85 per hour.

Runway Capacity
For sustained periods, between 85 and 87 movements per hour can be accommodated on the parallel runway modes, assuming an equal balance of arrivals and departures. 85 movements per hour is considered to be the theoretical movement cap pending further analysis of airspace and runway capacity.

Taxiway Capacity
Applying proposed Sydney Airport Master Plan taxiway infrastructure, taxiways are assessed as having sufficient capacity for sustained movement rates equal to the capacity of runways and gates.

Gate Capacity

Applying proposed Sydney Airport Master Plan gate infrastructure, the upper limit of aircraft gate capacity is considered to be 1,200 movements per day. 85 movements is considered the upper limit hourly rate; movement rates above this figure would create significant congestion due the number of aircraft unaccommodated on gates.

System Capacity
The overall, sustainable system capacity is considered to be 85 movements per hour. Primarily, this figure is derived from the gate capacity figure, the effect on taxiways of movement rates above 85 and the sustainable runway capacity.

DATA, METHODOLOGY and ANALYSIS

Factors determining variations to nominal capacity

From an Air Traffic Management operational perspective it is not unusual to see some variation in the estimated capacity of a particular runway configuration deployed at different locations as there is a wide range of operational and structural inputs that can effect runway movement rates.

1. Aerodrome configuration – base capacity

Three basic types of aerodrome configuration are discussed in this section; single runway, cross runways and parallel runways. Base estimates of capacity assume a two minute interval between consecutive arrivals. This interval allows for a departure between each arrival.

Base Capacity	Single Runway	Cross Runways	Parallel Runways
Arrivals	30	30	60
Departures	30	30	60
Total	60	60	120

The cross runway configuration base capacity is the same as a single runway as the separation point is the intersection of the runways, i.e. the intersection can be considered similar to a single runway as only one aircraft can occupy the intersection at a time.

Note that this is a simplistic base capacity estimate – two minutes between arrivals, two minutes between departures. From the base capacity estimate, allowance is made for fleet mix and separation standards.

2. Fleet mix and Separation Standards – effect on base capacity

Base capacity is affected by the spacing required between:

a) Successive runway movements (between landing aircraft, between departing aircraft and between departing and landing aircraft) and;
b) Runway occupancy times - the time it takes for aircraft to enter and subsequently leave the runway on take-off or on landing and;
c) Radar separation between airborne aircraft and;
d) Wake turbulence separation standards.[1]

[1] Wake turbulence is primarily generated by wingtip vortices that form behind an aircraft. Wingtip vortices occur when a wing is generating lift. Air from below the wing is drawn around the wingtip into the region above the wing by the pressure differential between the upper

Other factors can affect the runway movement rate such as weather conditions and the level of interaction between air traffic patterns at adjacent airports.

The ATC applied runway separation, radar separation and wake turbulence separation minima applied between the landing and departing stream of aircraft, vary according to aircraft performance and size.

Generally the required spacing between successive aircraft is less for lighter aircraft and more for heavier aircraft. The wake turbulence separation minima are larger when a lighter aircraft follows a heavier aircraft.

Likewise runway occupancy times are shorter for the lighter aircraft and longer for the heavier aircraft.

It can be seen therefore that the runway movement rate will to a large extent be a function of the fleet mix (mix of aircraft size and aircraft performance).

The tables at appendix A show the wake turbulence standards applied by ATC. The standards are either time based or distance (by radar) based.

In a mixed traffic environment (heavy, medium and light aircraft) the runway acceptance rate is reduced to accommodate the local conditions. As a general rule, at a primary RPT airport, the arrival acceptance rate will not exceed 25 movements per hour for a single runway configuration. This figure is based on what can be achieved operationally. Consequently, the departure rate will also be in the region of 25 movements per hour, given one departure will occur between successive arrivals. A similar rate can be assumed, in the first instance, for parallel runway operations, however, this rate if further affected by other factors.

For a cross runway configuration, 30 arrival movements and 25 departure movements per hour is considered reasonable and achievable.

3. Parallel Runway dependencies

Parallel runway operations have additional dependencies to manage the parallel arrival and departure streams. The basic separation standard for airborne aircraft in a terminal area is 3NM by radar. Given the fact that parallel runways are displaced by distances much less than 3NM, additional restrictions are imposed to ensure safe operations. In good weather, Independent Visual Approaches, where the pilot is able to visually avoid traffic on the adjacent final approach path, deliver close to single runway capacity to each runway. Vertical separation (1000') is applied by ATC until the pilot is on a radar heading to final approach and the runway is in sight. This requirement reduces capacity ***in the airspace***. Acceptance rates for parallel runway operations in VMC rarely

---

and lower wing surfaces, causing a vortex to trail from each wingtip. Wake turbulence exists in the vortex flow behind the wing. The strength of wingtip vortices is determined primarily by the weight and airspeed of the aircraft. Vortex generated wake turbulence can remain in the air for up to three minutes after the passage of an aircraft.

Wake turbulence is especially hazardous in the region behind an aircraft in the takeoff and landing phases of flight. During take-off and landing, aircraft operate at high angle of attack to generate lift, maximising the formation of strong vortices. In the vicinity of an airport there can be multiple aircraft, all operating at low speed and low height, exacerbating the risk of wake turbulence encounters. For this reason, ATC stringently apply wake turbulence separation standards – refer to Appendix A.

exceed 42 movements per hour. Acceptance rates reduce in accordance with weather conditions – 3NM or 1000’ is applied until pilots sight the runway. There are numerous other dependencies which affect parallel runway capacity (e.g. threshold displacement, distance between runways).

In summary, parallel runway capacity is determined by a more complex set of variables than single or cross runway configurations.

Estimated operational nominal capacities

The following shows the estimated operational nominal capacity in good weather conditions in a mixed traffic environment. The figures will vary subject to local conditions; such variance would not be expected to exceed (+/-) 5 movements per hour.

Nominal Capacity	Single Runway	Cross Runways	Parallel Runways VMC
Arrivals	25	30	42
Departures	25	25	42
Total	50	55	84

Airspace capacity

Detailed modelling and analysis of airspace capacity has not been conducted due to the timeframe for reporting. Accordingly, analysis is qualitative, however the airspace is considered to have the capacity to sustain movement rates equal to the capacity of runways and gates.

As all arrival/departure conflicts are currently mitigated through a vertically segregated airspace structure, the primary focus of any future modelling should be a quantification of conflict pairs resulting from arrival tracks crossing in the immediate vicinity of the airport. These crossovers occur in order to place aircraft into the arrival circuit for the designated arrival runway. As fleet up-gauging increases, the number of aircraft requiring the main runway increases; consequently, the number of potential conflictions increase.

Approach Control resolves crossover conflictions through vertical separation (1000FT apart). The current airspace model allocates 4 altitudes to Approach to manage this separation (6000FT, 7000FT, 8000FT and 9000FT). At current traffic levels, during peak arrival periods, all allocated levels are utilised to manage the arrival sequence. Detailed modelling will provide an indication of the upper limit of potential crossover conflictions within the current airspace model and point at which additional altitudes would have to be allocated to Approach; precipitating a re-design of the terminal airspace structure and associated flight-paths.

Runway capacity

The most recent analysis of runway capacity was conducted in 2002 in order to quantify arrival and departure acceptance rates. The runway allocation rules utilised in that study are largely unchanged; therefore, the findings are considered to be valid for preliminary analysis; however, fleet up-gauging and the effect of such on (present day and future) main runway demand should be taken into account. Airservices recommends further analysis is conducted utilising current schedules.

Airport capacity is defined by various aviation organisations as being a level of traffic in an hourly period, which gives rise to an average delay per aircraft of a particular specified time. The specified delay time is used to determine practical capacity. USA Federal Aviation Administration analysis concluded that when an airport’s (where air carrier operations predominate) demand equals its capacity the average delay per aircraft is approximately 4 minutes. The UK CAA uses a ten minute delay when calculating capacity for London, Heathrow. Airservices (then Civil Aviation Authority, 1982) adopted the four-minute average delay when calculating both airport and airspace capacity within Australia.

The tables below summarise the results of the 2002 analysis for Mode 9 (Runway 34 parallel operations) and Mode 10 (Runway 16 parallel operations).

The Arrival Peak column represents the maximum achievable rate of arrivals and departures (combined) during peak arrival hours.

The Departure Peak column represents the maximum achievable rate of arrivals and departures (combined) during peak departure hours.

The Balanced Peak column represents the maximum achievable rate of arrivals and departures (combined) if the number of arrivals and departures are equal in a given hour.

The VMC row represents capacity using Independent Visual Approaches; IMC represents Dependent Instrument Approaches: PRM represents Independent Instrument Approaches.

The Planning Capacity Rates tables represent achieved movements per hour resulting in a mean delay of 4 minutes per achieved movement per hour. The Balanced Peak rate provides a reasonable indication of the practical capacity for the Runway Mode.

Planning capacity movements per hour			
Mode 9	**Arrival Peak**	**Departure Peak**	**Balanced Peak**
VMC	75	80	85
IMC	43	59	55
PRM	60	64	65

Table 1: Mode 9 Planning Capacity Rates

Planning capacity movements per hour			
Mode 10	**Arrival Peak**	**Departure Peak**	**Balanced Peak**
VMC	**79**	**79**	**87**
IMC	**45**	**59**	**54**
PRM	**61**	**61**	**63**

Table 2: Mode 10 Planning Capacity Rates

Taxiway Capacity

Applying proposed Sydney Airport Master Plan taxiway infrastructure, taxiways are assessed as having sufficient capacity for sustained movement rates equal to the capacity of runways and gates. Taxiway capacity becomes an issue when considering movements above the upper limit of gate capacity due to the requirement to store aircraft on taxiways. The analysis concludes that 90 movements per hour would create an unacceptable amount of congestion and delay.

Gate capacity

Analysis was conducted by Landrum & Brown (L&B) using Gate Management Software. In lieu of a detailed forecasting exercise to prepare design day forecast aircraft schedules for each theoretical movement cap scenario, L&B prepared notional future busy morning period (06:00 – 12:00) forecasts based on extrapolating the 2010 design day aircraft schedule and Booz & Co forecast growth rates.

To assess the effects of an increased runway cap L&B developed 3 schedules with 3 consecutive morning hours with peaks of 85, 90 and 95 movements.

- L&B applied the Booz & Co. forecast 20-year total passenger movement CAGR (3.2%) to grow the baseline schedule.
- The passenger growth rate is used because of the assumption of maintaining similar aircraft mix (i.e. minor up-gauging). Therefore, more (smaller) aircraft movements will be required to deliver passenger growth.
- Individual demand levels for different sectors, airlines or aircraft types are not separately forecast.
- The extra movements were added to the hours between 6am and 12pm in the 2010 actual schedule, which produced the following hourly profile.

85 CAP

95 movements added to 2010 schedule between 6am-12pm to achieve 3 consecutive hours of 85 movements.

90 CAP

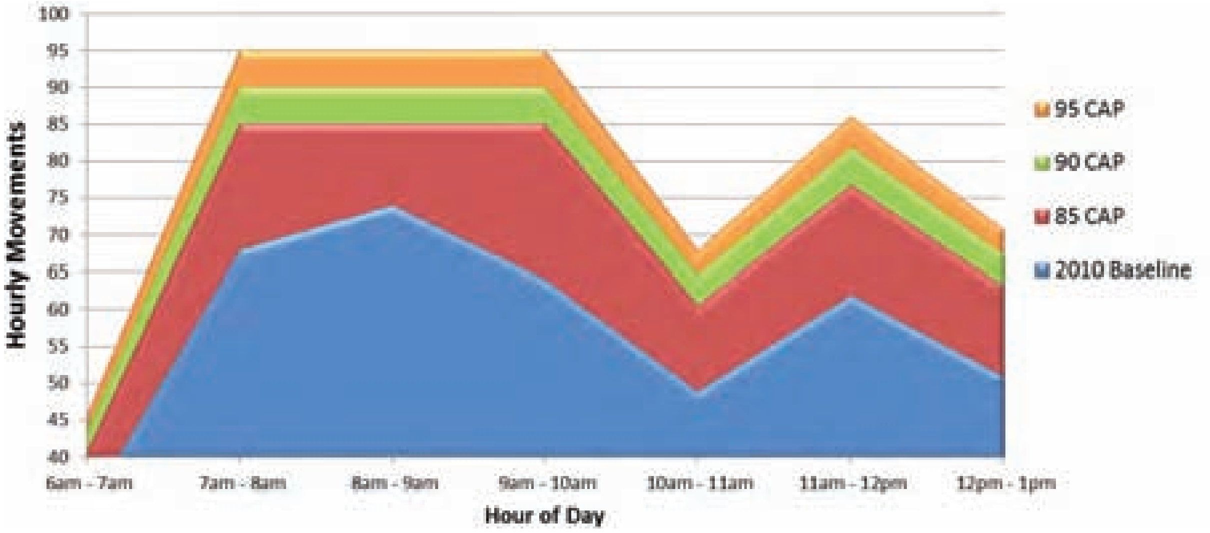
127 movements added to 2010 schedule between 6am-12pm to achieve 3 consecutive hours of 90 movements.

95 CAP

155 movements added to 2010 schedule between 6am-12pm to achieve 3 consecutive hours of 95 movements.

Minimal aircraft up-gauging was assumed when increasing the aircraft schedules for each higher Cap scenario to take account of practical difficulties of rapid up gauging when similar up-gauging of stands is not apparent in Master Plan. New flights added to the 2010 baseline schedule were primarily assumed to be Code C and E aircraft. The slight increase in Code E percentage of the aircraft mix reflects some up-gauging, for example in the gradual replacement of Qantas 767 fleet.

Hour	2010	85 CAP edited schedule	90 CAP edited schedule	95 CAP edited schedule
6	33	41	44	46
7	68	85	90	95
8	74	85	90	95
9	64	85	90	95
10	49	61	65	68
11	62	77	82	86
12	51	63	67	71



The length of time for "terminal turnaround" was optimised for the additional flights with the following assumptions to facilitate the gating as many flights as possible:

- Code C International & Domestic Aircraft – 45 minutes turnaround
- Code E Domestic Aircraft – 60 minutes turnaround
- Code E & F International Aircraft – 180 minutes turnaround

Master Plan stand capacity was identified in previous work as the limiting constraint that will inhibit growth at SYD.

- This is pronounced in the short term (2015, 2020) by the fact that planned stand expansion will not keep up with growth and aircraft up-gauging forecast by Booz.
- In the long term the 2029 master plan falls 16 stands short of what is required for the 2035 Booz forecast (1,272 daily movements).
- Approximately 1,200 daily movements appear to be the approximate upper limit of capacity at SYD governed by available stands in the Master Plan.

Increasing the aircraft movements CAP from 80 to 85/90/95, assuming only minor up-gauging and applying optimum aircraft turnarounds results in:

- Some better matching of available stands to aircraft size, however;
- Ultimate (2029) master plan gate capacity remains the constraint around the 1,200 daily movement mark,
- This constraint is reached earlier due to faster growth in aircraft movements due to increase in CAP and less up-gauging of fleet.

<u>85 movements per hour</u>

Full Master Plan (2029) infrastructure:

- Terminal 1 is unable to accommodate 3 aircraft between the hours of 0600 and 1200
- All Terminal 1 stands are occupied between 0730 and 1000
- Terminal 2 has unused capacity between the hours of 0600 and 1200
- Terminal 3 is fully utilised between the hours of 0600 and 1200

Partial Master Plan (2020) infrastructure:

- Terminal 1 is unable to accommodate 4 aircraft between the hours of 0600 and 1200
- All Terminal 1 stands are occupied between 0800 and 1000

- Terminal 2 has unused capacity between the hours of 0600 and 1200
- Terminal 3 is fully utilised between the hours of 0600 and 1200

Effect on ground operations:

- Unaccommodated aircraft would be queued on taxiways until gates become available
- This number of unaccommodated aircraft would not have a significant effect on ground operations

<u>90 movements per hour</u>

Full Master Plan (2029) infrastructure:

- Terminal 1 is unable to accommodate 5 aircraft between the hours of 0600 and 1200
- All Terminal 1 stands are occupied between 0730 and 1000
- Terminal 2 has unused capacity between the hours of 0600 and 1200
- Terminal 3 is unable to accommodate 4 aircraft between the hours of 0600 and 1200

Partial Master Plan (2020) infrastructure:

- Terminal 1 is unable to accommodate 6 aircraft between the hours of 0600 and 1200
- Terminal 2 is unable to accommodate 2 aircraft between the hours of 0600 and 1200
- Terminal 3 is unable to accommodate 3 aircraft between the hours of 0600 and 1200

Effect on ground operations:

- Unaccommodated aircraft would be queued on taxiways until gates become available
- The number of unaccommodated aircraft would create significant taxiway congestion and ground delay

<u>95 movements per hour</u>

Full Master Plan (2029) infrastructure:

- Terminal 1 is unable to accommodate 8 aircraft between the hours of 0600 and 1200
- All Terminal 1 stands are occupied between 0730 and 1000
- Terminal 2 has unused capacity between the hours of 0600 and 1200
- Terminal 3 is unable to accommodate 5 aircraft between the hours of 0600 and 1200

Partial Master Plan (2020) infrastructure:

- Terminal 1 is unable to accommodate 9 aircraft between the hours of 0600 and 1200
- Terminal 2 is unable to accommodate 3 aircraft between the hours of 0600 and 1200
- Terminal 3 is unable to accommodate 6 aircraft between the hours of 0600 and 1200

Effect on ground operations:

- Unaccommodated aircraft would be queued on taxiways until gates become available
- The number of unaccommodated aircraft would create unacceptable taxiway congestion and ground delay

CONCLUSIONS

Airspace capacity

The current airspace model has demonstrated ability to accommodate 80 movements per hour over a number of hours. Isolated occurrences of runway movements above the legislated movement cap indicate that a figure above 80 can be accommodated. The qualitative conclusion is that 85 movements per hour would not be constrained by airspace capacity and is considered to be the upper limit pending more detailed analysis of airspace capacity using current schedules and fleet mix.

Runway capacity

The parallel runway modes have demonstrated ability to accommodate 80 movements per hour over a number of hours. Isolated occurrences of runway movements above the legislated movement cap indicate that a figure above 80 can be accommodated. The conclusion is that 85 to 87 movements per hour would not be constrained by runway capacity.

VMC balanced peak figures provide a reasonable indication of a theoretical cap setting. The 2002 analysis indicates that 85 to 87 movements per hour would be sustainable on either of the parallel runway modes.

Taxiway Capacity

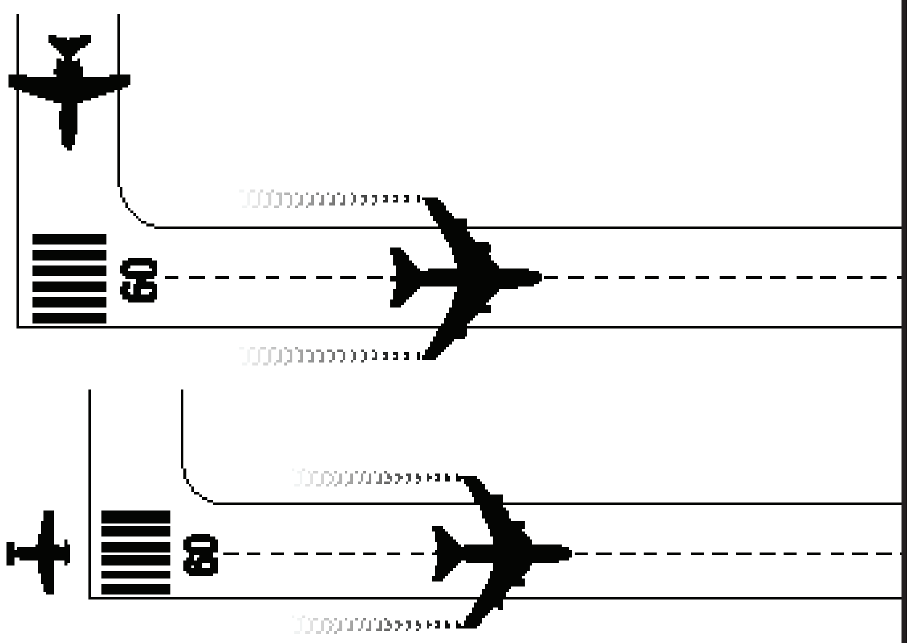
Applying proposed Sydney Airport Master Plan taxiway infrastructure, taxiways are assessed as having sufficient capacity for sustained movement rates equal to the capacity of runways and gates. The conclusion is that 85 movements per hour is sustainable, and that the number of aircraft unaccommodated on gates at or above 90 movements per hour would create an unacceptable amount of congestion and delay.

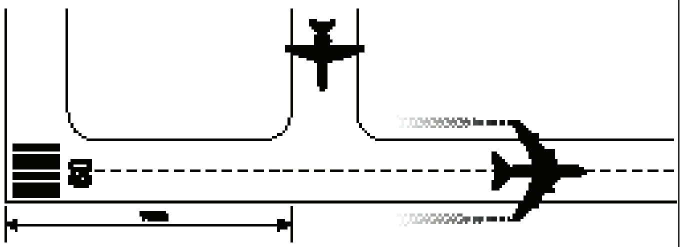
Gate capacity

Applying proposed Sydney Airport Master Plan gate infrastructure, the upper limit of aircraft gate capacity is considered to be 1,200 movements per day. 85 movements is considered the upper limit hourly rate; movement rates above this figure would create significant and congestion due the number of aircraft unaccommodated on gates. At 95 movements per hour, ground delays and consequent taxiway congestion are considered unacceptable

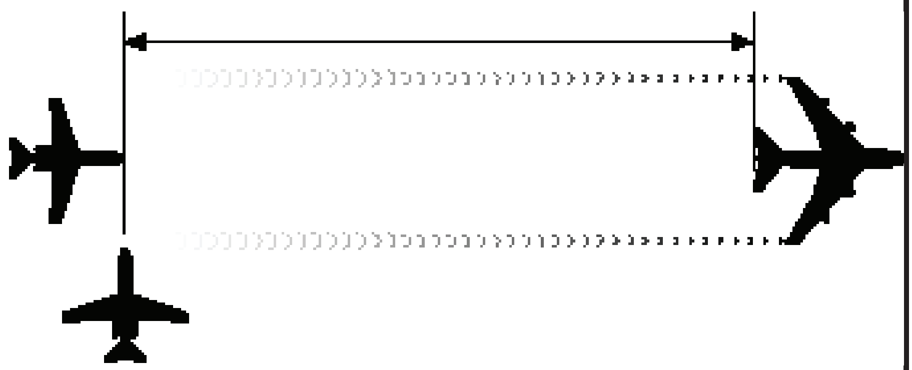
Appendix A: Wake Turbulence Separation Minima

Full Length Operations			
Aircraft Categories		Separation Minima	
Leading Aircraft	Following Aircraft	Departure (MIN)	Arrival (MIN)
Super	Heavy Medium Light	2 3 3	3 3 4
Heavy	Medium Light	2 2	2 3
Medium fixed wing aircraft with MTOW of 25 000 KG or more and all Medium helicopters	Light	2	3



<table>
<tr><th colspan="4">Intermediate Departures</th></tr>
<tr><th colspan="2">Aircraft Categories</th><th colspan="2">Separation Minima</th></tr>
<tr><th>Leading Aircraft</th><th>Following Aircraft</th><th>MIN</th><th>Application</th></tr>
<tr><td>Super</td><td>Heavy
Medium
Light</td><td>4
4
4</td><td rowspan="4">Apply intermediate standards when the following aircraft will depart from the
same runway, or a parallel runway separated by less than 760 m from a point more than 150 m after the take-off commencement point of the preceding aircraft.</td></tr>
<tr><td>Heavy</td><td>Medium
Light</td><td>3
3</td></tr>
<tr><td>Medium fixed wing aircraft with MTOW of
25 000 KG or more and all Medium helicopters</td><td>Light</td><td>3</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="4"></td></tr>
</table>

Distance-based Wake Turbulence Minima		
Aircraft Categories		**Separation Minima**
Leading Aircraft	**Following Aircraft**	**NM**
Super	Heavy Medium Light	6 7 8
Heavy	Heavy Medium Light	4 5 6
Medium fixed wing aircraft with MTOW of 25 000 KG or more and all Medium helicopters	Light	5



Planning day peak spreading at Sydney (Kingsford-Smith) Airport

B3

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FINAL REPORT

The Joint Study on Aviation Capacity for the Sydney Region

Planning Day Peak Spreading
Sydney (Kingsford-Smith) Airport

Canberra

Table of Contents

Important Note

Booz & Company has devoted its best professional efforts to this assignment and our findings represent our best judgment based on the information available.

In preparing our traffic forecasts for the Sydney region, we have relied upon the information provided by all entities. While we have checked our sources of information, data and assumptions, we will not assume responsibility for the accuracy of such data, information and assumptions received from any entity.

Any airport traffic forecast is subject to uncertainties. Inevitably, some assumptions used to develop the forecasts will not be realised, and unanticipated events and circumstances may occur. Therefore Booz & Company cannot provide any form of assurance that the forecasts documented in this report will be achieved. The actual traffic outcome will vary from that forecast and the variations may be material.

Specifically, the following factors could result in an actual outcome outside the forecast range:

- Lower than assumed economic growth rates in Australia and/or those countries expected to provide a significant source of inbound international air passengers
- Shifts in Government policy which directly, or indirectly, impact on Sydney region aviation activity
- Adverse impacts for Sydney region aviation activity associated with aviation industry developments
- A significant shift in the distribution of aviation traffic between Sydney region airports and competing international and domestic airports
- Significant changes in airline costs which are passed on by way of significantly higher air fares
- External factors, including, but not limited to, natural disasters, political unrest, acts of terrorism and associated security concerns and labour disputes

This report was prepared for the exclusive use of the Department of Infrastructure and Transport, in advising the Steering Committee on the Joint Study on Aviation Capacity in the Sydney Region and in their advice to Government. The Report may be relied upon solely by Department of Infrastructure and Transport, Booz & Company disclaims all liability to any persons other than Department of Infrastructure and Transport for all costs, loss, damage and liability that the third party may suffer or incur arising from or relating to or in any way connected with the provision of the Report to a third party. You have agreed that you will not amend the Report without prior written approval from Booz & Company. If any person, company or Government Department or Agency, other than the Department of Infrastructure and Transport chooses to rely on the Report in any way, they do so entirely at their own risk.

Background

This report provides a detailed analysis of 2010 allocated slots and actual aircraft movements for the ‗planning day' to identify markets where capacity issues are likely to occur at Sydney (Kingsford-Smith) Airport. This paper builds on aviation demand forecasts prepared for the Joint Study on Aviation Capacity for the Sydney Region presented in the report ―Forecast growth estimates for aviation activity in the Sydney Region". This paper discusses the applied approach, assumptions and analysis of aircraft movement forecasts, disaggregated by hour-of-day, market and aerodrome reference code (aircraft type).

The overarching objective behind this research was to determine corresponding ‗planning day' movement profiles by:

- applying market specific growth rates to base traffic movements;
- peak spreading - constraining and redistributing traffic movements; and
- incorporating forecast fleet composition changes.

The analysis provides insight on:

- future planning day profiles on an hourly basis;
- when the policy setting which limits movements to 80 per hour starts to impact growth; and
- how market and fleet composition shares changed across the time period after capacity limiting policies were applied.

The forecasts and analysis cover the base year and three forecast years to 2035 as follows:

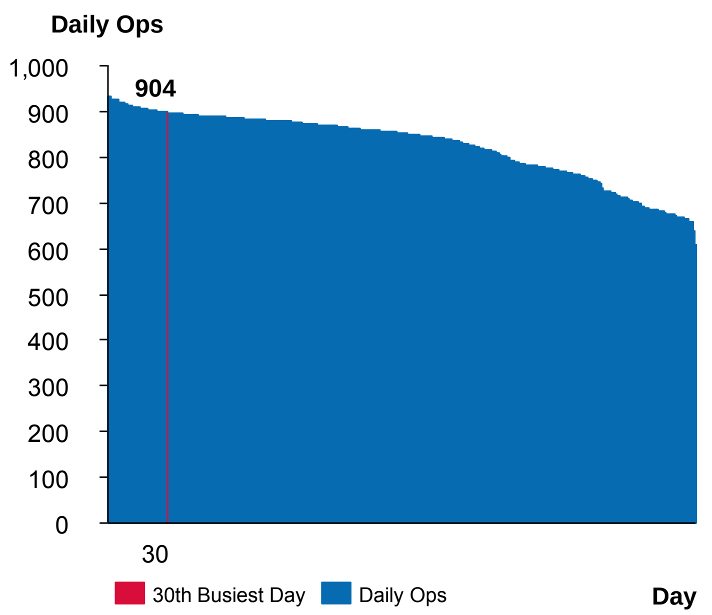
- 2010 (base year);
- 2015;
- 2020; and
- 2035.

1. Base Data

1.1 Planning Day Definition

The planning day was based on the 30th busiest day methodology. This method is commonly used for airport planning as it takes out the absolute peaks during public holidays and other special events to avoid planning for excess capacity. Using actual daily aircraft movement data from Airservices Australia for May 2010 to April 2011, the 30th busiest day was identified as 12th November 2010 which had 904 movements throughout the day. This is shown in Figure 1.

Figure 1- Daily Level of Operations at Sydney (Kingsford-Smith) Airport, May 2010- April 2011
(Most to Least Busy)



Source: Airservices Australia, Booz & Company analysis

The 12th November 2010 was therefore used as the planning day and detailed actual data was obtained from Airservices Australia. The data was sorted and segmented by type of market and time-of-day.

Analysis was also undertaken on the allocated slots for the planning day (12 November 10) to understand the implications of the difference between slot allocations and actual movements on the future planning day profiles.

1.2 Data segmentation

1.2.1 Market type

Each movement falls into one of four markets:

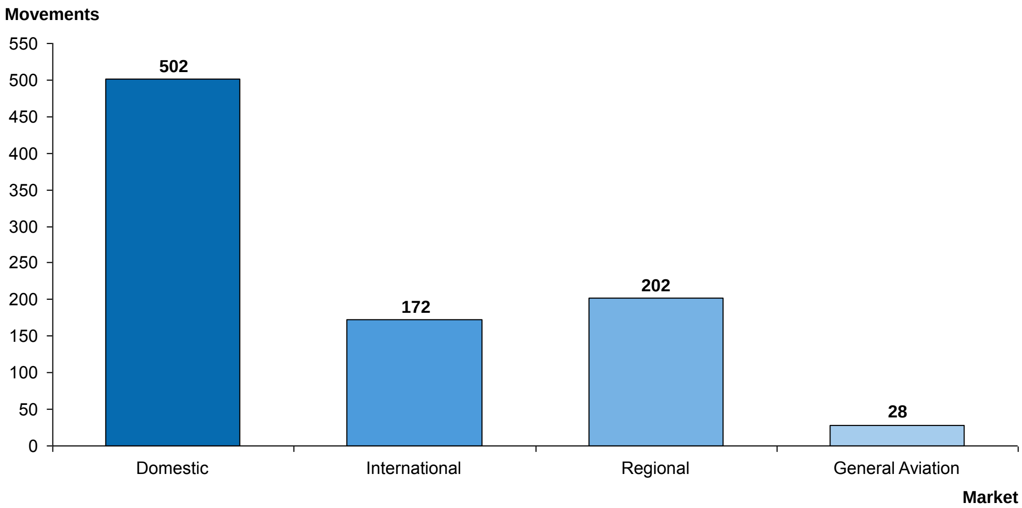
- Domestic[1] – defined as services to Australian destinations outside New South Wales;

[1] The definition of domestic and regional services is defined for the purpose of this report as it allows the consideration of the policy setting guaranteeing Sydney Airport access to intra-state regional services.

- International – defined as services to any destinations outside of Australia;
- Regional – intra-New South Wales services; and
- General Aviation – all other non-RPT (regular public transport) (excluding military movements).

These market segments were assumed to have varying growth rates as determined by the Booz & Company report entitled ‗Forecast Growth Estimates for Aviation Activity in the Sydney Region' (hereafter referred to as the Forecast Growth Report'). Figure 2 provides the 2010 breakdown of hourly movements by market segment.

Figure 2 - Movements by Market at Sydney (Kingsford-Smith) Airport for the 2010 Planning Day

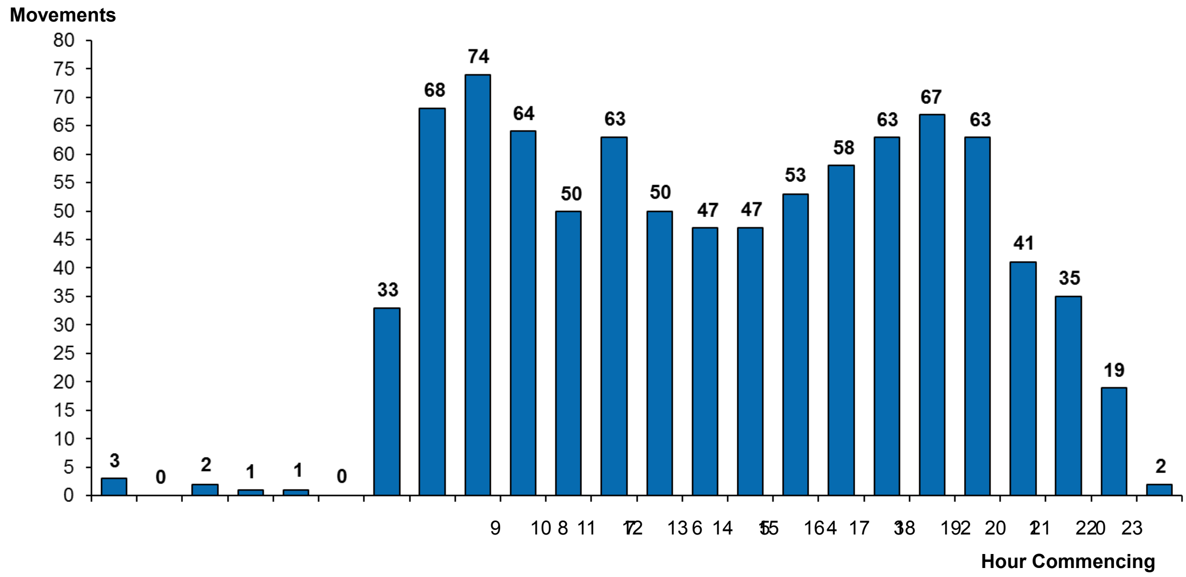


Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

1.2.2 *Time of Day*

The data was segmented on an hourly basis to consider the impact of capacity constraints, assumed to be at 80 movements per hour. A summary of hourly aircraft movements is shown in Figure 3.

Figure 3 - Distribution of Movements at Sydney (Kingsford-Smith) Airport for the 2010 Planning Day



Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

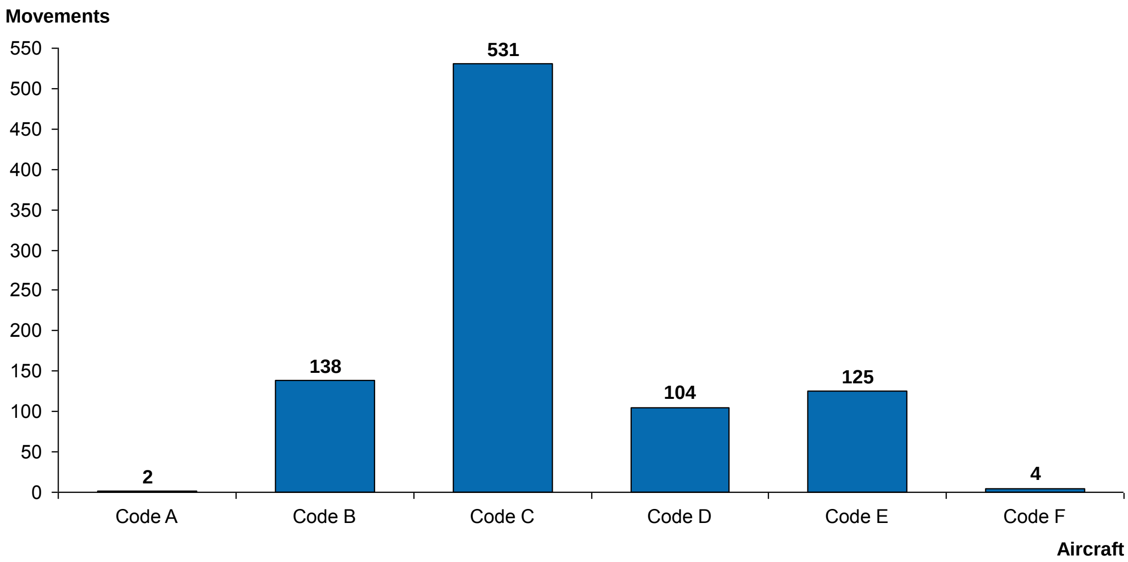
The 2010 planning day profile revealed two distinctive peak periods (07:00 to 09:59 and 17:00 to 19:59) where movements exceeded 60 per hour. The busiest hour across the day occurred between 8 and 9am where the number of movements reached 74.

The morning peak generally had a higher number of movements (i.e. total of 206 movements) compared to the evening peak (i.e. total of 193 movements). There was very little activity between 23:00 and 06:00 which is consistent with the curfew in place for Sydney (Kingsford-Smith) Airport. There are only a few small aircraft that are allowed to operate outside of these hours (e.g. small freighters), but these can be seen as negligible for the purpose of the planning day analysis.

1.2.3 Aircraft type

The final layer of segmentation applied was the aerodrome reference code (based on categories of aircraft types). Not only does fleet composition have an impact on the growth rate of overall movements, but the total number of seats grows as a result of aircraft with larger capacity. These changes also impact average aircraft utilisation. Figure 4 shows the fleet composition of the 2010 planning day.

Figure 4 - Fleet Composition at Sydney (Kingsford-Smith) Airport for the 2010 Planning Day



Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

1.3 Seat Capacity

Planning day data from Airservices Australia indicated that airlines operating at Sydney (Kingsford-Smith) Airport provided 149,200 seats (see Table 1 and Table 2) on 12 November 2010.

Table 1 shows total seat capacity by aircraft code and reveals that a large majority of total seat capacity throughout the planning day was provided by Code C aircraft at 53.2%, followed by Code E at 25.3% and Code D with 17.7%.

Table 1 - Sydney (Kingsford-Smith) Airport Planning Day Seat Capacity by Aerodrome Reference Code (1)

Aerodrome Code	Seat Capacity	Share of Seat Capacity
Code A	0	0.0%
Code B	4,200	2.8%
Code C	79,300	53.2%
Code D	26,400	17.7%
Code E	37,800	25.3%
Code F	1,500	1.0%
Total	**149,200**	100.0%

Note: Friday 12 November 2010. Rounded to the nearest hundred, 0.0% indicates the figure is smaller than 0.1%: (1) The seat capacity figures include aircraft which operated between 23:00 and 6:00 am;
Source: Airservices Australia, Booz & Company analysis

Table 2 shows the breakdown of seats by market, and reveals that the domestic market has the majority share.

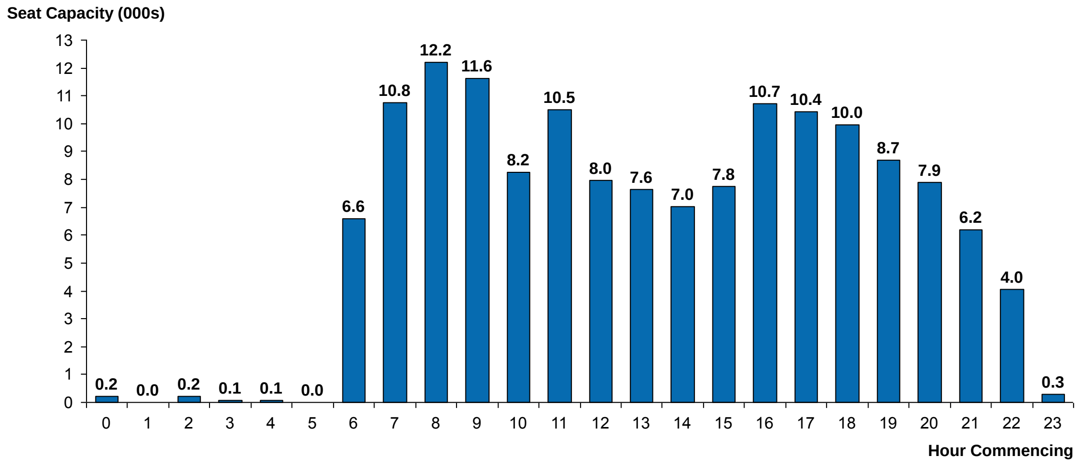
Table 2 – Sydney (Kingsford-Smith) Airport Planning Day Seat Capacity by Service Type (1)

Market	Seat Capacity	Percentage
Domestic	92,100	61.7%
International	46,700	31.3%
Regional	9,800	6.6%
General Aviation	600	0.4%
Total	**149,200**	**100.0%**

Note: Friday 12 November 2010. Rounded to the nearest hundred; (1)The seat capacity figures include aircraft which operated between 23:00 and 6:00 am;
Source: Airservices Australia, Booz & Company analysis

A summary of seat capacity by hour is shown in Figure 5. The hourly seat capacity was consistent with the analysis of movements.

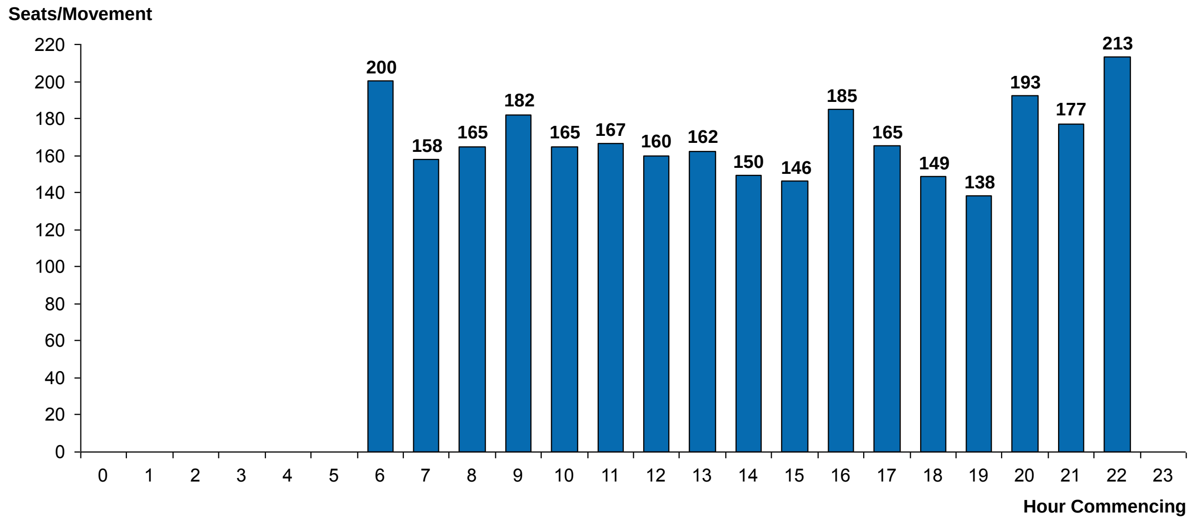
Figure 5 – Sydney (Kingsford-Smith) Airport 2010 Planning Day Seat Capacity by Hour



Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

Figure 6 presents the average hourly seat capacity per movement. Movements between midnight and 06:00 (i.e. outside of the operating hours) had a relatively small average capacity, indicative of smaller aircraft or freighter movements.

Figure 6 – Hourly Distribution of Average Seat Capacity per Movement for the 2010 Planning Day

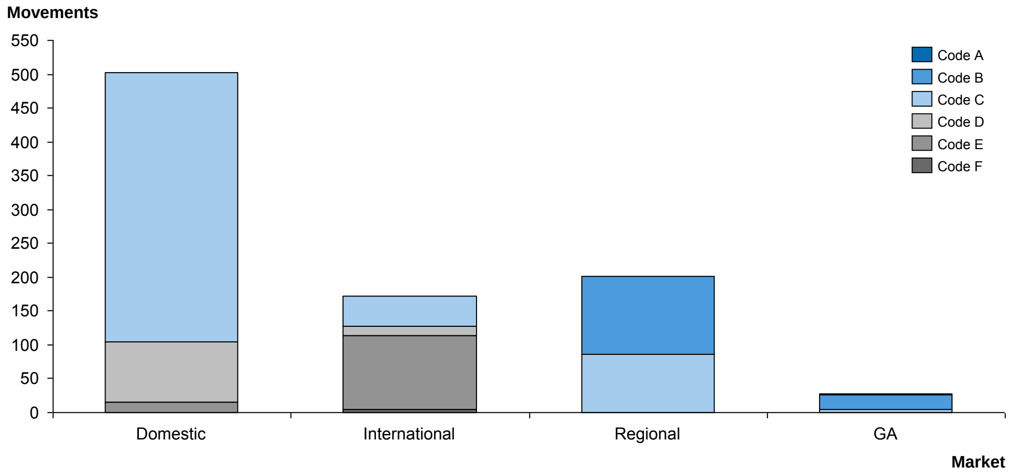


Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

1.4 Cross-analysis of Segments

This section of the report outlines our findings from a cross analysis of the above data. Figure 7 shows that the majority of domestic movements were operated by Code C aircraft, whereas the majority of international movements were operated by Code E aircraft. Regional movements were operated by Code B and C aircraft.

Figure 7 – Sydney (Kingsford-Smith) Airport Movements Segmented by Market and Aircraft Type for the 2010 Planning Day

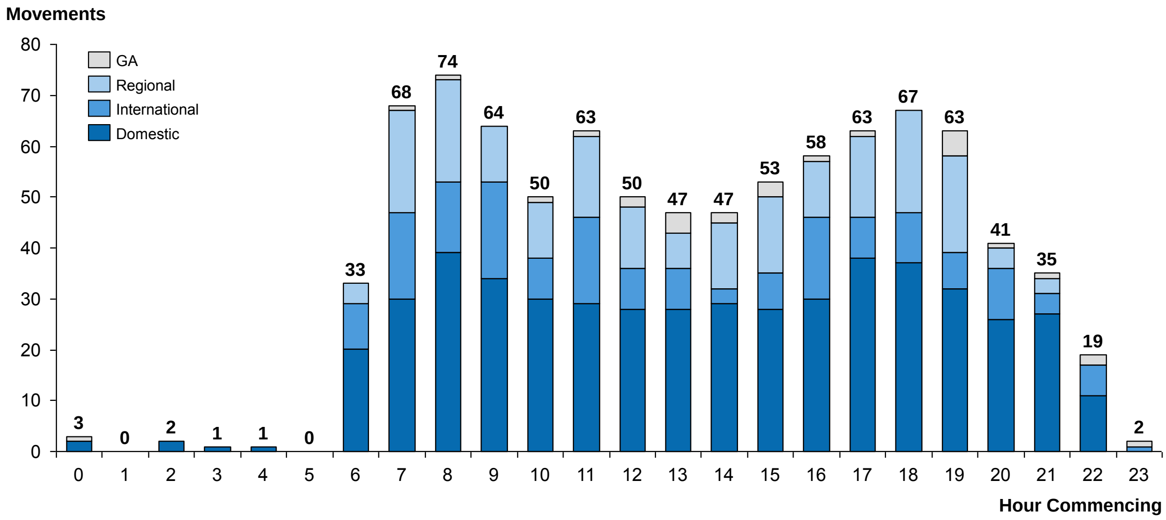


Note: Friday 12 November 2010

Source: Airservices Australia, Booz & Company analysis

Figure 8 illustrates the market composition of hourly movements for the planning day. Regional services are more strongly represented in the peak compared to the off-peak which is consistent with policy settings ensuring access for regional services at Sydney (Kingsford-Smith) Airport during peak times. This is consistent with Figure 9, which shows that Code B aircraft movements (confined mainly to the regional market) increase during the peak periods.

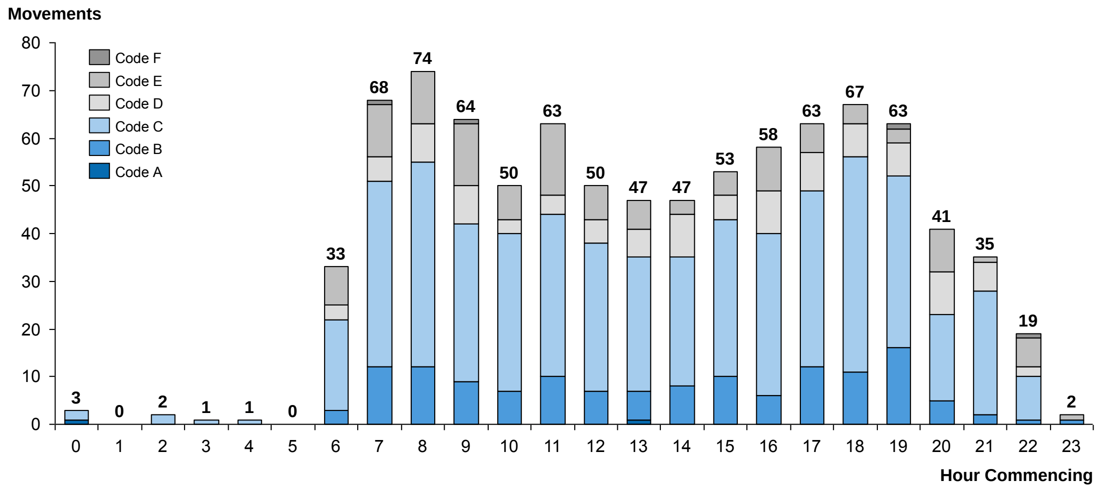
Figure 8 – Sydney (Kingsford-Smith) Airport Hourly Distribution of Movements by Market Type for the 2010 Planning Day



Note: Friday 12 November 2010

Source: Airservices Australia, Booz & Company analysis

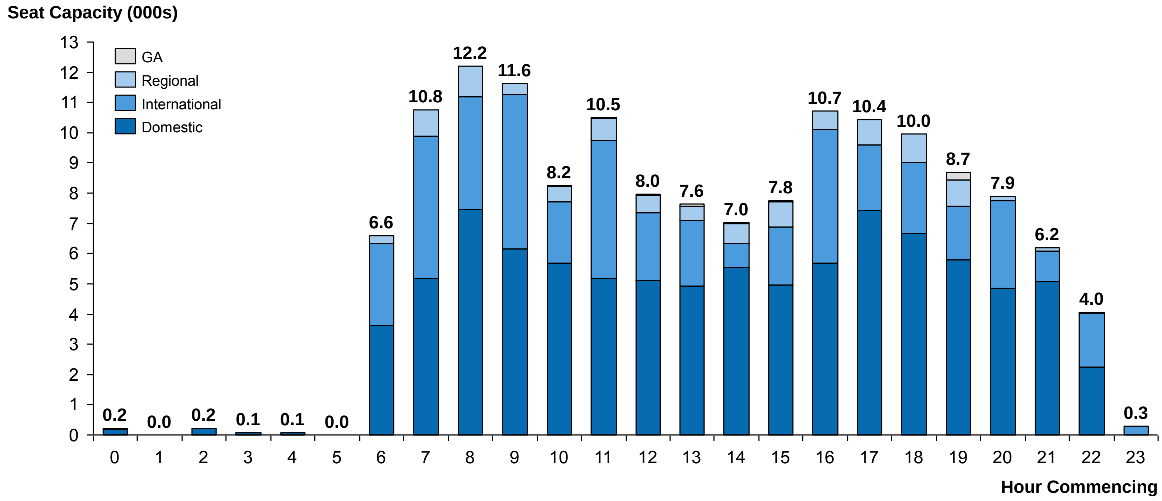
Figure 9 - Hourly Distribution of Movements by Aircraft Type at Sydney (Kingsford-Smith) Airport for the 2010 Planning Day



Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

Figure 10 shows the hourly distribution of seats by market. It can be observed that in the peak periods, especially in the PM peak, the share of regional seats was relatively higher than in the off-peak periods.

Figure 10 – Hourly Distribution of Seat Capacity at Sydney (Kingsford-Smith) Airport by Market for the 2010 Planning Day

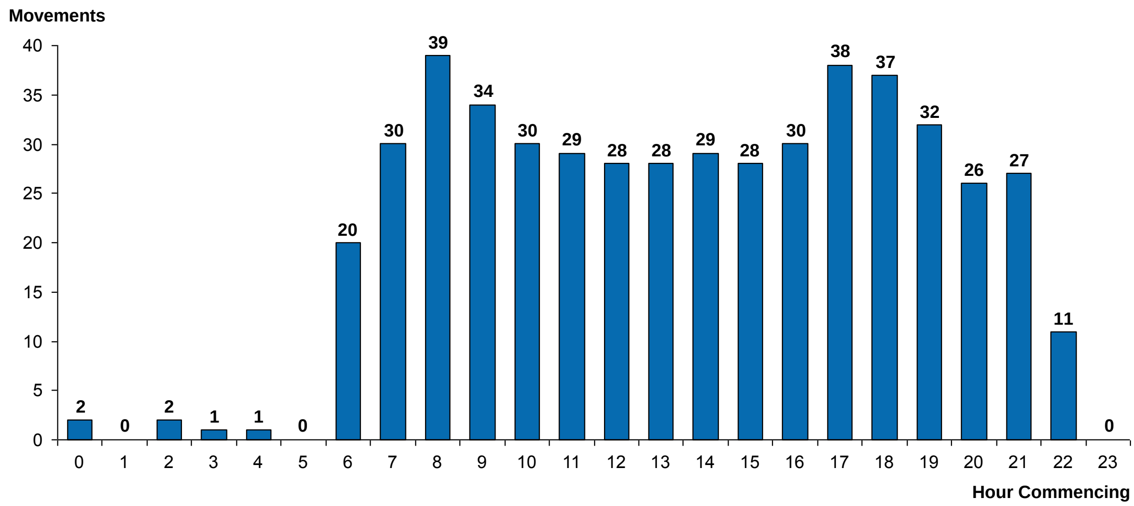


Note: Friday 12 November 2010. 0.0 indicate seat capacity of less than 5.
Source: Airservices Australia, Booz & Company analysis

1.4.1 Domestic

Domestic aircraft movements throughout the planning day are shown in Figure 11. During the Sydney (Kingsford-Smith) Airport operating hours of 06:00-22:59, the average hourly movements for domestic routes was 29. The number of domestic movements is fairly stable throughout the operating hours, with most hours (apart from peak hours) in the range of 26 to 30 movements. Domestic movements during peak periods averaged 35 movements per hour whilst off-peak movements averaged 26 movements per hour.

Figure 11 – Sydney (Kingsford-Smith) Airport Domestic Aircraft Movements by Hour for the 2010 Planning Day

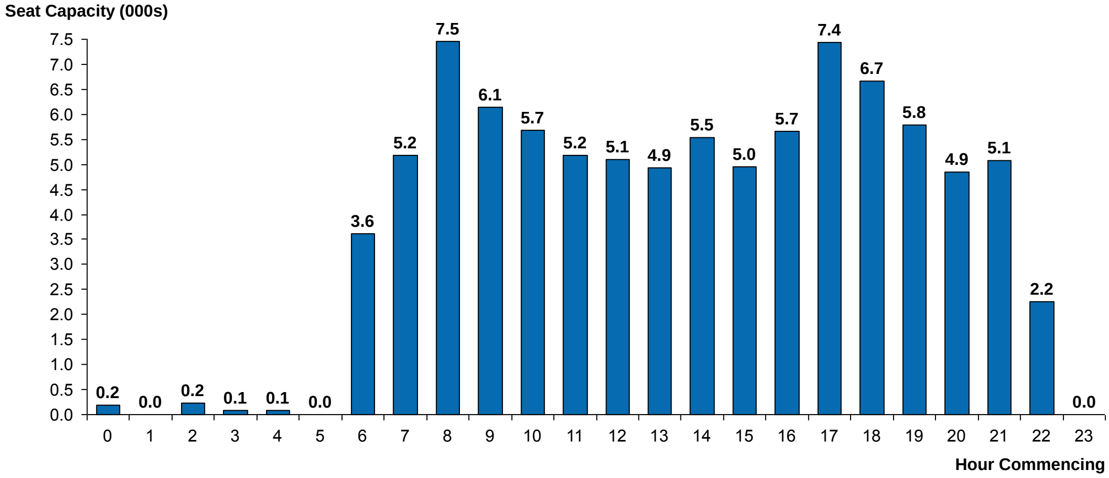


Note: Friday 12 November 2010

Source: Airservices Australia, Booz & Company analysis

Domestic seat capacity throughout the planning day is shown in Figure 12. During the Sydney (Kingsford-Smith) Airport operating hours of 06:00-22:59, average hourly seat capacity for domestic routes was approximately 5,400 seats. Domestic hourly seat capacity was generally higher in the peak periods, with an average of 6,400 compared to 4,800 in the off-peak. The morning peak period makes up 20.5 per cent of total domestic seat capacity with up to 7,500 seats during the peak hour. The evening peak period makes up 21.7 per cent of total domestic seat capacity with a peak of 7,400 seats per hour.

Figure 12 – Sydney (Kingsford-Smith) Airport Domestic Aircraft Seat Capacity by Hour for the Planning Day

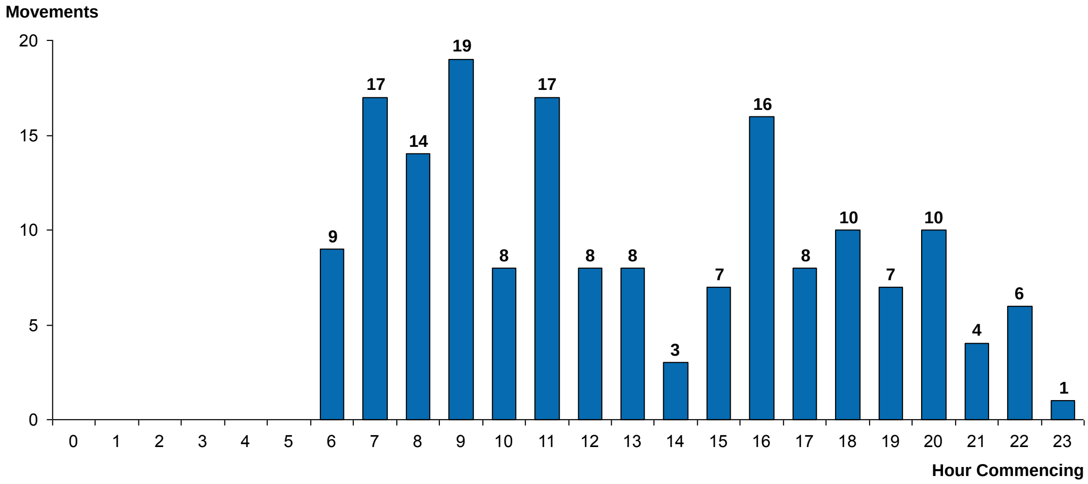


Note: Friday 12 November 2010. 0.0 indicate seat capacity of less than 50
Source: Airservices Australia, Booz & Company analysis

1.4.2 International

Figure 13 presents the hourly international aircraft movements throughout the planning day. During the operating hours, hourly movements for international routes averaged 10. International movements were higher during the morning period, with around half of all international movements occurring before 12:00 and a peak number of 19 movements between 09:00-10:00. There was no distinctive evening peak, with the maximum hourly movements after midday of 16 occurring between 16:00 and 16:59.

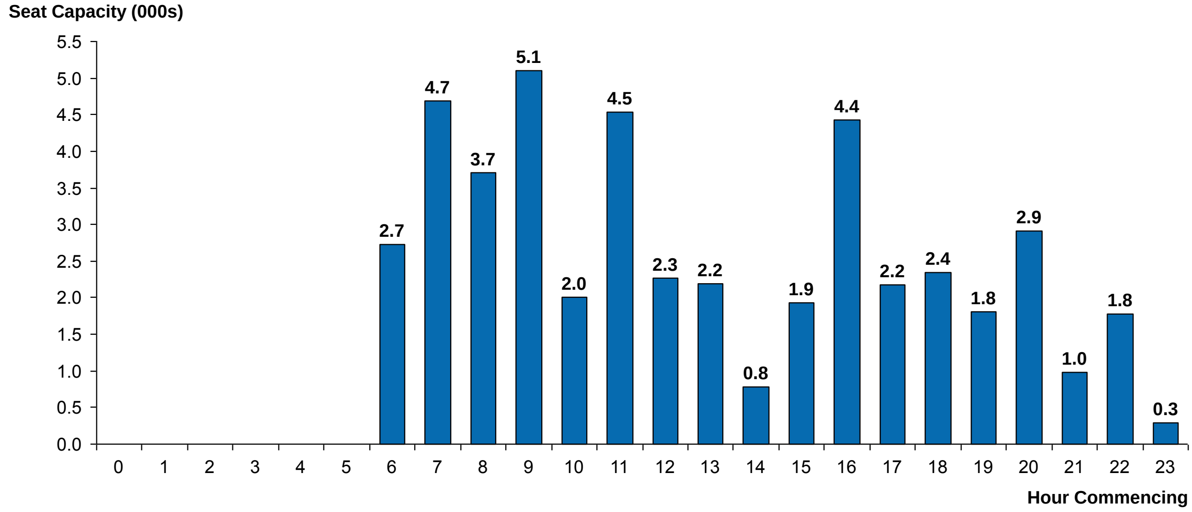
Figure 13 –Sydney (Kingsford-Smith) Airport International Aircraft Movements by Hour for the Planning Day



Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

The average hourly seat capacity for international routes was 2,700 seats during the operating hours (i.e. 06:00 – 22:59). Figure 14 shows that international seat capacity was higher in the morning period, with almost half of the daily seat capacity occurring before noon. Seat capacity before midday averaged 3,800 seats per hour with seat capacity after midday averaging 2,100 seats per hour.

Figure 14 – Sydney (Kingsford-Smith) Airport International Aircraft Seat Capacity by Hour for the Planning Day

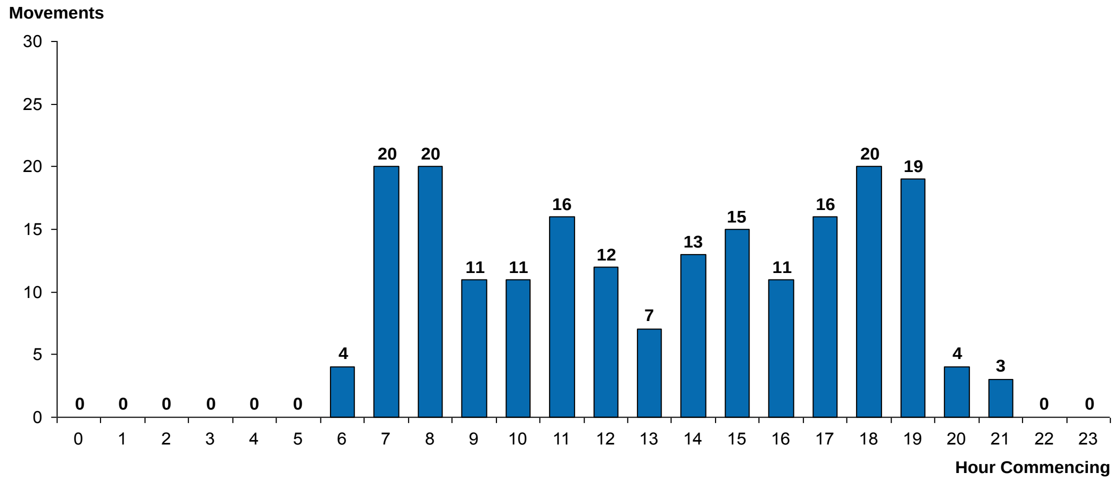


Note: Friday 12 November 2010. 0.0 indicates seat capacity of less than 50
Source: Airservices Australia, Booz & Company analysis

1.4.3 Regional

Figure 15 presents the hourly movements for regional routes throughout the planning day. During the operating hours, this was 12 per hour. Regional movements generally spike in the peaks. Regional movements during peak periods averaged 18 movements per hour whilst only averaging 9 movements per hour during the off-peak. Over half of the daily regional movements occurred during the peak periods.

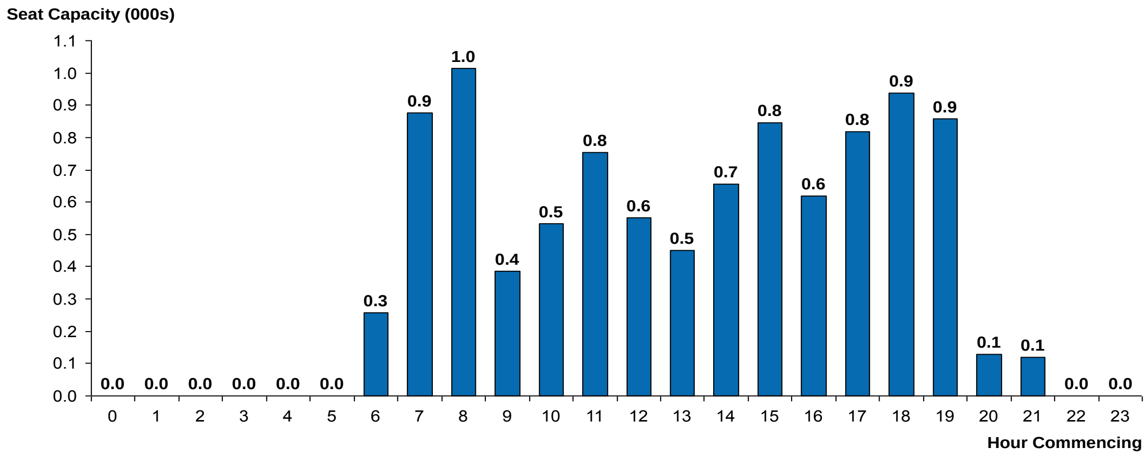
Figure 15 – Sydney (Kingsford-Smith) Airport Regional Aircraft Movement by Hour for the Planning Day



Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

During Sydney (Kingsford-Smith) Airport operating hours, the average hourly seat capacity for regional routes was 600, as illustrated in Figure 16. Regional seat capacity during the peak periods averaged 800 seats per hour while seat capacity during off-peak periods averaged 450 seats per hour. The peak periods represented half of the daily regional seat capacity.

Figure 16 – Sydney (Kingsford-Smith) Airport Regional Aircraft Seat Capacity by Hour for the Planning Day

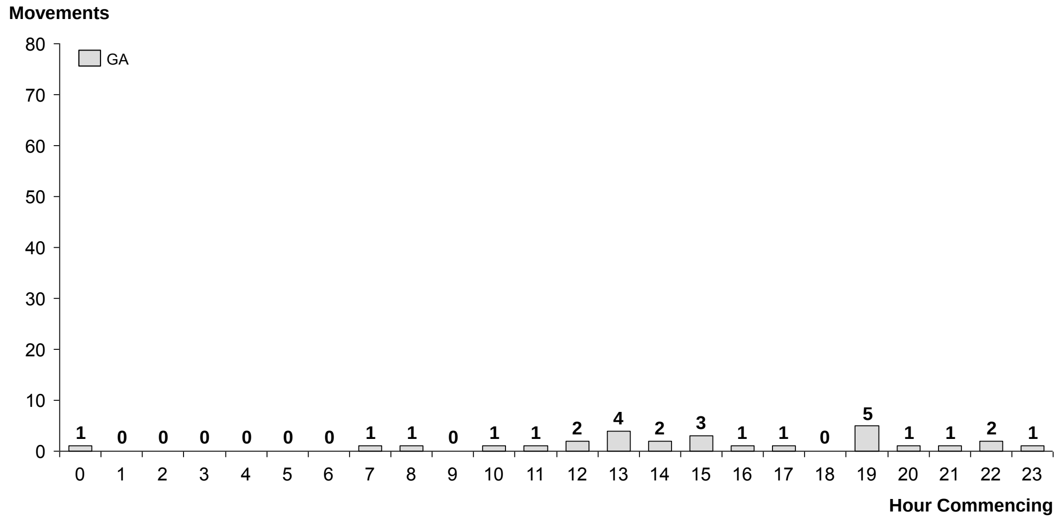


Note: Friday 12 November 2010. 0.0 indicate seat capacity of less than 50
Source: Airservices Australia, Booz & Company analysis

1.4.4 General Aviation

On the 2010 planning day, a total of 904 movements occurred at Sydney (Kingsford-Smith) Airport. As shown in Figure 17, GA activity[2] accounted for only 28 of these movements, which corresponds to a 3.1% share. The profile for GA movements is spread across the day and a minimal number of GA movements occur within the peak periods.

Figure 17: Distribution of GA Movements at Sydney (Kingsford-Smith) Airport for the 2010 Planning Day



Source: Airservices Australia, Booz & Company analysis

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[2] *Helicopter movements have not been included in this figure*

As illustrated in Figure 17, only 8 movements occurred during the peak periods (i.e. 2 movements between 07:00 and 09:59, and 6 movements between 17:00 and 19:59), which constitutes only 1.0 per cent of all movements during the morning peak and 3.1 per cent in the afternoon peak. The highest hourly movements occurred at 19:00 with 5 movements in the hour. However, the highest level of GA activity was recorded during the off-peak periods when a total of 20 GA movements occurred, accounting for 4.0 per cent of total off-peak movements.

Table 3 shows that GA movements at Sydney (Kingsford-Smith) Airport are typically high value corporate jet and charter services. Code B/C aircraft account for 60 per cent of the GA movements at Sydney (Kingsford-Smith) Airport. During the planning day the majority of GA movements at Sydney (Kingsford-Smith) Airport were operated by corporate charters (e.g. Beechcraft Super King Air 200) and business jets (e.g. Dassault Falcon 2000, Learjet 60), which are typically used by –high end” customers. This customer segment is likely to value easy access to Inner Sydney.

Table 3: GA Aircraft Types by Aerodrome Reference Code

Code	Share	Aircraft Type	Seating Capacity
CODE A	7.1%	Cessna Titan 404	10
		Learjet 35	8
CODE B	78.6%	Beechcraft SKA 200	9
		Canadair Challenger	50
		Gulfstream 4	19
		SAAB 340	37
		Pilatus PC12	8
CODE C	14.3%	A321	221
		Bombardier Global Express	19

Source: Airservices Australia, Booz & Company analysis

1.5 Peak and Off-Peak Utilisation

1.5.1 Market type

From earlier analysis, it has emerged that movements at Sydney (Kingsford-Smith) Airport are nearing the 80 movement per hour cap during peak periods and are likely to reach this threshold in the near future.

Table 4, Table 5, and Table 6 show the share of movements, the share of seat capacity and the average seat capacity in peak periods compared with off-peak periods. This analysis shows how the available capacity is distributed across the four markets during the peak off-peak periods. Domestic movements made up 52.6 per cent of movements during the peak and 57.7 per cent of movements during the off-peak, indicating that there is demand for domestic services throughout the day, not just during peak times. The domestic market accounted for 55.4per cent of total movements and 61.7 per cent of total seat capacity during operational hours. Domestic seats per movement averaged 182 during the morning peak and 186 during the afternoon peak compared with 185 seats per movement during the off-peak. Lower domestic seats per movement during the morning peak compared to the afternoon peak indicate opportunity for up gauging during this period to optimise capacity.

The international market formed a larger proportion of peak movements compared to off-peak movements. The demand for these services was higher during the morning peak with international movements comprising 24.3 per cent of movements during the morning peak compared with 19.4 per cent of movements during the off-peak. The international market contributed 19.1 per cent of daily movements and 31.3 per cent of daily seat capacity, reflective of the larger aircraft used for international services; seat capacity averaged 271 seats per movement throughout the operational day.

The regional market contributed 24.7 per cent of total movements in the morning peak and 28.5 per cent of movements during the afternoon peak. This compared with 19.4 per cent during the off-peak, highlighting that the demand for regional services appears to be higher during peak periods. Regional services made up 22.6 per cent of movements throughout the operational day but contributed only 6.6 per cent of seat capacity. This is reflective of the small aircraft used for regional services. This indicates that whilst regional services used a large number of slots (particularly during the peaks), movements did not cater for a relatively large number of passengers. Average seat capacity of regional services was 49 throughout the operational day, with 45 during the morning peak and 48 during the evening peak.

The General Aviation market made up a small proportion of movements during the planning day with movements higher in the off-peak periods. Table 4 shows the share of peak and off-peak aircraft movements segmented by market on the planning day.

Table 4 – Sydney (Kingsford-Smith) Airport Planning Day Share of Peak and Off-Peak Aircraft Movements by Market

Market	AM Peak (07:00 09:59)	PM Peak (17:00 19:59)	Total Peak	Off Peak	Full Operational Day[1)]
Domestic	50.0%	55.4%	52.6%	57.7%	55.4%
International	24.3%	13.0%	18.8%	19.4%	19.1%
Regional	24.7%	28.5%	26.6%	19.4%	22.6%
General Aviation	1.0%	3.1%	2.0%	3.6%	2.9%
Total[(2)]	100.0%	100.0%	100.0%	100.0%	100.0%

1) 06:00 to 22:59
2) These numbers may not add up to 100% due to rounding

Note: Friday 12 November 2010. Peaks vary between markets, however AM and PM peaks refer to overall market where hourly movements above 60 are sustained for more than one consecutive hour.
Source: Airservices Australia, Booz & Company analysis

Table 5 shows the share of peak and off-peak seat capacity by market.

Table 5 – Sydney (Kingsford-Smith) Airport Planning Day Share of Peak and Off-Peak Seat Capacity by Market

Market	AM Peak (0700 0959)	PM Peak (1700 1959)	Total Peak	Off Peak	Full Operational Day
Domestic	54.3%	68.3%	60.7%	62.5%	61.7%
International	39.0%	21.7%	31.1%	31.4%	31.3%
Regional	6.6%	9.0%	7.7%	5.8%	6.6%
General Aviation	0.1%	0.9%	0.5%	0.3%	0.4%
Total(2)	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Friday 12 November 2010
(2) These numbers may not add up to 100% due to rounding
Source: Airservices Australia, Booz & Company analysis

Table 6 shows the average seat capacity per movement for peak and off-peak periods on the planning day.

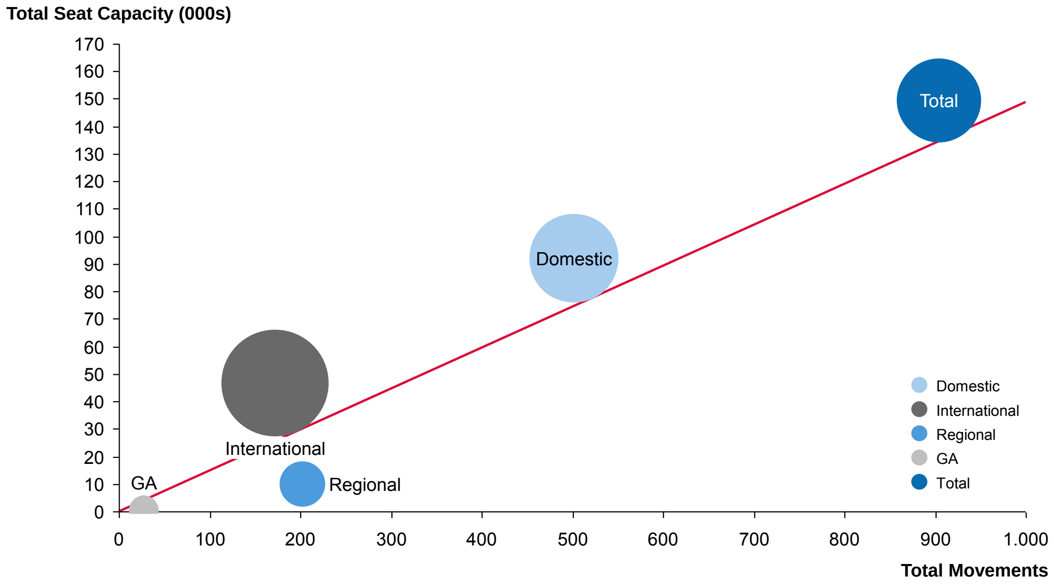
Table 6 – Sydney (Kingsford-Smith) Airport Planning Day Aircraft Seat Capacity per Movement

Market	AM Peak (0700 0959)	PM Peak (1700 1959)	Total Peak	Off Peak	Full Operational Day
Domestic	182	186	184	185	185
International	270	253	264	277	271
Regional	45	48	46	51	49
General Aviation	9	46	37	16	22
Average for the time period	168	151	160	171	166

Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

As illustrated in Figure 18, the regional market average seat capacity per movement was well below that of the international and domestic markets. The size of the bubbles represents the average seat capacity per movement by market.

Figure 18 – Sydney (Kingsford-Smith) Airport Planning Day Aircraft Seat Capacity per Movement by Market



Size of bubble = Average seats per aircraft
Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

1.5.2 *Aircraft Type*

Analysis of the percentage share of aircraft seat capacity and movements shows how capacity is distributed across aircraft types across the day. Code C aircraft made up 58.4 per cent of total movements and provided 54.8 per cent of seat capacity during the peaks, averaging 150 seats per movement. Larger Code E aircraft comprised 12.0 per cent of movements in the peak period compared to 15.3 per cent in the off-peak period, and provided 22.9 per cent of seats in the peak period compared to 27.1 per cent in the off-peak. This is shown in Table 7, Table 8 and Table 9.

Table 7 – Sydney (Kingsford-Smith) Airport Planning Day Share of Movements by Aircraft Type and Time of Day

Aerodrome Code	Morning Peak (07:00 09:59)	Afternoon Peak (17:00 19:59)	Total Peak	Off Peak	Full Operational Day
Code A	0.0%	0.0%	0.0%	0.2%	0.1%
Code B	16.0%	20.2%	18.0%	13.1%	15.3%
Code C	55.8%	61.1%	58.4%	58.9%	58.7%
Code D	10.2%	11.4%	10.8%	12.3%	11.6%
Code E	17.0%	6.7%	12.0%	15.3%	13.9%
Code F	1.0%	0.5%	0.8%	0.2%	0.4%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

Table 8 – Sydney (Kingsford-Smith) Airport Planning Day Share of Seat Capacity by Aircraft Type and Time of Day

Aerodrome Code	Morning Peak (07:00 09:59)	Afternoon Peak (17:00 19:59)	Total Peak	Off Peak	Full Operational Day
Code A	0.0%	0.0%	0.0%	0.0%	0.0%
Code B	3.0%	4.1%	3.5%	2.3%	2.8%
Code C	48.7%	62.0%	54.8%	51.8%	53.1%
Code D	15.3%	19.3%	17.1%	18.3%	17.8%
Code E	30.9%	13.3%	22.9%	27.1%	25.3%
Code F	2.1%	1.3%	1.7%	0.4%	1.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

Table 9 – Sydney (Kingsford-Smith) Airport Planning Day Average Aircraft Seat Capacity per Movement by Aerodrome Reference Code

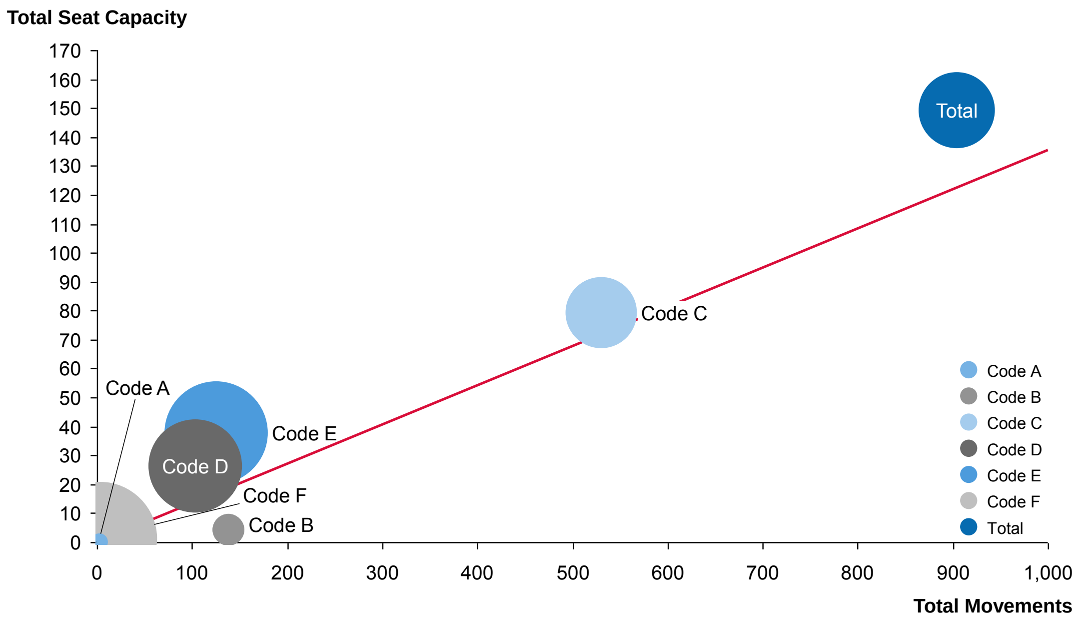
Aerodrome Code	Morning Peak (07:00 09:59)	Afternoon Peak (17:00 19:59)	Total Peak	Off Peak	Full Operational Day
Code A	-	-	-	8	8
Code B	31	30	31	30	30
Code C	147	153	150	150	150
Code D	252	255	254	254	254
Code E	305	299	303	302	303
Code F	364	364	364	364	364
Average for the time period	168	151	160	171	166

Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

Reflective of the regional market, Code B aircraft utilised a significant proportion of movements, particularly during the peaks, but only contributed a small proportion of available seats. If seat capacity were to be maximised during peak periods at Sydney (Kingsford-Smith) Airport, it could be achieved through up gauging of code B aircraft, however demand will need to exist in these markets to support this.

Analysis of aircraft code, seat capacity and movements is presented in Figure 19. The size of the bubbles represents the average seat capacity per movement.

Figure 19 – Sydney (Kingsford-Smith) Airport Aircraft Seat Capacity per Movement by Aircraft Type



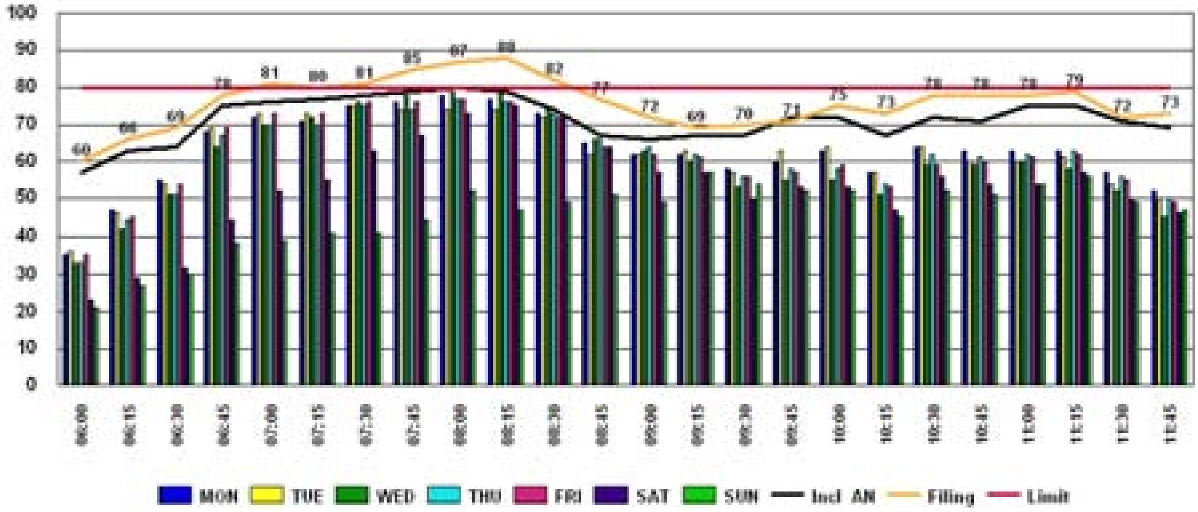
Note: Friday 12 November 2010
Source: Airservices Australia, Booz & Company analysis

1.6 Allocated Slot Analysis

1.6.1 Slot Demand

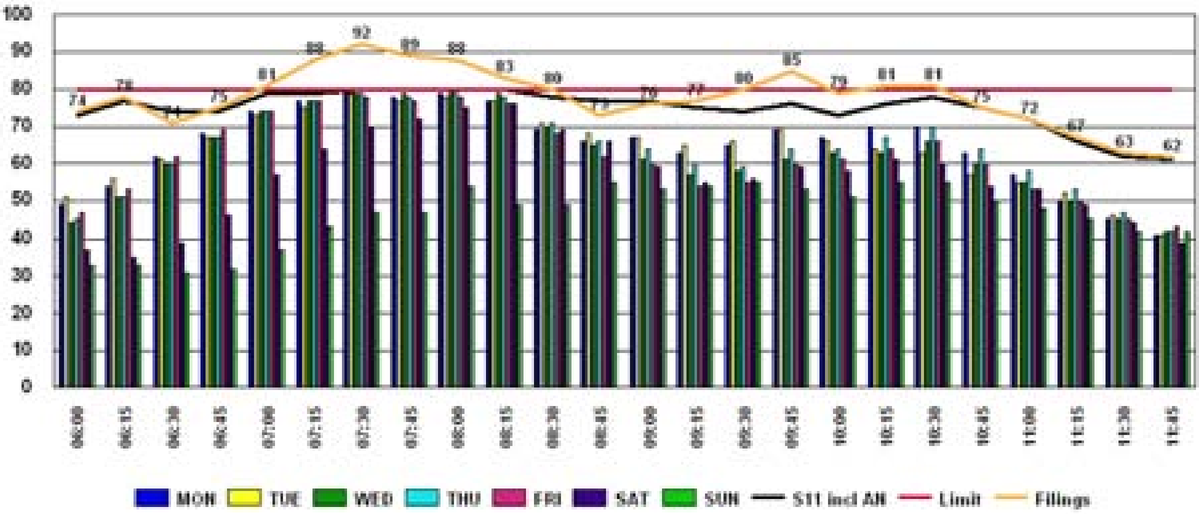
Figure 20 and Figure 21 were provided by ACA and illustrate the demand for slots during the morning peak for a sample week in the Winter 2010 and Summer 2011 scheduling seasons. For much of the morning, there were more than 80 filings for slots which implies that there is a much higher demand for slots than is actually being allocated (airlines may however, bid for several slot options). Demand for shoulder and off-peak slots was not as high. This indicates that opportunity for peak spreading at Sydney (Kingsford-Smith) Airport may be limited as there may not be demand during off-peak times to operate services commercially.

Figure 20 – Sydney (Kingsford-Smith) Airport Allocated Gate Movements and Demand Northern Hemisphere Winter 2010 (November 2010 – March 2011) - February Sample Week



Note: Updated 17 December 2010
Source: Airport Coordination Australia

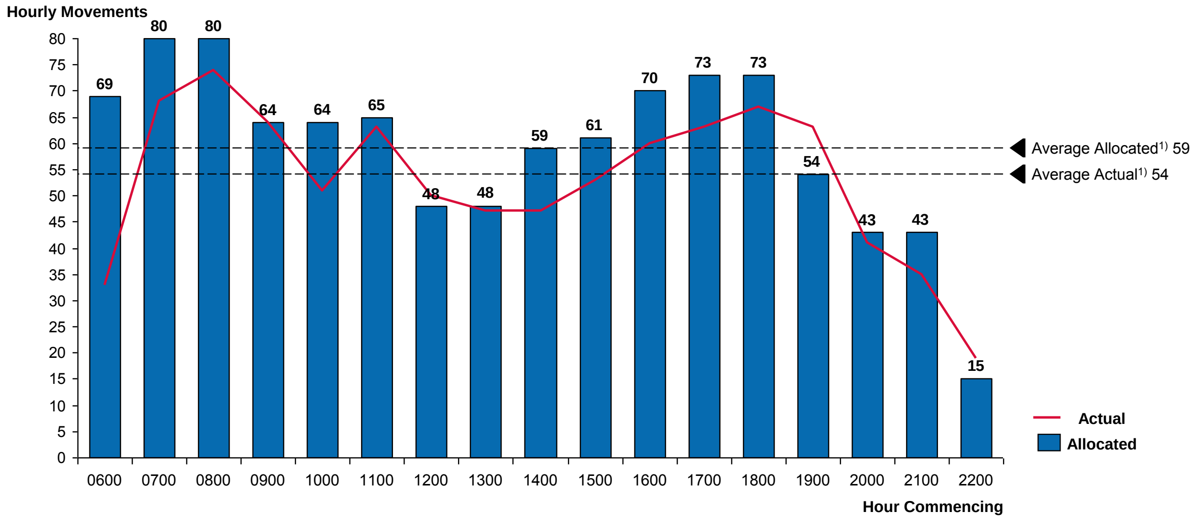
Figure 21 – Sydney (Kingsford-Smith) Airport Allocated Gate Movements and Demand Northern Hemisphere Summer 2011 (April - October 2011) - August Sample Week



Note: Updated 26 November 2010
Source: Airport Coordination Australia

Figure 22 compares allocated slots for a Friday during the northern hemisphere winter 2010/2011 season and actual movements on the 2010 planning day (Friday, November 12 2010). This shows that on the 2010 planning day there were 80 movements allocated during the morning peak (07:00-08:59), however, the maximum number of actual movements was only 74. On average, between 07:00 and 22:59, actual aircraft movements were approximately 9 per cent lower than slot allocations (54 compared to 59).

Figure 22 – Sydney (Kingsford-Smith) Airport Actual Planning Day Movements Compared to Northern Hemisphere Winter 2010/11 (October 2010 - March 2011) - Friday



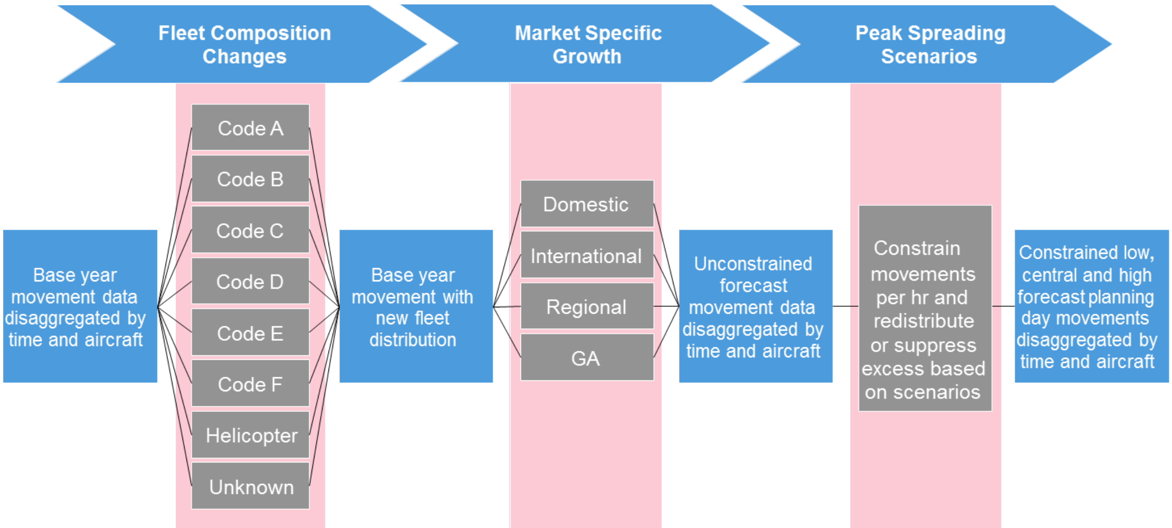
1) Averages based on 07:00 to 22:59 as 06:00 appears to be an outlier with a large difference between allocated and actual movements.
Note: Planning day is Friday 12th November 2010.
Source: Airport Coordination Australia

2. Forecasting Approach

2.1 Introduction

Figure 23 illustrates the forecasting process as described in the remainder of this chapter.

Figure 23 - Forecasting Process Illustration



Source: Booz & Company

For each forecast year, the previous year‘s forecast/actual data was taken as the base (i.e. for the forecast of 2015, the 2010 base data was used, and for forecast year 2020, the 2015 forecast data was used as the base, etc.). Market specific growth rates and forecast impacts from changes in fleet composition were applied to the base data of each forecast period. The aircraft movement data was re-organised by time (hour), market type and aircraft type to provide the base planning day data set (i.e. data was aggregated to provide the number of movements for every combination of these three attributes). Figure 24 provides an illustration of the ‗movement matrix'.

Figure 24 - Movement Matrix Example

Movements	**Domestic**								**International**			
Hour	Code A	Code B	Code C	Code D	Code E	Code F	Helicopter	Unknown	Code A	Code B	Code C	Code D
0												
1												
2												
3												
4												
5												
6												
7												

Source: Booz & Company

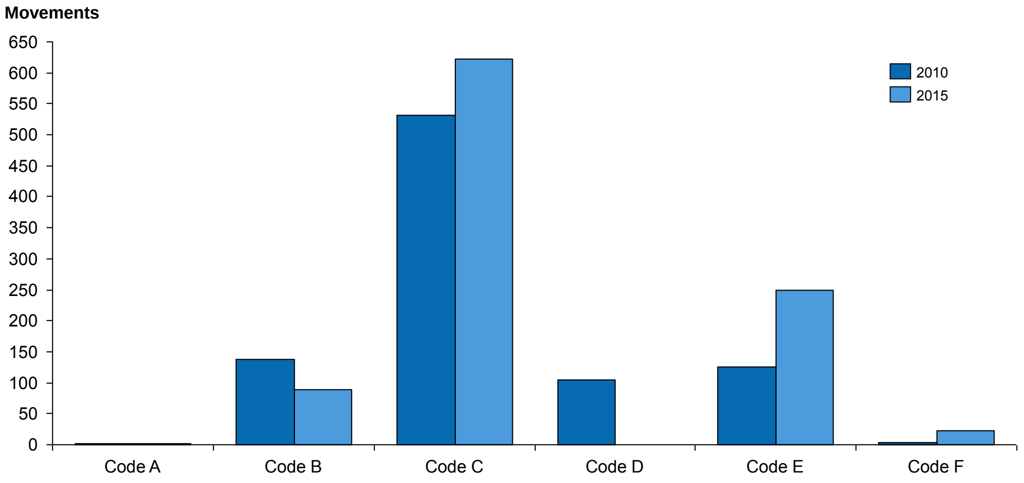
2.2 Fleet Composition Changes

Changes in fleet composition were calculated and distributed across each hour of the day using the existing distribution of movements. These changes have no impact on the total number of movements, but only on the way movements are distributed across aircraft type and hour of day.

The methodology behind determining future fleet composition is outlined in Appendix A which contains all of the calculations and assumptions. These assumptions were based on aircraft orders and long term third party aircraft demand projections. The assumptions were applied to the total movements from the base planning day data, which provided a new distribution of aircraft. Figure 25 shows the change in distribution of aircraft type between forecast years.

Whilst this process provided fleet composition for the forecast years, further analysis was required to determine the distribution of new aircraft across the four markets. The current (i.e. 2010) distribution of aircraft type across the different markets for our 2010 planning day was determined from the Airservices Australia data set and was used as the base to calculate any incremental changes.

Figure 25 - Changes in Distribution of Aircraft Type



Source: Booz & Company analysis

The general process behind the redistribution of fleet changes for the forecast was as follows: where Code A reduced, it was replaced with Code B, Code B to Code C, Code C to Code E, etc; although Code C was maintained in the international market at 44 movements per hour in 2015 for the Trans-Tasman route. Code D was phased out completely with the retirement of all 767 aircraft. Code A was phased out of the domestic market first, followed by regional then GA, similarly for Code B. By 2020 and 2035, Code C was reduced but not phased out; this is due to smaller ports in NZ not being equipped with the infrastructure to sustain larger craft. The type of aircraft that can be used for each of the market segments are summarised in Table 10.

Table 10 – Allowable Aircraft Types by Market

Market	Aircraft Type
International	Code C to Code F
Domestic	Code C to Code E
Regional	Code A to Code C
GA	Code A to Code C

Source: Booz & Company

2.3 Growth Assumptions for Movements

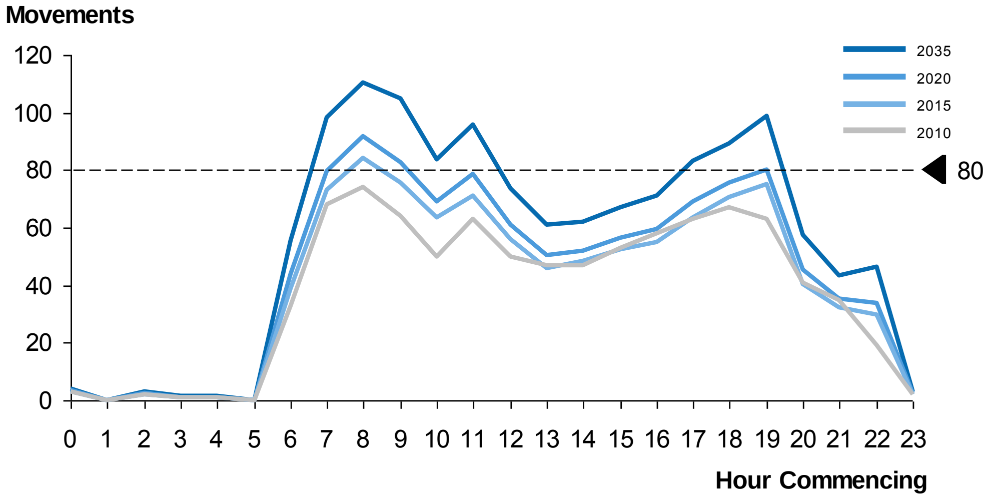
Once fleet changes were incorporated, market and year specific growth was applied to each relevant data value to uplift it to the forecast year. The growth rates used were taken from the Forecast Growth Report.

The growth rates incorporated changes to a number of variables which are discussed below. As these factors have already been incorporated into the growth rates, they are only discussed below and not included again in the modelling process for the busy day profiles:

- *Peak Spreading:* In the annual traffic model, it was assumed that peak spreading occurs, allowing aircraft movements to increase more rapidly during off-peak periods compared to peak periods.
- *Up-gauging:* aircraft movement growth rates account for up gauging and increased aircraft capacity. This implies that aircraft movements grow at a slower rate than passenger movements.
- *Increased load factors:* The growth rates also assumed increasing aircraft load factors which also ensure that movement growth is slower than passenger growth

Figure 26 shows the unconstrained daily movement profiles for each of the forecast years and demonstrates that in 2015, 2020 and 2035 forecast movements will exceed the policy cap of 80 movements per hour at various points throughout the day.

Figure 26 – Unconstrained movement forecasts



2.4 Peak Spreading Methodology

A passenger can respond in one of two ways to a situation where a seat is not available at their preferred departure time. They can choose to travel at an alternative time (i.e. trip redistribution) or, alternatively, they can choose not to undertake the trip at all (i.e. trip suppression).

After growth was applied to each hourly movement, it was constrained to ensure that movements did not exceed 80 movements per hour. Any excess movements from forecasts which exceeded this limit were either redistributed across other time slots where capacity existed (i.e. trip diversion) or suppressed and removed from the forecast. The methodology used and the assumptions formulated to conduct this are described in the remainder of this section.

Passengers were assumed to respond to capacity constraints by moving away from the peak to the shoulder and off-peak periods as follows:

- It was assumed that any growth in international movements which exceeded the 80 movements cap was unable to be accommodated due to constraints in terms of time zone and availability of slots at the origin/destination airport and were therefore suppressed[3];
- In any one hour, if the total movements exceeded 80, the peak spreading model moved the excess to alternative slots on the given day with a small level of suppression as discussed below; and
- Within each hour, priority was given to regional movements; i.e. the model did not redistribute any of the regional movements to different hours unless total regional movements exceeded 80 per hour (this did not occur). Excess movements were assumed to come from the remaining markets and hence were distributed to those markets in other hours.

We assessed the extent of diversion and suppression within a 'generalised cost' framework. The generalised cost concept is used frequently in transport planning studies and measures both the pecuniary and non-pecuniary costs associated with a given trip. In essence, it includes the fare paid, together with the estimated monetary value of the time spent completing the journey.

Assume that the generalised cost of travel by the desired flight = GCD

The generalised cost of travel by a flight 'n' hours earlier (or later) is given by:

GCD + xn

where:

x = is the monetary value of a 1 hour change in departure time; and

n = the number of hours away from preferred departure time that flight is available.

The other key input to calculating the passenger response to not being able to travel at the preferred departure time is the passenger elasticity of demand with respect to the generalised cost of the trip (εGC). εGC is given by εf/p, where:

εf = estimated air fare elasticity for the route in question; and

p = proportion of the generalised trip cost accounted for by the air fare.

Drawing together the parameters discussed above, the proportional change in passenger demand associated with an n hour change in departure time is given by:

$$\Delta D = (\varepsilon GC \,.\, x \,.\, n)/GCD \qquad (1)$$

The variables in Equation (1) have been calibrated using data points from the Melbourne – Sydney flow. This means that the estimated relationship between suppression levels and ‗number of hours displaced' determined for Melbourne - Sydney has been used to determine suppression levels for all non-international movements at Sydney airport (as international

[3] *The full suppression of international services exceeding the limit of 80 movements per hour on the planning day is an assumption which has been applied to the planning day analysis only. It is assumed that additional growth in international services is accommodated on other days. The annual forecast model developed by Booz & Company assumes that international services will continue being accommodated as a priority over domestic services, given the higher yields associated with international services.*

movements are 100 per cent suppressed). That is, using the Melbourne – Sydney as a proxy for all movements (excluding international), it is estimated that 9.4per cent of all movements (excluding international) would be suppressed under circumstances where passengers are offered a departure time 1 hour away from the preferred departure time (i.e. define as S1).

Equation (1) is a linear function, however it was not considered realistic to assume that the suppression function would be linear against time (i.e. the extrapolation of a linear function was considered to overstate the level of suppression). Accordingly, the extent of trip suppression for movements away from preferred departure times of 2 hours or greater was moderated by the application of the following function:

$$S_n = S_{n-1} + \ln(S_1/n) \qquad (2)$$

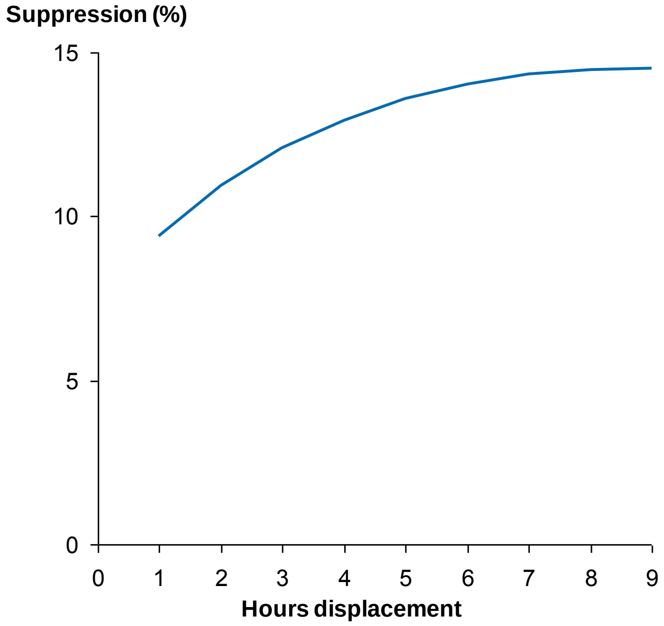
where:

n is the number of hours displacement and,

S_n is the amount of suppression for ‗n' hours of displacement

It should be noted that Equation (2) is entirely judgmental and is not supported by any theoretical framework. The relationship adopted to estimate the extent of trip suppression for movements away from a preferred departure produces is consistent with suppression levels ranging between 9-15 per cent depending on displacement as demonstrated in Figure 27 below.

Figure 27 - Suppression Function



Source: Booz & Company

This function was used to calibrate the peak spreading model. Under circumstances where excess demand was identified, the hour with the highest utilisation was identified and the model 'searched' for capacity in adjacent hours. If capacity was available, it was assumed that 85 per cent of passengers would move to the closest hour with slots remaining with the balance of flights being suppressed. The remaining 15 per cent are suppressed and are excluded from the forecast. The 85 per cent redistribution and 15 per cent suppression rates are based on the suppression function outlined above.

Once all excess movements for that hour were redistributed or suppressed, the process was repeated for the next hour which now has the highest number of movements above 80. This process was repeated until all time slots were at 80 or less. The process did not allow for any movements to be allocated between 11pm-6am.

This process was undertaken at the end of each forecast year after the growth had been applied, and the results were fed into the following forecast period as the base case. The results of this process are presented in the next chapter.

2.4.1 Alternative Constraining Scenarios

The methodology described above has been labelled the ‗Medium Scenario'. However, Low and High peak spreading scenarios[4] were also created to understand how different assumptions affect the forecasts:

Low Scenario

The Low case assumed 100 per cent suppression. When forecast hourly movements exceeded 80/hour, it was assumed that excess flights would not be accommodated or redistributed. These movements were removed from the forecast.

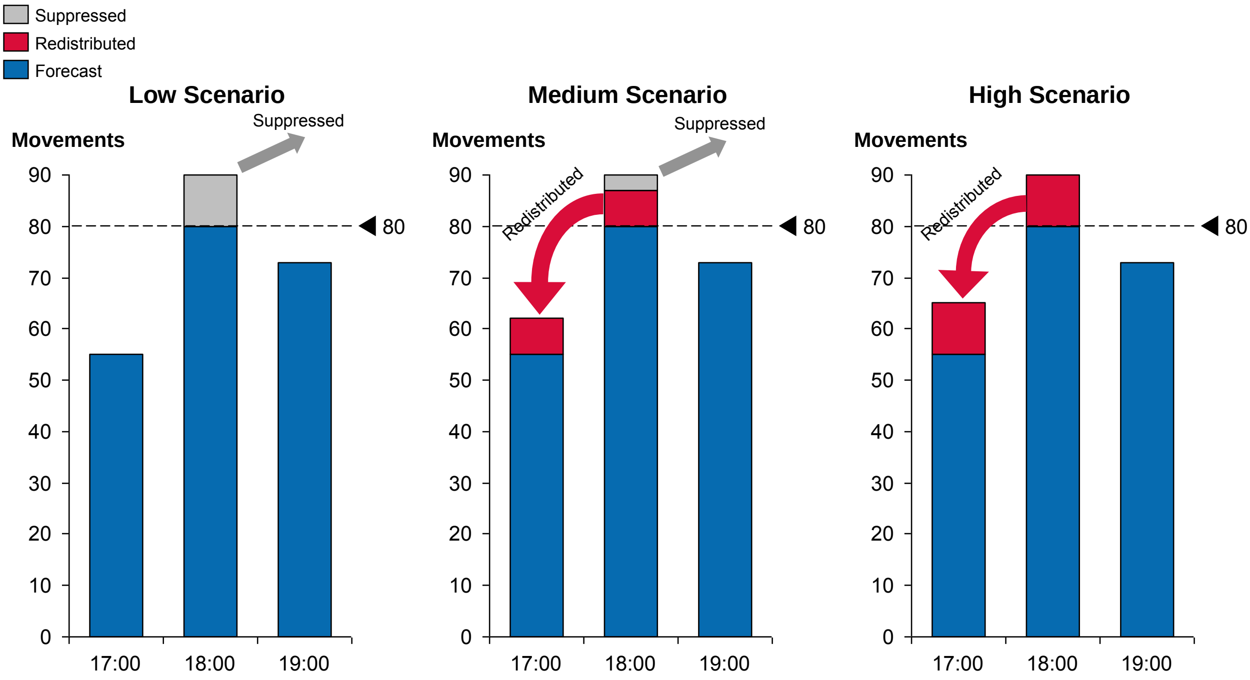
High Scenario

The High case assumed 100 per cent redistribution for all domestic, regional, GA and military flights within the same day, and 100 per cent suppression of international flights. Any excess movements were redistributed to other time slots with capacity available.

Figure 28 illustrates the approach taken with peak distribution under the Low, Medium and High scenarios.

[4] *It should be noted that the low and high scenarios used in this report make specific behavioural assumptions regarding the capacity for peak spreading unlike the 'Forecast Growth Report', which is based on international benchmarks regarding busy hour to annual movement ratios.*

Figure 28 - Peak Distribution Scenarios Example



Source: Booz & Company

2.5 Determining Average Daily Changes in Utilisation across the Forecast Periods

Appendix A contains an in depth description of the assumptions, methodology, and analysis behind the calculations for future fleet composition. Not only does this analysis impact the number of movements at Sydney (Kingsford-Smith) Airport, but it provides insight into the supply of total seat numbers at the airport. By cross analysing these forecasts with passenger demand forecasts and with the hourly forecasts by aircraft type, average utilisation levels for each forecast year were constructed. The assumptions for average seats per movement are presented in Table 11 below.

Table 11 – Sydney (Kingsford-Smith) Airport Average Seat Capacity Assumptions, 2010 to 2035

Market	2010	2015	2020	2035
Domestic	173	180	188	211
International	289	301	314	352
Regional	45	50	55	72

Source: Booz & Company analysis

3. Outcome of analysis

3.1 Introduction

This chapter is split into the following four sections:

- Movement profiles of constrained forecasts for the three peak spreading scenarios;
- Detailed analysis of the ‗medium scenario' focusing on changes in fleet composition and market shares;
- Analysis of projected average utilisation levels in the ‗Medium scenario' which incorporates demand forecasts from previous work;
- Shock testing of the ‗Medium scenario' for the 2035 planning day, by reducing the movement constraint from 80 to 55 and 25 movements/hour across two hours in the AM peak; and
- Analysis of peak spreading impacts of changing the movement constraint to 85, 90 and 95 movements per hour.

3.2 Constrained Forecasts of Movements per Hour – Peak Spreading Scenarios

This section presents the forecasts of movements/hour across the day for the three forecast years of 2015, 2020 and 2035, across the three peak spreading scenarios:

- Low scenario – 100 per cent suppression beyond 80 movements/hour (i.e. no redistribution);
- Medium case – varying suppression in the domestic and regional markets depending on the difference between forecast arrival time and the available redistributed arrival time; and 100 per cent suppression of movements in the international market; and
- High case – 100 per cent redistribution of all movements beyond 80 movements/hr in the domestic and regional market (i.e. no suppression; all excess movements are redistributed); and 100 per cent suppression of movements in the international market.

Figure 29 compares the daily movement profiles for each of the three scenarios for each forecast year.

For the 2010 profile, movements in the peak hours reached high utilisation levels of between 79-93 per cent, and 59-79 per cent in the inter-peak hours. For the remaining forecast profiles, up gauging assumptions based on the growth rates described in the previous chapter were applied.

In 2015, hourly movements surpassed the constraint by 4 movements between 08:00-08.59. The excess can be suppressed and/or redistributed (depending on the High/ Medium/ Low case) to the shoulder peak. For the Medium case, the 4 excess movements were allocated to the prior hour. The morning peak increased to 97 per cent utilisation and the inter-peak period average utilisation increased to 70 per cent.

By 2020, the AM peak exceeded 80 movements per hour and provided an excess of 12 movements which were distributed in the hour either side of the AM peak. In the PM peak, 19:00-19:59 reached the constraint of 80 movements per hour. The average utilisation in the peak was 97 per cent, and in the inter-peak period was 77 per cent.

In the final forecast year of 2035, the majority of hourly slots in the morning operated considerably more than 80 movements/hour. The PM peak surpassed the hourly movement constraint which meant that a proportion of all peak hour services were reallocated. The inter-peak was at 98 per cent of capacity after hourly services were capped at 80 movements/hour.

Peak Spreading Scenarios

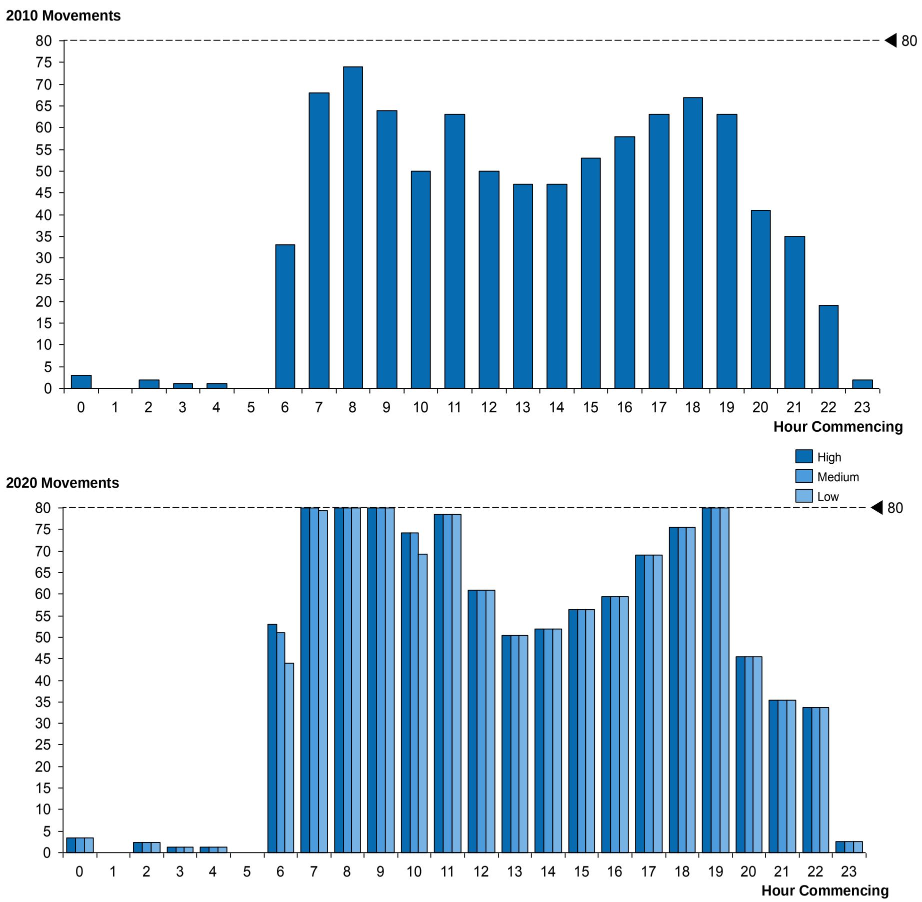
Focusing on the three scenarios, it can be observed that there are negligible differences in daily movement distribution between the High, Medium and Low cases for 2015 and 2020, but in 2035 the differences become more apparent.

Peak spreading and movement redistribution and/or suppression only occurs if movements exceed the planned capacity limit of 80/hour. In 2015, there are only four movements across the day which requires redistribution/suppression to a shoulder period and given that there are close to 1,000 movements across the day, a difference between the Low scenario and the other scenarios of four movements is negligible. The same applies to 2020 where only 12 movements out of nearly 1,100 needed redistribution.

In 2035, as more hours exceed the movement cap and by a larger magnitude, peak spreading and movement redistribution occurred more.

Figure 29 overleaf demonstrates that by 2035, Sydney (Kingsford-Smith) Airport operates near to full capacity.

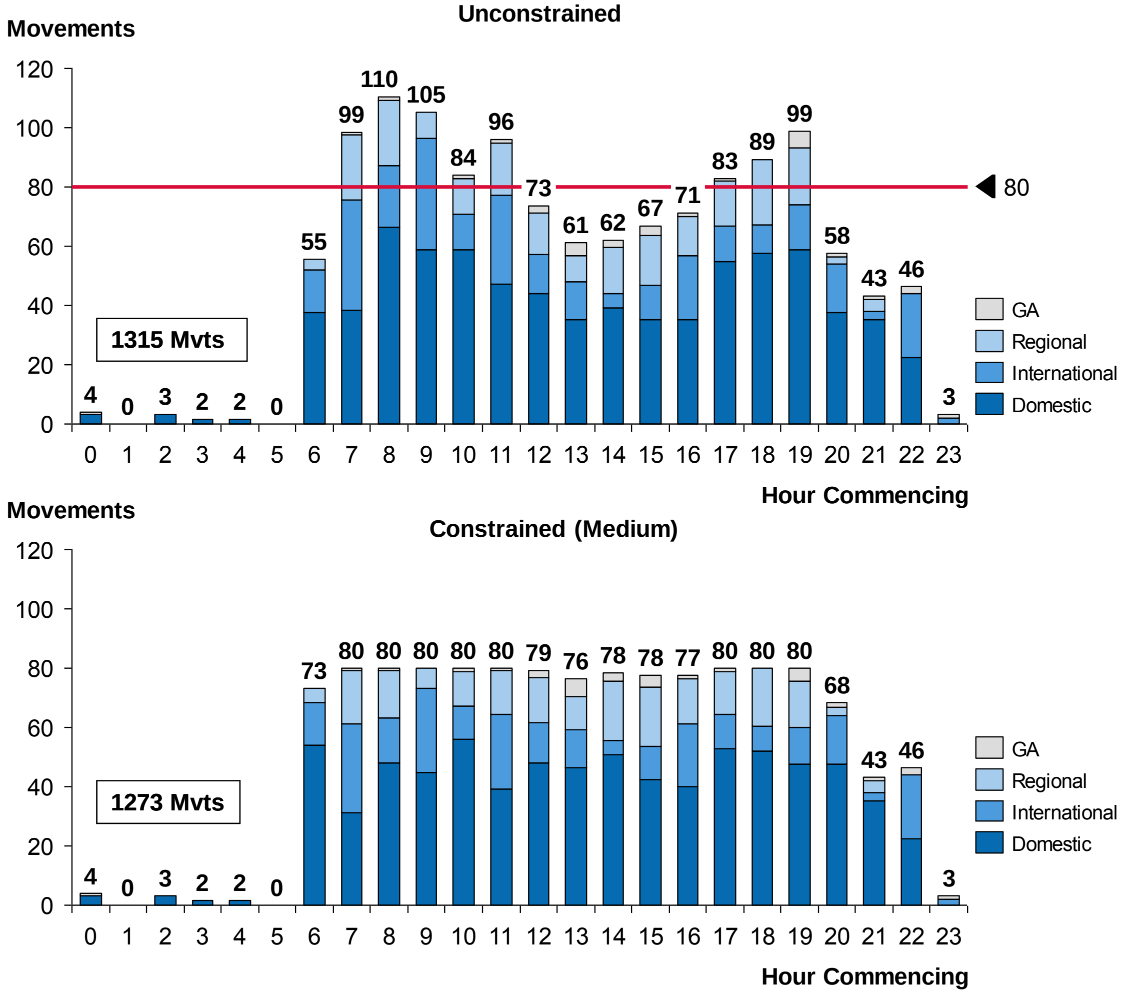
Figure 29 - Distribution of Movements Across the Day at Sydney (Kingsford-Smith) Airport for Each Forecast Year for Each Scenario, 2010, 2015, 2020 and 2035



Source: Booz & Company analysis

Figure 30 shows a comparison of the unconstrained and constrained forecasts across the forecast period up to 2035. In the unconstrained case, there are a total of 125 movements which exceed the 80 movements cap at various points across the day. In the constrained case (medium scenario), 83 of those movements are redistributed across hours where capacity exists, and 42 are suppressed. The 125 excess movements represent 9.5 per cent of the total daily movements.

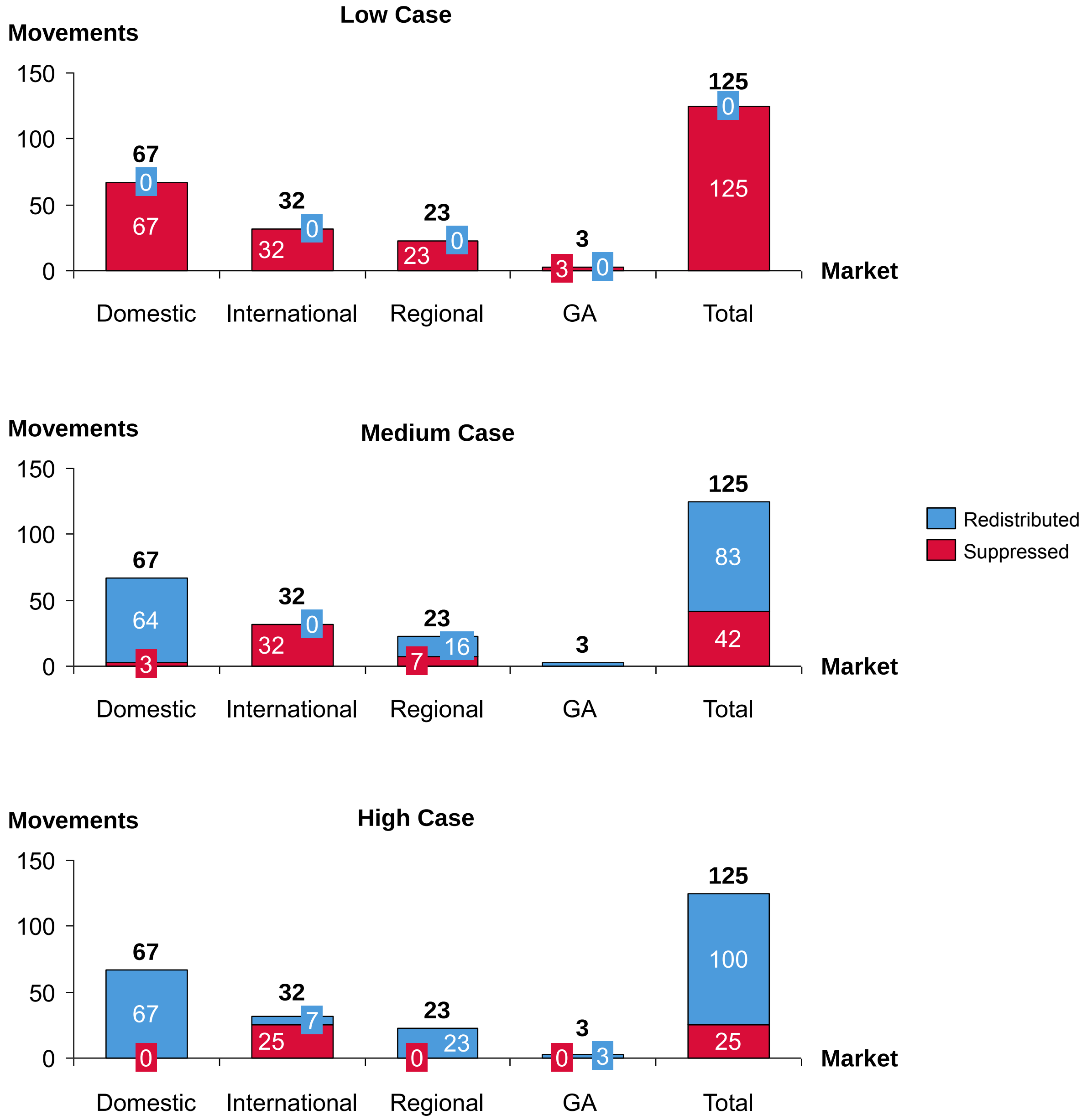
Figure 30 – Hourly Movements at Sydney (Kingsford-Smith) Airport in 2035: Constrained and Unconstrained (Medium Scenario)



Source: SRS Analyser, Booz & Company analysis

Figure 31 illustrates the redistribution and suppression levels of these 125 excess movements between the three scenarios. The low case suppresses all 125 movements and as a result has lower forecasts in the shoulder/inter-peak time slots. In the Medium and High case, all excess international movements were suppressed because these services are assumed to be reallocated to a different day with more capacity. The difference between the Medium and High case was 10 movements; these were suppressed in the Medium case and redistributed in the High case (described in Section 2.4).

Figure 31 – Sydney (Kingsford-Smith) Airport Redistribution and Suppression Scenarios for 2035

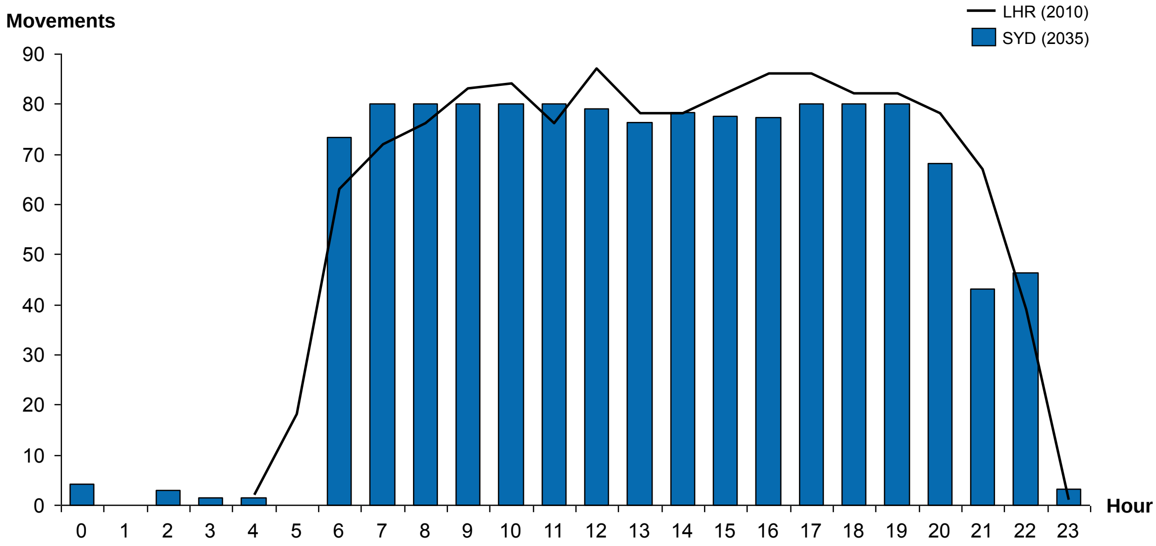


Source: SRS Analyser, Booz & Company analysis

3.2.1 Sense Check

Heathrow currently shows a relatively similar overall profile shape to the forecast profile for Sydney (Kingsford-Smith) Airport in 2035 as shown in Figure 32. Most operating hours at London Heathrow are operating at or close to maximum capacity of around 87 movements indicating that it may be possible for an airport to operate at close to full capacity.

Figure 32 – Comparison of Sydney 2035 Central Case Movement Profile and Heathrow's Current Profile



Source: SRS analyser, Booz & Company estimates

3.3 Detailed Analysis of the 'Medium Scenario' Focusing on Changes in Fleet Composition and Market Shares

This section ‗drills down' into the hourly forecasts of the Medium scenario to reveal changes in fleet mix and market composition across each hour slot.

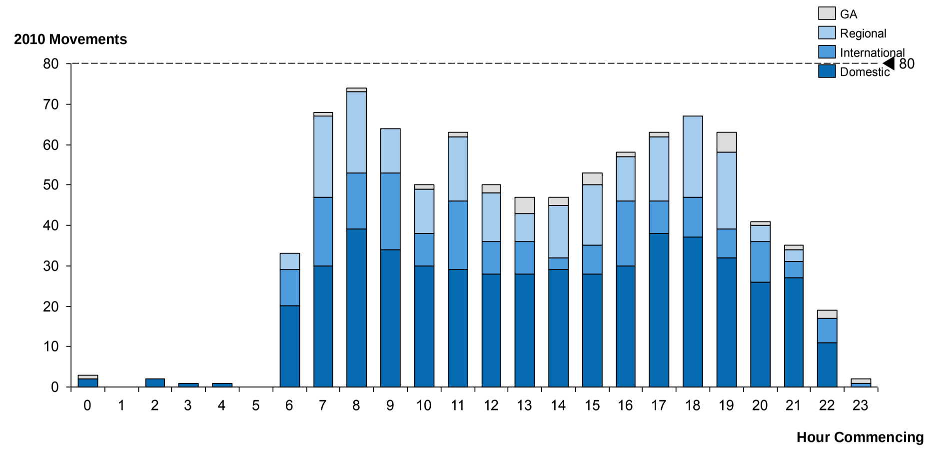
3.3.1 Growth in Movements Categorised by Market Type

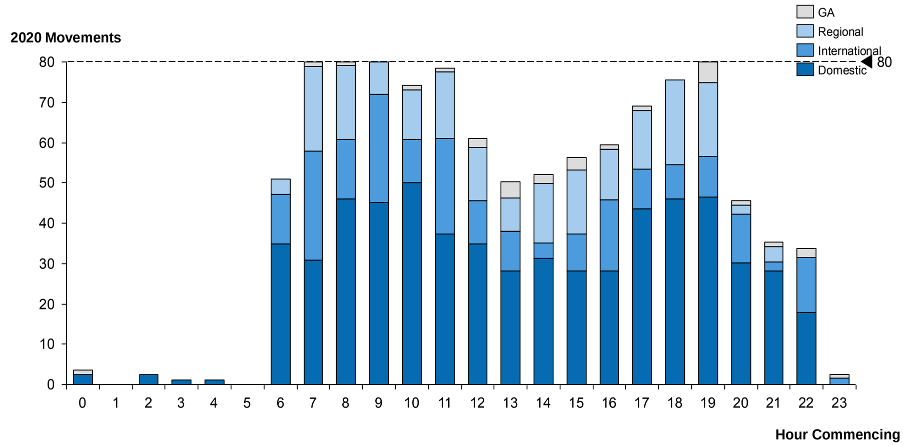
Different growth rates were applied to each market segment within each hour. Given that market share varies across each hour, different hours experience different overall growth rates. This can be observed in Figure 33.

It can be observed that in hours which reach full capacity, international movements experience a more subdued growth relative to other markets. This is because the peak spreading modelling completely suppresses international services based on the assumption that additional international movements are likely to not occur or be moved to a different day[5].

[5] *It should be noted that full suppression of international services exceeding the limit of 80 movements per hour on the planning day is an assumption which has been applied to the planning day analysis only. It is assumed that additional growth in international services is accommodated on other days. In particular, the annual forecast model developed by Booz & Company assumes that international services will continue to be accommodated as a priority over domestic services, given the higher yields associated with international services.*

Figure 33 - Market Type Distribution for Each Forecast Year at Sydney (Kingsford-Smith) Airport, 2010, 2015, 2020 and 2035 (Medium Case)





Source: Booz & Company analysis

3.3.2 *Growth in Movements Categorised by Aircraft Type*

By using the fleet composition assumptions and forecasts, changes in fleet composition were calculated on an hourly basis for the ‗planning day' across each of the market types.

The four graphs in Figure 34 depict the proportional changes across each operational hour. Figure 35 shows market type against aircraft type which provides insight into fleet composition within each market. Both sets of analysis include the impacts of ‗peak spreading' (constraining movements to 80/hour and redistributing/suppressing the excess).

Changes in fleet composition were determined through analysis of purchase orders from airlines operating out of Sydney (Kingsford-Smith) Airport and fleet retirement arrangements. The assumptions that are used to forecast aircraft type for each forecast year is described in *Section 2.2*.

For the current base year (2010), the majority of movements within each hour at Sydney (Kingsford-Smith) Airport consisted of Code C aircraft. Generally, there was a larger proportion of Code C movements outside of the peak hours, which corresponded to a relatively higher proportion of Code B movements in the peak. Given that business travel increases in the peak periods, this is an expected pattern as the majority of Code B movements are regional movements.

By 2015, all Code D movements were removed from the daily schedule and replaced by a combination of other aircraft. In the domestic market, Code D movements were replaced by Code C movements. In the international market, Code C movements were maintained at the same 2010 level for the Trans-Tasman routes. This was because smaller NZ ports cannot sustain larger craft such as Code E and Code F. The transition from Code B to Code C in the regional market coupled with Code C increases in the domestic market caused an increase in Code C.

The changes moving into 2020 are largely similar to changes in 2015. Growth in movements was mainly distributed across Codes C and E, and there was a further reduction in Code B movements. The distribution of aircraft type across the four markets generally remained constant. However, there was a large increase in Code E movements in the international market but this was partially offset by a decrease of Code C.

By 2035, Code C movements continued to grow strongly in the domestic and regional markets. Code C reduced further in the international market with these services kept in operation to fly to smaller airports. Whilst the international market was almost entirely dominated by Code E movements, the regional and domestic markets comprised mainly of Code C movements.

Across the forecast years, the changes in proportions of aircraft type in each market are a result of seat capacity evolving. In each market, it is assumed that smaller aircrafts are replaced by larger aircrafts with greater capacity[6].

[6] *This has been derived from research of aircraft purchase orders – see appendix A.*

Figure 34 - Proportions of Aircraft Type by Time of Day at Sydney (Kingsford-Smith) Airport, 2010, 2015, 2020 and 2035 (Medium Case)

Source: Booz & Company analysis

Figure 35 - Market Type and Aircraft Type Proportions at Sydney (Kingsford-Smith) Airport, 2010, 2015, 2020 and 2035 (Medium Case)

Source: Booz & Company analysis

3.4 Analysis of Average Capacity and Utilisation

Using the average movement capacities calculated in Section 2.5, the total number of seats available in each market on the ‗planning day' was calculated. This provided an estimate for the total supply of seats within each market. By cross analysing this with forecast passenger demand from the demand model, a high level assessment of utilisation was derived; this is shown in Table 12.

Table 12 - Sydney (Kingsford-Smith) Airport Forecast Utilisation of Seats 2010, 2015, 2020 and 2035

	2010	2015	2020	2035
Seats	149,200	175,000	199,000	276,000
Passengers	110,000	128,000	150,000	221,000
Utilisation	**74%**	**73%**	**75%**	**80%**

Source: Booz & Company analysis

Note: General Aviation has been excluded from this analysis

Utilisation of seats increased from the current estimate of 74 per cent to 80 per cent in 2035. The movement constraint has limited supply growth to a lower rate than passenger demand growth, thereby increasing the utilisation rate.

3.5 Shock Testing Aircraft Movement Forecasts

Further analysis was carried out to understand the impact of unexpected weather conditions at Sydney (Kingsford-Smith) Airport with the potential to only allow limited usage of one runway. This is to illustrate the flow on effects throughout the day and the time required for recovery if such an event occurred during the morning peak period.

Four hypothetical scenarios have been tested:

- Limit of 55 movements per hour for 2 hours in the morning peak (07:00 - 08:59); displaced flights have been modelled to shift to the next available slot where existing hourly services remain uninterrupted.
- Limit of 25 movements per hour for 2 hours in the morning peak (07:00 - 08:59); displaced flights have been modelled to shift to the next available slot where existing hourly services remain uninterrupted.
- Limit of 55 movements per hour for 2 hours in the morning peak (07:00 - 08:59); displaced flights are modelled to be shifted to the next hour, disrupting the hourly profile.
- Limit of 25 movements per hour for 2 hours in the morning peak (07:00 - 08:59); displaced flights are modelled to be shifted to the next hour, disrupting the hourly profile.

55 movement cap - existing hourly services remain uninterrupted

Table 13 and Figure 36 describe the impact on the daily schedule for each forecast year if aircraft movements are capped at 55 movements per hour for 2 hours in the morning peak. Displaced flights have been modelled to shift to the next available slot where existing hourly services remain *uninterrupted*.

Table 13 - The Impact of Limiting Movements at Sydney (Kingsford-Smith) Airport to 55/hr between 07:00-08:59
2010, 2015, 2020 and 2035

Year	Number of displaced movements	Number of delayed movements	Number of hours affected[1)]	Recovery time[2)]
2010	32	32	2	11:00
2015	47	47	4	13:00
2020	50	50	5	14:00
2035	50	50	13	22:00

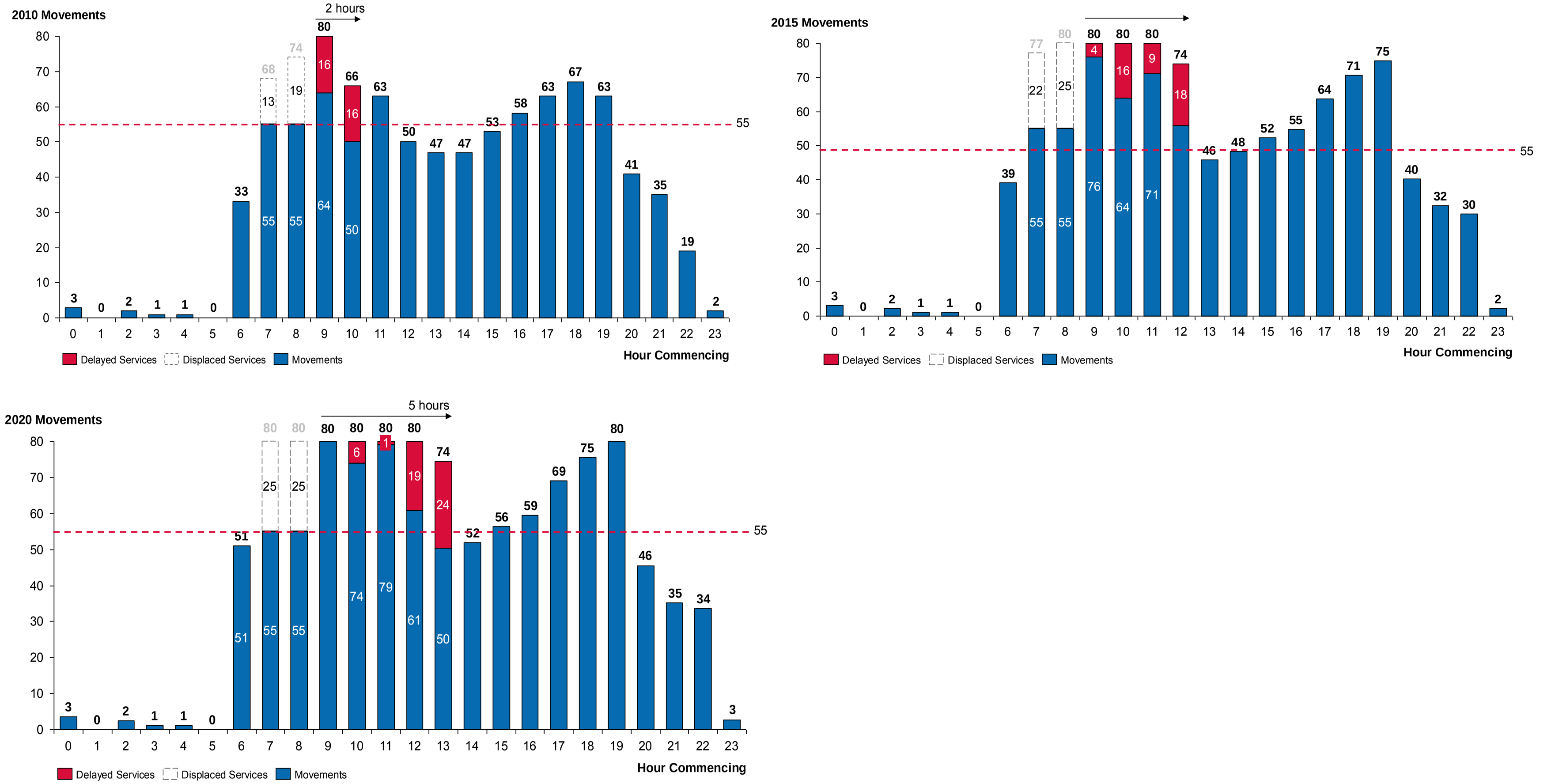
Note:
1) 'Number of hours affected' shows the total number of hours needed before all delayed movements can be recovered

2) The time where the normal level of movements/hour resumes without the need to allocate delayed flights at the next available hour

Source: Booz & Company analysis

The estimated impact of a 55 movement cap in the AM peak in 2035 appears very severe; 50 services would be delayed. Out of the 50 delayed movements, 38 will be displaced by up to 12-13 hours after scheduled departure time. Recovery times for the 2015 and 2020 forecast years are substantially less at 4 to 5 hours maximum.

Figure 36 - Limiting Sydney (Kingsford-Smith) Airport Movements to 55/hour between 07:00-08:59 and Displacing Surplus Services without Causing Delays in Shoulder Hours, 2010, 2015, 2020 and 2035 (Medium Case)



Source: Booz & Company analysis

25 movement cap- existing hourly services remain uninterrupted

Table 14 and Figure 37 describe the impact on the daily schedule for each forecast year if aircraft movements are capped at a hypothetical 25 movements per hour for 2 hours in the morning peak. Displaced flights have been modelled to shift to the next available slot where existing hourly services remain *uninterrupted*.

The forecast shows that if movements are reduced to 25 in the morning peak in 2035, 110 services will be affected. All displaced flights will be allocated to an available slot by 23:00, 15 hours after their scheduled departure. Only at 00:00 would the normal hourly movement profiles resume without delayed services needing to be allocated.

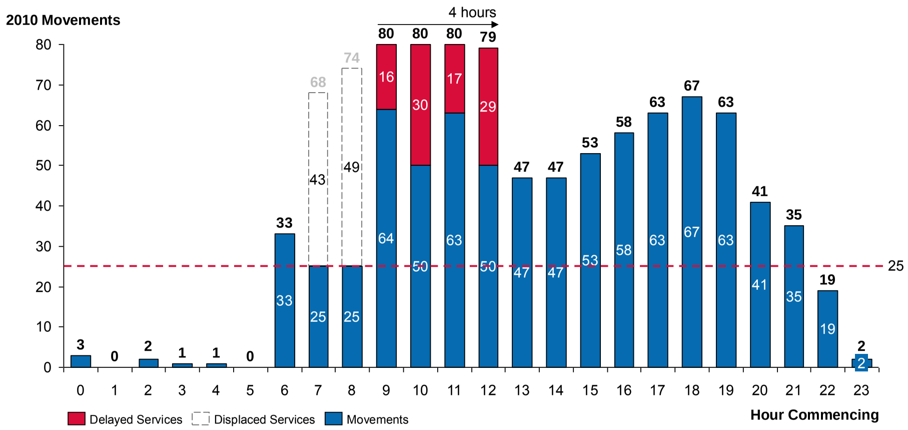
Table 14 - The Impact of Limiting Sydney (Kingsford-Smith) Airport Movements to 25/hr between 07:00-08:59 2010, 2015, 2020 and 2035

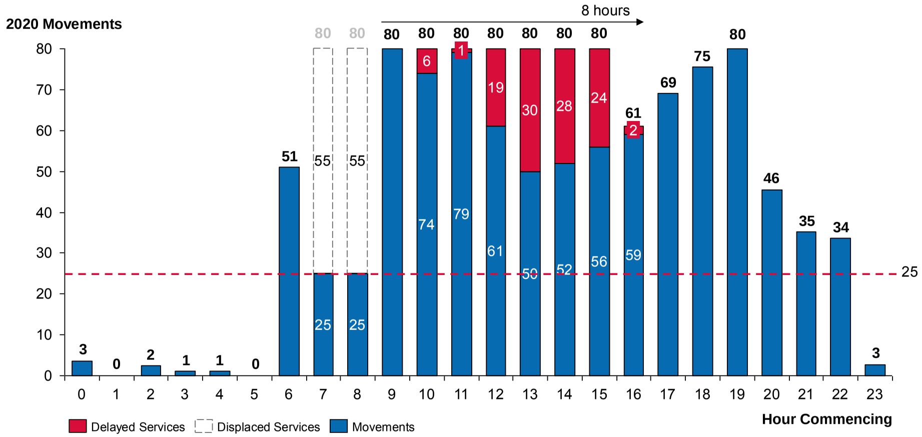
Year	Number of displaced movements	Number of delayed movements	Number of hours affected	Recovery time(1)
2010	92	92	4	13:00
2015	107	107	6	15:00
2020	110	110	8	17:00
2035	110	110	15	00:00

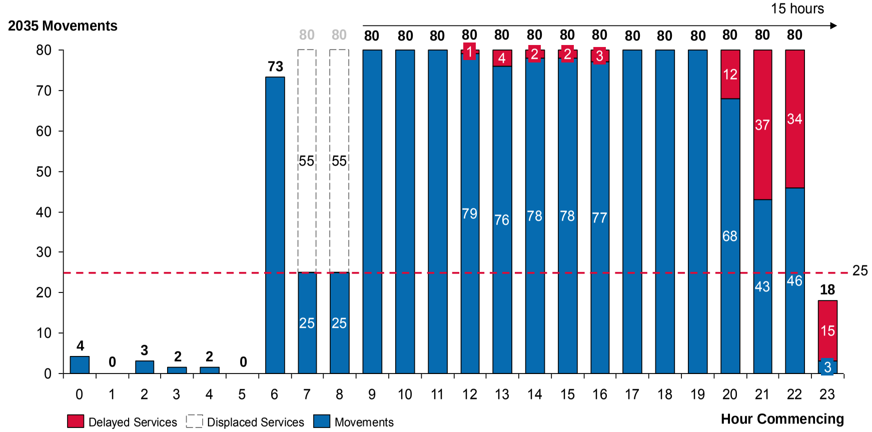
Note: (1)The time where the normal level of movements/hour resumes without the need to allocate delayed flights at the next available hour

Source: Booz & Company analysis

Figure 37 - Limiting Sydney (Kingsford-Smith) Airport movements to 25/hour between 07:00-08:59 and displacing surplus services without causing delays in shoulder hours, 2010, 2015, 2020 and 2035 (Medium Case)







Source: Booz & Company analysis

55 movement cap - disrupting the hourly profile

Table 15 and Figure 38 illustrate the impact on the daily schedule for each forecast year if aircraft movements are capped at 55 movements per hour for 2 hours in the morning peak. Displaced flights will be shifted to the next hour, *disrupting* the hourly profile. If the reallocation of movements to the shoulder hour causes movements to exceed 80/hour, scheduled flights for the hourly profile receiving the delayed flights are moved to the next hour.

The model forecasts 50 delayed services in 2035 if these constraints are imposed which impacts all consequent hours for the majority of the day. Aside from those movements delayed in the AM peak as a result of the constraint, a further 556 movements are delayed by one hour to accommodate for ‗unexpected constraint'. At 21:00, 13 hours after the runway constraint of 55 movements per hour, all delayed flights would be allocated to an available slot. At 22:00, the normal hourly movement profile would resume without the need to receive delayed services.

Table 15 - The Impact of Limiting Sydney (Kingsford-Smith) Airport Movements to 55/hr between 07:00-08:59 2010, 2015, 2020 and 2035

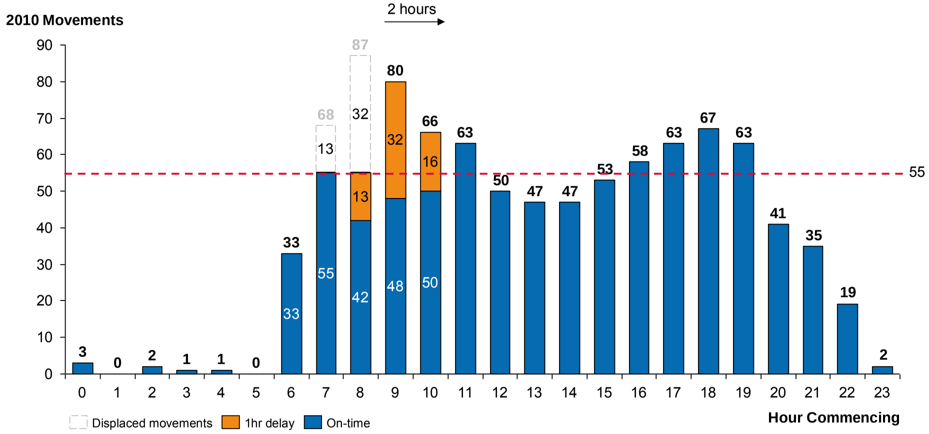
Year	Number of displaced movements	Number of movements delayed by 1hr[1]	Number of hours affected	Recovery time[(2)]
2010	45	48	2	11:00
2015	69	135	4	13:00
2020	75	211	5	14:00
2035	75	556	13	22:00

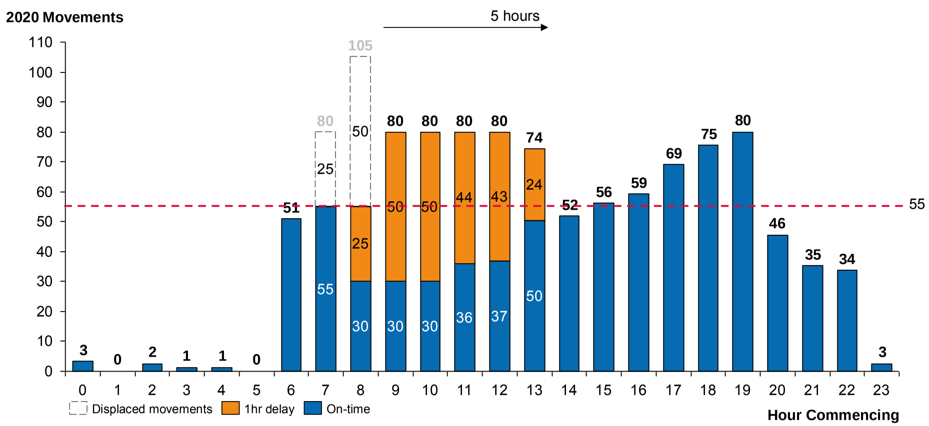
Note: (1)The time where the normal level of movements/hour resumes without the need to allocate delayed flights at the next available hour

(2)After 08:59 (when the available runway slots resumed to 80 movements/hour)

Source: Booz & Company analysis

Figure 38 - Limiting Sydney (Kingsford-Smith) Airport movements to 55/hour between 07:00-08:59 and minimising the delay time of surplus services,
2010, 2015, 2020 and 2035 (Medium Case)





Source: Booz & Company analysis

25 movement cap - disrupting the hourly profile

Table 16 and Figure 39 describe the impact on the daily schedule for each forecast year if aircraft movements are capped at 25 movements per hour for 2 hours in the morning peak. Displaced flights are modelled to shift to the next hour, *disrupting* the hourly profile. If the reallocation of movements to the shoulder hour causes movements to exceed 80/hour, scheduled flights for the hourly profile receiving the delayed flights are moved to the next hour.

The effect of this lower movement constraint in 2035 causes 135 movements to be displaced from the AM peak and impact movements throughout the rest of the day. Aside from movements delayed between 07:00-08:59, 778 movements are delayed by one hour and 326 movements are delayed by two hours. All displaced flights are allocated to an available slot by 23:00, 15 hours after their scheduled departure. It is estimated that only at 00:00 (i.e. the following day) normal hourly movement profiles would resume without delayed services needing to be reallocated.

Table 16 - The Impact of Limiting Sydney (Kingsford-Smith) Airport Movements to 25/hr between 07:00-08:59
2010, 2015, 2020 and 2035

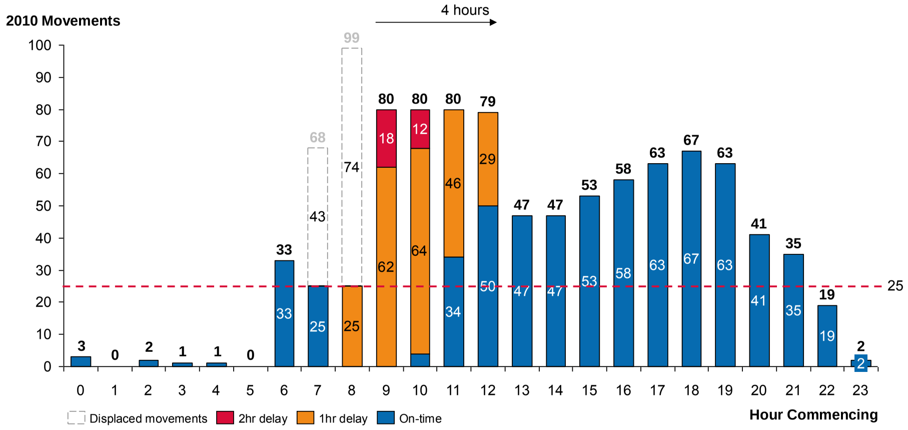
Year	Number of displaced movements	Number of movements delayed by 1hr[1]	Number of movements delayed by 2hrs	Number of hours affected	Recovery time[(2)]
2010	117	201	30	4	13:00
2015	130	308	84	6	15:00
2020	135	341	141	8	17:00
2035	135	778	326	15	00:00

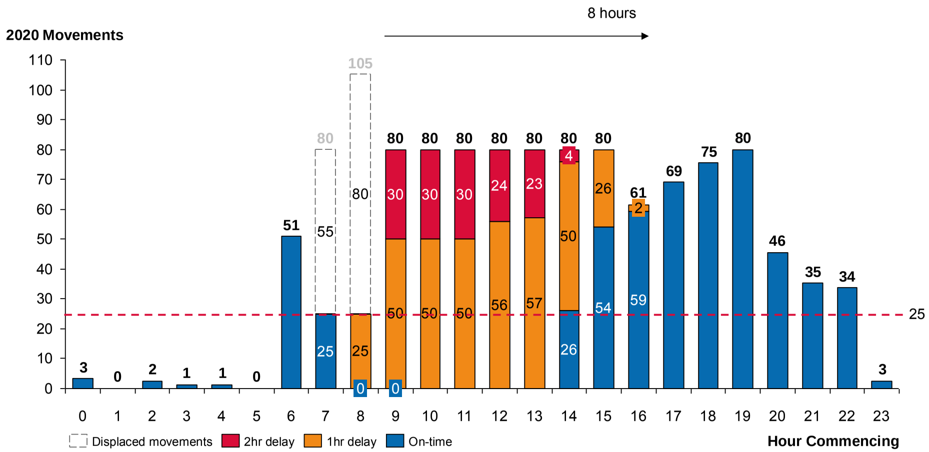
Note: (1)The time where the normal level of movements/hour resumes without the need to allocate delayed flights at the next available hour

(2) After 08:59 (when the available runway slots resumed to 80 movements/hour)

Source: Booz & Company analysis

Figure 39 - Limiting Sydney (Kingsford-Smith) Airport movements to 25/hour between 07:00-08:59 and minimising the delay time of surplus services, 2010, 2015, 2020 and 2035 (Medium Case)





Source: Booz & Company analysis

3.6 Increasing the hourly movement cap policy

This section provides an analysis of scenarios where the hourly movement cap is (hypothetically) increased from 80 per hour. Impacts on hourly movement profiles were captured for three additional scenarios:

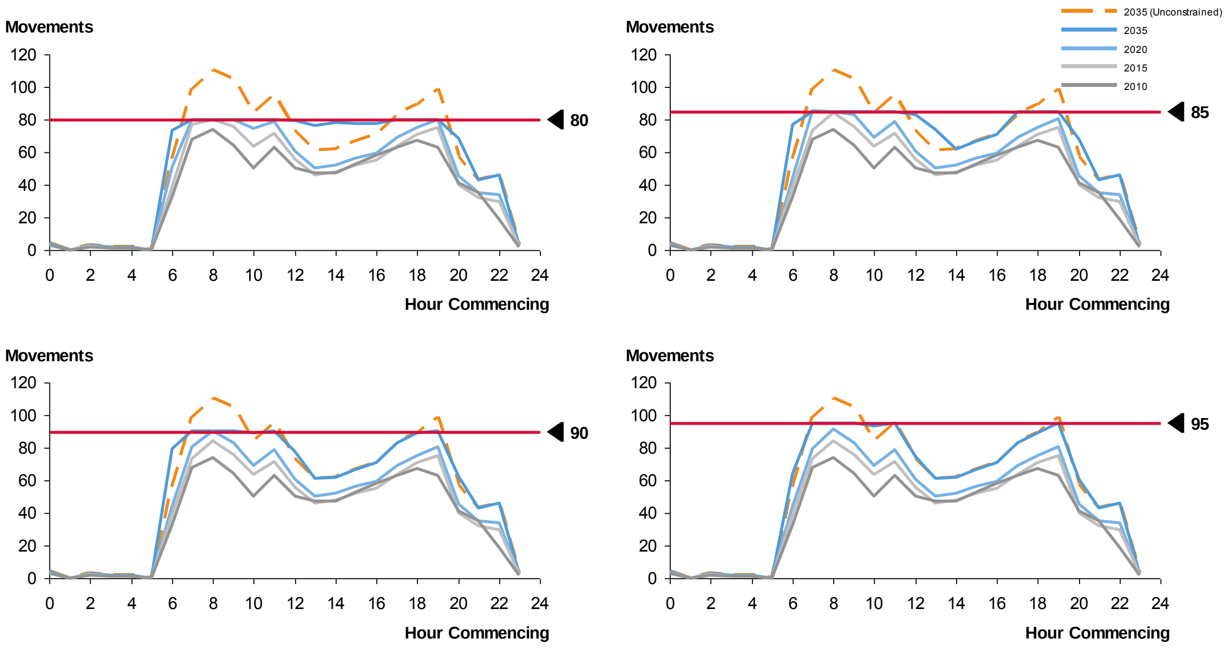
- 85 movements per hour
- 90 movements per hour
- 95 movements per hour

No consideration has been made on the ability of an airport to support these movements. This analysis is limited to a comparison conducted across the three redistribution/suppression scenarios; high, medium and low.

Medium Case

Figure 40 contains a graph for each of the four tested policy caps across each of the forecast years. It can be observed that in each case, generally the peak spreading impacts are negligible up until the 2035 forecast year. For the 80 movement cap case, the impacts of peak distribution are severe; all operational hours are at or close to 100 per cent utilisation of capacity. As the cap is increased to 85 and 90, less movements are redistributed to the shoulder peak and inter-peak periods and an increase in available capacity can be observed. In the case where the cap is increased to 95 movements per hour, peak distribution is minimal as the daily profile largely resembles that of the unconstrained case, apart from in the peak hours of 08:00 and 09:00.

Figure 40 - Daily profiles for 80, 85, 90 & 95 movements per hour caps across each forecast year (medium case)



Source: Booz & Company analysis

Table 17 below identifies the number of redistributed movements for each of the different capping scenarios for each year. There are four times as many movements redistributed in the 80 cap scenario than there are in the 95 cap scenario. Increasing the cap by 5 for 85 movement per hour extends the period before peak spreading is required by 5 years, increasing it to 95 movements per hour would extend it by 20 years.

Table 17 – Number of redistributed movements under each policy setting

Year	80 movements per hour	85 movements per hour	90 movements per hour	95 movements per hour
2015	4	0	0	0
2020	14	4	1	0
2035	83	67	44	25
Total	**101**	**71**	**45**	**25**

Note: The figures here presented might differ from other redistribution/suppression figures in this report due to rounding.
Source: Booz & Company analysis

Table 18 summarises the number of services that would be suppressed under the four capping scenarios for the medium case, which assumes 15 per cent suppression.

Table 18 – Number of suppressed movements under each policy setting (Medium Case)

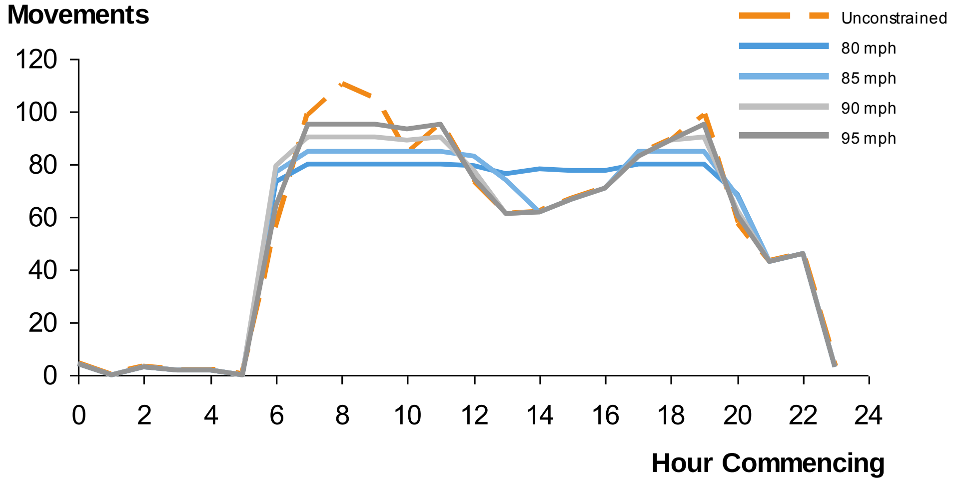
Year	80 movements per hour	85 movements per hour	90 movements per hour	95 movements per hour
2015	0	0	0	0
2020	2	1	0	0
2035	42	31	20	11
Total	**44**	**32**	**20**	**11**

Note: The figures here presented might differ from other redistribution/suppression figures in this report due to rounding.
Source: Booz & Company analysis

As shown in the table above, the number of suppressed services would decrease from 42 movements, under the 80 movements per hour scenario, to only 11 services by 2035 for the 95 movements per hour capping scenario. If the policy settings were modified to accommodate 90 services per hour, suppression would be delayed by 15 years, with 20 movements suppressed in 2035.

The extent of the differences in peak spreading in 2035 between the four capping scenarios and the unconstrained case for the medium suppression situation can be observed in Figure 41 below.

Figure 41 – Comparison of 2035 forecasts for different policy caps (Medium Case)

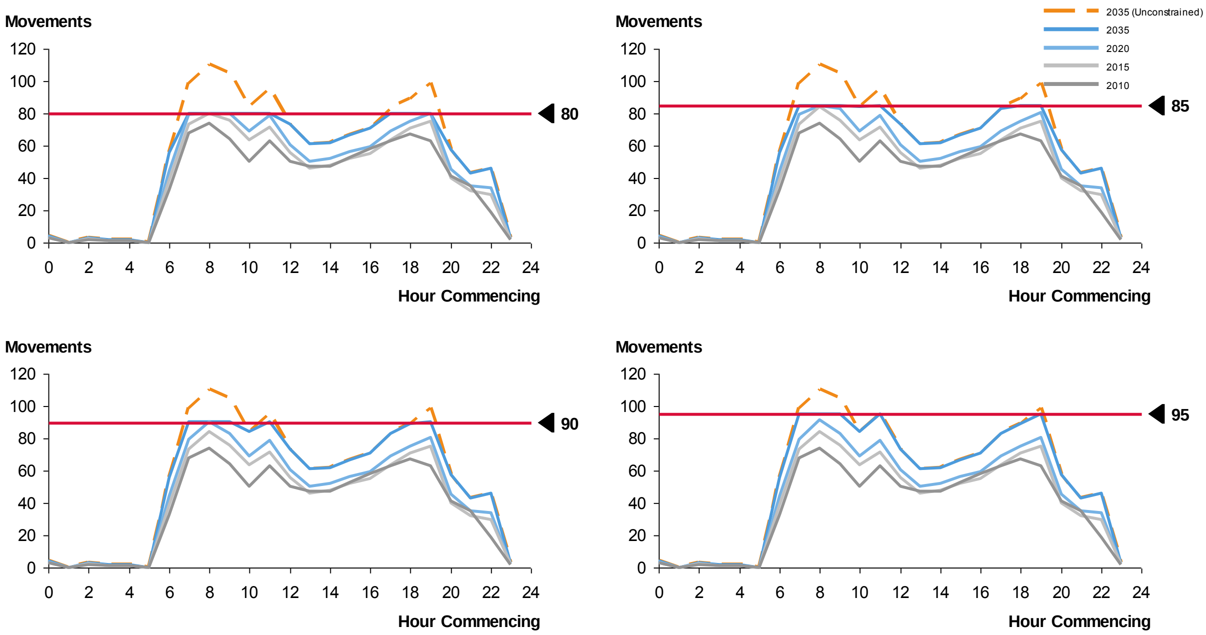


Source: Booz & Company analysis

Low Case

We can observe the impacts of enforcing 100 per cent suppression of all excess movements over each of the caps in Figure 42 below. Because there are no redistributions in this scenario, the daily movement profiles across each of the capping scenarios remain unchanged in hours where capacity is not reached. In the 95 and 90 cap scenarios, suppression does not occur until the 2035 forecast period at which point 33 and 58 movements are suppressed across the entire day. The 85 movement cap causes suppression of 87 movements whilst the current 80 movement cap sees 125 suppressions in 2035; this is respectively 6.7 per cent and 9.5 per cent of the total number of movements in the day.

Figure 42 - Daily profiles for 80, 85, 90 & 95 movements per hour caps across each forecast year (Low Case)



Source: Booz & Company analysis

Table 19 summarises the number of suppressed movements under the selected capping scenarios for the low case, which assumes 100 per cent suppression of services and no redistribution to different hours.

Table 19 – Number of Suppressed Movements under each Policy Setting (Low Case)

Year	80 movements per hour	85 movements per hour	90 movements per hour	95 movements per hour
2015	4	0	0	0
2020	14	7	2	0
2035	125	87	58	33
Total	**143**	**94**	**60**	**33**

Note: The figures here presented might differ from other redistribution/suppression figures in this report due to rounding.
Source: Booz & Company analysis

As shown above, under the policy cap of 80 movements per hour, it is assumed that four services will start being suppressed by 2015 with a total of 125 services to be suppressed by 2035. Suppression of movements would be delayed by 5 years if the current policy cap was lifted to 85 movements per hour.

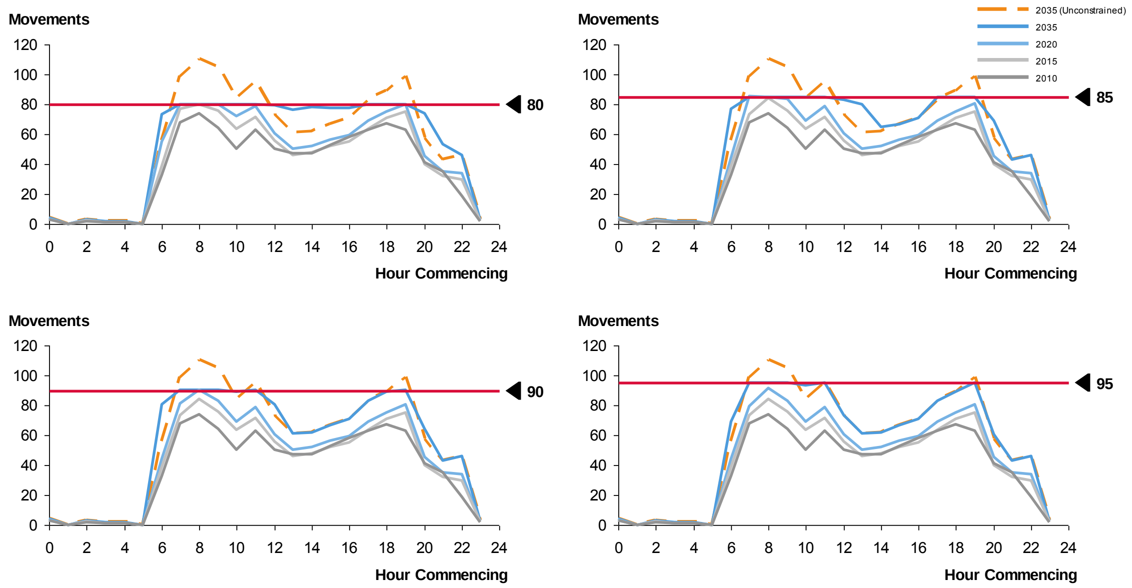
High Case

The high case scenario enforces 100 per cent redistribution of excess movements where there is capacity to do so (except in international movements which are 100 per cent suppressed). We can see from Figure 43 that this higher level of redistribution has a more significant peak spreading impact on less busy hours of the day. In the 80 cap case, a total of 2 per cent of movements are constrained (due to international market), the rest are redistributed across the day which results in an average of 94 per cent utilisation of slots across the operational hours of the day, with 8 hours at 100 per cent.

In the 85 cap case, in 2035, 1.5 per cent of total movements are suppressed and the rest are redistributed to other slots giving an average utilisation of 87 per cent. 6 of the hour slots operated at 100 per cent capacity. At a 90 movement per hour cap, only 1 per cent of total movements are suppressed and the average hourly utilisation level is 84 per cent.

If the cap is increased to 95 movements, average hourly utilisation falls to 80 per cent with only 5 of the hourly movements reaching 100 per cent. Table 20 below shows the number of redistributions for each cap scenario at each forecast year.

Figure 43 - Daily profiles for 80, 85, 90 & 95 movements per hour caps across each forecast year (High Case)



Source: Booz & Company analysis

Table 20 – Number of redistributed movements under each policy setting (High Case)

Year	80 movements per hour	85 movements per hour	90 movements per hour	95 movements per hour
2015	0	0	0	0
2020	14	7	2	0
2035	100	67	53	26
Total	**114**	**74**	**55**	**26**

Note: The figures here presented might differ from other redistribution/suppression figures in this report due to rounding.
Source: Booz & Company analysis

Table 22 shows the number of services suppressed under the high case, which assumes 100 per cent redistribution and suppression of movements only where the services cannot be accommodated.

Table 21 – Number of Suppressed Movements under each Policy Setting (High Case)

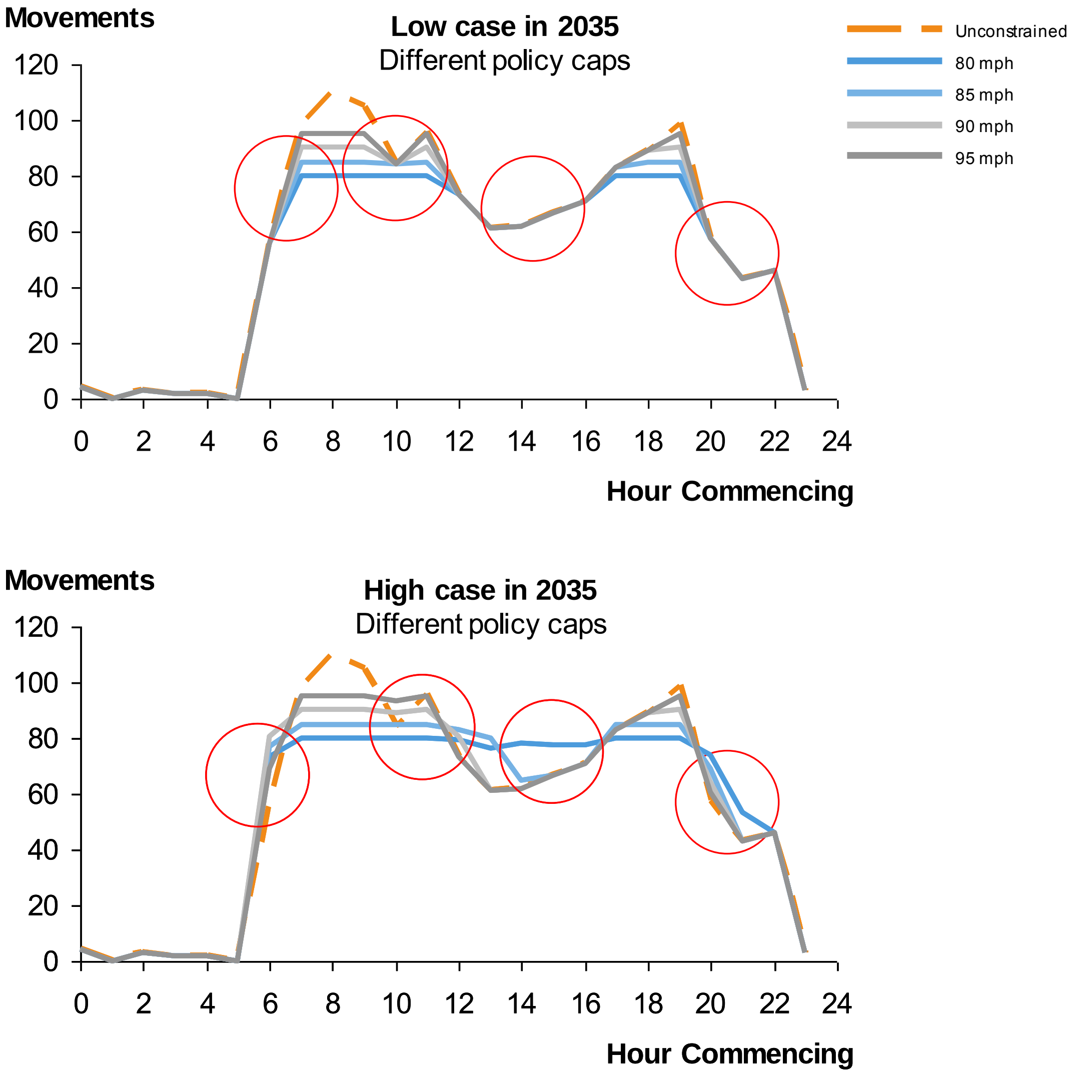
Year	80 movements per hour	85 movements per hour	90 movements per hour	95 movements per hour
2015	0	0	0	0
2020	0	0	0	0
2035	25	20	14	7
Total	**25**	**20**	**14**	**7**

Note: The figures here presented might differ from other redistribution/suppression figures in this report due to rounding.
Source: Booz & Company analysis

Suppression of services under each of the capping scenarios starts in 2035 ranging from a maximum of 25 services suppressed in 2035, under the current policy cap (i.e. assumed to be of 80 movements per hour) to only 7 services not being catered for in the same year under the 95 movements per hour policy setting.

Figure 44 below provides a comparison of the daily movement profiles for each of the policy caps in 2035 between the high and low cases. The graphs highlight the differences in and impacts of peak spreading in the two scenarios. In the low case, whilst the peaks reach maximum capacity, the shoulder peaks and inter peak periods operated at levels less than maximum capacity. This is case across each of the different policy cap settings. However in the high case, the impacts of peak spreading can be observed in the shoulder peaks, particularly in the 80 and 85 movement cap scenarios.

Figure 44 - Comparison between different policy caps between high and low case

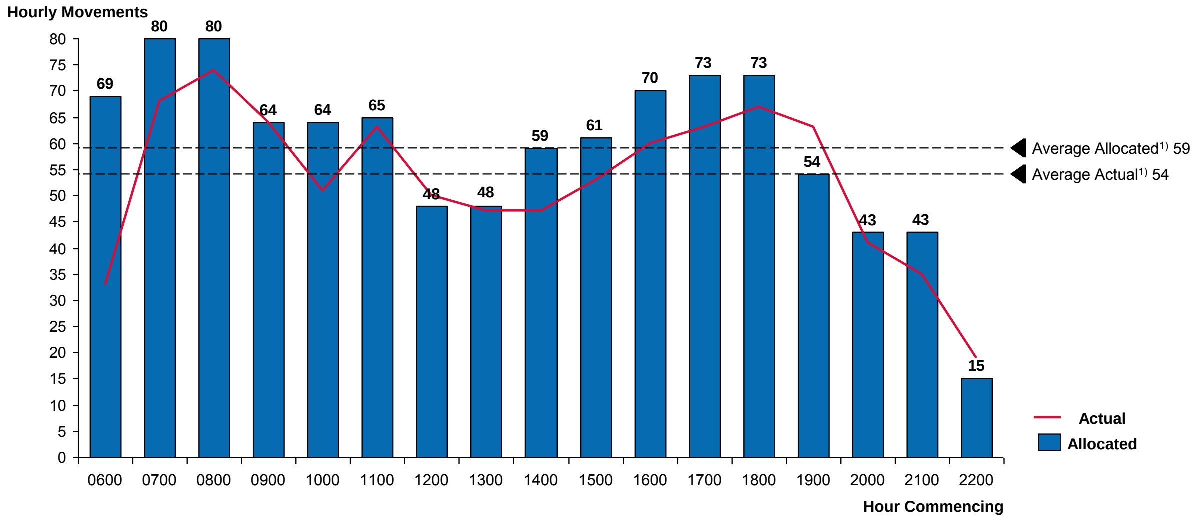


Source: Booz & Company analysis

3.7 Forecast Planning Day Profiles for Slot Allocations

A comparison of the number of slots allocated to the number of actual aircraft movements for the planning day (12 November 2010) shows 9 per cent of unused slots throughout the day. The percentage of unused slots is greatest either side of the AM peak period, between 0600-0700 and 1000-1100. The data also shows a consistent underutilisation of slots in the three hours leading up to the PM peak, between 1400-1700 as shown in Figure 48. The difference in profiles is the result of both off-schedule operations and services cancelled on the day of scheduled operations and services cancelled before the day of scheduled operations.

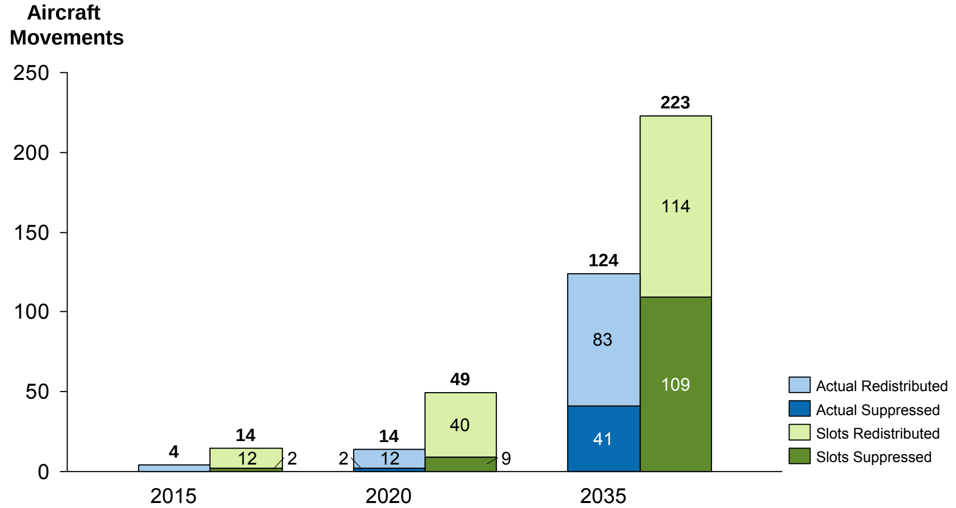
Figure 45 – Actual aircraft movements versus allocated slots for Planning Day



Note: 1) The hour commencing at 0600 is excluded from the comparison of allocated slots and slots actually used given the extent of the difference between the two measures on the planning day (i.e. 69 slots allocated and only 36 slots actually used)
Source: ASA movement data and ACA slot allocations

The difference in allocated slots and actual aircraft movements results in greater suppression of demand in forecast years. Whilst airlines may not use all of their allocated slots, they are able to hold the slots from one scheduling season to the next so long as they operate within the requirements to maintain each slot. The result is that the unused slots are not made available to other airlines to commence new services hence reducing the practical capacity of the airport and bringing forward the time at which Sydney (Kingsford-Smith) Airport reaches capacity. Figure 46 shows the resulting redistribution and suppression of demand from forecasting planning day profiles from slot allocations rather than actual aircraft movements for the 12 November 2010 planning day. Figure 47 shows the forecast planning day profiles based on slot allocations for the 12 November 2010.

Figure 46 – Redistribution and Suppression of Actual Movements and Allocated Slots

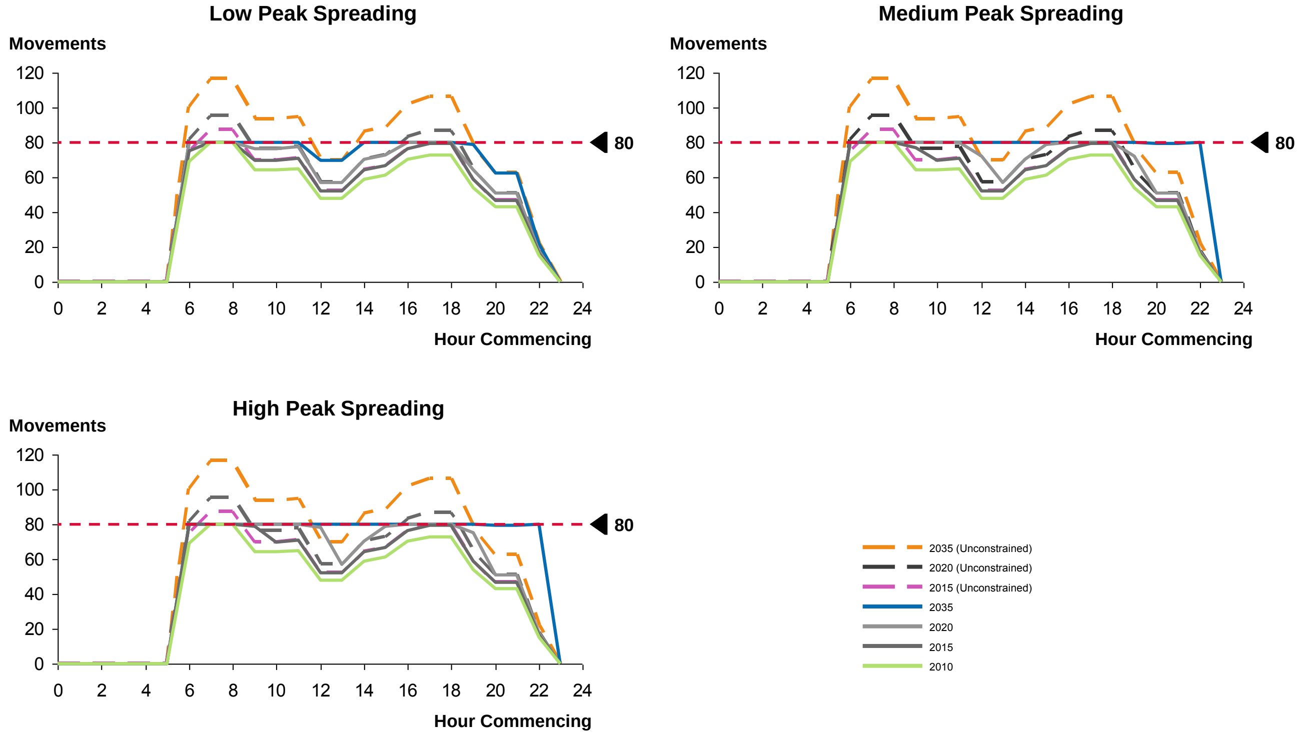


Note: The figures here presented might differ from other redistribution/suppression figures in this report due to rounding.

Source: Booz & Company forecasts based on 2010 ASA movement data and ACA slot allocations

Suppression of aircraft movements increases from 3.1 per cent to 7.4 per cent by 2035 for profiles built from allocated slots instead of actual movements. Unconstrained movements increased by 11.6 per cent from 1,315 to 1,468 and whilst redistribution increased by 37 per cent, not as many can be re-distributed. This, results in suppression of movements increasing by 266 per cent to 109 movements (compared to 41 movements). Figure 47 shows the forecast planning day profiles based on slot allocations for 12 November 2010.

Figure 47 – Planning Day Profiles for 2010, 2015, 2020 and 2035 based on allocated slots



Source: Booz & Company analysis

Figure 47 above illustrates the daily profiles for the years of 2010, 2015, 2020 and 2035, which were developed on the basis of allocated slots, for the low, medium and high cases under the constrained and unconstrained scenarios.

In 2015 and 2020, for the medium case, the difference between the unconstrained and constrained scenarios shows a total suppression of 2 and 9 services, respectively. The number of services subject to suppression is forecast to increase to 109 by 2035.

Similarly to what was observed for the daily schedules, developed on the basis of actual slots, those developed using allocated slots show that whilst the peaks reach maximum capacity the shoulder peaks and inter peak periods operated at levels less than maximum capacity for the years leading to 2035. As suggested in Figure 47, it is forecast that by 2035 the theoretical maximum capacity of 1360 would be reached under the medium and high peak spreading scenarios.

Appendix A – Fleet Mix Assumptions

The fleet mix was analysed and assumptions were made for the short, medium and long term fleet mix and the associated average seat capacity based on the approach outlined in Table 22.

Table 22 – Approach to Fleet Mix Assumptions

1 Base Data	2 Short Term Projections	3 Medium - Long term Projections
▪ Analysis of Airservices data to identify key airlines and aircraft types operating at KSA ▪ Analysis of ACAS fleet information for top airlines	▪ Analysis of aircraft orders for key airlines operating at KSA ▪ Projection of total fleet in 2015 ▪ Assumptions of fleet to be used at KSA	▪ Based on trends and forecasts by aircraft type from Airbus and Boeing

Source: Booz & Company

Base Data

Table 23 shows daily movements and average seat capacity by specific aircraft type on the 2010 planning day at Sydney (Kingsford-Smith) Airport. The average seat capacity for the 2010 planning day was 165.

Table 23 – Sydney (Kingsford-Smith) Airport Movements by Aircraft and Average Seat Capacity (2010)

Aircraft	Movements	Average Seat Capacity
A320	108	177
A321	9	221
A332	23	252
A333	19	301
A342	2	249
A343	4	273
A346	10	312
A388	4	364
B461	3	82
B463	3	110
B734	28	292
B737	46	144
B738	181	177
B744	33	320
B752	1	289
B762	2	216
B763	99	254
B772	16	324
B773	6	332
B77L	4	249
B77W	8	362
BE20	16	9
C404	1	10
CL60	1	50
DH8B	10	50

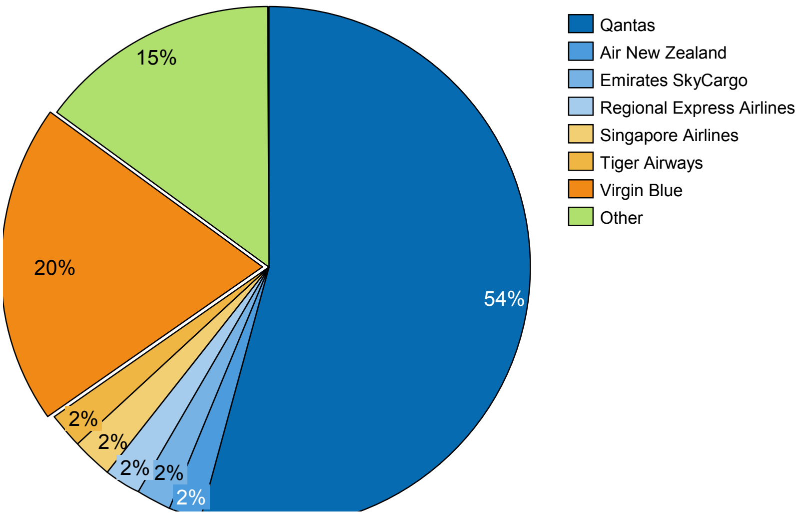
Aircraft	Movements	Average Seat Capacity
DH8C	38	50
DH8D	53	74
E170	31	78
E190	18	108
GLEX	3	19
GLF4	1	19
JS32	20	19
LJ35	1	8
MD11	2	297
PC12	2	8
SF34	94	37
SW4	4	19
Total	**904**	**165**

Note: this figure reflects average seat capacity
Source: Airservices Australia, SRS analyser, ATI, Booz & Company analysis

Short Term Projection

The short term projections to 2015 were based on fleet orders for the major airlines operating at Sydney (Kingsford-Smith) Airport. The top 10 airlines and all other Australian carriers were included in the analysis. The top 10 carriers made up around 85 per cent of planning day capacity and consisted of the Qantas group (including QantasLink and Jetstar), Virgin Australia Group (which includes Virgin Blue and V Australia), Tiger Airways Australia, Singapore Airlines, Air New Zealand, Emirates, Cathay Pacific, Regional Express, etc). Figure 48 shows the breakdown of capacity by carrier for the planning day (i.e. 12 November 2010).

Figure 48 - Share of Planning Day Seat Capacity by Airline at Sydney (Kingsford-Smith) Airport



Source: Airservices Australia, Booz & Company analysis

The fleet in service for these airlines was analysed and the types of aircraft that are used at Sydney (Kingsford-Smith) Airport were identified. From the information presented in Table 25, the average seat capacity for the fleet in service at Sydney (Kingsford-Smith) Airport for the major airlines was estimated to be 166. This is comparable to the average seat capacity (165) for the planning day which is represented in Table 23. The larger longer haul aircraft did not have as many rotations as lower capacity aircraft (such as regional services) therefore the weighted average seat capacity was lower. The average number of rotations by aircraft type is set out in Table 24.

Table 24 - Average Daily Rotations by Aircraft Code at Sydney (Kingsford-Smith) Airport

Aircraft Aerodrome Reference Code	2010
Code A	1.6
Code B	3.7
Code C	4.1
Code D	3.3
Code E	2.0
Code F	2.3
Helicopter	2.3
Unknown	2.0
Total	3.3

Source: Airservices Australia, Booz & Company analysis

Table 25 – Fleet Details for the Major Airlines by Total Seat Capacity Operating at Sydney (Kingsford-Smith) Airport (on 12 November 2010)

Operator	Aircraft	Seat Capacity	# In Service	#In Service at Sydney (Kingsford Smith) Airport[1)]
Air New Zealand	767-300ER	221	5	3
	A320-200	171	14	2
Cathay Pacific	A330-300	311	32	3
	A340-300	283	11	1
Emirates	777-300ER	364	54	1
	A380-800	489	15	1
Jetstar	A320-200	178	44	18
	A321-200	221	6	3
	A330-200	253	9	3
Qantas [2)]	737-400	292	17	9
	737-800	170	40	25
	747-400	304	20	5
	767-300ER	254	26	24
	A330-200	257	8	3
	A330-300	290	10	4
QantasLink	Dash 8 Q200	50	5	1
	Dash 8 Q300	50	15	5
	Dash 8 Q400	74	21	6
Regional Express	340B	37	45	19
Singapore Airlines	777-200	385	35	3
	777-300	332	12	3
Thai Airways	A340-600	267	6	4
Tiger Airways	A320-200	180	16	7
United Airlines	747-400	347	24	2
Virgin Blue	737-700	144	18	14
	737-800	182	34	27
	E-170	78	6	5
	E-190 LR/AR	108	15	3
Total		**166[3)]**	**563**	**204**

1) On the planning day (note that more long haul aircraft will be used at Sydney (Kingsford-Smith) Airport, however these may not operate daily)
2) Given no Qantas A380s were operating at Sydney (Kingsford-Smith) Airport on the planning day (12 November 2010), they have not been included in the fleet analysis which takes into account only aircraft calling at the port of interest on the selected planning day.
3) Number of aircraft operating at Sydney (Kingsford-Smith) Airport on 12 November 2010
Source: ACAS, SRS Analyser, CASA, Airservices Australia, Air Transport Intelligence, Booz & Company analysis

Each individual aircraft listed in the table above was allocated to a specific market based on the route served on the planning day. Table 26 sets out average seats per movement (i.e. weighted) and average seats per aircraft (i.e. straight average) by market for the 2010 planning day at Sydney (Kingsford-Smith) Airport.

Table 26 – 2010 Average Seats by Market at Sydney (Kingsford-Smith) Airport (as at 12 November 2010)

Market	Per Movement	Per Aircraft
Regional	45	69
Domestic	173	193
International	289	263
Average	165	166

Note: The number of rotations will impact the average seats per movement and therefore will differ from the seat capacity per aircraft.
Source: ACAS, SRS Analyser, CASA, Airservices Australia, Air Transport Intelligence, Booz & Company analysis

Fleet Orders[7]

The following sections look at the fleet development plans[8] for the key airlines operating at Sydney Airport.

3.7.1.1 Qantas

Qantas has an ageing fleet of 26 767-300s with an average age of 17.7 years[9]. The airline announced they will be replacing their fleet of 767-300s with 787-8 (15 on order) and 787-9s (20 on order) once these are delivered from mid-2012[10]. The fleet of 21 747-400 has an average age of 18.6 years and is likely to be replaced by 787s and Airbus A380s (14 on order, and 6 currently operating). Qantas' fleet of 17 737-400s have an average age of 18.5 years and are likely to be phased out in coming years and replaced with next generation 737-800s (28 on order).

In June 2011, Qantas announced cuts in capacity growth target which are likely to impact on the timescale of delivery for new aircraft and slow down fleet expansion and renewal.

3.7.1.2 Jetstar

Jetstar operates a young fleet of A320-200, A321-200 and A330-220 with an average age of 3.9 years. The airline currently has 15 787-900 aircraft on order to expand their network.

3.7.1.3 QantasLink

QantasLink currently has 7 Bombardier Dash 8 Q400 aircraft on order to expand their fleet. The airline operates 5 Dash 8 Q200s with an average age of 13.9 years. These are assumed to be phased out over the next 5 years.

3.7.1.4 Virgin Australia

Virgin Australia has 55 737-800s on order with expected delivery between mid-2011 and 2017 both replacing existing fleet as well as expansion of routes and service frequency.

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7 Note that this section is current as at November 2010

8 As at 12 November 2010

9 As at 12 November 2010

10 http://www.qantas.com.au/regions/dyn/au/publicaffairs/details?ArticleID=2010/jul10/4096

Virgin Blue has 3 order and 3 options for Embraer E190s to replace the fleet of E170s which will be phased out[11]. Virgin Australia also operates a young fleet of 5 777-300ERs.

3.7.1.5 Air New Zealand

Air New Zealand currently has a fleet of 15 737-300s with an average age of 12.7 years. This fleet is to be phased out and replaced by A320-200s (12 in service with a further 12 on order). Air New Zealand's fleet of 6 474-400s has an average age of 15.6 years. This is to be phased out and replaced by 777-300ERs (5 on order). The airline's fleet of 5 767-300ERs has an average age of 15.1 and is to be replaced by 787-9s (8 on order).

3.7.1.6 Emirates

Emirates has significant fleet expansion plans with their existing fleet of 153 aircraft estimated to reach 320 in 2018 and 400 in 2020. The airline is committed to maintaining a young fleet and therefore older aircraft are phased out. Emirates has 15 747-800F freighter aircraft on order to add to their fleet of 747-400ERF and 747-400Fs. The airline's fleet of 3 777-200 (14.4 years), 6 777-200ER (13 years), 29 A330-200 (9.6 years) and 8 A340-300 (13.5 years) are likely to be phased out and replaced by A350 aircraft (20 A350-100s and 50 A350-900s on order) once they are delivered. It is assumed that the aging fleet of 777-300s are likely to be replaced by 777-300ER aircraft (49 on order). Emirates has 75 A380-800s on order to add to their existing fleet of 15.

3.7.1.7 Cathay Pacific

Cathay Pacific's fleet of 747-200F and 747-400F freighters are likely to be phased out and replaced with 747-8Fs. The airline's fleet of 20 747-400s has an average age of 18.6 years and a fleet of 11 A340—300s with an average age of 13.4 years, it is assumed that these aircraft are likely to be phased out and replaced by A350 aircraft (30 on order). It is assumed that the ageing fleet of 5 777-200s will be replaced with 777-300ERs (18 on order).

3.7.1.8 Singapore Airlines

Singapore Airlines has large orders of 20 787-9, 20 A350-900s and 9 A380-800s and 4 A330-300s to expand their already large fleet of 110 aircraft. It is likely that the fleet of 8 aging 747-400s will eventually be retired and replaced by new aircraft.

3.7.1.9 Tiger Airways Australia

Tiger Airways Australia currently operates a fleet of 9 A320-200s. The parent company Tiger Airways has 50 A320-200s on order, however it is unclear how many will be allocated to Tiger Airways Australia.

3.7.1.10 Other

It was assumed that all other airlines maintain a fleet comparable to that currently in service. A detailed summary of fleet renewal assumptions is shown below.

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[11] *http://australianaviation.com.au/2010/08/a330s-etihad-alliance-for-virgin-blue-as-profit-meets-expectations/*

2015 Fleet Assumptions

Fleet mix assumptions at KSA for 2015 airline were based on the assumption that current fleet orders by airlines would be delivered over the next 5 years. Furthermore, it was assumed the proportionate share of an airline's fleet operating at Sydney airport remained constant. The fleet mix assumptions for 2015 for major airlines operating at KSA are shown in Table 27.

Table 27 – Projected Fleet Details for Major Airlines Operating at Sydney (Kingsford-Smith) Airport in 2015

Operator	Aircraft	# In Service	#In Service at KSA[1)]
Air New Zealand	767-300ER	5	3
	A320-200	26	4
Cathay Pacific	A330-300	52	5
	A340-300	11	1
Emirates	777-300ER	101	1
	A380-800	62	4
Jetstar	A320-200	88	36
	A321-200	6	3
	A330-200	9	3
Qantas	737-400	17	9
	737-800	62	39
	747-400/A380-800[2)]	20/20	5
	767-300ER	26	24
	A330-200	8	3
	A330-300	10	4
QantasLink	Dash 8 Q200	5	1
	Dash 8 Q300	15	5
	Dash 8 Q400	27	6
Regional Express	340B	45	19
Singapore Airlines	777-200	35	3
	777-300	12	3
Thai Airways	A340-600	6	4
Tiger Airways	A320-200	59	7
United Airlines	747-400	24	2
Virgin Australia	737-700	18	14
	737-800	34	27
	E-170	6	5
	E-190 LR/AR	15	3
Total		**804**	**243**

Note: The analysis above is purely illustrative. It has been developed as an input to our planning day forecast and has no bearing on the annual aircraft movement forecast. Fleet changes/replacement plans may have changed since the time the analysis has been undertaken.

A350 aircraft are due to enter service from late 2013. For the purposes of this analysis it has been assumed that the aircraft currently on order will be in operation by 2015, however the delivery schedule may extend past this date.

1) Number of aircraft assumed to operate at Sydney (Kingsford-Smith) Airport (based on proportionate share of airlines' aircraft operating on 12 November 2010)

2) It should be noted that the table above has taken into account Qantas asset replacement program, which sees the 747 series aircraft in the process of being replaced with the newly acquired Airbus A380-800s, which are similar in seating capacity.

Source: Booz & Company analysis

The short term fleet analysis revealed an increase from 204 aircraft in 2010 to 243[12] potential aircraft operating at Sydney (Kingsford-Smith) Airport in 2015. Furthermore, Table 28 shows that the average size of aircraft operating at Sydney (Kingsford-Smith) Airport is estimated to increase from 166 in 2010 to 174 in 2015, representing an increase of 8 seats per aircraft.

Table 28 – 2015 Average Seats by Market at Sydney (Kingsford-Smith) Airport

Market	2010	2015	2010	2015
	Per Aircraft(1)		Per Movement(1)	
Regional	69	70	45	50
Domestic	193	195	173	180
International	263	281	289	301
Average	166	174	165	179

Note: (1) The number of rotations will impact the average seats per movement and therefore will differ from the seat capacity per aircraft.
Source: ACAS, SRS Analyser, CASA, Airservices Australia, Air Transport Intelligence, Booz & Company analysis

Categorising the aircraft fleet listed in Table 27 by aerodrome reference codes, we are able to determine the number of aircraft by type operating at Sydney (Kingsford-Smith) Airport. Aircraft categories Code B and E will see little change, Code D aircraft, consisting of Boeing 767s, are assumed to retire completely from service, with Code C and especially Code F experiencing significant growth in aircraft numbers as shown in Table 29.

Table 29 - Number of Aircraft by Type operating at Sydney (Kingsford-Smith) Airport for Key Airlines

Aircraft Code	2010	2015	CAGR
Code B	19	19	0.0%
Code C	125	159	4.9%
Code D	27	27	0.0%
Code E	32	34	1.2%
Code F	1	4	32.0%
Grand Total	204	243	3.6%

Source: ACAS, Airservices Australia, Booz & Company analysis.

The compound average annual growth rates (CAGRs) by aircraft code from Table 29 were applied to the number of aircraft in service at Sydney (Kingsford-Smith) Airport in 2010 and adjusted for the number of daily rotations (see Table 24) to estimate the share of aircraft movements for 2015. The share of aircraft movements by aerodrome reference code is outlined in Table 30.

[12] *This is likely to be an overestimate since stronger growth is likely to be experienced in alternative, less constrained markets. However this approach will provide an indication of the mix of aircraft likely to be used at Sydney (Kingsford-Smith) Airport.*

Table 30 – Estimated Share of Aircraft Movements at Sydney (Kingsford-Smith) Airport (2010 and 2015) by Aerodrome Code

Aircraft Aerodrome Reference Code	2010	2015
Code A	0%	0%
Code B	15%	9%
Code C	59%	63%
Code D	12%	0%
Code E	14%	25%
Code F	0%	2%
Total	100%	100%

Source: Airservices Australia, Booz & Company analysis

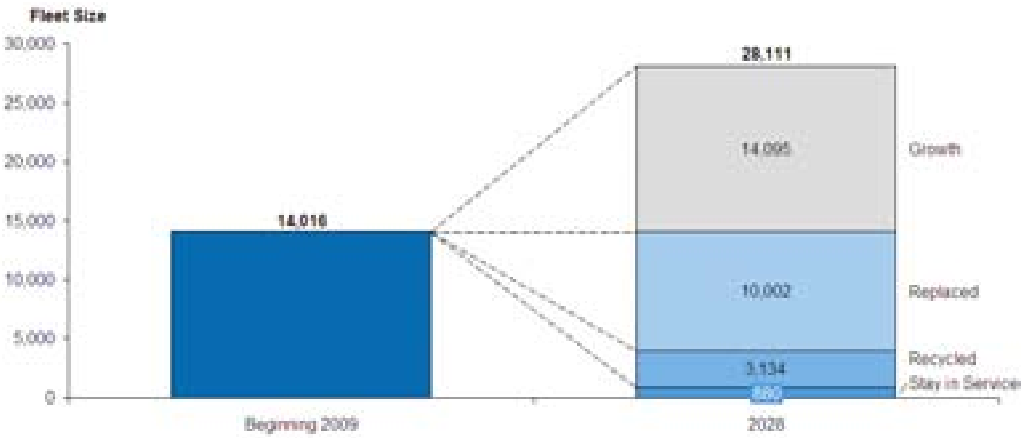
Medium - Long Term Projections

For fleet projections from 2020-2035, market outlook and forecasts from Boeing and Airbus were used.

Understanding of Market Outlook and Forecast

The Airbus forecast indicates there will be demand for 24,097 (86 per cent) passenger aircraft in the next two decades. A doubling of the global fleet with 14,095 (50 per cent) new aircraft resulting from natural growth and 10,002 aircraft (33 per cent) will be direct replacement of existing aircraft. This is shown in Figure 49.

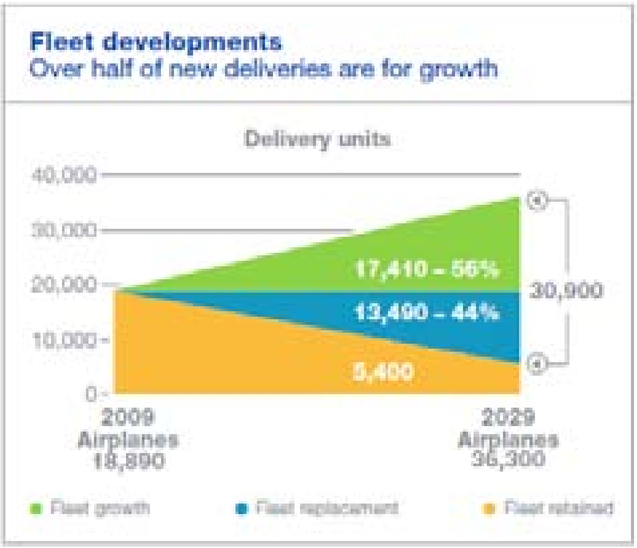
Figure 49- Global Fleet Size and Development 2009 - 2028



Source: Airbus Global Market Forecast 2009-2028

On the other hand, as indicated in Figure 50, Boeing's forecast provides a more optimistic outlook on fleet developments in the next decade. The forecast suggests there will be demand for 30,900 (85 per cent) new aircraft, replacing some 13,490 (44 per cent of existing aircraft and 17,410 (55 per cent) of the global fleet resulting from market growth.

Figure 50- Boeing Fleet Development 2009 - 2029

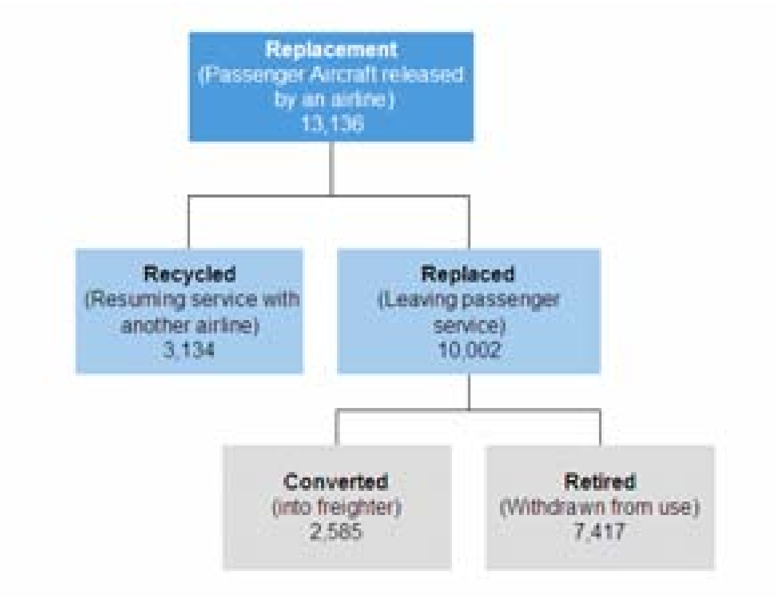


Source: Boeing Current Market Outlook 2010-2029

Both forecasts estimate the 2029 fleet to roughly be an 85 per cent/15 per cent split between new and remaining 2009 aircraft. This suggests there are more market pressures for airlines to retire their existing fleet earlier and upgrade to higher capacity, more fuel efficient aircraft.

Figure 51 illustrates the options for replacing passenger aircraft. Unless completely withdrawn from use, airliners are likely to retire their fleet of aircraft to be either recycled/re-used by another airline or leave passenger service as converted freighters. Airbus forecast indicate half of the existing fleet will completely retire from service by 2028.

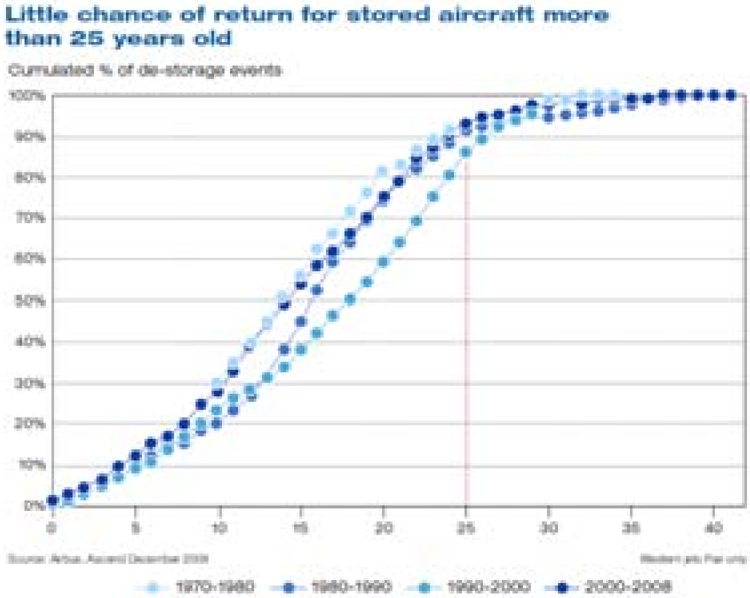
Figure 51- Airbus Fleet Replacement Plans



Source: Airbus Global Market Forecast 2009-2028

Analysis by Airbus (refer Figure 52) suggests the average retirement phase of an aircraft typically begins at year 15 and becomes dramatically more likely after year 20, with close to 0 per cent returning to service after year 25.

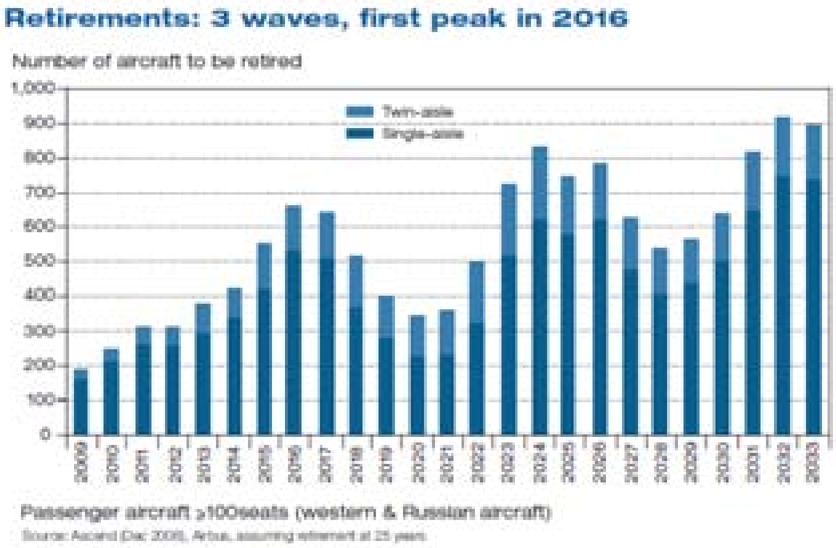
Figure 52 – Airbus Retirement Age



Source: Airbus Global Market Forecast 2009-2028

Historically aircraft manufacturers have experienced periods of high aircraft deliveries, resulting in peak and troughs of aircraft retirement numbers. Furthermore, assuming a retirement age of 25 years the industry will be entering a new period of increased retirement over the next six years, projecting 3 waves of peak and troughs over the next 2 decades as illustrated in Figure 53.

Figure 53- Fleet Retirement Assumptions



Source: Airbus Global Market Forecast 2009-2028

Forecast Methodology

The methodology applied to project aircraft fleet mix at Sydney (Kingsford-Smith) Airport in 2020 and 2035 is as follows:

- Use 2015 Sydney (Kingsford-Smith) Airport fleet projections as baseline
- Estimate share of aircraft by aircraft family at Sydney (Kingsford-Smith) Airport in 2035 using Boeing and Airbus long term fleet projections as a reference
- Interpolate 2020 mix based on 2015 and 2035 fleet mix assumptions
- Apply assumptions on average rotations to estimate number of movements by aircraft type
- Calculate assumed share of aircraft movements for 2015 and 2035 at Sydney (Kingsford-Smith) Airport.

Boeing Oceania Projection

Boeing project an increase in Oceania fleet from 420 aircraft in 2009 to 920 aircraft in 2029, representing an average annual increase of 4.0 per cent. The projections by aircraft family are summarised in Table 31.

Table 31 – Boeing Projections for Oceania Fleet 2009 to 2029

Aircraft Family	Typical Code	2009 Fleet	2029 Fleet	CAGR 2009 2029
Regional	Code B	20	10	-3.4%
Single Aisle	Code C	280	620	4.1%
Twin Aisle	Code E	80	250	5.9%
Large	Code F	40	40	0.0%
Total		**420**	**920**	**4.0%**

Source: Boeing Current Market Outlook 2010-2029

Boeing‘s figures indicate declining growth in regional aircraft and zero growth in large aircraft in Oceania over the next two decades. Suggesting over time there will be declining market share of large aircraft and an increasing share of single and twin aisle aircraft.

Contrasting Boeing and Airbus perspective on large aircraft

Whilst both Airbus and Boeing project growth in global passenger aircraft fleet over the next 20 years, with regards to large aircraft Boeing projects orders for new large aircraft to reach 1,089 representing a 3 per cent market share, compared to Airbus‘s figure of 1,318 representing a 5.5 per cent market share. This is shown in Table 32 and Table 33.

Table 32 – Boeing Projection of Global Aircraft Market in 2029

Aircraft Family	Aerodrome Code	Fleet 2029	Market Share
Regional	Code B	2,178	6.0%
Single Aisle	Code C	24,684	68.0%
Twin Aisle	Code E	8,349	23.0%
Large	Code F	1,089	3.0%
Total		**36,300**	**100.0%**

Source: Boeing Current Market Outlook 2010-2029

Table 33– Airbus Projection of Global New Passenger Aircraft Deliveries for 2009-2028

Aircraft Family	Aerodrome Code	New Aircraft 2009 2028	Share
Single Aisle	Code C	16,977	70.5%
Twin Aisle	Code E	4,097	17.0%
Intermediate Twin Aisle	Code E	1,705	7.1%
Very Large	Code F	1,318	5.5%
Total		**24,097**	**100.0%**

Source: Airbus Global Market Forecast 2009-2028

Long Term Market Share Projections for Sydney (Kingsford-Smith) Airport

We have determined the mix of aircraft for 2035 based on a combination of Boeing and Airbus long term projections and maintaining a constant number of Code A aircraft and Helicopters. The 2020 market share was interpolated based on the 2015 and 2035 assumptions. These assumptions are summarised in Table 34.

Table 34 – Forecast Share of Aircraft at Sydney (Kingsford-Smith) Airport

Aircraft Code	2010	2015	2020	2035
Code A	3%	2%	2%	1%
Code B	13%	8%	8%	6%
Code C	49%	59%	61%	66%
Code D	9%	0%	0%	0%
Code E	24%	26%	25%	23%
Code F	2%	4%	4%	4%
Helicopter	1%	1%	1%	0%
Unknown	0%	0%	0%	0%
Total	**100%**	**100%**	**100%**	**100%**

Note: Figures may not add to 100% due to rounding
Source: Booz & Company analysis

Summary of Assumptions

Table 35 sets out the fleet mix assumptions for the planning day at Sydney (Kingsford-Smith) Airport.

Table 35 – Forecast Share of Aircraft Movements at Sydney (Kingsford-Smith) Airport

Aircraft Aerodrome Reference Code	2010	2015[1)]	2020	2035
Code A	0%	0%	0%	0%
Code B	15%	9%	8%	7%
Code C	59%	63%	62%	61%
Code D	12%	0%	0%	0%
Code E	14%	25%	27%	28%
Code F	0%	2%	2%	3%
Helicopter	0%	0%	0%	0%
Unknown	0%	0%	0%	0%
Total	100.0%	100.0%	100.0%	100.0%

Source: Airservices Australia, ACAS, Booz & Company analysis

Seats per movement were assumed to increase from 165 seats per movement on average for the 2010 planning day to 220 in 2035, representing an increase of 33 per cent over the 25 year period. These assumptions are set out in Table 36.

Table 36 – Average Seat per Movement Assumptions for the Planning Day at Sydney (Kingsford-Smith) Airport

Seats per Movement	2010	2015	2020	2035
Domestic	173	180	188	211
International	289	301	314	352
Regional	45	50	55	72
Total	165	179	189	220

Source: Booz & Company analysis.

Effect of forecast demand on the Long Term Operating Plan for Sydney (Kingsford-Smith) Airport

B4

AIRSERVICES AUSTRALIA

JOINT STUDY ON AVIATION CAPACITY FOR THE SYDNEY REGION

AIRSERVICES AUSTRALIA

REPORT ON THE EFFECT OF FORECAST DEMAND ON THE LONG TERM OPERATING PLAN FOR SYDNEY (KINGSFORD-SMITH) AIRPORT

Executive Summary

As part of a joint Commonwealth and NSW State Government initiative to develop an Aviation Strategic Plan for the Sydney region, Airservices Australia has been requested to undertake analysis in relation to aviation capacity in the Sydney region. Specifically, the tasks undertaken in this report include:

- An analysis of the effect of forecast traffic demand on the Long Term Operating Plan for Sydney Airport.
- An analysis of the effect of forecast traffic demand on airborne and ground delays.

This report is not intended for circulation beyond the Department of Infrastructure and Transport and the Joint Study Steering Committee.

Airservices provides no warranty or guarantee as to the accuracy or completeness of this report. Readers should rely on their own enquiries and seek independent advice.

Airservices makes no representation, warranty or guarantee concerning any findings in this report. Any findings are to be treated as indicative only, and based on Airservices limited role in the overall study.

This report represents the view of Airservices and not the view of any individual person.

This report should be considered in conjunction with the demand/capacity findings contained in the Airservices Report on Capacity at Sydney (Kingsford Smith) Airport. In particular, the analysis in this report assumes available capacity at Sydney airport is maintained at 80 movements per hour.

Key Findings

The key finding of the analysis to date is that the available hours of utilisation of LTOP noise respite runway modes of operation during the middle of the day (1100 to 1500) will reduce over time as traffic demand increases. Specifically:

1. At current traffic levels, Modes 5, 14A and SODPROPS are not normally sustainable for the full hour between 1100 and 1200.
2. Modes 5, 14A and SODPROPS will not be sustainable in the middle of the day after 2020.

3. Mode 7 is sustainable at current traffic levels between 1100 and 1500.
4. Mode 7 is sustainable, subject to reasonable delay and ground complexity, between 1100 and 1500 for the forecast period.
5. If no trigger is applied to move to a parallel runway arrival mode, the cumulative delay for Modes 5, 14A and SODPROPS, will increase significantly, particularly between 1100 and 1300.

Assumptions

The key assumptions applied in this report are:

1) That the currently legislated cap of 80 aircraft movements per hour and the aerodrome curfew between the hours of 2300 and 0600 local time remain.
2) The Long Term Operating Plan continues to be applied at Sydney airport.
3) Forecast traffic demand growth is 1.8% per annum to 2020 and 1.6% per annum between 2020 and 2025[1].

Any indicators pointing to a limitation on the spreading of peak hour slot demand into adjacent hours has not been factored in. It has been assumed that growth forecasts will translate into demand for slots outside the peak hours. Recent history has indicated a steady increase in demand for middle of the day slots, mainly from the Low Cost Carrier market. It is not yet clear if this growth will be sustained over a longer timeframe. Furthermore, analysis is on weekday traffic only.

Currently, 20 minutes of airborne holding, applied to an individual aircraft, or airborne holding exceeding the Flow Fuel Advisory NOTAM figures, are the traffic demand triggers for selection of a noise sharing arrival runway mode of operation. If the trigger is reached, ATC will maintain operations on, or move to, a higher capacity parallel runway mode of operation. ATC must also take into account prevailing weather conditions when selecting the runway mode to be used.

Exclusions

This analysis is limited to consideration of air traffic management capacity and forecast demand. Matters such as airport infrastructure, terminal and apron development and consumer market research have not been analysed within this report.

[1] Booz&Co 2011

Analysis is further limited to the middle of the day mode selection period (1100 to 1500) and noise respite runway modes of operation (SODPROPS, Mode 5, Mode 7 and Mode 14A).

Forecast traffic analysis is limited to the years 2015, 2020 and 2025.

This analysis does not take into account cluster scheduling by airlines and assumes that demand is spread evenly over a given hour.

Mode Selection

ATC are constrained by various rules when nominating the runways to be used throughout the day. A typical day at Sydney will have legislated curfew operations until 6am. Prior to this time, at around 4am, forecast weather conditions and actual traffic demand is assessed to determine the runway nomination at 6am. ATC will apply the preferred runway selection rules in this determination. (Mode selection determinants are discussed in further detail below.) As traffic demand builds up, approaching 7am, ATC will determine an appropriate time to change to a high capacity mode of operation (Mode 9 or 10, depending on the wind direction). After the morning busy period, approaching 11am, weather conditions and traffic demand is again assessed to determine the timing of the change to a noise sharing mode and which mode to select. ATC will continue to operate on a parallel mode if dictated by weather conditions or traffic demand. Similar to the morning process, as traffic demand builds in the afternoon, runway selection and timing for a change to Mode 9 or 10 is again assessed. The parallel runway mode is operated until evening demand reduces (around 8pm) and a noise sharing mode can be selected. At 11pm ATC will apply curfew operations regardless of traffic or weather considerations. Aircraft which are not approved to operate in curfew, or have not been granted a dispensation to do so, are required to remain on the ground at Sydney until the end of curfew or, if arriving, divert to an alternative aerodrome.

The following are typical midweek mode changes, subject to weather conditions and traffic demand:

- Prior to 6am: Curfew mode
- 6am to 7am: Noise sharing mode
- 7am to 11am: Parallel runway mode
- 11am to 3pm: Noise sharing mode
- 3pm to 8pm: Parallel runway mode
- 8pm to 11pm: Noise sharing mode
- 11pm to 6am: Curfew mode

Centralised Traffic Management System (CTMS) and peak demand spill

In ideal operating conditions, ATC are able to process traffic up to the 80 movement per hour cap during peak hours. Ideal operating conditions assume good weather which permits the maximum movement rate for parallel runway operations. Demand, indicated by the next day's schedules, is initially managed through the CTMS. The weather forecast[2] for the next day is assessed and arrival and departure slots are either validated or revised and promulgated through CTMS to the airlines. The weather forecast is reviewed again at 4am on the day and CTMS is adjusted if required and then promulgated to airlines. Occasionally, the weather may deteriorate below the forecast conditions, a forecast condition may arrive earlier or later than predicted or stay in the area longer than predicted. Similarly, a short notice facility loss such as a runway outage or navigation aid failure may have an impact on the predicted capacity. It should be noted that CTMS is a "broad brush" traffic management

[2] The Bureau of Meteorology issues Terminal Area Forecasts every 6 hours: 10am, 4pm, 10pm and 4am.

program. CTMS is not dynamically updated, nor would airlines be able to adjust schedules to continuous dynamic CTMS updates. When conditions dictate a lower movement rate than CTMS, there is a possibility that some peak hour demand will spill into the following hours. The variables precipitating a demand spill make it difficult to quantify the effect on demand in subsequent hours.

Preferred runway mode selection[3]

RWY 34 PROPS (Mode 9) and RWY 16 PROPS (Mode 10) should only be considered for use if required for traffic management purposes during the following hours:

0700 - 1100 Monday to Saturday
0800 - 1100 Sunday
1500 - 2000 Sunday to Friday.

In order to take advantage of suitable traffic conditions, minor variations to these times are acceptable.

Outside these hours a crossing runway mode of operation, or SODPROPS, should be used unless weather conditions or unusual traffic conditions dictate otherwise.

Preferred Runway Selection – Monday to Friday[4]

0700 to 2245

During this period runway selection shall be in accordance with:

Priority	LTOP Mode Description/Operating Conditions
1.	SODPROPS
2. (equal)	RWY 07 ARR, RWY 16L and R DEP *(Mode 14A)* RWY 34L and R, RWY's 34R, 25 and 34L DEP *(Mode 8)* RWY 34L and R ARR, RWY 25 DEP *(Mode 7)* RWY 25 ARR, RWY 16L and R DEP *(Mode 5)*
3. (equal)	RWY 34 PROPS *(Mode 9)* RWY 16 PROPS *(Mode 10)*
4. (equal)	RWY 07 only *(Mode 12)* RWY 25 only *(Mode 13)*

3 ATC LOA 3181 - Sydney Noise Management Procedures

4 ATC LOA 3181 - Sydney Noise Management Procedures

Mode selection determinants

Mode selection is determined by weather conditions or traffic demand.

The weather constraints on the nomination of LTOP noise sharing runway modes of operation are the wind conditions affecting the proposed runways or cloud-base and visibility affecting the approach to the proposed runways:

- ATC is constrained in the nomination of runways when downwind exceeds 5 knots or crosswind exceeds 20 knots.
- ATC is constrained to runway 16 arrivals when visibility reduces below 1500 metres due to approach lighting facilities (HIAL).
- ATC is unable to nominate SODPROPS when the cloud-base is below 3000 feet or visibility is less than 10 kilometres.

The capacity constraint on the nomination of LTOP noise sharing runway modes of operation is the schedule of arriving aircraft to a single arrival runway mode (Modes 5, 14A and SODPROPS) or the schedule of departing aircraft from a single departure runway mode (Mode 7 and SODPROPS).

The maximum acceptance rate for a single arrival runway is 24 arrivals per hour. This figure is subject to weather – the rate may be reduced during conditions of low cloud-base, low visibility or thunderstorms. When arrival traffic demand triggers 20 minutes of airborne holding to be applied to an individual aircraft or Flow Fuel Advisory NOTAM figures will be exceeded, ATC will maintain, or change to, a parallel arrival runway mode of operation.

The acceptance rate for a single departure runway is approximately 25 to 30 departures per hour. The actual figure is dependent on the traffic mix in a given hour. ATC will maintain, or change to, a parallel departure runway mode of operation when ground delays are considered excessive or aircraft holding for departure have a significant effect on ground complexity such as blocked access to aprons and taxiways.

SODPROPS selection

It should be noted that SODPROPS is the most environmentally desirable mode of operation but is also the most constrained by weather.

Due to the parallel runways being so close to each other (only 1,037 metres between runway centrelines) and the traffic operating opposite direction to each other (departures passing arrivals in close proximity), weather conditions must be such that the pilots and ATC are able to see the conflicting aircraft as they pass each other. This is termed "visual separation".

If visual separation is not possible, a minimum radar separation standard of 3 nautical miles must be applied between aircraft. When considering the viability of SODPROPS, if cloud or visibility precludes the application of visual separation, as aircraft are less than 1 nautical mile apart on initial departure or final approach, the mode cannot be selected.

To ensure visual separation can be applied, a cloud base minimum of 3000' and a visibility minimum of 10 kilometres must exist for selection of this mode.

The wind criterion is a significant factor – wind direction and speed must be such that no more than 5 knots of downwind (wind coming from behind the aircraft) exist on both the landing and departure runways. Essentially, conditions must be close to calm or the wind direction at 90 degrees to the runways to enable this mode to be used.

Any one, or a combination, of the above weather limitations (cloud base, visibility and wind) limits the availability of SODPROPS.

Mode Capacities and separation requirements

As discussed, ATC must also consider traffic demand when considering mode selection. Each mode has a capacity limitation defined by weather conditions and ATC aircraft separation rules.

This section provides detail on the capacity of each mode and the separation standards applied by ATC.

MODE	MAXIMUM CAPACITY / HOUR		APPLIED SEPARATION STANDARDS
	ARRIVALS	DEPARTURES	
CURFEW	*5*	*5*	OPPOSITE DIRECTION STANDARD *10NM RADAR SEPARATION BETWEEN ARRIVALS AND DEPARTURES*
SODPROPS	25	*30 - 40*	VISUAL STANDARD *ATC AND PILOT VISUALLY SEPARATE WITH OTHER AIRCRAFT*
MODE 5	25	*30 - 40*	RUNWAY STANDARD *ATC ENSURE SEPARATION BETWEEN ARRIVALS AND DEPARTURES AT THE RUNWAY INTERSECTION*
MODE 7	48	*25 - 30*	PARALLEL RUNWAY STANDARDS *ATC AND PILOT ENSURE ARRIVING AIRCRAFT ARE ESTABLISHED ON PARALLEL FINAL APPROACH PATHS*
MODE 14A	25	*30 - 40*	RUNWAY STANDARD *ATC ENSURE SEPARATION BETWEEN ARRIVALS AND DEPARTURES AT THE RUNWAY INTERSECTION*
MODES 9 & 10	42	*42*	PARALLEL RUNWAY STANDARDS *ATC AND PILOT ENSURE ARRIVING AIRCRAFT ARE ESTABLISHED ON PARALLEL FINAL APPROACH PATHS.* *ATC AND PILOT ENSURE DEPARTING AIRCRAFT PATHS DIVERGE WHEN AIRBORNE.*

Notes:

1. *Capacity figures in italics are indicative and, subject to traffic disposition, the aircraft type mix and the 80 per hour movement cap.*
2. *The arrival capacity for Modes 7, 9 and 10 are the maximum in good weather conditions. The rate will reduce as weather conditions deteriorate (see below)*

This table shows the arrival rates programmed for various cloud base altitudes. Runway 16 has a lower acceptance rate for Independent Visual Approaches due to a different aircraft traffic circuit than Runway 34 and therefore slightly different ATC separation requirements.

RUNWAY 16 ARRIVALS		
CLOUD BASE	**APPROACH TYPE**	**RATE PER HOUR**
4001 FT OR HIGHER	INDEPENDENT VISUAL APPROACH	46
3001 FT TO 4000 FT	DEPENDENT VISUAL APPROACH	42
2001 FT TO 3000 FT	DEPENDENT VISUAL APPROACH	38
BELOW 2000 FT	PRECISION RUNWAY MONITOR	34
RUNWAY 34 ARRIVALS		
CLOUD BASE	**APPROACH TYPE**	**RATE PER HOUR**
3501 FT OR HIGHER	INDEPENDENT VISUAL APPROACH	48
2501 FT TO 3500 FT	DEPENDENT VISUAL APPROACH	42
2001 FT TO 2500 FT	DEPENDENT VISUAL APPROACH	38
BELOW 2000 FT	PRECISION RUNWAY MONITOR	34

Mode Analysis

Mode usage

The data for this analysis is sourced from the Airservices Environment and Climate Change Branch. Mode usage data is collected for monthly reporting. The period of analysis is from January 2000 to December 2007. Data from 2008 and 2009 is not representative of typical mode usage due to Runway End Safety Area (RESA) works affecting the availability of the crossing runway. It should be noted, however, that the use of SODPROPS increased from historical levels during the RESA works period and has been maintained since the completion of those works. For this analysis, the most recent SODPROPS usage data is applied.

Table 1 shows the percentage of time that a noise respite runway mode was in use outside curfew hours (0600 to 2300), as an annualised average over the analysis period.

Table 1

Mode	Percentage (Average 2000 – 2007)
SODPROPS	6.45% (2009)
Mode 5	7.58%
Mode 7	8.72%
Mode 14A	10.29%
Total	33.04%

Table 2 shows the percentage of time that a noise respite runway mode was in use during the middle of the day noise respite period (1100 to 1500), as an annualised average over the analysis period.

Table 2

Mode	Percentage (Average 2000 – 2007)
SODPROPS	6.70% (2009)
Mode 5	12.14%
Mode 7	12.57%
Mode 14A	16.81%
Total	48.22%

Table 3 shows the percentage of time that a parallel runway mode was in use during the middle of the day noise respite period (1100 to 1500), as an annualised average over the analysis period.

Table 3

Mode	Percentage (Average 2000 – 2007)
Mode 9	29.64%
Mode 10	22.04%
Total	51.68%

Forecast Traffic Analysis

Data and methodology

Data is sourced from CTMS for a sample day.[5] A growth figure[6] of 1.8% per annum is applied until the 80 movements per hour cap is reached. When forecast arrivals and departures combined exceed the hourly cap, the figure obtained for each is the unconstrained (uncapped) growth figure for the hour with a proportional reduction applied to reduce the combined equated amount to 80 in the hour. The constrained growth figures are evident when the scheduled arrival or departure amount does not change after a particular year.

Modes 5, 14A and SODPROPS

The capacity constraint on the nomination of these modes is scheduled arrivals (single arrival runway). The time interval between arrivals is flowed at 2 minute gaps between each aircraft. The 20 minute trigger is reached when 10 aircraft are in consecutive holding (2 minutes x 10 aircraft = 20 minutes). Therefore, the determining constraint is 35 scheduled arrivals in a given hour (24 arrivals per hour plus 10 aircraft in airborne holding).

Year	Scheduled Arrivals by Hour			
	1100 - 1200	1200 - 1300	1300 - 1400	1400 -1500
2010	37	36	24	27
2015	40	39	26	30
2020	44	43	29	32
2025	48	47	31	35

Mode 7

The capacity constraint on the nomination of this mode is scheduled departures (single departure runway). The time interval between departures is normally 2 minutes between each aircraft, subject to wake turbulence separation standards and separation between departing and arriving aircraft at the intersection of runway 25 and runway 34L. The determining constraint is considered to be 30 scheduled departures in a given hour.

Year	Scheduled Departures by Hour			
	1100 - 1200	1200 - 1300	1300 - 1400	1400 -1500
2010	26	14	23	20
2015	28	15	25	22
2020	31	17	27	24
2025	34	18	30	26

[5] 12th November 2010

[6] Booz&Co – 1.8% to 2020 and 1.6% 2020 to 2025

Cumulative Delays

A cumulative delay can be defined as the sum of all accrued delays when more than one aircraft is delayed. Once an acceptance rate for a runway is reached, the next aircraft in the queue is delayed by 2 minutes, the aircraft after that also gets the 2 minute delay, plus another 2 minutes in the queue. Aircraft 3 gets 2 + 2 + 2 minutes – a delay of 6 minutes. The cumulative delay for those three aircraft is 12 minutes.

Cumulative delay is useful when calculating the cost of the delay (fuel, CO2, etc).

The following tables represent the cumulative delay effect on the scheduled traffic in a given hour if an LTOP noise respite mode is utilised. Cumulative delay figures assume 2 minutes between each arrival or each departure. It should be noted that these figures do not take into account cluster scheduling[7] by airlines and assumes that demand is spread evenly over a given hour.

Departures – Mode 7

Year	Cumulative Minutes of Delay			
	1100 - 1200	1200 - 1300	1300 - 1400	1400 -1500
2010	0	0	0	0
2015	0	0	0	0
2020	2	0	0	0
2025	20	0	0	0

Arrivals – Modes 5, 14A and SODPROPS

Year	Cumulative Minutes of Delay			
	1100 - 1200	1200 - 1300	1300 - 1400	1400 -1500
2010	182	156	0	12
2015	272	240	6	42
2020	420	380	30	72
2025	600	552	56	132

Major Findings

1. At current traffic levels, Modes 5, 14A and SODPROPS are not normally sustainable for the full hour between 1100 and 1200.

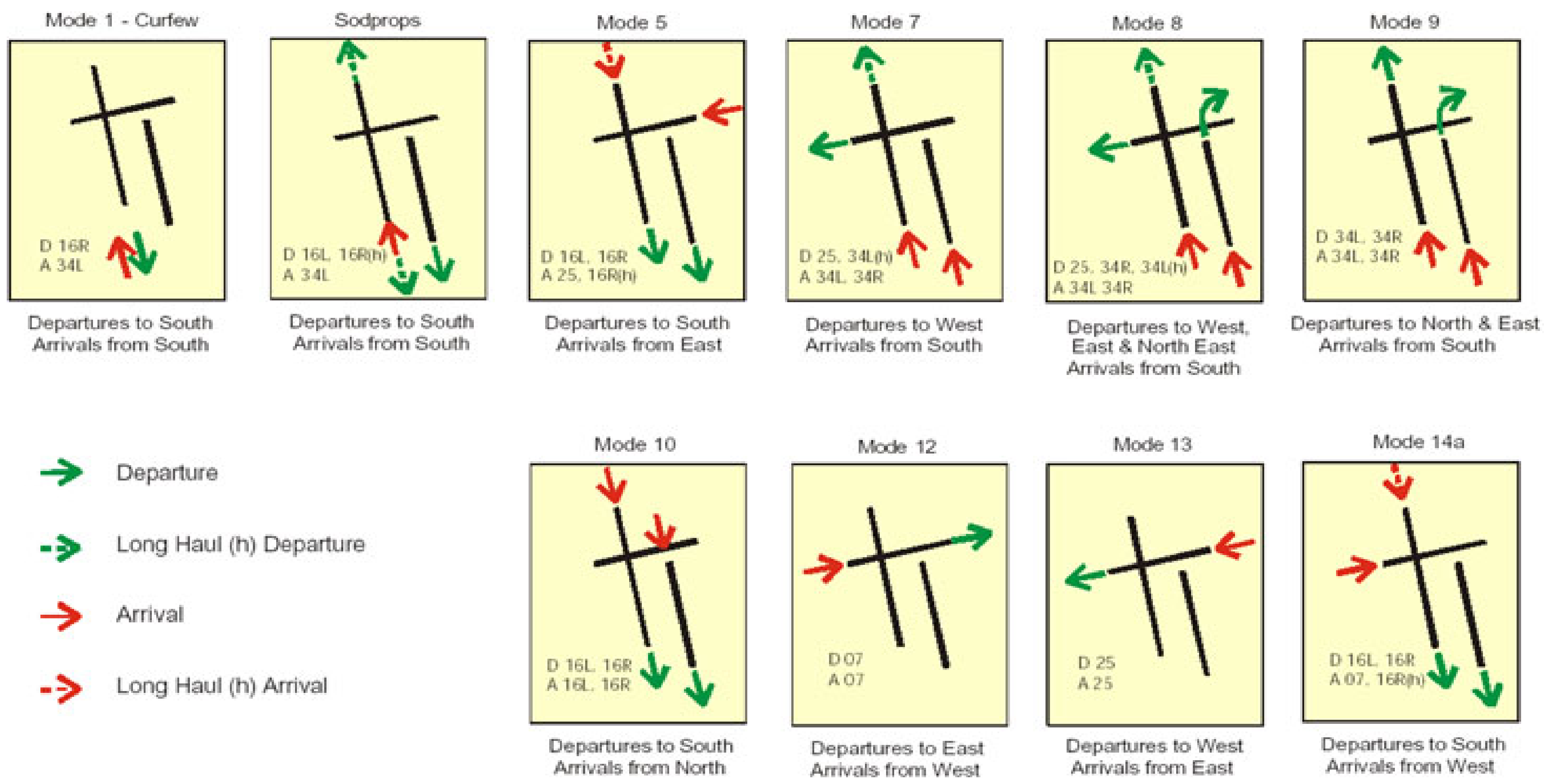
[7] Cluster scheduling refers to multiple aircraft scheduled to operate at the same time, normally driven by airline business or marketing requirements. On-time-performance measuring drives airlines to meet the scheduled off-block and on-block times resulting in multiple movements at a given time.

2. Modes 5, 14A and SODPROPS will not be sustainable in the middle of the day after 2020.
3. Mode 7 is sustainable at current traffic levels between 1100 and 1500.
4. Mode 7 is sustainable, subject to reasonable delay and ground complexity, between 1100 and 1500 for the forecast period.
5. If no trigger is applied to move to a parallel runway arrival mode, the cumulative delay for Modes 5, 14A and SODPROPS, will increase significantly, particularly between 1100 and 1300.

Glossary of Terms

Term	Definition
ATC	Air Traffic Control
CTMS	Central Traffic Management System – strategic demand and capacity management system
Flow Fuel Advisory NOTAM	Advice to pilots regarding the carriage of extra fuel to accommodate airborne holding for arrival.
HIAL	High Intensity Approach Lighting – runway lighting providing visual guidance to a runway threshold
LTOP	Long Term Operating Plan for Sydney Kingsford-Smith airport and surrounding airspace
NOTAM	Notice to Airmen – operational advice to pilots of a short term duration.
RWY	Runway

Long Term Operating Plan (LTOP) Modes



Effect of weather on aircraft delays at Sydney, Canberra and Newcastle Airports

B5

AIRSERVICES AUSTRALIA

JOINT STUDY ON AVIATION CAPACITY FOR THE SYDNEY REGION

AIRSERVICES AUSTRALIA

REPORT ON THE EFFECT OF WEATHER ON AIRCRAFT DELAYS AT SYDNEY, CANBERRA AND NEWCASTLE AIRPORTS

Executive Summary

As part of a joint Commonwealth and NSW State Government initiative to develop an Aviation Strategic Plan for the Sydney region, Airservices Australia has been requested to undertake analysis in relation to aviation capacity in the Sydney region. The task undertaken in this report is an analysis of weather delays to aircraft at Sydney, Canberra and Newcastle airports.

This report is not intended for circulation beyond the Department of Infrastructure and Transport and the Joint Study Steering Committee.

Airservices provides no warranty or guarantee as to the accuracy or completeness of this report. Readers should rely on their own enquiries and seek independent advice.

Airservices makes no representation, warranty or guarantee concerning any findings in this report. Any findings are to be treated as indicative only, and based on Airservices limited role in the overall study.

This report represents the view of Airservices and not the view of any individual person.

Key Findings

Sydney Airport

1. Maximum Capacity (80 movements per hour) utilising independent parallel runway operations is available for approximately 232 days per year.
2. Capacity is significantly reduced (less than 60 movements per hour) for approximately 125 days per year.
3. Capacity is severely reduced (less than 40 movements per hour) for approximately 8 days per year.
4. Single runway operations severely restricted capacity on approximately 6 days per annum during the morning and on 10 days per annum during the evening.
5. Parallel runway operations were programmed on approximately 359 days per annum during the morning and on 355 days per annum during the evening.

Canberra Airport

1. Canberra airport recorded weather conditions which could restrict capacity for an average of 163 hours per annum.
2. Fog occurs an average 28 days per annum.
3. Thunderstorms occur an average 26 days per annum.
4. Visibility below ILS minimum (<800M) occurs an average 55.75 hours per annum.
5. Cloud below ILS minimum (300FT AGL) occurs an average 77.25 hours per annum.
6. The total number of days when the operating efficiency of the airport may have been significantly impaired for a period of time is estimated to be 18 days per annum.

Newcastle Airport

1. Newcastle airport recorded weather conditions which could restrict capacity for an average of 170 hours per annum.
2. Fog occurs an average 19 days per annum.
3. Thunderstorms occur an average 28 days per annum.
4. Visibility below ILS minimum (<800M) occurs an average 70.6 hours per annum.
5. Cloud below ILS minimum (330FT AGL) occurs an average 75 hours per annum.
6. The total number of days when the operating efficiency of the airport may have been significantly impaired for a period of time is estimated to be 24 days per annum.

Data Analysis

Arrivals

Analysis of the Centralised Traffic Management System (CTMS) data was used to assess delays to arriving aircraft at Sydney.

CTMS is a ground delay program – it does not manipulate airline schedules to manage demand on a given day. CTMS notifies a delay for aircraft scheduled to arrive at the target airport. How an airline schedule is adjusted to manage the daily CTMS program is transparent to the Air Traffic Management system. A general commentary on this subject is included later in this report.

CTMS is generally programmed on forecast weather one day prior to the day of operation which throws up variations between programmed arrival rates and the rate (or schedule) available on the day of operation. Where significant variation occurs (generally more than four arrivals per hour) CTMS is reprogrammed to reflect the change in runway capacity. The data used is final CTMS data, therefore these variations were captured.

Also of note is that, *for Sydney*, CTMS rates are generally two arrivals per hour higher than the corresponding Maestro (tactical flow) rates for that weather pattern, to allow a traffic 'pressure factor' and maintain a high level of efficiency in the arrival sequence.

The CTMS program is limited to Sydney Airport. Canberra and Newcastle do not have the traffic demand to justify demand smoothing with programmed acceptance rates.

For Canberra and Newcastle, meteorological data was analysed against minimum weather conditions for the best available approach procedure (ILS in both cases) or the incidence of thunderstorms in the vicinity of those airports.

Departures
Reduced visibility and thunderstorm conditions are the main weather delay factors for departures.

The basic visibility criterion for departure is 550 metres. Specific approvals allow for a reduction in the visibility minimum, published in airline company operations manuals, and subject to a range of criteria being met. For airline operators at the major airports the visibility criterion is generally reduced to around 150 metres. As visibility reductions to this level are extremely rare, it was considered that such analysis would not reveal anything of significance.

Although it can be assumed that the incidence of thunderstorms in the vicinity of an airport *may* affect a departure, the ability to quantify the average delay is problematic due to the variable nature, quantity and disposition of cells affecting departure tracks.

<u>As a general rule, it can be assumed that the departure rate is correspondingly reduced when there is a reduction to the arrival rate.</u>

Weather Patterns

The airports analysed normally experience thunderstorm events between November and March, fog between May and July and strong westerly winds during August.

Airline Operations

CTMS is a ground delay program – it does not manipulate airline schedules to manage demand on a given day. CTMS notifies a delay for aircraft scheduled to arrive at the target airport. How an airline schedule is adjusted to manage the daily CTMS program is transparent to the Air Traffic Management system. The following commentary is intended to provide a basic understanding of aerodrome capacity restriction management applied by airlines to their schedules and the effect of those decisions on airline customers.

Constraints

Airline schedules are constrained by crew endorsements, crew duty hours, aircraft maintenance schedules, passenger loadings, crew dispersal and fleet dispersal issues.

Pilots and cabin crew are required to hold separate qualifications (endorsements) for discrete aircraft types – for example, a B747 captain cannot operate a B737 unless suitably qualified and licensed for the B737 and has recency operating that type of aircraft. The stringency of licensing requirements for aircraft type endorsements means that flight crew are generally only endorsed on one type. Similarly, cabin crew licensing is by aircraft type, although they may hold multiple aircraft type endorsements across an airline fleet.

Cockpit and cabin crew are further restricted by duty hour limitations. Duty hours are legislated by Australian Civil Aviation Orders.

Aircraft are required to be serviced in accordance with defined schedules, normally based on hours of operation of the aircraft. Maintenance schedules are legislated by Australian Civil Aviation Orders. Additionally, ad-hoc maintenance can be required to address unscheduled aircraft serviceability issues.

Passenger loadings dictate the size or number of aircraft which will operate a particular service or city pair.

On any given day, the aircraft fleet and crew are dispersed over the network. Airline dispatch departments continuously manage schedules and crew rosters to meet aerodrome (or network) capacity. A service needs the correct aircraft for the passenger loading and appropriately qualified crew within duty hours at the required location at the required time. Dispatch must also consider the flow on effect to the daily schedule of aircraft and/or crew out of place, out of duty hours or requiring maintenance.

Airline schedules are complex systems due to these requirements. The flight dispatch departments of major airlines have a large amount of staff, operating 24 hours a day, 7 days a week, with specialist areas managing aircraft availability, network amendments, crew rostering and customer interface.

A restriction of capacity at key network airports such as Sydney places significant strain on airline schedules. Airlines may be required to delay flights, consolidate services to larger aircraft or cancel services to manage capacity constraints. Constraints at key network airports have a flow on effect throughout the airline network – a bad weather day at Sydney may precipitate delays and cancellations to services unrelated to Sydney airport and may cause congestion issues at other key network airports. A flight thread example will be examined later in this commentary.

International schedules

International schedules are comparatively simple, in a network sense, in the Australian context. Services to Australian ports are generally "end of the line" – aircraft operate into the airport and, sometime later in the day, out again on a return journey.

The British Airways service from London to Sydney is an example. An aircraft will depart London, via Singapore to Sydney, landing in the early morning. The inbound crew will leave the aircraft and a new crew will take the aircraft on the return journey later the same day. The inbound crew will lie over in Sydney and take a different aircraft outbound to London on a subsequent day.

Long haul international aircraft and crew are a significant distance from the home base, and normally airborne en-route to destination when a ground delay program is published or significant weather at destination occurs. This type of service will conduct airborne holding to meet a landing slot or, if unable to do so due to fuel limitations, divert to a suitable alternate airport and wait for a landing slot at destination. In either case, the aircraft will eventually end up at the destination airport - the aircraft needs to be at the same location as the crew which will take the aircraft out on the next leg of the schedule (and the passengers booked on that service).

In an international context, the schedules are more complex due to the variety of ports flown into, the varied requirements of those ports (such as curfew, gate occupancy, etc) and the limited ability of airlines to amend schedules, aircraft and crew in response to any disruption. An airline which runs a domestic network in Australia in addition to an international network will normally prioritise international network aircraft over domestic network aircraft in order to mitigate these complexities. For example, where there is a reduction to available landing slots at a destination airport in Australia, an airline will give priority to the international service for the available slots and manage the domestic network around this.

Domestic schedules

Domestic schedules are complex systems due to network, fleet, crew and maintenance management requirements and often, due to the need to prioritise international network operations over domestic operations. The complexities of schedule management and the inter-relationship of sub-systems within the schedule management system have a flow on effect throughout the network.

At an airline customer interface level, these complexities are generally not known but will affect the customer through schedule delays, aircraft change (or consolidation) or even flight cancellations. As discussed above, a customer may be affected even if the causal network issue is not directly related to the booked flight.

The following flight thread scenario provides some examples of the way a network restriction may be managed and the potential effect on an airline customer.

Flight Thread

A Brisbane to Sydney flight (B737) scheduled 0600 departure for a 0730 arrival, with Sydney aerodrome forecast fog.

The aircraft flying this leg is scheduled to depart Sydney for Melbourne at 0830 for a 1000 arrival, and then Melbourne to Brisbane at 1100 for a 1330 arrival. The aircraft is crewed out of Brisbane and the crew is expecting to return to base inside the duty hours.

The CTMS arrival rate is set at 42 by the Sydney Traffic Manager, based on operations to Parallel Runway Operations to 16 Right and Left, forecast cloud-base 2500' and probability 30% of fog occurring. Note that fog probability is not a significant restriction on the CTMS rate – 30% probability is considered high and implies a 70% probability that fog will not occur. This assumption is agreed by airlines within CTMS business rules. PRM will be used to maintain arrival capacity.

The fog forms at 0530 and will significantly delay arrivals into Sydney due to restrictions caused by the low visibility.

Network effects

International flights are attempting landing approaches and then diverting to alternate aerodromes and waiting until the fog situation improves.

The Brisbane to Sydney flight departs on time at 0600 and, based on reports of missed approaches at Sydney diverts to Melbourne to wait until there is an improvement in the weather at Sydney.

The next 4 departures to Sydney scheduled by this airline also depart on time and also divert to alternate aerodromes, 2 to Melbourne and 2 return to Brisbane.

The need to accommodate diversion flights at other airports creates arrival demand delays at other airports, particularly at Melbourne and Brisbane. The arrival delays will have a flow-on delay affect to subsequent departures from these ports.

By 0900 there are no longer sufficient aircraft or crew on the ground at Sydney to cover scheduled departures. Flight delay notifications are broadcast to customers.

At 1000, the conditions improve enough to permit limited arrivals to Runways 16R and 16L. Aircraft in holding patterns are processed first.

The airline prioritises the international diversions for a return to Sydney in order to recover the international schedule.

The other diverted aircraft depart for Sydney and enter holding patterns to wait in the (now significant) arrival queue.

The 0600 flight arrives in Sydney at 1130, the other 4 flights arriving over the next hour.

The delayed departure schedule commences recovery.

The aircraft and crew on the original 0600 (Brisbane to Sydney) service depart for the next leg, Sydney to Melbourne at 1200, 3 ½ hours late. They will be out of duty hours for the Melbourne to Brisbane leg of this service. A replacement crew is required and the original crew will dead-head on the aircraft back to the Brisbane base. The Melbourne to Brisbane flight will depart at 1400, 3 hours later than scheduled.
Across the network, aircraft and crew are out of position, late or out of hours. This will affect the network for the rest of the day.

Passengers are, naturally, late – for business (meetings cancelled) or connecting aircraft (travel plans disrupted), or, in some cases, have cancelled their bookings.

If, by the end of the day, the network has not fully recovered, some services will not be able to arrive or depart Sydney before the start of the curfew. Passengers on these aircraft may have to be provided with accommodation at point of origin, normally at airline expense.

Sydney Airport

CTMS Operation - Programming and Acceptance Rates

Rate assessment

In the application of CTMS programming, the following tables are used as a guide by the Sydney Traffic Manager (SYTM) when determining acceptance rates.

a. In making this assessment, 'Cloud Base' refers to the lowest base at which SCT cloud is present, or where two amounts of FEW cloud added together produce SCT cloud at the higher level.

b. When INTER period is incorporated into the forecast (TAF or TTF), the acceptance rate may be determined by splitting the difference between the rate for the INTER period and the rate for the main body of the TAF.

c. When a TEMPO is incorporated in the forecast, the acceptance rate may be based on the rate determined for the TEMPO period, ie the TEMPO over-rides the TAF for the TEMPO period.

d. IVA's will be considered available as per the cloud base indicated in the table and with an in-flight visibility of 5000 M or more.

Fog forecast

If the probability of Fog is forecast, the CTMS rate based on the body of the TAF (or as modified by INTER/TEMPO periods) is programmed.

Variation of stated rates

The SYTM may vary these rates based on the information available at the time. If required, contingency arrangements (such as tactical ground delays) may be utilised to manage traffic.

PARALLEL RUNWAY OPERATIONS
ARRIVAL ACCEPTANCE RATES for RUNWAYS 16/34

Visibility/Cloud Base	IVA's 16/34	PRM 16/34	SS or ILS 16/34
>5000 M and >4001 FT	46/50[1]	-	-
>5000 M and CLD between 3001 FT and 4000 FT	42/46	-	-
>5000 M and CLD between 2001 FT and 3000 FT	38/44	42/46	-
>5000 M and CLD between 1500 FT and 2000 FT	-	42/46	36/42
More than 2000 M and/or SCT <1500 FT	-	42/46	34/40
Less than 2000 M and/or BKN <1500 FT	-	42/46	34/38
TS Probability	-	-	36
Headwind Forecast > 25 KT	-	RWY 16-36 RWY 34-38	

LTOP OR SINGLE RUNWAY OPERATIONS - ARRIVAL ACCEPTANCE RATES

Single runway forecast

When the forecast indicates 'single runway only' an initial minimal arrival acceptance rate of 34 is set and reassessed when and if the forecast wind actually eventuates.

LTOP RUNWAY 34 ARRIVAL	34
MODE 5 RUNWAY 25 ARRIVAL	28
MODE 14A RUNWAY 07 ARRIVAL	26
MODE 12, MODE 13 OR SODROPS	24

[1] The figure on the left refers to runway 16 parallel operations. The figure on the right refers to runway 34 parallel operations.

CTMS Analysis

Figures in the following table are from analysis of CTMS rates for Sydney Airport for years 2006 to 2010 inclusive and show the average number of days that a particular rate was set over the period. The analysis is further broken down to morning and evening rates.

CTMS RATE	AVG AM DAYS	AVG PM DAYS
50	134	142
46	39	41
44	37	7
42	47	17
40	10	7
38	35	51
36	31	52
34	27	37
28	3	3
26	1	2
24	2	5

The following assumptions are applied:

1. Maximum capacity of 80 movements per hour is achieved when the CTMS rate is 42 and above. Weather conditions allow Independent Visual Approaches to the parallel runways or PRM is utilised to maintain capacity.
2. Capacity is considered to be significantly reduced when the CTMS rate is less than 42 and greater than or equal to 34. Weather conditions dictate that the parallel runways are dependent. Capacity is estimated to be less than 60 movements per hour.
3. Capacity is considered to be severely reduced when the CTMS rate is less than 34. Capacity is estimated to be less than 40 movements per hour.
4. AM and PM rates are averaged.

- Maximum Capacity is available 232 days per year
- Capacity is significantly reduced 125 days per year
- Capacity is severely reduced 8 days per year

Note that this is an indicative estimate of daily capacity.

Canberra Airport[2]

Canberra Airport analysis is based on weather observations of conditions below the lowest ILS cloud and visibility minima or thunderstorms in the vicinity of the airport.

The following table shows the number of days per year that fog (FG) and thunderstorms (TS) were observed at the Canberra Airport (YSCB). It also gives the total number of hours that observations (manual and automatic) were made in the year, as well as the number of hours that each of the criteria occurred.

Criteria: Visibility below 800m; Cloud Height below 300ft; Thunderstorms.

YSCB	2006	2007	2008	2009	2010	Average
Days FG	26 days	29 days	29 days	27 days	57 days	27.75 days
Days TS	22 days	39 days	22 days	20 days		25.75 days
Total hours of observation	8709 hrs	8712 hrs	7443 hrs	8733 hrs	8649 hrs	8700 hrs
Hours TS	27 hrs	36 hrs	17 hrs	21 hrs	35 hrs	29.75 hrs
Hours Visibility <800m	54 hrs	52 hrs	40 hrs	72 hrs	45 hrs	55.75 hrs
Hours Cloud <300ft	75 hrs	84 hrs	43 hrs	105 hrs	45 hrs	77.25 hrs

NOTES:

1. *Canberra airport is not manned 24hrs by Observation staff and hours covered has varied considerably over the past 5 years. Cloud and visibility observations are automatically generated by observing equipment during hours when observing staff are not present but thunderstorms are not recorded.*
2. *The location of Canberra Airport observations was relocated in March 2010. The higher incidence of fog in 2010 could be attributed to operationally not significant fog now being reported due to better visibility of the whole airport area. Data from 2010 was not included in the average calculation of number of fog days. Significant fogs are captured in the data for low visibility.*
3. *Thunderstorms are recorded when thunder is heard or thunderstorms are observed. Observation of thunderstorms is included in visibility and cloud data if conditions reached below minima criteria. Data from 2010 was not included in the average calculation of number of thunderstorm days (the inclusion of 2010 data does not change the average figure).*
4. *There are approximately 1000 hours of data missing for Canberra Airport in 2008, however, for the purposes of this report, the available 2008 data is included in the calculation of average number of hours of TS, low visibility and low cloud (e.g. if 2008 is excluded, the fog day average increases to 34.75).*

[2] Data analysis period: 1st January 2006 to 1st January 2011 (5 years). Data and analysis is supplied by the Bureau of Meteorology.

Analysis

To extrapolate the number of days when capacity may have been impaired the following assumptions have been applied:

1. Visibility <800m will often translate to cloud <300ft as the fog lifts.
2. Other days when cloud <300ft occurred would normally be attributed to other types of weather such as frontal stream or thunderstorm events.
3. Fog and low cloud conditions affect the airport for no more than 3 hours per event.

The assumptions are applied as follows:
(Hours of Visibility <800m plus Hours of Cloud <300ft divided by 3 (hours per event) and further divided by 2.5 (fog translating to low cloud)

55.75 + 77.25 = 132.00 / 3 = 44 / 2.5 = 17.6

The total number of days when the operating efficiency of the airport may have been significantly impaired for a period of time is estimated to be 18 days per annum.

Newcastle Airport[3]

Newcastle Airport analysis is based on weather observations of conditions below the lowest ILS cloud and visibility minima or thunderstorms in the vicinity of the airport.

The following table shows the number of days per year that fog (FG) and thunderstorms (TS) were observed at the Williamtown Airport (YWLM). It also gives the total number of hours that observations (manual and automatic) were made in the year, as well as the number of hours that each of the criteria occurred.

Criteria: Visibility below 800m; Cloud Height below 320ft; Thunderstorms.

YWLM	2006	2007	2008	2009	2010	Average
Days FG	13 days	18 days	27 days	23 days	15 days	19.2 days
Days TS	35 days	18 days	24 days	26 days	21 days	24.8 days
Total hours of observation	8686 hrs	8747 hrs	8766 hrs	8728 hrs	8718 hrs	8729 hrs
Hours TS	24 hrs	38 hrs	26 hrs	12 hrs	20 hrs	24.0 hrs
Hours Visibility <800m	44 hrs	103 hrs	81 hrs	64 hrs	61 hrs	70.6 hrs
Hours Cloud <330ft	43 hrs	102 hrs	86 hrs	72 hrs	72 hrs	75.0 hrs

NOTE: Newcastle airport is not manned 24hrs by Observation staff and hours covered has varied considerably over the past 5 years. Cloud and visibility observations are automatically generated by observing equipment during hours when observing staff are not present but thunderstorms are not recorded.

Analysis

To extrapolate the number of days when capacity may have been impaired the following assumptions have been applied:

4. Visibility <800m will often translate to cloud <300ft as the fog lifts.
5. Other days when cloud <300ft occurred would normally be attributed to other types of weather such as frontal stream or thunderstorm events.
6. Fog and low cloud conditions affect the airport for no more than 3 hours per event.

The assumptions are applied as follows:
(Hours of Visibility <800m plus Hours of Cloud <300ft divided by 3 (hours per event) and further divided by 2 (fog translating to low cloud)

70.6 + 75.0 = 145.6 / 3 = 48 / 2 = 24

[3] Data analysis period: 1st January 2006 to 1st January 2011 (5 years). Data and analysis is supplied by the Bureau of Meteorology.

The total number of days when the operating efficiency of the airport may have been significantly impaired for a period of time is estimated to be 24 days per annum.

ABBREVIATIONS	
AGL	Above Ground Level
BKN	Broken cloud – more than half of the sky is obscured
CLD	Cloud
CROPS	Converging Runway Operations – simultaneous arrivals to non-intersecting runways
CTMS	Centralised Traffic Management System
FG	Fog
FT	Feet
ILS	Instrument Landing System – enables instrument guided landing in conditions less then cloud 220 FT AGL and 800 M visibility
IMC	Instrument Meteorological Conditions - pilots must navigate by instruments
INTER	Intermittent weather variation from forecast for a period less than 30 minutes
IVA	Independent Visual Approach to parallel runways
LAHSO	Land and Hold Short Operations – 2 runways can be used simultaneously
M	Metres
PRM	Precision Runway Monitor – high definition radar which facilitates independent approaches to parallel runways in instrument conditions
SCT	Scattered cloud – less than half of the sky is obscured
SYTM	Sydney Traffic Manager (Air Traffic Control)
TAF	Terminal Area Forecast - issued every 6 hours, valid for 12 hours
TEMPO	Temporary weather variation from forecast for a period between 30 and 60 minutes
TS	Thunderstorms
TTF	Trend Type Forecast – amends TAF, valid for 3 hours
VMC	Visual Meteorological Conditions – pilots can navigate visually

Newcastle Airport planning day peak spreading

B6

FINAL REPORT

Joint Study on Aviation Capacity for the Sydney Region

Newcastle Airport Planning Day Peak Spreading

Canberra

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Important Note

Booz & Company has devoted its best professional efforts to this assignment and our findings represent our best judgment based on the information available.

In preparing our traffic forecasts for the Sydney region, we have relied upon the information provided by all entities. While we have checked our sources of information, data and assumptions, we will not assume responsibility for the accuracy of such data, information and assumptions received from any entity.

Any airport traffic forecast is subject to uncertainties. Inevitably, some assumptions used to develop the forecasts will not be realised, and unanticipated events and circumstances may occur. Therefore Booz & Company cannot provide any form of assurance that the forecasts documented in this report will be achieved. The actual traffic outcome will vary from that forecast and the variations may be material.

Specifically, the following factors could result in an actual outcome outside the forecast range:

- Lower than assumed economic growth rates in Australia and/or those countries expected to provide a significant source of inbound international air passengers
- Shifts in Government policy which directly, or indirectly, impact on Sydney region aviation activity
- Adverse impacts for Sydney region aviation activity associated with aviation industry developments
- A significant shift in the distribution of aviation traffic between Sydney region airports and competing international and domestic airports
- Significant changes in airline costs which are passed on by way of significantly higher air fares
- External factors, including, but not limited to, natural disasters, political unrest, acts of terrorism and associated security concerns and labour disputes

This report was prepared for the exclusive use of the Department of Infrastructure and Transport, in advising the Steering Committee on the Joint Study on Aviation Capacity in the Sydney Region and in their advice to Government. The Report may be relied upon solely by Department of Infrastructure and Transport, Booz & Company disclaims all liability to any persons other than Department of Infrastructure and Transport for all costs, loss, damage and liability that the third party may suffer or incur arising from or relating to or in any way connected with the provision of the Report to a third party. You have agreed that you will not amend the Report without prior written approval from Booz & Company. If any person, company or Government Department or Agency, other than the Department of Infrastructure and Transport chooses to rely on the Report in any way, they do so entirely at their own risk.

Glossary

Expression	Definition
Air Transport Intelligence (ATI)	ATI is an online data source providing up-to-date news and data for the global air transport industry
BITRE	Bureau of Infrastructure, Transport, and Regional Economics
Domestic Traffic	Services to Australian destinations outside NSW.
International Traffic	Services to destinations outside of Australia
Load Factor	Utilisation measure defined as the number of passengers divided by the seat capacity
Peak Spreading	Peak spreading is the tendency for services to be spread more evenly throughout the day as airport traffic increases and access to preferred peak hour times becomes limited
Planning Day	A „typical" busy day for planning purposes
Regional Traffic	For the purpose of this report, regional traffic is defined as intra-state services. For Newcastle Airport, services to/from NSW and ACT destinations are also classified as regional.
SRS Analyser	SRS Analyser is an online tool allowing access to IATA"s Schedule Reference Service (SRS). SRS is a neutral source of schedule data that collects, validates, consolidates and distributes airline flight schedules and related data for over 900 airlines worldwide.
Sydney Region	The catchment covered in this study, specifically, areas served by Sydney (Kingsford-Smith) Airport, Canberra Airport, Newcastle Airport / RAAF Base Williamtown, Bankstown Airport, RAAF Base Richmond, Goulburn Airport, Camden Airport, Maitland Aerodrome and Cessnock Aerodrome.
Up gauging	The tendency for airlines to increase the average seat capacity of their fleet over time through the use of higher capacity aircraft.

1. Introduction

The purpose of this report was to understand the growth potential and capacity constraints at Newcastle Airport by conducting analysis on current aircraft movements to derive forecasts for 2015, 2020 and 2035. This report discusses the applied approach, assumptions and analysis of forecast growth and potential civil movement capacity constraints at Newcastle Airport by analysing aircraft movement forecasts, disaggregated by hour-of-day, aerodrome code (aircraft type) and passenger market for a specified planning day. The outcome of this report was to identify the impact of the civil movement cap on growth potential for the chosen forecast years.

Newcastle Airport operates civilian operations at RAAF Base Williamtown under arrangement with the Department of Defence with the agreed civil movement cap currently fixed at 6 arrivals per hour. This report focuses on the limitations of this movement constraint (i.e. assumed to be 12 movements per hour) to the planning day schedule and does not consider air space, apron or gate capacity constraints.

The overarching objective of this research was to analyse annual forecast movements at Newcastle Airport in more detail and determine corresponding „planning day" movement profiles by:

- applying market specific growth rates to base traffic movements;
- developing a fleet composition forecast;
- analysing aircraft movement growth forecasts by market; and
- applying aircraft movement constraints to forecast profiles.

The analysis conducted in this paper aims to provide insight on:

- growth opportunities and constraints at Newcastle Airport by hour-of-day, market and aerodrome code;
- future planning day profiles for Newcastle Airport for the unconstrained case;
- future planning day profiles for Newcastle Airport for a constrained case, where current constraints on hourly movements are applied;
- how market shares change and how Newcastle Airport might play a greater role in capturing unmet demand from Sydney (Kingsford-Smith) Airport; and
- the potential impact of forecast scenarios, such as the impact of constraint variations on domestic, regional and international markets.

The forecasts and analysis cover the base year and three forecast years to 2035 as follows:

- 2010 (base year);
- 2015;
- 2020; and
- 2035.

Forecasts growth rates, were drawn from the Booz & Company report "Forecast Growth Estimates for Aviation Activity in the Sydney Region" (thereafter referred to as the "Forecast

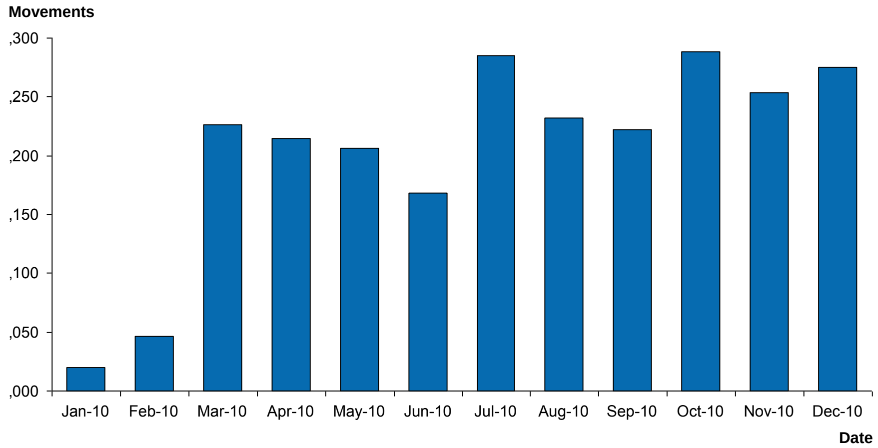
Growth Report") as part of the Joint Study on aviation capacity for the Sydney Region. These are discussed in more detail in Section 3.3

2. Base Data

The base Newcastle Airport schedule data was collected from SRS Analyser[1] and contained detailed information on scheduled aircraft movements and passengers at Newcastle Airport for the selected planning day. The data was sorted and segmented by time-of-day, aerodrome code (aircraft type) and passenger market.

Since actual daily movements were not available to assess the 30th busiest day for 2010, the planning day was chosen as an average day of the peak month. Analysis of monthly scheduled movements and passengers at Newcastle Airport for 2010 allowed us to identify a typical peak day. Figure 1 illustrates that October 2010 was the month of highest aircraft movements and Figure 2 shows that it was the busiest month by passengers; therefore October was chosen as the planning month. A mid-week day was selected as this was considered representative of a typical day and would avoid the spike in commuter traffic that would be expected at the tail ends of the week. This ensured that the absolute maximum is not taken as the planning day and thus overestimating the peak for the base data. As a result, Wednesday 13 October 2010 was selected as the planning day for analysis.

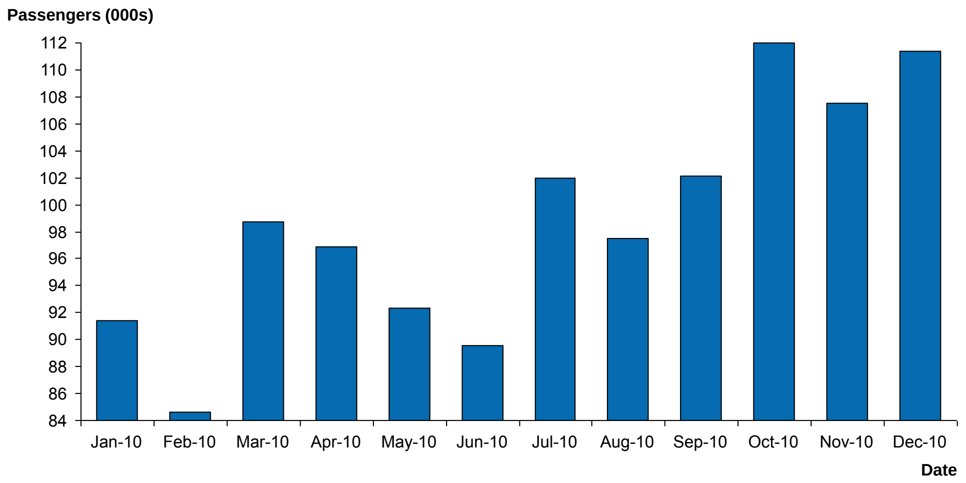
Figure 1- Monthly Aircraft Movements at Newcastle Airport, January 2010 to December 2010



Source: SRS Analyser, Booz & Company analysis

[1] *SRS analyser is an online tool allowing access to IATA's Schedule Reference Service (SRS). SRS is a neutral source of schedule data that collects, validates, consolidates and distributes airline flight schedules and related data for over 900 airlines worldwide.*

Figure 2 - Monthly Passengers at Newcastle Airport, January 2010 to December 2010



Source: BITRE, Booz & Company analysis

2.1 Data segmentation

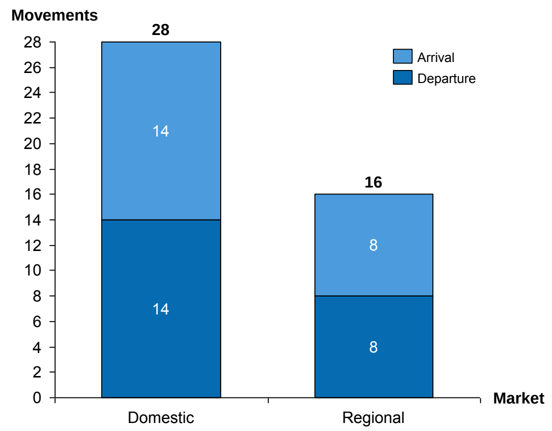
2.1.1 Market type

Each movement falls into one of three markets:

- Regional - services to/from airports in New South Wales, however, for Newcastle Airport, services to/from Canberra Airport are also classified as regional;
- Domestic services to/from Australian airports excluding New South Wales (this also includes services operating between Sydney (Kingsford-Smith) Airport and Newcastle); or
- International -services to/from airports outside Australia.

These market segments were assumed to have varying growth rates as determined in the Forecast Growth Report. The current market size (total movements in our „planning day") is shown in Figure 3.

Figure 3 - Movements by Market at Newcastle Airport for the 2010 Planning Day

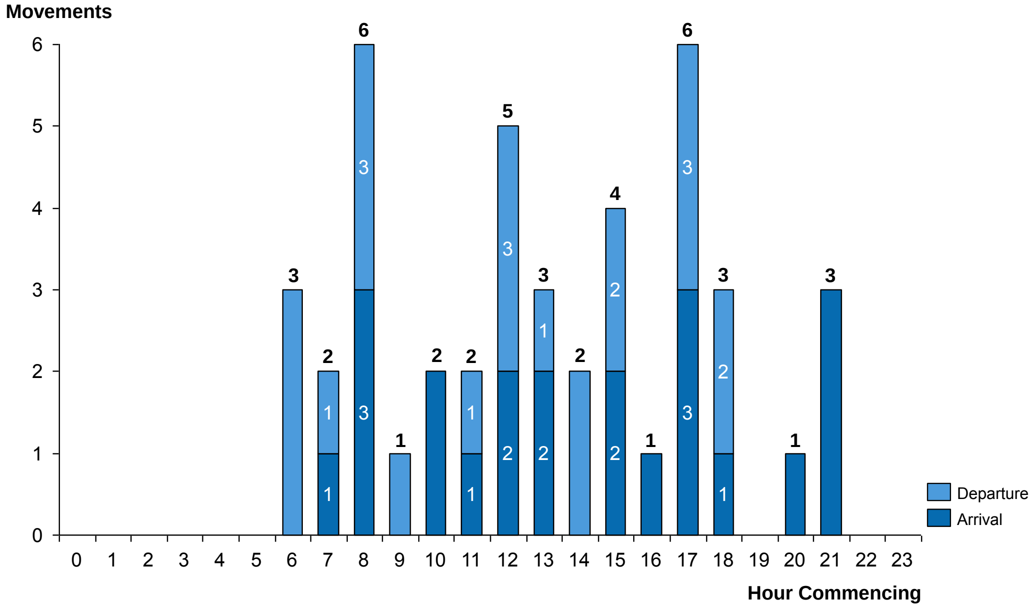


Note: Wednesday 13 October 2010. There are currently no international services at Newcastle Airport
Source: SRS Analyser, Booz & Company analysis

2.1.2 *Time-of-Day*

The distribution of movements for the adopted planning day in 2010 is shown in Figure 4.

Figure 4 - Distribution of Movements at Newcastle Airport for the 2010 Planning Day



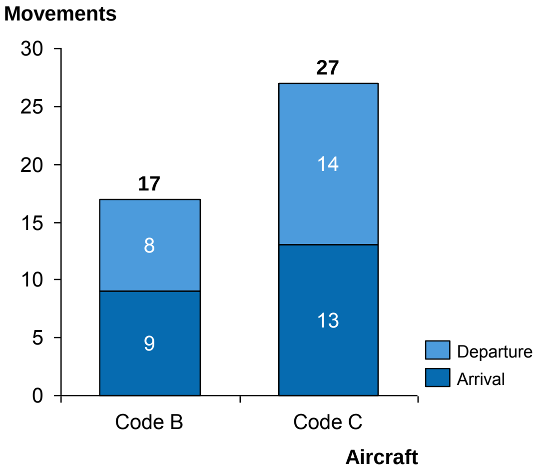
Note: Wednesday 13 October 2010
Source: SRS Analyser, Booz & Company analysis

All movements occur between 06:00 and 22:00 which is a result of the curfew for civil operations at Newcastle Airport. Figure 4 shows that the AM peak occurs between 08:00 to 08:59 with 6 movements and the PM peak as 17:00 to 17:59 with 6 movements in each period. Civil aircraft movements at Newcastle Airport are limited to 6 arrivals per hour (i.e. assumed to correspond to an equivalent cap of 12 movements per hour) implying that two of the current peak hours are operating at 50 per cent of the maximum allowable movements. Throughout the operational day, there are generally similar amount of arrivals and departures leaving each hour.

2.1.3 *Aircraft type*

The final layer of segmentation added was the aerodrome reference code (aircraft type). Figure 5 shows the fleet composition of the chosen planning day, and illustrates that aircraft operating at Newcastle Airport fall into one of two aerodrome reference code categories, namely Code B and Code C.

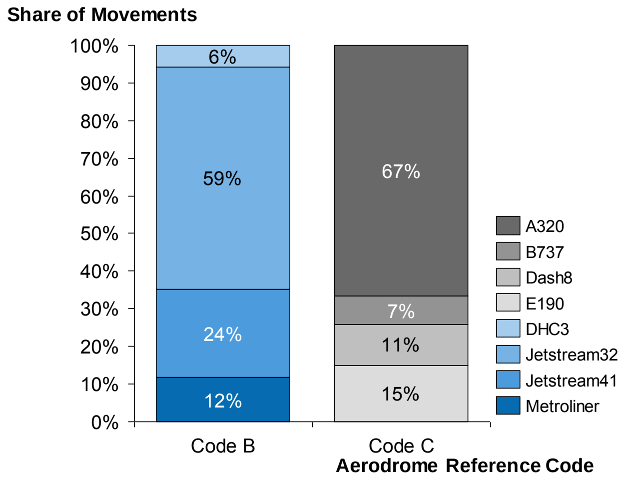
Figure 5 - Fleet composition at Newcastle Airport for the 2010 Planning Day



Note: Wednesday 13 October 2010
Source: SRS Analyser, Booz & Company analysis

Figure 6 illustrates that Code B is made up of Jetstream (82 per cent), Swearingen Metroliner (12 per cent) aircraft and De Havilland DHC-3 (6 per cent), whilst Code C is comprised of Airbus A320-200 (67 per cent), Embraer E190 (15 per cent), De Havilland Dash 8 (11 per cent) and Boeing 737 (7 per cent) aircraft.

Figure 6 - Aircraft Code by Equipment Type for the 2010 Planning Day

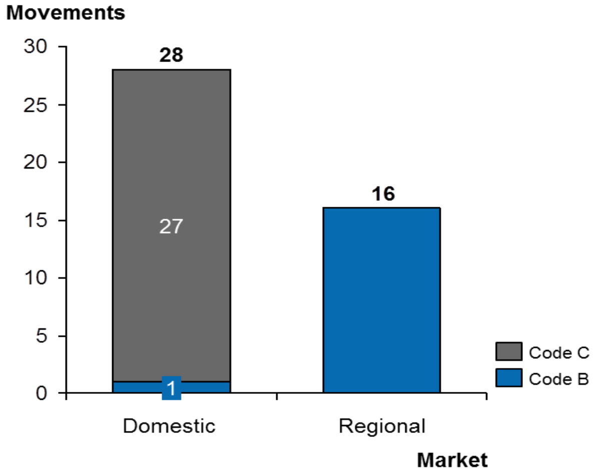


Note: Wednesday 13 October 2010
Source: SRS Analyser, Booz & Company analysis

2.2 Cross-analysis of Segments

Our cross-sectional analysis of the data reveals some expected findings. As it can be seen in Figure 7, the majority of domestic movements are made up of Code C aircraft (96 per cent). Regional movements are comprised fully of Code B. Arrivals and departures remain at an even split between aerodrome code and market share, with the exception of the domestic market where one Code B route reduces one Code C route for arrivals.

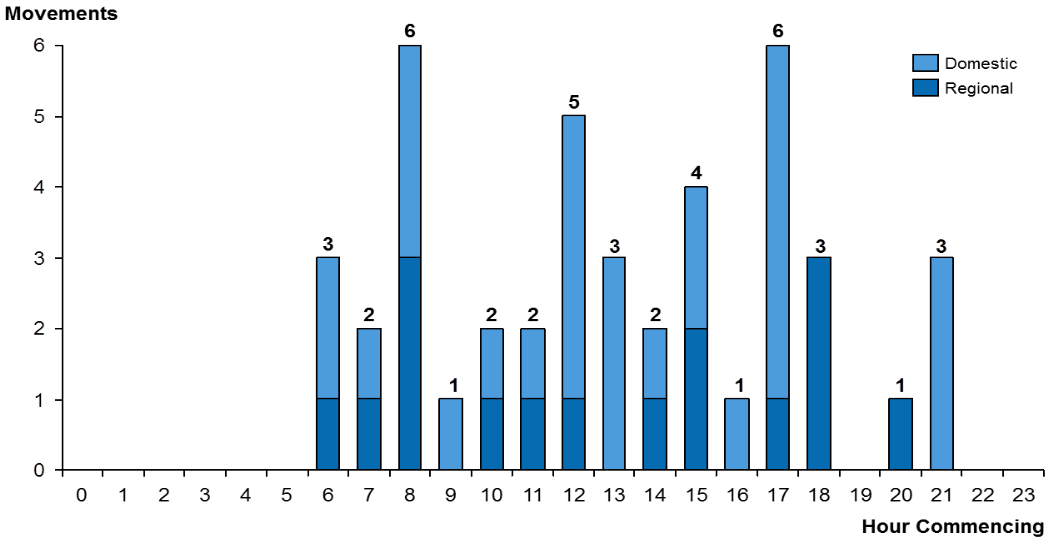
Figure 7 - Market by Aircraft Type at Newcastle Airport for the 2010 Planning Day



Note: Wednesday 13 October 2010
Source: SRS Analyser, Booz & Company analysis

Figure 8 illustrates that for most hours of the day, the domestic and regional markets generally have a comparable proportion of movements.

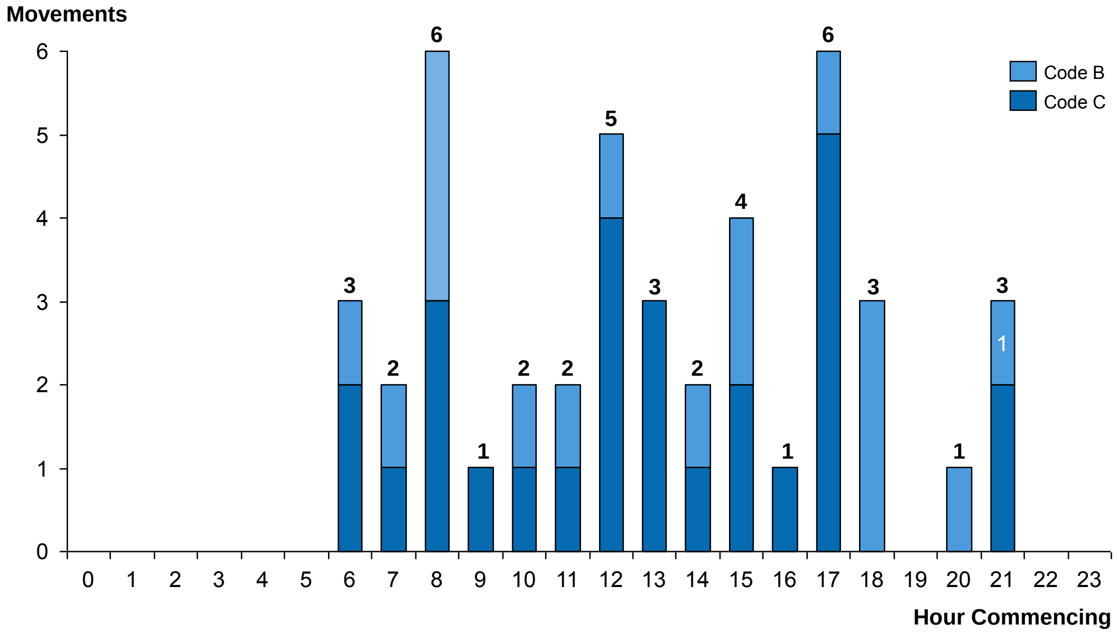
Figure 8 - Distribution of Movements by Market Type at Newcastle Airport for the 2010 Planning Day



Note: Wednesday 13 October 2010
Source: SRS Analyser, Booz & Company analysis

Figure 9 depicts the fleet composition for each hour, and shows that there is a comparable split between Code B and Code C aircraft (i.e. compared to the shares of domestic and regional traffic).

Figure 9 - Distribution of Movements by Aircraft Type at Newcastle Airport for the 2010 Planning Day



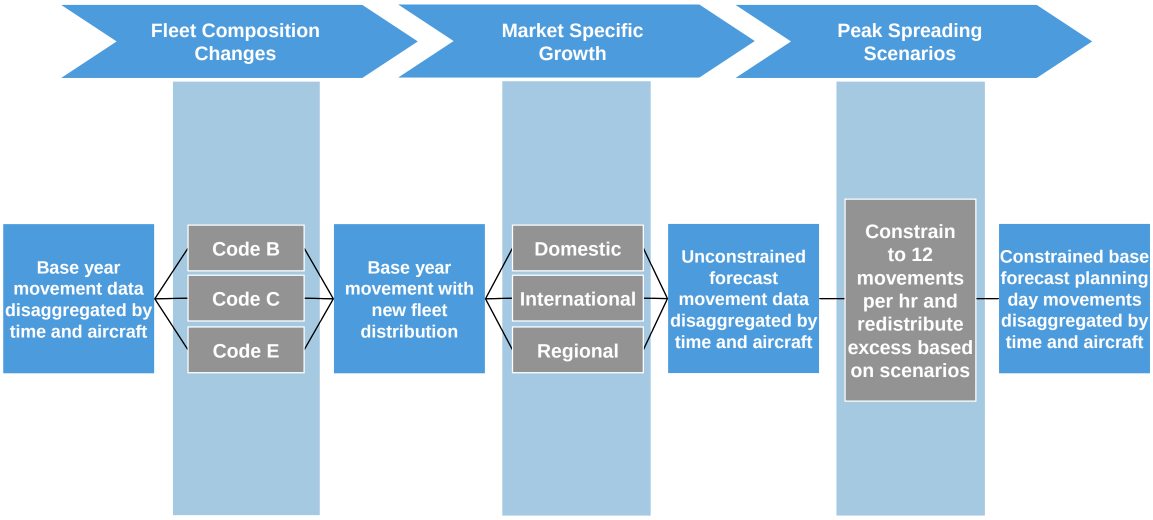
Note: Wednesday 13 October 2010
Source: SRS Analyser, Booz & Company analysis

3. Forecasting Approach

3.1 Introduction

Figure 10 illustrates the forecasting process used in the remainder of this chapter.

Figure 10 - Forecasting process illustration



Source: Booz & Company

For each forecast year, the previous year‟s forecast/actual data was taken as the base (i.e. for the forecast of 2015, the 2010 base data was used, and for forecast year 2020, the 2015 forecast data was used as the base, etc). Market specific growth rates and forecast impacts from changes in fleet composition were applied to the base data for each forecast period. The aircraft movement data was re-organised by time (hour), market type and aircraft type to provide the base planning day data set (i.e. data was aggregated to provide the number of movements for every combination of these three attributes). Figure 11 provides an illustration of the „movement matrix‟.

Figure 11 - Movement Matrix Example

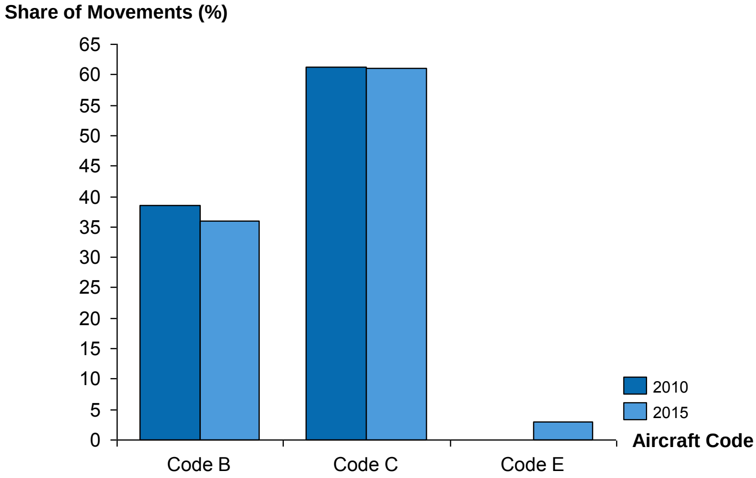
2010 Movements	**Domestic**								**TOTAL**	**International**			
Hour	Code A	Code B	Code C	Code D	Code E	Code F	Helicopter	Unknown		Code A	Code B	Code C	Code D
0									0				
1									0				
2									0				
3									0				
4									0				
5									0				
6			2						2				
7		1							1				

Source: Booz & Company

3.2 Fleet composition changes

Changes in fleet composition were estimated and distributed across each hour of the day using the distribution of movements at Newcastle Airport on the planning day. The current distribution of aircraft type across different markets for the 2010 planning day was determined from published schedule data. The 2010 planning day was used as the base to calculate any incremental changes. It was assumed that there will be no significant change to the aerodrome codes for domestic and regional movements, however, up gauging is expected to occur through increases in seat capacity within these groups (e.g. an A320 may be replaced by an A321 or a new generation aircraft). The change in distribution of aircraft type between forecast years 2010 and 2015 is shown in Figure 12.

Figure 12 - Assumed Changes in Aircraft Fleet Mix at Newcastle Airport, 2010-2015



Source: SRS Analyser, Booz & Company analysis

The change in fleet mix is explained by the planned commencement of international services. We have applied international service assumptions at Newcastle Airport consistent with annual forecasts presented in the Forecast Growth Report. For 2010 to 2015, there was no assumed change in fleet mix for domestic and regional flights. By 2015, daily international return services to New Zealand and South East Asia are assumed to be operating at Newcastle Airport[2]. These international services were assumed to be redistributed from Sydney (Kingsford-Smith) Airport in order to relieve some capacity demand at the airport[3]. The service to New Zealand is assumed to increase the use of Code C aircraft whilst an assumed service to South East Asia is expected to introduce Code E aircraft to the fleet mix.

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2 For the purpose of this report, we have relied on the information provided by Newcastle Airport in their Master Plan. However, it should be noted that these are only assumptions and that they should be treated as such

3 The redistribution of international services from Sydney (Kingsford-Smith) Airport is an assumption which has been formulated by Booz & Company as a construct necessary to forecast movements at Newcastle Airport for the selected years of 2015, 2020 and 2035

3.3 Growth assumptions for movements

Once fleet changes were incorporated, market and year specific growth was applied to each relevant data value to uplift it to the forecast year. The growth rates used were drawn from the „Forecast Growth Report", where for each forecast year, the previous year"s forecast/actual data was taken as the base year.

The Forecast Growth Report considered the ambitions of Newcastle Airport to commence international service operations as identified in its Master Plan. It assumed that in the short term (2012), Newcastle Airport would start capturing unmet international demand from Sydney (Kingsford-Smith) Airport. It was also assumed that a relatively small proportion of excess international services would be diverted from Sydney (Kingsford-Smith) Airport to Newcastle Airport, with the majority of these routes being allocated to the Hunter/Central Coast region.

It is interesting to note that in the 2006 Sydney Airport Ground Travel Plan, it is reported that approximately 2 per cent of passengers using Sydney (Kingsford-Smith) Airport originate from the Newcastle catchment[4]. However, from a market perspective, Newcastle Airport and Sydney (Kingsford-Smith) Airport are not perfectly interchangeable. A detailed analysis around route schedules at the Sydney (Kingsford-Smith) Airport and Newcastle Airport was undertaken to develop a potential scenario for the establishment of international routes and associated timing of assumed international services at Newcastle Airport. To allocate the redistributed Sydney (Kingsford-Smith) Airport movements to appropriate hours, the „busy hours" of movements at Sydney (Kingsford-Smith) Airport and Newcastle Airport were identified, and redistributed services were kept close to their original timing. This would keep the service more convenient to passengers and minimise a reduction in demand.

In the Forecast Growth Report, it was assumed that four return services per week to New Zealand would commence operating from Newcastle Airport from 2012. It was assumed that a small amount of passengers using these services would be diverted from Sydney (Kingsford-Smith) Airport; however, it is assumed that the service would also stimulate additional demand between the regions. These services to New Zealand were assumed to increase to a daily service by 2015. This translates to one return movement to New Zealand for the planning day, beginning at the 2015 base year.

In 2014, it was assumed that services between Newcastle Airport and South East Asia commence with four return services per week. It was assumed that services to South East Asia increase to a daily return service by 2017. In 2015, this translates to one return movement to South East Asia for the planning day. For the following base forecast years (2020 and 2035), it was assumed that one return service between Newcastle Airport and South East Asia operates on the planning day.

The growth rates incorporate changes in a number of variables which are discussed below. As these factors have already been incorporated into the growth rates, they are only discussed below and not included again in the modelling process for the day profile:

---

[4] *SACL (2006), 2006 Airport Ground Travel Plan, p.10*

- *Up gauging:* The growth rates in Table 1 below account for up gauging and increased aircraft capacity. This implies that aircraft movements grow at a slower rate than passenger movements.
- *Increased load factors:* The growth rates also assumed increasing aircraft load factors which also ensure that movement growth is slower than passenger growth.

Growth rates were defined based on the demand model created for the Forecast Growth Report. The growth rates applied are shown in Table 1 below.

Table 1 - Forecast Aircraft Movement Growth Rates at Newcastle Airport, 2010 to 2035 (Unconstrained Base Case)

Market	Total		
	2015	2020	2035
Regional	26%	18%	40%
Domestic	26%	18%	40%
International	n/a[1]	27%	24%
GA	0%	0%	0%
Military	0%	72%	0%

Note: Aggregate growth rates (i.e. 2010-2015, 2015-2020 and 2020-2035)
(1) International services were only assumed to commence from 2012
Source: Booz & Company analysis

The proportion of international passengers being diverted from Sydney (Kingsford-Smith) Airport to Newcastle Airport was assumed to be approximately 30 per cent. Therefore, in 2012, out of the forecast 23,400 international passengers at Newcastle Airport around 7,000 are expected to be passengers diverted from Sydney (Kingsford-Smith) Airport. In 2060, international passenger movements are expected to increase to 189,000 passengers.

3.4 Redistribution Methodology

Once growth was applied to hourly movements for each forecast year at Newcastle Airport, a constraint of 12 movements per hour was set. Any hourly forecasts which exceeded this limit were redistributed across other time slots where capacity exists (i.e. peak spreading). This only began to impact Newcastle Airport in the long term due to the amount of spare capacity in the peak periods.

3.5 Average Seat Capacity per Movement

As mentioned in Section 3.2, it was assumed that domestic and regional services were served by aircraft with the same aerodrome code with some fleet up gauging within that aerodrome code occurring. The assumed international flights are expected to be operated by larger capacity aircraft, therefore uplifting average seat capacity in the longer term. The assumptions for average seats per movement were based on up gauging assumptions as per the Forecast Growth Report. These are presented in Table 2.

Table 2 - Average Seats per Movement Assumptions, 2010 to 2035

Forecast Year	2010	2015	2020	2035
Domestic	150	160	170	200
Regional	22	22	22	22
International	n/a	225	245	269
Average across all markets	103	118	124	141

Source: Booz & Company analysis

4. Outcomes of analysis

4.1 Introduction

This chapter is split into three sections:

- Analysis of daily movement profiles of the constrained forecasts;
- Analysis of fleet composition and market shares; and
- Analysis of projected annual seat capacity, passengers and load factors which incorporates demand forecasts from previous work (Forecast Growth Report).

4.2 Constrained forecasts of movements per hour

This section presents the forecasts of movements per hour across the day for the three forecast years of 2015, 2020 and 2035. Figure 13 compares the daily movement profiles for each forecast year.

For the base year 2010, it can be seen that the movements in the peak hours are at low levels of utilisation, with significant excess capacity throughout the day. The peak hours have varying utilisation levels up to 50 per cent of the maximum 12 movements (i.e. 6 arrivals and 6 departures). The busiest hour commences at 08:00 and 17:00 recording 6 movements. The inter-peak hours (09:00-16:00) experience utilisation levels of up to 42 per cent and an average utilisation level for the inter-peak period of 21 per cent.

For 2015 and the rest of the period, growth rates have been applied as described in the previous chapter. It is observed that after applying 2015 growth rates, utilisation levels are still far lower than the constraint of 12 movements per hour and so redistribution is not necessary. The peaks operate at up to 75 per cent utilisation, whereas the inter-peak period is up to 50 per cent.

As explained in the previous chapter, the assumed redistribution of a limited number of international movements from Sydney (Kingsford-Smith) Airport to New Zealand and South East Asia is evident in the 2015 Newcastle Airport planning day schedule. The international flights to/from New Zealand and South East Asia were added in the same hours at Newcastle Airport as the peak movements for these markets out of Sydney (Kingsford-Smith) Airport. Accordingly, the South East Asia service was added at 07:00-08:00 and the New Zealand flight was added to the PM peak hour of 18:00 to19:00 at Sydney (Kingsford-Smith) Airport and kept in the PM period at Newcastle Airport. Keeping Newcastle Airport timing similar to Sydney (Kingsford-Smith) Airport means the new services will target peak demand and fit with airline operations.

Based on forecast growth rates, the maximum capacity at Newcastle Airport of 12 movements per hour is not expected to be reached by 2020. The average utilisation level in the peak period is 69 per cent per hour and as expected, this is lower in the inter-peak period.

It is not expected that movements will exceed the cap of 12 movements per hour and require redistribution until 2030. In the final forecast year (2035), full capacity is reached for two one hour slots (08:00 and 17:00). Utilisation of the peaks is at 92 per cent, with the 3 excess movements redistributed to the shoulder peak. Given it is only 3 flights that need to be redistributed to adjacent hours, no suppression of passengers has been assumed. The inter-peak period is at 46 per cent of capacity.

Peak spreading scenarios

Peak spreading is only assumed to occur where forecast movements exceed the planned cap of 12 per hour. In 2035, there are 3 movements across the day that are assumed to require redistribution to shoulder periods, representing 3 per cent of total movements. Movements exceeding 12 per hour all fall in the peaks, with 2 excess movements in the AM peak and 1 in the PM peak.

Using our described growth rates and assumptions, these forecasts illustrate that by 2035 the airport will be busy but just at 51 per cent utilisation in aggregate during current aircraft operational hours (i.e. 06:00-21:59).

Flexibility in policy for hourly movements is expected to reduce peak spreading in 2035. For example, by changing the fixed constraint of 12 movements per hour, to a variable constraint of 15 movements for peak hours and 11 for off-peak, hourly overcapacity is expected to be minimised. Based on the planning day, there would be no redistribution of movements with this alternative policy setting. Table 3 illustrates the impact of flexibility of the movement cap. Since it is forecast that only three movements would be required to be redistributed in 2035, the impact on demand is assumed to be minimal, however, increasing flexibility in the movement cap may generate demand for slots as more commercially viable slots would be made available.

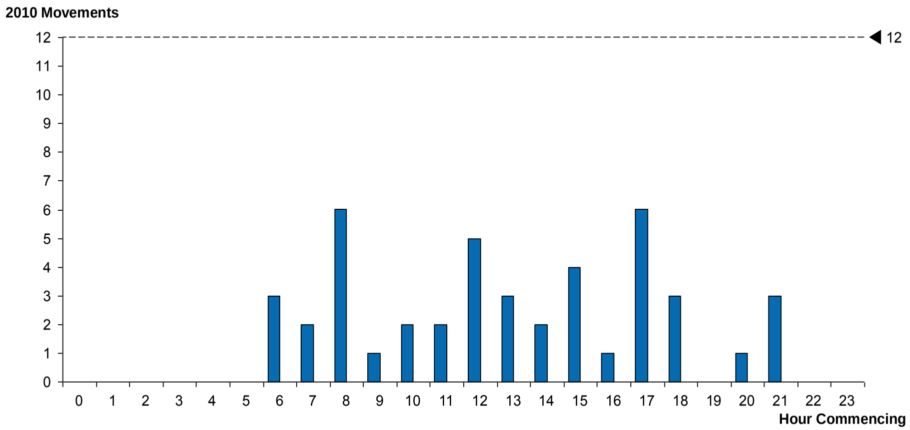
Table 3 - The Impact of Movement Constraint Policies on the 2035 Forecast

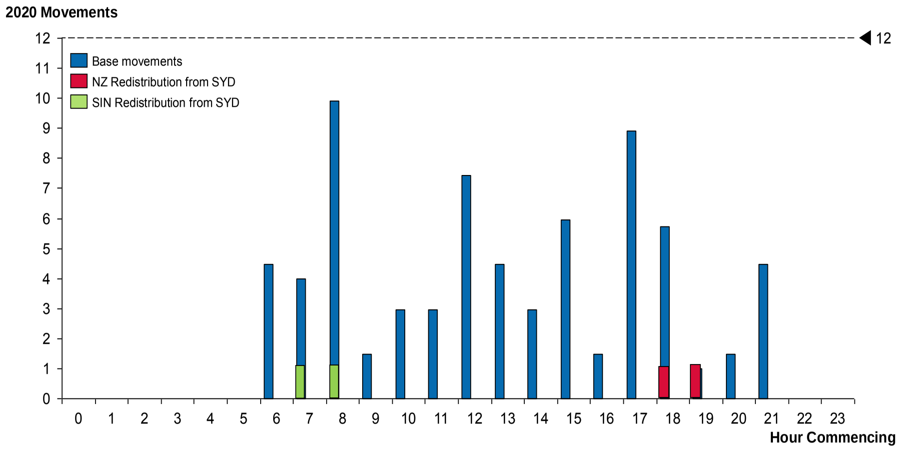
Policy	Number of hours at overcapacity	Number of redistributed services	Total number of available slots
12 Movements per hour	2	3	192
15 during the peak hours; 11 movements off-peak	0	0	192

Note: Wednesday 13 October 2010
SRS Analyser, Booz & Company analysis

Figure 14 shows the estimated distribution of movements across the day for the selected years 2015, 2020 and 2035.

Figure 13 - Newcastle Airport Distribution of Movements across the Day for each Forecast Year, 2010, 2015, 2020 and 2035





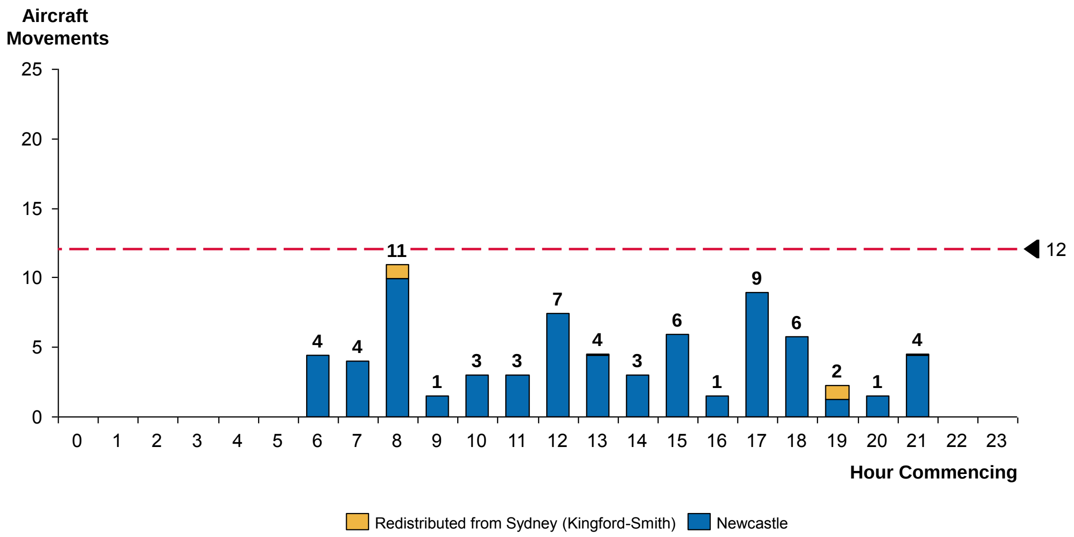
Source: Booz & Company analysis

4.3 Redistribution of Suppressed Traffic (from Sydney (Kingsford-Smith) Airport to Newcastle Airport)

To test the potential for Newcastle Airport to accommodate additional demand, a scenario of redistributing unmet demand from Sydney (Kingsford-Smith) Airport to Newcastle Airport was analysed. According to the analysis carried out as part of the Joint Study on Aviation Capacity in the Sydney Region in the report on "Planning day Peak Spreading at Sydney (Kingsford-Smith) Airport", a small amount of suppression of movements at Sydney (Kingsford-Smith) Airport is forecast as early as 2020. The daily utilisation of Newcastle Airport by 2020 is estimated to be of only 32 per cent, with demand peaking from 08:00-08:59 and 17:00-17:59 with an estimated total of 10 and 9 aircraft movements respectively.

Figure 14 shows the redistribution of suppressed traffic from Sydney (Kingsford-Smith) Airport to Newcastle Airport in 2020. A simplified assumption was made that movements suppressed at Sydney (Kingsford-Smith) Airport are scheduled at the same hour as they were due to arrive/depart Sydney.

Figure 14: Redistribution of Suppressed Traffic from Sydney (Kingsford-Smith) Airport to Newcastle Airport, 2020

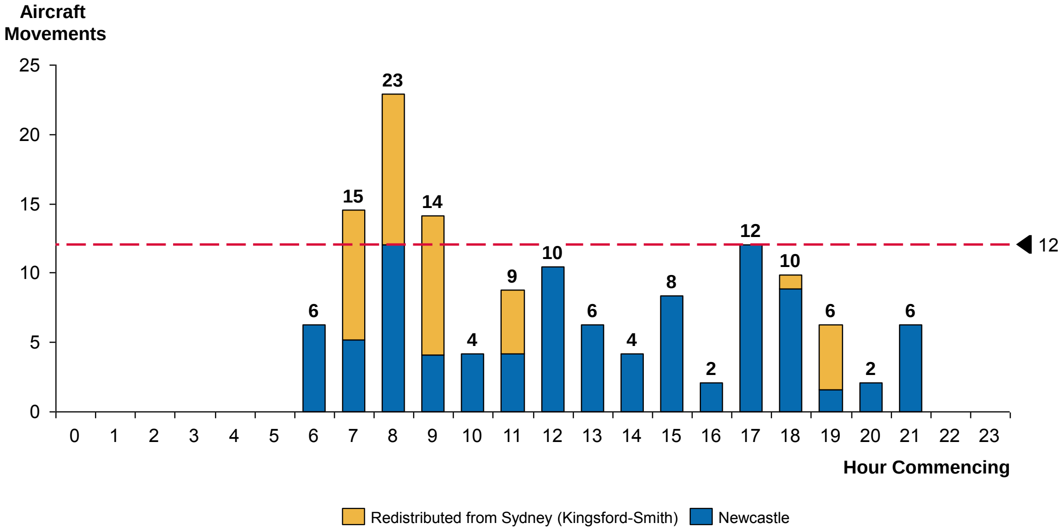


Note: A simplified assumption that movements are redistributed to the same hour as when suppressed at Sydney (Kingsford-Smith) Airport was made.
Source: Booz & Company analysis planning day profile model

The distribution of daily movements illustrated in Figure 14, shows that Newcastle Airport would have capacity to accommodate the additional suppressed traffic from Sydney (Kingsford-Smith) Airport, even during the busiest hours.

Based on this illustration, it is forecast that the number of suppressed services at Sydney (Kingsford-Smith) Airport will reach 42 movements by 2035, representing approximately 30 per cent of the total demand at Newcastle Airport. Assuming that all of these movements were redistributed to Newcastle Airport to the same hours as when suppressed at Sydney (Kingsford-Smith) Airport, the imposed cap of 12 movements per hour would be exceeded during the AM peak hours of 07:00 to 09:59, as shown in Figure 15.

Figure 15: Redistribution of Suppressed Traffic from Sydney (Kingsford-Smith) Airport to Newcastle Airport, 2035

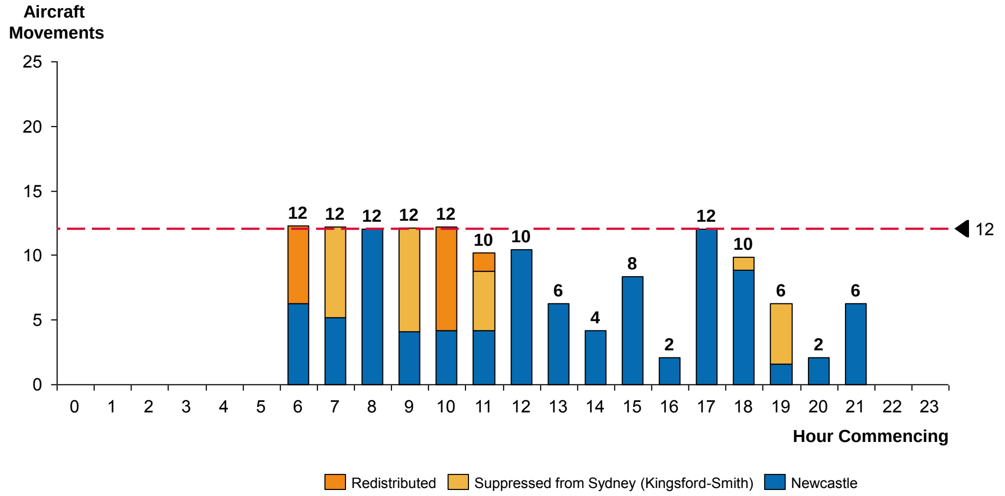


Note: A simplified assumption made that movements redistributed to the same hour as when suppressed at Sydney (Kingsford-Smith) Airport
Source: Booz & Company planning day profile model

Capacity exists in the either side of the AM peak period in 2035 to accommodate peak spreading, as shown in Figure 15. A total of 16 movements would need to be redistributed from 07:00 to 09:59 to the shoulder peak periods under a peak spreading scenario.

Figure 16 shows how service could be redistributed from the peak period at Newcastle Airport for the 2035 planning day profile. The utilisation rate in aggregate of Newcastle Airport by 2035, would increase from 32 per cent to 51 per cent with the additional services from Sydney (Kingsford-Smith) Airport without any peak spreading scenario. Under a peak spreading scenario the utilisation rate would increase further to 72 per cent, with significant peak spreading occurring in the morning peak.

Figure 16: Newcastle Airport Profile with Suppressed Movements from Sydney (Kingsford-Smith) Airport, 2035



Note: A simplified assumption made that movements redistributed to the same hour as when suppressed at Sydney (Kingsford-Smith) Airport. Movements redistributed where they can be accommodated in the initial hour.
Source: Booz & Company planning day profile model

4.4 Fleet Composition and Market Share

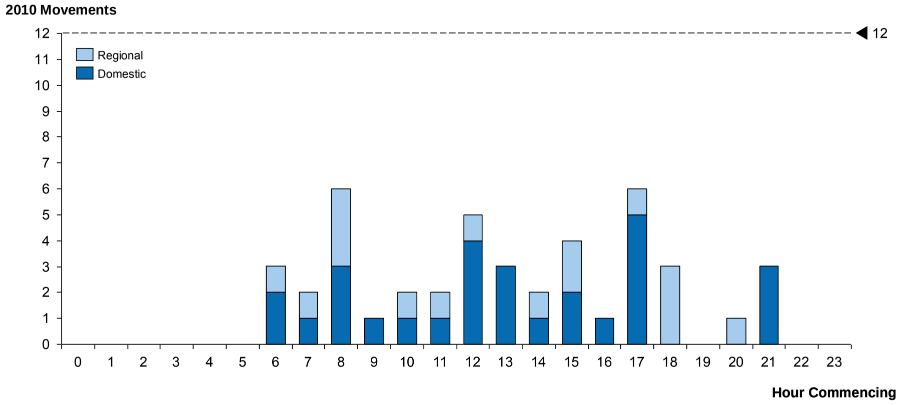
This section „drills down" into the hourly forecasts of the base scenario to reveal changes in fleet mix and market composition across each hour slot.

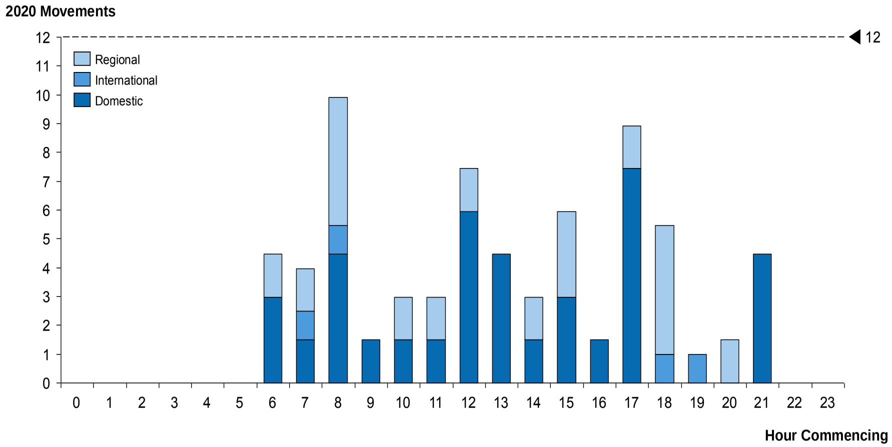
4.4.1 Growth in movements categorised by market type

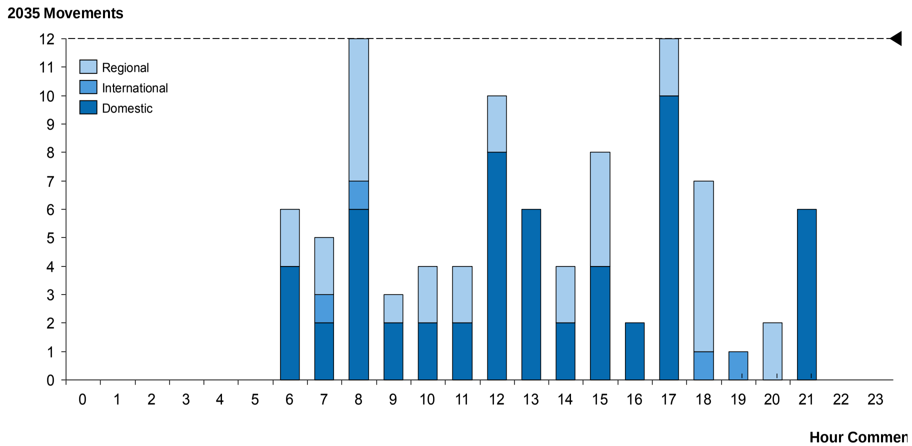
Annual movement growth rates for the domestic and regional markets were assumed to be equal throughout the forecast period. Therefore, the proportions of market share for domestic movements relative to regional remained constant over the time period.

The expansion of international movements following the assumed redistribution from Sydney (Kingsford-Smith) Airport caused movement shares to change from the 2015 forecast, as demonstrated in Figure 17. These changes were generally confined to the peak periods, where international movements were assumed to be allocated.

Figure 17 - Newcastle Airport Market Type Distribution for Each Forecast Year, 2010, 2015, 2020 and 2035







Source: Booz & Company analysis

Different totals in the same hour, as depicted in Figure 13, are due to rounding issues after growth rates have been applied. Affected hours for 2035: 18h and 19h

4.4.2 *Growth in Movements categorised by Aircraft type*

By using the fleet composition assumptions and forecasts, changes in fleet composition were calculated on an hourly basis for the „planning day" across each of the markets.

The four charts in Figure 18 depict the assumed proportional changes across each operational hour. The next 4 charts in Figure 19 show assumed market type compared with aircraft type which provides insight into forecast fleet composition within each market. Both sets of analysis include the impacts of „peak spreading" (i.e. constraining movements to 12/hour and redistributing the excess).

In 2010, the split of aircraft type is relatively even, though Code C aircraft have slightly higher movements within each hour at Newcastle Airport on average. This distribution remains irrespective of peak and off-peak hours. For Code B, there are a larger proportion of movements at the tail ends of the day, which is an expected pattern as the majority of Code B movements are regional.

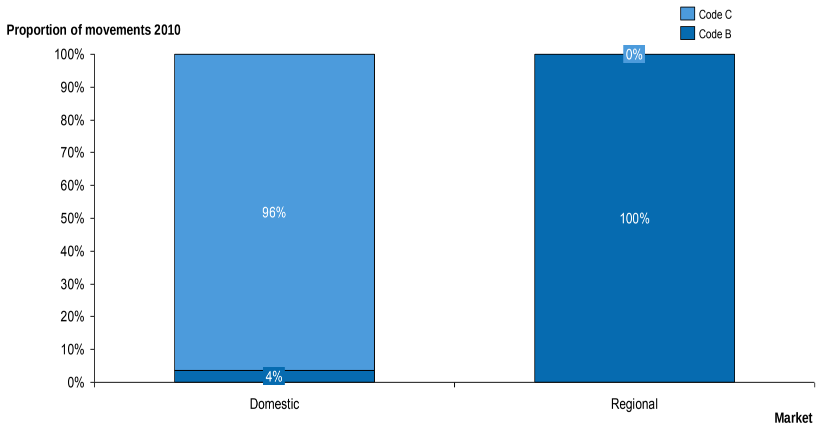
For the forecast year 2015, the fleet mix is assumed to change between 07:00-09:00 and 18:00-20:00 because of the planned international services. The assumed New Zealand service increases the forecast share of aircraft Code C and the assumed South East Asia service is expected to bring Code E aircraft to Newcastle Airport. There are no further changes assumed between 2015 and 2020 since the distribution of fleet mix by market is assumed to be constant. Unlike the forecast year 2015, there are no additional services assumed at Newcastle Airport. It is assumed that there is continued growth of existing services.

In 2035, changes to the share of aircraft type are assumed to occur due to peak spreading. This is the first forecast year to require movements to be redistributed into adjacent hours due to movement demand forecast to exceed 12 per hour during the peak hours at 08:00 and 17:00. Hours unaffected by peak spreading are assumed to have unchanged proportions of aircraft type.

Figure 18 - Proportions of Aircraft Type by Time of Day, 2010, 2015, 2020 and 2035

Source: Booz & Company analysis

Figure 19 - Market Type & Aircraft Type Proportions, 2010, 2015, 2020 and 2035



Source: Booz & Company analysis

4.5 Analysis of Daily Capacity and Passengers

Using the average seat capacity per movement by market shown in Section 3.5, the total number of seats available in each market on the „planning day" was calculated. The average load factor was estimated at 80 per cent for all movements, which is in line with the 2010 average annual load factor. This figure was assumed to remain constant throughout the forecast period. This resulted in estimated planning day passengers forecast to increase from 4,550 in 2010 to 13,500 in 2035, representing a compound annual growth rate (CAGR) of 4.4 per cent.

Table 4 - Forecast Supply of Seats for the Planning Day at Newcastle Airport 2010, 2015, 2020 and 2035

	2010	2015	2020	2035	CAGR
Domestic	4,200	5,660	7,080	11,690	4.2%
International	-	900	980	1,070	n/a
Regional	350	440	520	740	3.0%
TOTAL	**4,550**	**7,010**	**8,580**	**13,500**	**4.4%**

Source: Booz & Company analysis

Note: Figures have been rounded to the nearest tenth

Table 5 - Forecast Planning Day Passenger Demand at Newcastle Airport 2010, 2015, 2020 and 2035

	2010	2015	2020	2035	CAGR
Domestic	3,360	4,530	5,660	9,350	4.2%
International	-	720	780	860	n/a
Regional	280	350	420	590	3.0%
TOTAL	**3,640**	**5,610**	**6,860**	**10,800**	**4.4%**

Source: Booz & Company analysis

Note:
General Aviation has been left out of this analysis as no demand values have been forecast.
Figures have been rounded to the nearest tenth

Comparing this to the annual passenger forecast shows that forecast planning day passenger demand as a proportion of annual passenger demand remains constant throughout the forecast period.

Table 6 - Forecast Annual Passengers, 2010, 2015, 2020 and 2035

	2010	2015	2020	2035	CAGR
Domestic & Regional	1,185,967	1,587,395	1,974,214	3,220,940	4.1%
International		198,900	276,166	394,955	n/a
TOTAL	**1,185,967**	**1,786,295**	**2,250,380**	**3,615,895**	**4.6%**
Planning day passengers as % of annual passengers	0.3%	0.3%	0.3%	0.3%	

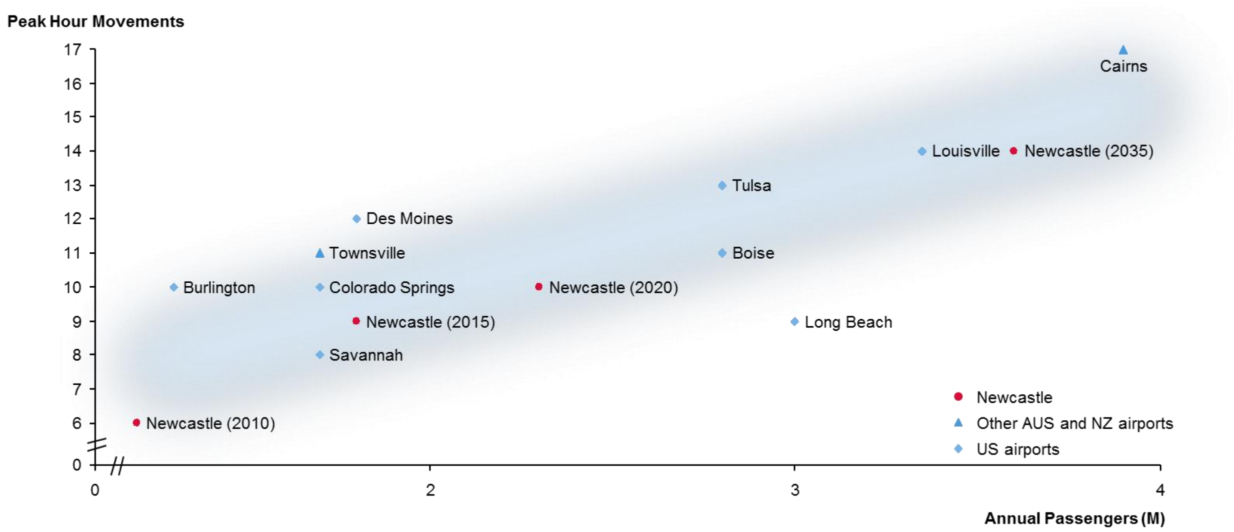
Note: Forecasts are based on the demand model created for Forecast Growth Report

Source: Booz & Company analysis

4.6 Peak Movement Benchmarking

To validate the forecast peak movements for Newcastle Airport, comparison of the forecast relationship between peak hour movements and annual passenger throughput has been compared to airports with similar levels of passengers to Newcastle Airport. Airports from Australia, New Zealand and the United States were selected where annual 2010 traffic was between 1.2 and 4 million passengers based on existing and forecast passenger volumes for Newcastle Airport. The benchmarking analysis shows that the forecast Newcastle Airport passenger traffic and peak hourly movements are reasonable based on current data for other airports.

Figure 20 - Comparison of Newcastle Airport Forecasts with Similar Airports (2010)



Source: Air Transport Intelligence[5] and Booz & Company analysis

[5] *Air Transport Intelligence (ATI) is an online data source providing up-to-date news and data for the global air transport industry*

Economic impact of not proceeding with additional aviation capacity in the Sydney region

B7

Economic Impact of not proceeding with additional aviation capacity in the Sydney region

Department of Infrastructure and Transport

21 February 2012

Ernst & Young

Contents

Executive summary

Introduction

The Australian and NSW Governments are currently working together on a Joint Study on Aviation Capacity for the Sydney region. The Joint Study is considering the short and long term aviation infrastructure requirements (including the supporting surface transport requirements) of the Sydney region, and identifying strategies and locations to meet future needs. It will also consider options for the use of Commonwealth land at Badgerys Creek, which the Australian Government has previously indicated is no longer an option for an airport.

The Joint Study will facilitate the development of an Aviation Strategic Plan, which will inform future infrastructure planning and investment by government and industry, and enable the proper integration of future airport operations with land use planning and surface transport networks.

As part of the Joint Study, Ernst & Young (EY) were asked by the Department of Infrastructure and Transport (DOIT) to estimate, based on available data, the total costs to the NSW and Australian economies of not proceeding with additional aviation capacity in the Sydney region: that is, maintaining the 'status quo'. This report details EY's assessment of these costs.

Project drivers

Airports are economic engines that reflect the communities they represent. Passenger traffic is closely linked to levels of economic development, demographics, business activity and tourism. Cargo volumes are linked to the strength of the economy. Because aviation is an enabler of this growth and activity, proceeding with an increase in aviation capacity in the Sydney region, including associated surface transport links, will allow for the enhanced economic development of the Sydney region.

Conversely, if aviation capacity is not increased and the growth of passenger and freight travel is restricted, this will threaten the region's economic growth. Specifically, the impact of restricting the growth in air travel could have the effect of:

- Causing fares to rise, increasing direct costs to the travelling public and businesses, which will result in potential passengers being priced out of the market. This is of particular concern in Sydney given that a number of low-cost carriers have expressed interest in slots at a Sydney Airport;
- Forcing the use of airports further away from where a passenger's journey originates, increasing surface access costs and travel times;
- Increasing indirect costs to business and the economy, reducing attractiveness for foreign direct investment and inbound tourism, and damaging the competitive positions of individual companies, regions or countries;
- Causing reductions in air services as low margin routes are dropped, with a concentration on a more limited range of higher yielding routes; or
- Restricting the access of remote communities to essential services (notwithstanding the regulatory protection for some routes).

Scope of work

Ernst & Young's assessment of the total costs to the NSW and Australian economies of not proceeding with additional aviation capacity in the Sydney region (i.e. maintaining the "status quo") was undertaken in two broad steps:

- **Step 1: Calculation of direct impacts ('economic shocks')** – this step involved the measurement of all changes in direct, incremental expenditures to the NSW and Australian economies which are expected to occur should forecast demand for aviation traffic in the Sydney region not be met through the supply of additional aviation capacity. These direct impacts were captured in terms of both output and value-added (defined as the economic value of the additional output); and

- **Step 2: Calculation of indirect impacts** – the associated indirect or flow-on impacts for the rest of the economy were calculated based on the direct impacts by the Centre of Policy Studies (CoPS) at Monash University, using Computable General Equilibrium (CGE) modelling. An example of these flow-on impacts is the downstream impacts that occur as a result of lost tourism expenditures to the accommodation sector, as well as restaurants and cafes.

Approach

In order to determine the expenditure impacts of not proceeding with increasing aviation capacity in the Sydney region beyond existing expansion plans, key data requirements were the forecast unmet demand for air travel to the Sydney region, including passenger and freight demand, and the impact that this unmet demand will have on expenditure on the following cost categories:

- Tourism (including business travel) – losses to the tourism industry and other industries that attract expenditure from visitors to NSW and Australia;
- Freight – losses to the freight industry in terms of volume and cost/value;
- Delays and passenger welfare – economic cost of passenger welfare and delays associated with the value of time and consumer surplus of undertaking an aviation journey. This category incorporates the impact on travellers who experience unexpected delays, the impact on travellers who shift their travel time as a result of lack of capacity at their preferred travel time, as well as the impact on potential travellers who do not travel at all as a result of aviation capacity constraints in the Sydney region;
- Aviation and airports – losses to the airport and aviation industry associated with aviation and airline operations, including retail operations; and
- Commercial developments – losses to potential hotels and business parks in the airport vicinity which would be developed if aviation capacity in the Sydney region was increased.

A mixture of data sources were used to capture the expenditure impacts of unmet aviation demand on the identified cost categories, including:

- Joint Study material, including aviation demand forecasts provided by Booz & Company;
- Existing departmental information, such as passenger elasticity information from the Bureau of Infrastructure, Transport and Regional Economics (BITRE); and
- Publicly available benchmarking data, such as average tourism expenditure and profiles of industry expenditure from Tourism NSW and other sources.

Using this information and the cost categories listed above, the direct costs of not proceeding with aviation capacity in the Sydney region were captured in terms of:

- Expenditure;
- Value-added (i.e. profit and wages, a net benefits figure); and
- Full-time equivalent (FTE) employment numbers.

The analysis was undertaken from the perspectives of both the NSW and Australian economies, given that some of the economic impact will shift from NSW to elsewhere in Australia.

In the absence of specific, publicly available data relating to the potential responses by passengers, the analysis of direct expenditure was undertaken using a range of scenarios to illustrate a range of potential outcomes in relation to unmet demand for travel to the Sydney region:

- Low;
- Medium; and
- High.

The low, medium and high scenarios in effect take into account a range of potential responses by passengers impacted by the unmet demand for aviation in the Sydney region, including the extent to which passengers impacted by aviation capacity may:

  - enter NSW through different transport modes (road, rail);
  - enter NSW through airports other than Sydney (Kingsford-Smith) Airport (Canberra Airport or Newcastle Airport);
  - be redistributed to other airports in Australia;
  - be redistributed to airports overseas; or
  - decide not to travel.

Foregone direct quantifiable impacts

The summary results of the foregone direct quantifiable expenditure impacts if aviation capacity in the Sydney region is not enhanced are presented in the tables below. The tables present the gross expenditure and the value-added outcomes for each of the identified categories. The results for Australia include NSW.

The table presents the **undiscounted** flow of expenditure and value-added over the 50-year evaluation. The outcomes of the analysis show that for:

- Expenditure, the range of outcomes is a loss of:
  - between $208.6 billion and $739.3 billion for NSW; and
  - between $166.5 billion and $442.5 billion for Australia.
- Value-added, the range of outcomes is a loss of:
  - between $55.1 billion and $216.6 billion for NSW; and
  - between $42.3 billion and $126.8 billion for Australia.

Table 1: Undiscounted outputs of analysis (Australia includes NSW)

Result type (Undiscounted 2010 $)	Jurisdiction	Low (real 2010 $billions)	Medium (real 2010 $billions)	High (real 2010 $billions)
Expenditure	NSW	208.6	401.9	739.3
	Australia	166.5	268.5	442.5
Value-added	NSW	55.1	113.1	216.6
	Australia	42.3	73.2	126.8

The table below presents the **discounted** flow of expenditure and value-added over the 50-year evaluation. The outcomes of the analysis show that for:

- Expenditure, the range of outcomes is a loss of:

- between $17.4 billion and $51.1 billion for NSW; and
- between $14.6 billion and $32.2 billion for Australia.

- Value-added, the range of outcomes is a loss of:
  - between $4.4 billion and $14.6 billion for NSW; and
  - between $3.6 billion and $8.9 billion for Australia.

Table 2: Discounted outputs of analysis (Australia includes NSW)

Result type (Present value $)	Jurisdiction	Low (PV $billions)	Medium (PV $billions)	High (PV $billions)
Expenditure	NSW	17.4	29.7	51.1
	Australia	14.6	21.2	32.2
Value-added	NSW	4.4	8.1	14.6
	Australia	3.6	5.6	8.9

The NSW employment outcomes under each of the scenarios are summarised in the table below. It should be noted these are not net employment numbers; that is, they do not consider jobs which would be created in other industries if aviation capacity in the Sydney region is not increased.

Table 3: Employment outcomes

	Low	Medium	High
FTE jobs	28,000	44,700	74,300

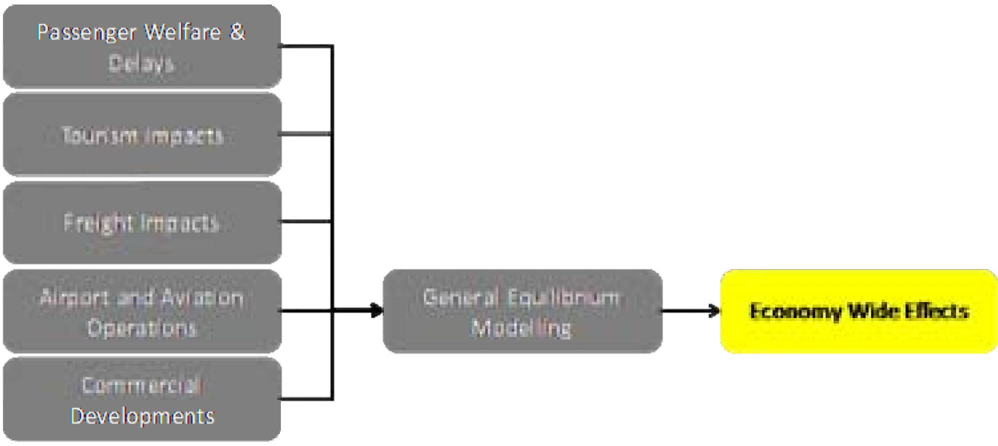
The outputs presented in the table above are presented as an annual average over the 50-year evaluation period (2011 – 2060). They were estimated based on pro-rating publicly available IBISWorld report estimates of employment per dollar of industry expenditure (as detailed in Chapter 3.4) with estimated foregone expenditure, with the exception of business parks in the commercial developments category, which were calculated based on benchmarking other international airports.

Foregone total quantifiable impacts

The foregone total quantifiable impacts, or the economy wide study, were undertaken using a general equilibrium modelling approach. Under a general equilibrium approach, the direct expenditure benefits and costs outlined above are used as inputs, driving the results for the entire NSW and Rest of Australia (ROA) economies.

The approach to capturing the economy wide effects of a lack of aviation capacity in the Sydney region is shown in the figure below.

Figure 1: General Equilibrium Modelling Inputs



Based on the direct expenditure impacts outlined above, a broad economic impact study was conducted on the NSW and Australian economies. The economic impact assessment was undertaken using The MMRF general equilibrium model developed at the Centre of Policy Studies (CoPS). A summary of the results across the major output variables is produced in the table below.

Table 4: NSW and national impacts of a lack of capacity in the Sydney region's aviation network

Scenario		2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	NSW ($'ms)										
	Real private consumption	5	15	32	54	265	800	1,530	2,499	3,763	5,398
	Real investment	50	59	77	103	243	521	831	1,200	1,653	2,215
	International export volumes	4	14	25	39	106	284	531	852	1,261	1,779
	International import volumes	24	32	45	62	143	315	523	780	1,102	1,505
	Real GSP	98	147	210	293	584	1,260	2,158	3,320	4,804	6,690
	Employment ('000 of persons)	0.1	0.1	0.2	0.2	1.0	2.6	4.6	7.2	10.5	14.7
	ROA ($'ms)										
	Real private consumption	92	152	225	316	586	1,171	1,948	2,955	4,243	5,883
	Real investment	80	97	122	158	251	409	571	751	960	1,207
	International export volumes	74	117	168	234	300	402	539	709	915	1,165
	International import volumes	65	88	118	158	262	458	686	964	1,305	1,729
	Real GDP	175	268	381	525	830	1,436	2,225	3,229	4,496	6,092
	Employment ('000 of persons)	0.0	0.1	0.1	0.1	0.4	0.9	1.5	2.4	3.6	5.1
Medium	NSW ($'ms)										
	Real private consumption	5	25	64	123	872	2,860	5,704	9,649	15,038	22,393
	Real investment	52	66	94	134	580	1,496	2,585	3,952	5,704	7,975
	International export volumes	6	18	35	58	259	836	1,666	2,777	4,213	6,006
	International import volumes	24	36	56	84	354	959	1,726	2,716	3,994	5,642
	Real GSP	102	160	245	363	1,184	3,310	6,327	10,472	16,096	23,733
	Employment ('000 of persons)	0.1	0.1	0.3	0.4	2.9	8.7	16.3	26.3	39.6	57.0
	ROA ($'ms)										
	Real private consumption	93	163	258	382	1,144	3,053	5,736	9,404	14,369	21,115
	Real investment	82	101	131	172	415	841	1,277	1,770	2,361	3,093
	International export volumes	75	118	170	237	310	456	661	913	1,208	1,533
	International import volumes	65	92	130	181	491	1,133	1,915	2,900	4,151	5,747
	Real GDP	179	280	411	581	1,294	2,998	5,354	8,541	12,836	18,672
	Employment ('000 of persons)	0.0	0.1	0.1	0.2	1.0	3.0	5.7	9.4	14.3	20.8
High	NSW ($'ms)										
	Real private consumption	4	43	124	252	2,002	6,739	13,709	23,816	38,875	63,063
	Real investment	54	78	124	189	1,168	3,209	5,699	8,922	13,261	19,472
	International export volumes	9	25	51	91	508	1,742	3,507	5,729	7,844	8,462
	International import volumes	24	43	76	123	736	2,126	3,910	6,234	9,262	13,299

Real GSP	105	181	306	489	2,244	7,011	14,063	24,274	39,250	62,657
Employment ('000 of persons)	0.1	0.2	0.4	0.8	6.5	19.9	37.6	61.5	93.5	136.9
ROA ($'ms)										
Real private consumption	94	182	314	500	2,152	6,507	12,855	22,033	35,773	58,186
Real investment	84	108	146	195	682	1,535	2,415	3,446	4,766	6,615
International export volumes	76	119	171	238	305	484	727	936	795	205
International import volumes	65	99	152	223	902	2,346	4,122	6,380	9,288	13,166
Real GDP	183	298	458	675	2,085	5,734	11,035	18,703	30,135	48,569
Employment ('000 of persons)	0.0	0.1	0.2	0.3	2.3	7.0	13.4	22.3	34.9	53.4

Source: CoPS and MMRF

The measures presented in the table above include:

- Real private consumption – presents the changes in expenditure on goods and services intended for individual consumption or use;
- Real investment – presents the changes in investment in tangible and productive assets such as plant and machinery, as opposed to investment in securities or other financial instruments;
- International export volumes – a measure of the change in international trade of products and services from NSW and the ROA;
- International import volumes – a measure of the change in international trade of products and services into NSW and the ROA;
- Real Gross Domestic/State Product – a measure of the total market value of all final goods and services produced in NSW and Australia (excluding NSW) in a given year which is equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports; and
- Employment ('000 of persons) – the change in employment driven by changes in economic activity within the economy at the NSW and the ROA levels.

As shown in Table 4, significant economic impacts will occur if Sydney's aviation capacity is not increased, including:

- An annual impact on NSW's Gross State Product (GSP) ranging from $210 million to $306 million in 2025, rising to range between $6,690 million and $62,657 million in 2060;
- An annual net reduction in real private consumption at the NSW level reaching between $5,398 million and $63,063 million in 2060, and an annual reduction for the ROA reaching between $5,883 million and $58,186 million in 2060;
- An annual reduction in real investment in NSW ranging from $50 million to $54 million in 2015 to between $2,215 million to $19,472 million in 2060; and
- A reduction of 14,700 to 136,900 potential jobs will not be created in NSW by 2060 if the aviation capacity status quo is maintained.

Foregone qualitative impacts

This report seeks to estimate the potential costs to the Australian and NSW economies of maintaining the status quo in terms of aviation infrastructure in the Sydney region. This analysis provides an important basis for policy makers to understand the potential implications of decisions regarding Australia's future aviation strategy.

However, this analysis does not capture the full story. There is a wide range of impacts associated with aviation infrastructure that are difficult to monetise; an analysis that sets aside such non-monetised impacts is at risk of significantly understating or overstating the benefits/costs of investment decisions.

A number of research studies have been undertaken that consider the wider impacts associated with aviation capacity in different countries. These studies include persuasive arguments as to how good aviation services are an important enabler of economic growth, particularly for the services sector. However, despite the importance of the issue, there is limited published literature on the direct quantifiable wider economic impacts of airports. This is largely driven by the fact it is difficult to show a precise link between certain levels of aviation activity and services and the wider economy, due to the inevitable complexity of factors that underpin events such as location or investment decisions by companies.

This report outlines the key considerations relevant to the Sydney region in relation to the following non-monetised impacts:

- Connectivity – With a high degree of connectivity critical to the maintenance of NSW's and Australia's reputations as world-class destinations for business and leisure, there is a risk that constrained aviation in the Sydney region will diminish Australia's ability to consistently attract visitors to the region. Constraints on global connectivity may also have a negative impact on the access of NSW firms to larger markets and their ability to compete internationally.

- Regional growth – While it is difficult to quantify the impact of individual transport investments on overall long-term economic growth and development, Sydney's role and reputation as the 'gateway' to Australia could be at risk if Sydney cannot meet the growing demand for aviation.

- Industry development – There may be negative impacts on industry development if firms find it more difficult to access emerging markets or connect with key business destinations; if the full benefits of agglomeration associated with firms locating in or near airport precincts cannot be realised; and if labour productivity decreases due to firms having access to a smaller pool of talent from which to recruit.

- Tourism – Australia's international reputation, as well as the economic and social benefits it generates, could be at risk if Sydney cannot meet the growing demand for aviation.

- Environmental impacts – A number of adverse effects associated with aviation warrant careful consideration in considering aviation capacity, including carbon emissions, noise and local air quality impacts, and impacts on local transport networks.

- Social impacts – It has been argued that airports can generate positive social impacts, such as enabling contact between residents and friends and families overseas and expanding the choice of products available to consumers. However, quantifying these benefits is challenging as they are not easily measured and are highly subjective.

Given the challenges in quantifying these impacts, it is ultimately a matter of judgement as to the degree to which the likelihood of these impacts being realised is incorporated into decision making.

Limitations

The forecasts presented in this report were prepared using the information and assumptions acknowledged in this document, supported by the judgement and experience of those providing the assumptions. Some of the assumptions used to develop the forecasts may not be realised and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and the actual results, and these differences may be material.

Limitations on the accuracy of the results due to the variability in the inputs used, and the preliminary nature of the assessment, mean that the results should not be used for budgeting purposes or project cost forecasting.

Whilst every care has been taken in preparing this report, Ernst & Young, and those whose inputs have been used in the analysis, will not accept any responsibility or liability to any person or corporation seeking to rely on information, advice or opinion provided in this publication for any loss or damage, whatever nature suffered by such person or corporation.

Peer review process

The approach, methodology and results generated from this analysis have been subjected to an internal peer review process to confirm the validity of the approach and identify any areas for further consideration.

Disclaimer of use of report

This Report was prepared for the exclusive use of the Department of Infrastructure and Transport ("the Department"), for the purpose of the Department advising the Steering Committee on the Joint Study on Aviation Capacity in the Sydney Region and in their advice to Government pursuant to the agreement between Ernst & Young and the Department including the scope and limitations set out therein. The Report may be relied upon by the Department, however, Ernst & Young disclaims all liability to any person other than the Department for all costs, loss, damage and liability that the third party may suffer or incur arising from or relating to or in any way connected with the provision of the Report to a third party and any use they may make of the Report without Ernst & Young's prior written consent. The Department has agreed that the Department will not amend the Report without prior written approval from Ernst & Young. If third parties choose to rely on the Report in any way, they do so entirely at their own risk.

1. Introduction

1.1 Scope of work

As part of the Joint Study on Aviation Capacity for the Sydney Region, Ernst & Young (EY) were asked by the Department of Infrastructure and Transport (DOIT) to estimate, based on available data, the total costs to the NSW and Australian economies of not proceeding with additional aviation capacity in the Sydney region: that is, maintaining the 'status quo'.

This work was undertaken in two broad steps:

- **Step 1: Calculation of direct impacts ('economic shocks')** – this step involved the measurement of all changes in direct, incremental expenditures to the NSW and Australian economies which are expected to occur should forecast demand for aviation traffic in the Sydney region not be met through the supply of additional aviation capacity. These direct impacts were captured in terms of both output and value-added (defined as the economic value of the additional output); and

- **Step 2: Calculation of indirect impacts** – the associated indirect or flow-on impacts for the rest of the economy were calculated based on the direct impacts by the Centre of Policy Studies (CoPS) at Monash University, using Computable General Equilibrium (CGE) modelling. An example of these flow-on impacts is the downstream impacts that occur as a result of lost tourism expenditures to the accommodation sector, as well as restaurants and cafes.

1.2 Structure of the report

The remainder of the report is structured as follows:

- Chapter 2 provides a discussion on aviation traffic in the Sydney region;

- Chapter 3 outlines the data inputs used to determine the economic impact of not proceeding with increasing aviation capacity in the Sydney region;

- Chapter 4 quantifies the foregone direct impacts;

- Chapter 5 quantifies the total foregone quantifiable impacts; and

- Chapter 6 provides a brief analysis of the qualitative impacts of not proceeding with increasing aviation capacity in the Sydney region.

2. Aviation traffic in the Sydney region

2.1 Aviation traffic in the Sydney region

Demand for aviation services is growing across the Sydney region. While Sydney's Kingsford Smith Airport dominates commercial airline movements in volume terms, other airfields are growing in importance.

Kingsford Smith is one of the oldest continually operating airports in the world and the busiest airport in Australia.[1] In 2010, the airport was ranked as the 27th busiest airport in the world[2] and handled:

- 35.6 million passengers;
- 656,000 tonnes of airfreight; and
- 308,914 aircraft movements.[3]

There have been longstanding concerns that effective capacity at Kingsford Smith Airport will be exhausted at some point in the future, given the significant growth in passenger numbers and aircraft movements at the airport. Recent growth has reinforced this concern: for example, between 2000 and 2009:

- Domestic flights through Sydney increased by 37%; and
- International passengers served increased by approximately 18%.[4]

Other airports that service the Sydney region have also seen growth in patronage, such as Newcastle and Canberra Airports:

- Newcastle Airport is the fastest growing regional airport in Australia. In 2007 passenger levels reached in excess of 1 million, with the Newcastle Airport Master Plan projecting passenger levels to grow to 1.8 million by 2025.[5] However, this forecast is considered conservative, given that the expansion of JetStar services at Newcastle will bring forward passenger growth at Newcastle Airport to 1.8 million well in advance of the prediction in the 20 year master plan.[6]
- Canberra Airport is forecasting ongoing passenger growth of 4% per annum and sees large opportunities in the growth of air freight through the airport.[7]

2.2 Drivers of increased demand for aviation services in the Sydney region

Growth in aviation traffic in the Sydney region is likely to have been due to a number of factors, including:

- Population and economic growth in NSW, Australia and globally;
- The affordability of air travel, especially due to the introduction of low-cost carriers; and
- Globalisation, which increases the reliance on airports and aviation infrastructure.

The increase in demand for aviation capacity in the Sydney region from an international perspective is typified by:

- AirAsia X looking to start flights to Sydney from Kuala Lumpur, if permission to fly the route is granted by the Malaysian government;[8]

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[1] Sydney Airport Factsheet – Airport History. *www.sydneyairport.com.au/SACL/DownloadDocument.ashx?...57*
[2] http://www.centreforaviation.com/news/2011/03/16/world-airport-rankings-2010-big-changes-to-global-top-30-beijing-up-to-2-heathrow-falls-to-4/page1
[3] Sydney Airports – Key Highlights 2010. www.sydneyairport.com.au/SACL/DownloadDocument.ashx?DocumentID...
[4] http://www.sydneyairport.com.au/SACL/Historical-Traffic.html
[5] http://www.infrastructure.gov.au/aviation/nap/files/Hunter_Economic_Development_Corporation.pdf
[6] Ibid
[7] http://www.canberraairport.com.au/PDF/masterplan/approved/5_AirlineAndAircraftMovementGrowth.pdf

- Batavia Air plans to commence services between Denpasar (Bali) and Sydney;[9] and
- Kenya Airways intends to start flights to Sydney in 2013-2014 when its 787s are delivered.[10]

2.3 Potential impacts of not increasing aviation capacity in the Sydney region

Airports are economic engines that reflect the communities they represent. Passenger traffic is closely linked to levels of economic development, demographics, business activity and tourism. Cargo volumes are linked to the strength of the economy. Because aviation is an enabler of this growth and activity, proceeding with an increase in aviation capacity in the Sydney region, including associated surface transport links, will allow for the enhanced economic development of the Sydney region.

Conversely, if aviation capacity is not increased and the growth of passenger and freight travel is restricted, this will threaten the region's economic growth. Specifically, the impact of restricting the growth in air travel could have the effect of:

- Causing fares to rise, increasing direct costs to the travelling public and businesses, this will result in potential passengers being priced out of the market. This is of particular concern in Sydney given that a number of low-cost carriers have expressed interest in slots at a Sydney Airport;
- Forcing the use of airports further away from where a passenger's journey originates, increasing surface access costs and travel times;
- Increasing indirect costs to business and the economy, reducing attractiveness for foreign direct investment and inbound tourism, and damaging the competitive positions of individual companies, regions or countries;
- Causing reductions in air services as low margin routes are dropped, with a concentration on a more limited range of higher yielding routes; or
- Restricting the access of remote communities to essential services (notwithstanding the regulatory protection for some routes).

The methodology used to quantify the economic impacts, and the results of the analysis, are discussed in Chapters 3 to 6.

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[8] http://news.smh.com.au/breaking-news-business/sydney-airport-still-wants-airasiax-20100611-y2xi.html
[9] http://australianaviation.com.au/2010/07/batavia-air-to-fly-to-australia/
[10] http://www.panapress.com/freenews.asp?code=eng048239&dte=04/06/2010

3. Data inputs

3.1 Definition of base case and active unconstrained demand

In order to determine the economic impact of not proceeding with additional aviation capacity in the Sydney region beyond existing expansion plans, the key data requirement was the forecast unmet demand for air travel to the Sydney region, including passenger and freight demand, if no further capacity is added beyond that which is envisaged in current Masterplans.

Booz & Company undertook this forecasting for the Department and estimated the:

- Base case domestic and international passenger demand (that is, the demand which can be met by the current aviation capacity in the Sydney region, including existing expansion plans);
- Unconstrained domestic and international passenger demand (that is, the passenger demand that will exist if no capacity constraints exist);
- Base case domestic and international aircraft movements;
- Unconstrained domestic and international aircraft movements;
- Base case domestic and international freight tonnage;
- Unconstrained domestic and international freight tonnage;
- The difference between the base case and unconstrained demand for passenger demand, aircraft movements and freight tonnes provides a forecast of unmet demand for aviation services. This level of unmet demand is a key driver of economic disbenefit; and
- The estimates were developed for the period 2011 – 2060, the same timeframe as covered by the Ernst & Young modelling. Based on the Booz & Company forecasts, the unmet demand for passengers, aircraft movements and freight tonnes begins by 2016 with the development of significant delays, suppression and peak spreading. By the mid 2030s, the constraints on aviation capacity are significant across the Sydney region according to the Booz & Company forecasts.

This unmet demand, by category, is shown in Figure 2 to Figure 4 below.

Figure 2: Unmet demand for passenger movements in the Sydney Region, 2009-2060 (source: Booz & Company)

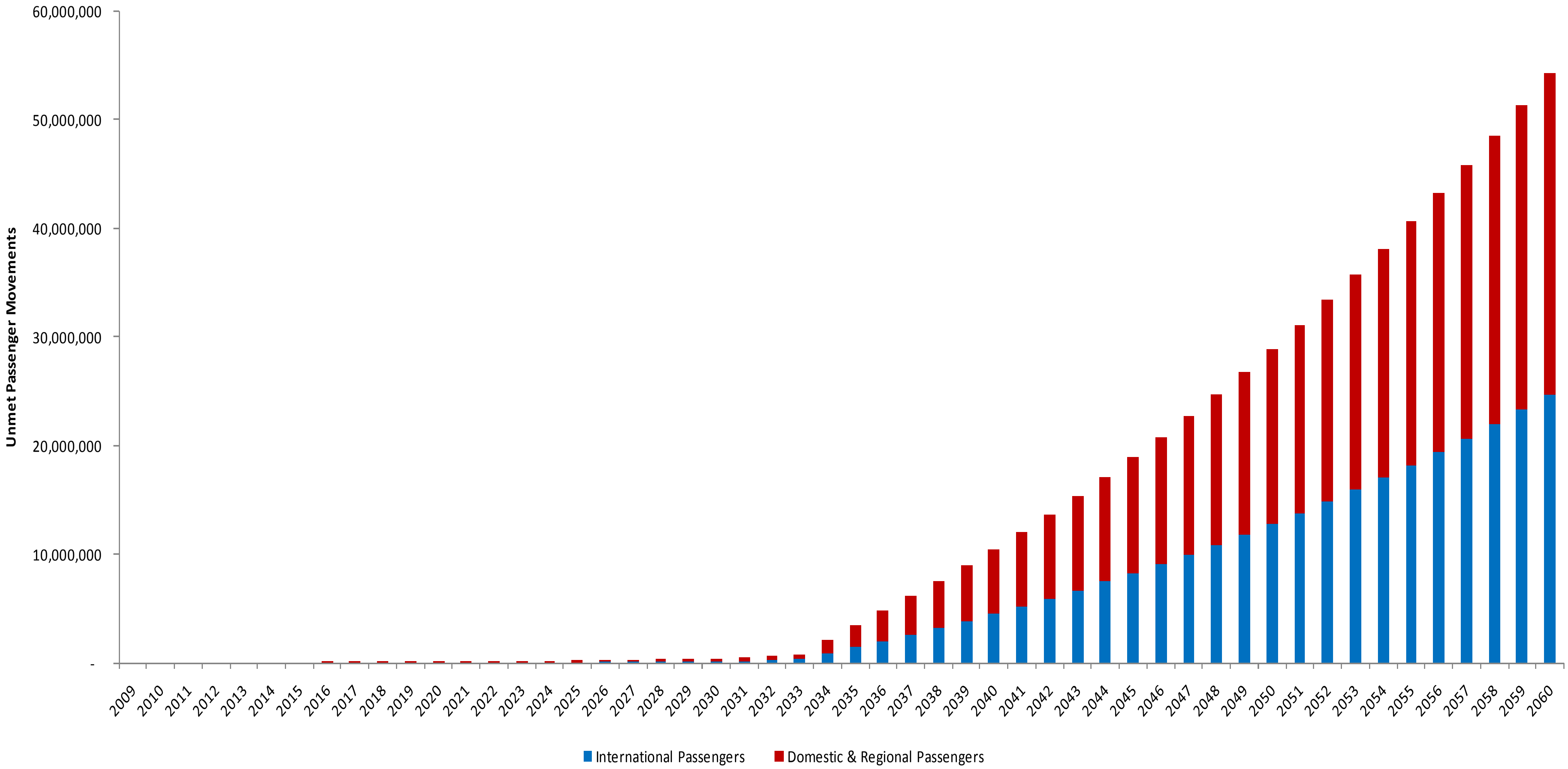


Figure 3: Unmet demand for aircraft movements in the Sydney Region, 2009-2060 (source: Booz & Company)

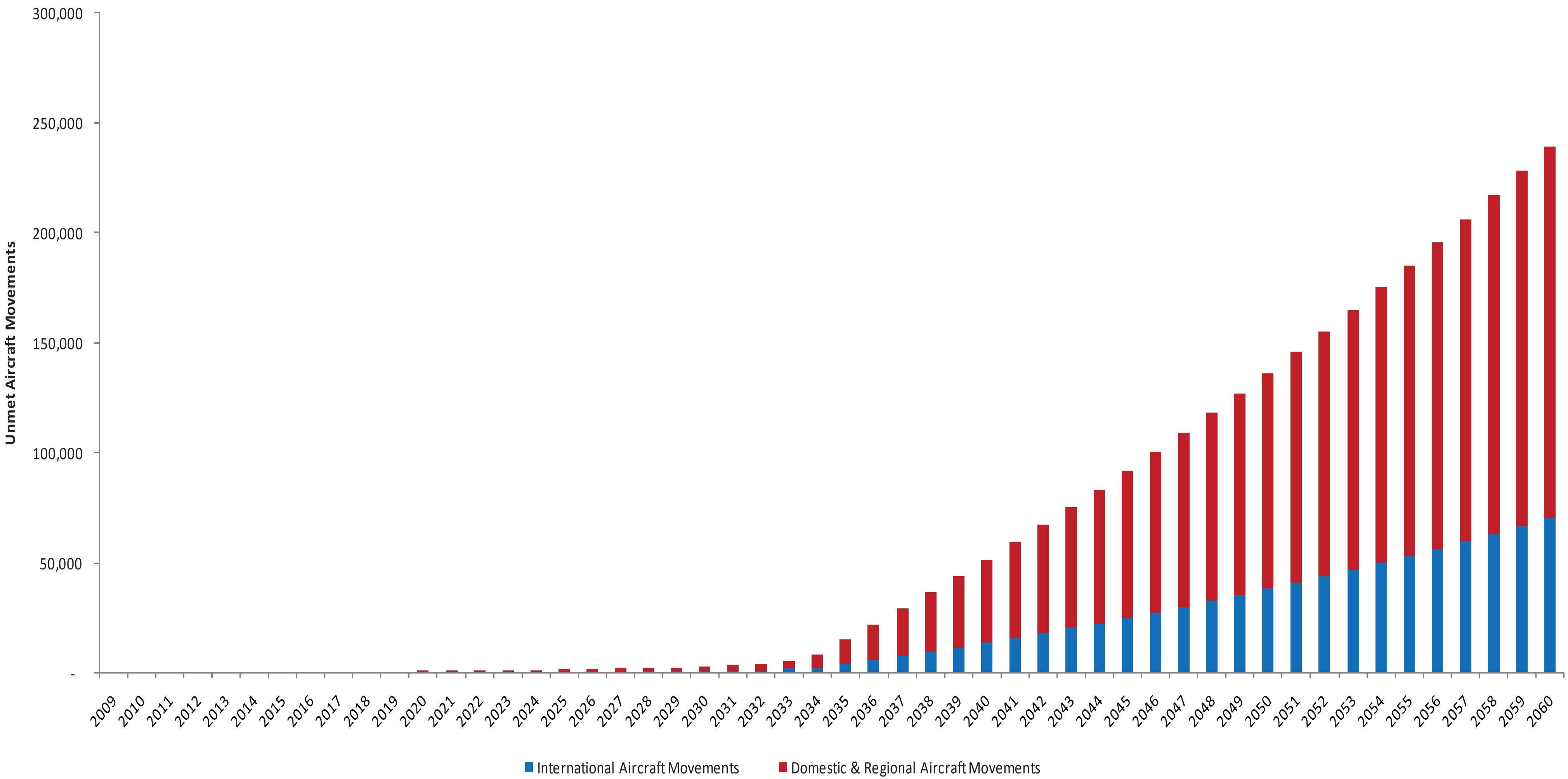
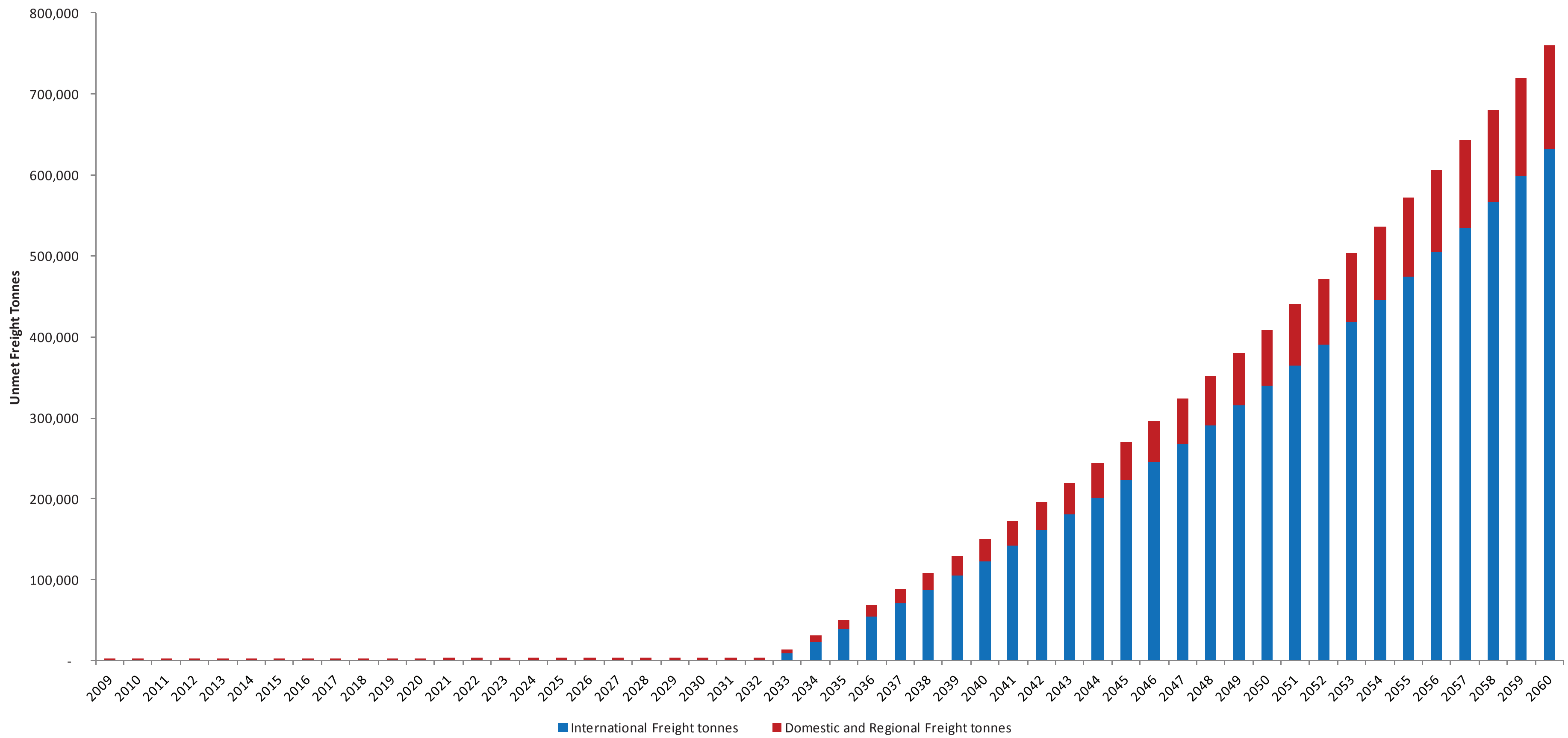


Figure 4: Unmet demand for freight tonnage in the Sydney Region, 2009-2060 (source: Booz & Company)



As can be seen, over the 50-year analysis, this unmet demand:

- *For passengers* begins in 2016 with suppressed demand of 13,847 trips. By 2034 there are 2.1 million unmet passenger trips, increasing to 54.3 million unmet passenger trips in 2060;
- *For aircraft movements* begins in 2016 with 90 movements. By 2034 there are 8,261 unmet aircraft movements, increasing to 239,026 unmet aircraft movements in 2060; and
- *For freight tonnage* exists from 2009, with 2,366 unmet freight tonnes, increasing to 759,836 unmet freight tonnes in 2060.

3.2 Other data inputs for the direct impacts

In addition to the forecast unmet demand, additional data inputs were required to determine the economic impact of not proceeding with additional aviation capacity in the Sydney region.

The categories of impacts which were calculated for the direct impact analysis, and hence the associated data required to undertake the analysis, were:

- Tourism (including business travel) – Losses to the tourism industry and other industries which receive spending from visitors to NSW and Australia;

- Freight – Losses to the freight industry in terms of volume and cost/value;

- Delays and passenger welfare – economic cost of passenger welfare and delays associated with the value of time and consumer surplus of undertaking an aviation journey. This category incorporates the impact on travellers who experience unexpected delays, the impact on travellers who shift their travel time as a result of lack of capacity at their preferred travel time, as well as the impact on potential travellers who do not travel at all as a result of aviation capacity constraints in the Sydney region;

- Aviation and airports – Losses to the airport and aviation industry associated with aviation and airline operations, including retail operations; and

- Commercial developments – losses to potential hotels and business parks in the airport vicinity which would be developed if aviation capacity in the Sydney region was increased.

Airport and associated surface transport construction was not included in the analysis, as it was assumed that should the Government not invest in increasing aviation capacity in the Sydney region, it would invest in alternative infrastructure project/s, requiring construction, resulting in no net impact on the economy.

Where specific data had not been developed for the purposes of the Study, Ernst & Young sourced data from publicly available information. Where there was no relevant publicly available information, broad assumptions were required to be made on the basis of industry benchmarks. In those situations, low and high sensitivities were undertaken on assumptions made, to provide a range of indicative perspectives.

3.3 Existing data sources

The data obtained from existing sources included:

- The price elasticity of air travel derived from BITRE analysis on passenger welfare loss; and

- The average value of airfreight from BITRE (taken as the weighted average value of imported commodity freight into Mascot Q3 2009 to Q4 2010 as provided on 23 March 2011).

3.4 Publicly available information

Where information was not obtained through existing sources, additional data for determining the direct impacts of not proceeding with increasing aviation capacity in the Sydney region was sourced from publicly available information. The sources of the information used, by category, are presented in Section 4.3 and Appendix B in more detail.

3.5 Impact of constrained aviation capacity on travel and freight movements to Sydney

Elasticities of demand for travel and freight movement to the Sydney region were not available. That is, there was no information to estimate the percentage of the unmet demand for aviation capacity which would travel to the Sydney region using alternative transport modes. This is important, given that if travel and freight still occurs through non-air travel modes, these is no net impact on the NSW or Australian economies. Therefore, assumptions were required to be made about:

- How tourist and business travellers will react to constraints (not travel at all / travel to NSW by non-air transportation modes / travel elsewhere in Australia / travel overseas);
- How airlines will react to constraints (not fly to Australia / fly to other Australian locations); and
- How freight will be transported due to constraints (not be transported / transported by alternative modes).

Low, medium and high scenarios were adopted to illustrate a range of possible future outcomes. These scenarios were designed to illustrate a spectrum of potential impacts; they were not designed to be predictions of specific outcomes.

The scenarios were determined based on adjustments to the BITRE elasticities of demand for air travel to reflect the estimated range of travellers and freight which would not enter the Sydney region via any transport mode. These adjustments were estimated based on publicly available data from Tourism Australia, which provided information on visitation across all states in Australia and information on how traveller behaviour operates under existing conditions.

Different adjustments were applied for the NSW and Australian impact scenarios. This is due to the fact that while some travellers / airlines / freight may no longer travel at all when Sydney region aviation capacity is not sufficient to meet demand, some travellers are expected to divert to other Australian cities such as Melbourne or the Gold Coast. This means that the economic impact is transferred from NSW to another state, negatively affecting NSW tourism and the NSW economy but having no net impact on Australian levels of visitation.

3.5.1 Tourist and business traveller adjustments

Tourist travellers have a higher elasticity than business travellers, given the large number of alternative tourist destinations outside Sydney, NSW and Australia. In contrast, business travellers may be required to travel to Sydney specifically for meetings or conferences and therefore have less flexibility in their travel.

This analysis resulted in a range of adjustments to Booz & Company unmet demand volumes as presented in Table 5.

Table 5: Tourist and business traveller adjustments

Scenario	Category	Low redistribution	Medium redistribution	High redistribution
NSW	Tourist travellers	9.0%	46.3%	115.0%
	Business travellers	4.5%	23.1%	57.5%
Australia	Tourist travellers	4.5%	23.1%	57.5%
	Business travellers	2.3%	11.6%	28.8%

Under the NSW high adjustment scenario, the effect on tourist traveller behaviour is greater than 100% as the scenario has assumed that because of the travel difficulties, individuals who would usually travel within the capacity constraints will actually decide not to move through the Sydney or NSW regions.

3.5.2 Aircraft movement adjustments

Given the lack of available data, the following low, medium and high aircraft movement adjustments set out in Table 7 below were applied to the unmet aviation demand by Ernst & Young. These are broad scenarios to illustrate a range of outcomes.

The range of the adjustments is presented in Table 6.

Table 6: Aircraft movement adjustments

Scenario	Category	Low redistribution	Medium redistribution	High redistribution
NSW	Aircraft movements	100.0%	100.0%	100.0%
Australia	Aircraft movements	27.8%	55.5%	83.3%

3.5.3 Freight adjustments

Given the lack of available data, low, medium and high freight movement adjustments were applied to the unmet aviation demand by Ernst & Young using a range of scenarios.

The range of these adjustments is presented in Table 7 below.

Table 7: Freight adjustments

Scenario	Category	Low redistribution	Medium redistribution	High redistribution
NSW	Freight movements	20.0%	50.0%	80.0%
Australia	Freight movements	10.0%	25.0%	40.0%

4. Foregone direct quantifiable impacts

Based on the information presented in Chapters 2 and 3, the direct quantifiable impacts of maintaining the status quo aviation capacity in the Sydney region were calculated.

4.1 Direct costs calculated

The direct costs of not proceeding with aviation capacity in the Sydney region were captured in terms of:

- Expenditure;
- Value-added (i.e. profit and wages, a net benefits figure); and
- Full-time equivalent (FTE) employment numbers.

The analysis was undertaken from the perspectives of both the NSW and Australian economies, given that some of the economic impact will shift from NSW to elsewhere in Australia.

4.2 Direct cost categories

The categories for which these direct costs were captured are:

- Tourism (including business travel) – Losses to the tourism industry and other industries which receive spending from visitors to NSW and Australia;
- Freight – Losses to the freight industry in terms of volume and cost/value;
- Delays and passenger welfare – Economic cost of passenger welfare and delays associated with the value of time and consumer surplus of undertaking an aviation movement;
- Aviation and airports – Losses to the airport and aviation industry associated with aviation and airline operations, including retail operations; and
- Commercial developments – losses to potential hotels and business parks in the airport vicinity which would be developed if aviation capacity in the Sydney region was increased.

As discussed further in section 5, these estimated direct costs are then used as inputs into the general equilibrium model that is used to estimate the indirect, or "flow on" impact of these direct shocks on NSW and the rest of Australia (i.e. a "bottom up" approach is used to estimate the combined impact of these shocks).

It is important to note that caution needs to be exercised when interpreting these estimated direct costs, due to the:

- uncertainty that surrounds the magnitude of the impact that aviation capacity constraints at Sydney Airport have on the number of planes and passengers arriving at Sydney Airport;
- potential scope for "double counting" of expenditure when summing these direct expenditure impacts to the extent that:
  - estimated tourism expenditure includes some airfare expenditure (50% of the estimated airfare expenditure of domestic tourists) that is also included in the estimated expenditure on aviation and airports (i.e. airline revenue and airport revenue from landing fees). However, this is not expected to have a significant impact on the magnitude of the estimated total direct impacts (e.g. if we were to exclude this airline fare component of the domestic tourism expenditure, total direct impacts would only be reduced by around 0.3%);
  - estimated tourism expenditure may contain some of the expenditure that is included in the estimated expenditure on aviation and airports (i.e. expenditure on food, beverages and other goods and

services at airport retail outlets). Once again, however, the magnitude of that overlap is unlikely to be significant to the extent that both the International Visitor Survey and the National Visitor Survey are based on small sample sizes that are likely to underestimate the magnitude of tourist expenditure at Sydney airport;

- potential scope for overestimating the direct cost that Australia incurs as a result of reductions in the amount of air freight entering the country. When estimating the direct costs of these freight reductions, it has been assumed that all of freight entering Australia is used up either by domestic consumers or businesses. In practice, however, not all air freight entering Australia is consumed or used in Australia. Rather, some of that freight is re-exported, either:

    - immediately (e.g. in the case of foreign freight that is routed through Sydney Airport to another country). As a result, there is a risk of over-estimating the direct cost that Australia incurs when the volume of that freight is reduced to the extent that some air freight entering Sydney Airport is immediately re-exported; or

    - at a later date (e.g. in the case of freight that is used by businesses in Australia as inputs into their exported goods and services). These possible sources of "leakage" of some of the value of imported freight back outside Australia are taken into account by the general equilibrium model in the course of estimating the indirect impacts.

However, it is also important to recognise that:

- these separate line items were required to properly input the CGE model;

- there is insufficient publicly available information to enable an explicit correction for this uncertainty and risk; and

- attempts to reduce the scope for double counting by simply excluding some expenditure (e.g. excluding the expenditure of tourists at Sydney airport on the grounds that this expenditure is already captured to some extent in the estimate of tourist expenditure) is likely to result in the underestimation of both the direct and indirect impacts (e.g. the direct impacts on airport retail outlets and the associated indirect impacts on airports and suppliers of inputs to those outlets).

As a result, rather than seek to explicitly adjust the estimates of the total direct expenditure impacts for these uncertainties and risks, this study instead conducts scenario analyses (low, medium and high) to illustrate how the results of the analysis vary under different assumptions regarding traveller behaviour.

Similarly, the employment impacts need to be treated with some caution. They have been determined on the assumption that aviation capacity issues will not change the ratio of hours worked per person: that is, it has been assumed that there is no change in labour productivity over the evaluation period. However, in reality, it is probable that the increased requirement for labour will be covered by increased skill levels and increased working hours of existing employees, as well as increased persons employed. To the extent that this occurs, the numbers will overstate the employment impacts of the aviation network.

4.3 Methodology for calculating direct impacts

The approach to calculating the expenditure, value-added, employment numbers and salaries / wages for each of the categories is presented in detail below.

4.3.1 Approach to direct impacts

Category	Expenditure	Value-added	Employment	Data sources
Tourism – foregone tourism / business traveller expenditure in the tourism industry from incoming tourists who will not travel	► The base data used for determining the foregone tourism expenditure was Booz & Company's forecast annual unmet domestic and international demand, shown in Chapter 3.1. ► Outgoing travellers and incoming residents were removed from the unmet demand, based on ABS historic data in Catalogue 3401.201012. These categories of travellers were removed as they will not contribute to tourism expenditure. ► Unmet demand was then split between business and non-business travel, based on Tourism NSW historic data, given the different adjustments of demand to travel of the two groups. ► The Ernst & Young estimated adjustments were applied to determine the business and non-business travellers who will not travel to Sydney. These traveller numbers were multiplied by average expenditure by business and non-business travellers from Tourism NSW historic data, escalated to account for the expected increase in real income and hence tourism expenditure. The expenditure of foreign tourists' airline fares was not included in Tourism NSW international visitor expenditure data. 50% of the airline expenditure of domestic tourists was included in Tourism NSW data, and whilst there may have been merit to remove to avoid potential double counting, it has been included in this analysis to reduce the risk of underestimating actual expenditure on other expenditure items. The removal would only reduce overall direct results by 0.3%. ► The annual expected real increase in tourism expenditure was estimated by Ernst & Young to be the difference between the10-year Compound Annual Growth rate (CAGR) of the Australian Wage Price Index (WPI) and Consumer Price Index (CPI). This was applied as an annual escalation to determine the total annual foregone expenditure. ► The WPI is used in conjunction with the CPI to determine the rate at which real wages are likely to rise over time, and hence expenditure by Australian residents on tourism. ► Although it is likely that real wages will grow at different rates in different countries (e.g. real wages in some EU countries are likely to grow at much lower rates than other countries such as China), it is reasonable to expect that the real wages of those foreign tourists who choose to visit Australia (i.e. those who mainly come from NZ, UK, China, USA) will grow by at least the same rate as average real	► Estimated based on calculated expenditure and cost structure breakdowns included in publicly available IBISWorld reports ► Value-added includes profit and wages for the industry.	► The base data used for determining the foregone tourism employment was the Ernst & Young estimated tourism expenditure. ► This expenditure was then multiplied by employment per dollar of expenditure in the *IBISWorld Tourism in Australia* report to determine the total annual foregone employment.	► BITRE's Airport Traffic Data 1985/86 – 2009/10 ► Australian Bureau of Statistics (ABS) Catalogue 3401.1 (Overseas Arrivals and Departures (long and short-term), Australia, April 2011 ► Tourism NSW Travel to New South Wales, Year ended June 2011 ► ABS Catalogue 6401.0, Tables 1 and 2: CPI: All Groups, Index numbers and percentage changes, March 2011 ► ABS Catalogue 6302.0, Table 3: Average weekly earnings, Australia (dollars) – Original, February 2011 ► ABS Catalogue 6202.0, Table 3: Average weekly earnings, Australia (dollars) – Original, May 2011 ► IBISWorld Industry Report X0003, Tourism in Australia, 4 March 2011

Category	Expenditure	Value-added	Employment	Data sources
	wages in Australia as a result of a process of “self selection” – that is, those foreign tourists whose real incomes are not as high as average Australians, and are not growing by at least the same rate of growth as the expected increase in the real wages of Australians, are unlikely to be able to afford to continue to visit Australia. ► Use of WPI was considered a relevant inflator since expenditure by Australian tourists comprises over 20% of total tourism expenditure in Australia. It was therefore considered reasonable to expect that future demand for domestic tourism will be significantly influenced by their main source of income – that is, income from salaries and wages. It was also considered unrealistic to assume that nominal expenditure on tourism would increase at the same rate as CPI (i.e. in line with the general level of price inflation). ► Although it is likely that real wages will grow at different rates in different countries (e.g. real wages in some EU countries are likely to grow at much lower rates than other countries such as China), it is reasonable to expect that the real wages of those foreign tourists who choose to visit Australia (i.e. those who mainly come from NZ, UK, China, USA) will grow by at least the same rate as average real wages in Australia as a result of a process of “self selection” – that is, those foreign tourists whose real incomes are not as high as average Australians, and are not growing by at least the same rate of growth as the expected increase in the real wages of Australians, are unlikely to be able to afford to continue to visit Australia. ► The real increase in expenditure was also applied to airport retail expenditure.			
Delays and passenger welfare – impact on travellers of flight delays and the cost to the economy of peak demand spreading and ultimately a lack of capacity and opportunity to access aviation services	*Passenger delays* ► The base data used to calculate passenger delays at Sydney Airport is Booz & Company’s demand forecasts. ► BITRE historical delay and on-time arrival/departure data was used to establish delay trends in the current operating climate. ► Changes in delay over the analysis period were based on a pro-rata basis with passenger forecast growth and represent the delays experienced entering and exiting Sydney Airport. The average number of minutes for which delayed flights are impacted was held constant throughout the 50 year evaluation, with the change in delays calculated over time assumed to result from a change in the number of aircraft arriving/departing:	► Estimated based on calculated expenditure and cost structure breakdowns included in publicly available IBISWorld reports ► Value-added includes profit and wages for the industry	► The base data used for determining the foregone employment as a result of delays was the cost of delays. ► This expenditure was then multiplied by employment per dollar of expenditure in the *IBISWorld Business Services in Australia* report to determine the total annual foregone employment. ► No employment impacts are associated with passenger welfare.	► BITRE’s Sydney Airport: Indicative estimate of cost of doing nothing reportBITRE’s on-time running performance data 2003 – 2010 (with current on-time running arrivals and departures for Sydney (75.2%) taken as the base, and the historical growth rate between 2003 to 2010 (-1.7%) used to project annual change in flight arrivals and departures) ► CASA Value of Time (business and private travel value of time, with a factor

Category	Expenditure	Value-added	Employment	Data sources
	► From 2011-2031, the percentage of aircraft arriving/departing on time was assumed to decrease ► Post 2031, the percentage of aircraft arriving/departing on time was assumed to flatline, indicating there is no further impact on the percentage of aircraft arriving/departing on time due to upgauging and peak spreading ► The economic value of time was sourced from the CASA guidelines. Total delay minutes experienced by all passengers are converted into hours and the value of time is applied to produce an economic cost. ► Only business travellers have been included in the flow on economic contribution analysis because there are real productivity implications associated with delays in business related travel, which have a quantifiable impact on the economy. Although the leisure impacts are real and quantifiable, the link to economic impact on NSW and Australia is less tangible. This approach is typically used when investigating the impact of investment of transport assets (such as road and rail) on economies. *Passenger welfare and consumer surplus* ► The base data used to calculate passenger welfare at Sydney Airport is BITRE's welfare forecasts (to estimate the net welfare loss that passengers incur as a result of having to travel at different times). ► Consumer surplus has also been calculated and incorporated within passenger welfare. ► Average fare values have been calculated as a means of identifying the loss in consumer surplus to travellers (resulting from potential passengers who do not fly at all as a result of constrained aviation capacity in the Sydney region). EY estimated medium-scenario adjustment (46%) was applied as the elasticity to travel to calculate the consumer surplus. ► Airline fares were considered to be the best publicly available proxy for the 'value in exchange' that tourists derive from their trip, and in this analysis have been assumed a 'travel cost' indicator of the willingness to pay for the benefits a traveller expects to derive from a trip as opposed to the additional value they would gain from the additional goods and services they consume while travelling.			applied for unexpected delay) ► Publicly available information on airline ticket pricing

Category	Expenditure	Value-added	Employment	Data sources
Freight – foregone expenditure, value-added and employment to the freight movement industry as a result of goods imported and exported which will not be transported by alternative transport modes	► The base data used for determining the foregone domestic and international freight expenditure was Booz &Company's forecast annual unmet freight tonnage demand. ► Ernst & Young's estimated freight adjustments were applied to determine the domestic and international freight tonnages which will not be transported to the Sydney region by alternative modes. It was acknowledged that including both domestic and international freight in the estimation has the potential to overestimate the extent of this cost to Australia to the extent that not all of the freight value might be derived or added in Australia. However, this approach was considered reasonable as the CGE modelling takes into account some leakage (eg. the extent to which some of the imported freight value is attributable to foreign owned factors of production or may be used as inputs into Australian exports). ► These domestic and international freight tonnages were then multiplied by average value per tonne of international freight, as provided by BITRE ($8,000 per tonne – a weighted average of imported freight commodities into Sydney Airport between Q3 2009 and Q4 2010), to determine the total annual foregone expenditure. Analysis showed that the value of domestic and international freight was comparable. In addition, the international freight volumes are the dominant form of aviation freight.	► Estimated based on calculated expenditure and cost structure breakdowns included in publicly available IBISWorld reports ► Value-added includes profit and wages for the industry.	► The base data used for determining the foregone freight employment was the Ernst & Young estimated freight expenditure. ► This expenditure was then multiplied by employment per dollar of expenditure in the *IBISWorld Global Logistics – Air Freight* report to determine the total annual foregone employment.	► ABS Catalogue 6202.0, Table 3: Average weekly earnings, Australia (dollars) – Original, May 2011 ► IBISWorld Industry Report H4832-GL, Global logistics – Air Freight, 22 December 2010
Commercial developments – lost business industry expenditure, value-added and employment as a result of passengers who will not fly. This loss is a result of business parks and hotels in the airport vicinity which will not be built and operated due to reduced demand	*Hotels in the airport vicinity* ► The base data used for determining the foregone hotel developments within the airport vicinity was foregone hotel employment per passenger derived from *URS' Economic Impact of Growth at Sydney Airport* (see the employment column to the right) ► This was then multiplied by the revenue per employee in the *IBISWorld Global Hotels & Resorts* report *Business parks in the airport vicinity* ► The base data used for determining the foregone business parks in the airport vicinity was publicly available information on the size of international airports' current and planned business parks and airport passenger numbers were sourced for benchmarking purposes. These international airports were Beijing, Gatwick, Incheon, Hong Kong, Singapore Changi and Frankfurt Airports. ► The average size of associated business parks per passenger determined from the benchmarking data was then multiplied by Booz & Company's forecast annual unmet passenger demand to	► Estimated based on calculated expenditure and cost structure breakdowns from publicly available data ► Value-added includes profit and wages for the industry.	*Hotels in the airport vicinity* ► The base data used for determining the foregone employment in hotels in the airport vicinity was *URS' Economic Impact of Growth at Sydney Airport* report. ► This report estimated the direct employment in hotels and also the corresponding number of passengers for the year, allowing a hotel employment per passenger to be determined. ► The hotel employment per passenger was multiplied by unmet demand to estimate the foregone employment. *Business parks in the airport vicinity* ► The base data used for determining the foregone hotels in the airport vicinity	► Changi Airport Data (Singapore), 2010 ► Beijing Airport Data, 2010 ► Hong Kong Airport Data, 2010 ► Incheon Airport Data (South Korea), 2010 ► Gatwick Airport Data (United Kingdom) ► Frankfurt Airport Data, 2010 ► *URS' Economic Impact of Growth at Sydney Airport, 2008* ► IBISWorld Industry Report H5711, Hotels and Resorts in Australia, January 2011

Category	Expenditure	Value-added	Employment	Data sources
	determine the forecast size requirements for a business park in the airport vicinity. ► It has been assumed that land is available within the airport vicinity for business park development. The site selection undertaken by Worley Parsons included availability of commercial purpose land. ► This business park size was then divided by the NSW Government workplace benchmark of 15sqm/person for new offices, as a proxy used to determine the number of employees expected within the business park.		value-added was the Ernst & Young estimated business parks in the airport vicinity expenditure. ► This expenditure was pro-rated with the profit and wages (value-added) as a percentage of total costs for the industry, as presented in the *IBISWorld Business Services in Australia* report, to determine the total annual foregone value-added.	► NSW Government Workplace Guidelines, available at: http://www.gamc.nsw.gov.au/workplace-guidelines/2_ToolsContent/tools_2_02.htm.
Aviation and airport – lost aviation and airport industry expenditure, value-added and employment as a result of passengers who will not fly. This category includes airlines, airports and airport retail outlets	*Airlines* ► The base data used for determining the foregone airline expenditure was Booz & Company's forecast annual unmet domestic and international passenger demand. This unmet domestic and international passenger demand was multiplied by revenue per domestic and international passenger, as presented in the *IBISWorld Domestic Airlines in Australia* and *IBISWorld International Airlines in Australia* reports respectively, to determine the total annual foregone expenditure for airports. ► However, given that not all airline revenue is retained in Australia, and the high proportion of foreign ownership compared to other expenditure components measured in this analysis, the domestic and international expenditures were reduced by 65% and 85%, respectively. (Assumptions had to be made regarding the percentage of profit for airlines retained in Australia. For domestic airlines, it was assumed to be 35%, and for international airlines, it was assumed to be 15% based on industry benchmark data including IBISWorld.) *Airports* ► The base data used for determining the foregone airport expenditure was Booz & Company's forecast annual unmet flight demand. ► For the NSW impact, there are no alternative airports which can meet demand; therefore, 100% of the unmet flight demand was used for determining the foregone expenditure. For the Australian impact, Ernst & Young's estimated flight adjustments were applied to determine the flights which will not be flown into alternative Australian locations. ► The unmet demand was then multiplied by the revenue per aircraft movement, as presented in the report, to determine the total	► Estimated based on calculated expenditure and cost structure breakdowns included in publicly available IBISWorld reports ► Value-added includes profit and wages for the industry.	*Airlines* ► The base data used for determining the foregone airport employment was the Ernst & Young estimated airline expenditure. ► This expenditure was then multiplied by employment per dollar of expenditure by domestic and international passengers in the *IBISWorld Domestic Airlines in Australia* and *IBISWorld International Airlines in Australia* reports respectively to determine the total annual foregone employment. *Airports* ► The base data used for determining the foregone airport employment was the Ernst & Young estimated airport expenditure. ► This expenditure was then multiplied by employment per dollar of expenditure in the *IBISWorld Airports in Australia* report to determine the total annual foregone employment. *Airport retail outlets* ► The base data used for determining the foregone airlines value-added was the Ernst & Young estimated domestic and international airport retail outlet	► ABS Catalogue 6202.0, Table 3: Average weekly earnings, Australia (dollars) – Original, May 2011 *Airlines* ► IBISWorld Industry Report I6402, Domestic Airlines in Australia, February 2011 ► IBISWorld Industry Report I6402, International Airlines in Australia, March 2011 *Airports* ► IBISWorld Industry Report I6630, Airports in Australia, April 2011 *Airport retail* ► Moodie's The Airport Commercial Revenues Study 2010/11 ► ABS Catalogue 6401.0, Tables 1 and 2: CPI: All Groups, Index numbers and percentage changes, March 2011 ► ABS Catalogue 6401.0, Tables 1 and 2: CPI: All Groups, Index numbers and percentage changes, March 2011 ► ABS Catalogue 6302.0, Table 3: Average weekly earnings, Australia

Category	Expenditure	Value-added	Employment	Data sources
	annual foregone expenditure. *Airport retail outlets* ► The base data used for determining the foregone airport retail expenditure was Booz & Company's forecast annual unmet domestic and international passenger demand. ► Also utilised was *Moodie's 2010/11 Airport Retail Study*, which provided the range of expenditure per category of spend per passenger for international airports. These categories were food and beverage, duty free, retail, car parking and currency change. ► International passengers' airport retail spend was then determined by multiplying the unmet demand for international passengers with the sum of the total spend of all categories, while domestic passengers' airport retail spend was determined by multiplying the unmet demand for domestic passengers with the sum of food and beverage, retail and car parking spend (given that duty free and currency change expenditure is only realised for international passengers). The result was the annual forecast annual foregone expenditure. ► As it was not possible to exclude airport expenditure from overall tourism expenditure, it is possible that there is some overlap between this measure and the tourism impact measure. However, exclusion of airport expenditure would significantly understate the economic impact of restricted aviation capacity on airport duty free and retail outlets. As a result, potential double counting was corrected for in the scenario analysis.		expenditures. ► These expenditures were pro-rated with the average employment per dollar of expenditure from the *IBISWorld Take-Away Food Retailing in Australia* and *IBISWorld Clothing Retailing in Australia* reports for domestic airport retail outlets, and employment per dollar of expenditure from the *IBISWorld Duty Free Stores in Australia* report for international airport retail outlets to determine the total annual foregone employment.	(dollars) – Original, February 2011 ► Exchange rate (SDR / AUD) http://coinmill.com/AUD_SDR.html#SDR=1 ► IBISWorld Industry Report G5256, Duty-Free Stores in Australia, October 2010 ► IBISWorld Industry Report G5125a, Fast Food in Australia, April 2011 ► IBISWorld Industry Report G5221, Clothing Retailing in Australia, June 2011

4.4 Outcomes of the direct quantifiable impacts

As described in the previous chapter, the analysis of direct expenditure has been undertaken using a range of scenarios to illustrate a range of potential outcomes:

- Low;
- Medium; and
- High.

The low, medium and high scenarios provide a range of potential responses by passengers impacted by the unmet demand for aviation in the Sydney region:

- they may enter NSW through different transport modes (road, rail);
- they may enter NSW through airports other than Sydney (Kingsford-Smith) Airport (Canberra Airport or Newcastle Airport);
- they may be redistributed to other airports in Australia;
- they may be redistributed to airports overseas; or
- they may decide not to travel.

The results of the analysis are presented in the figures below. The following should be noted:

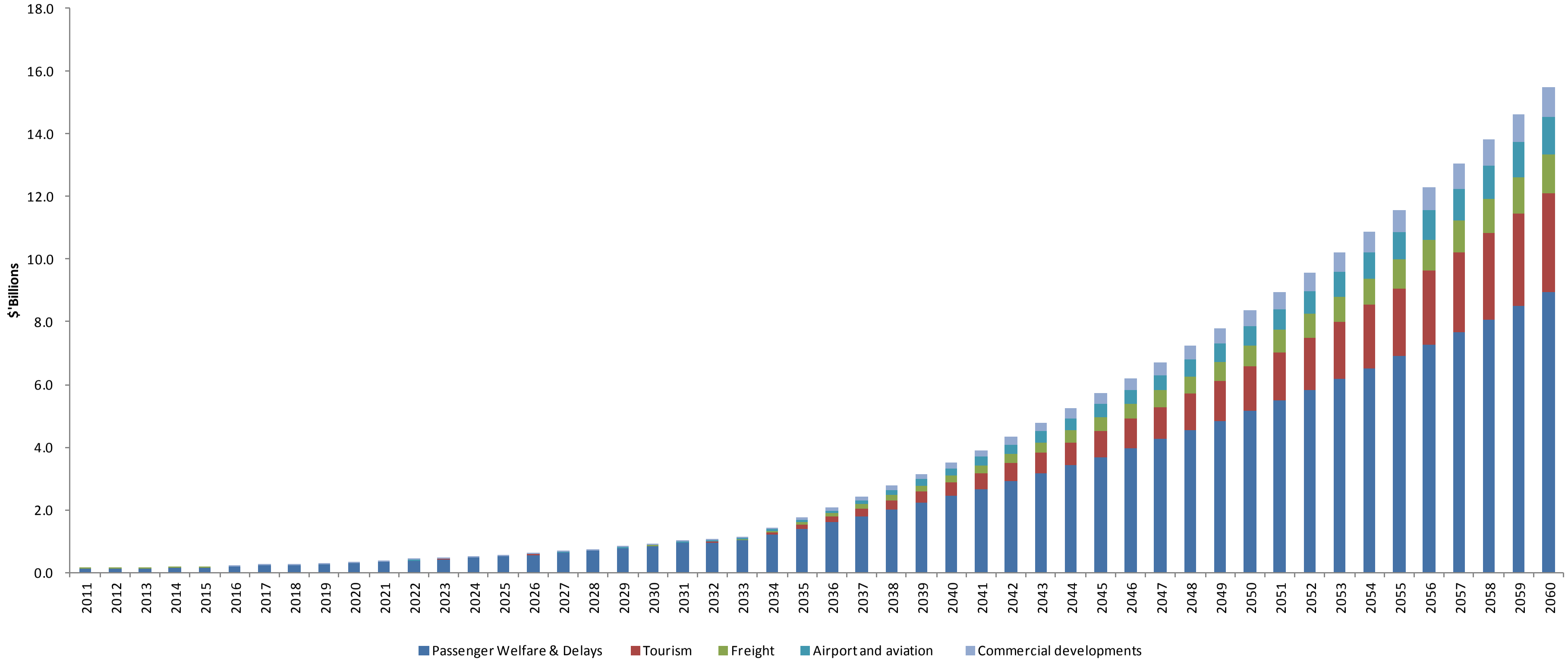
- As expected, the costs of inaction build over time; and
- Commercial developments are not visible on the graph, given the small magnitude of the impact, relative to other categories.

4.4.1 Low scenario

The low direct expenditure outcomes between 2011 and 2060 are presented in the figures below. Based on the flow of direct expenditure, the:

- Total undiscounted direct foregone expenditure from 2011 to 2060 is $208.6 billion; and
- Total present value from 2011 to 2060 is $17.4 billion.

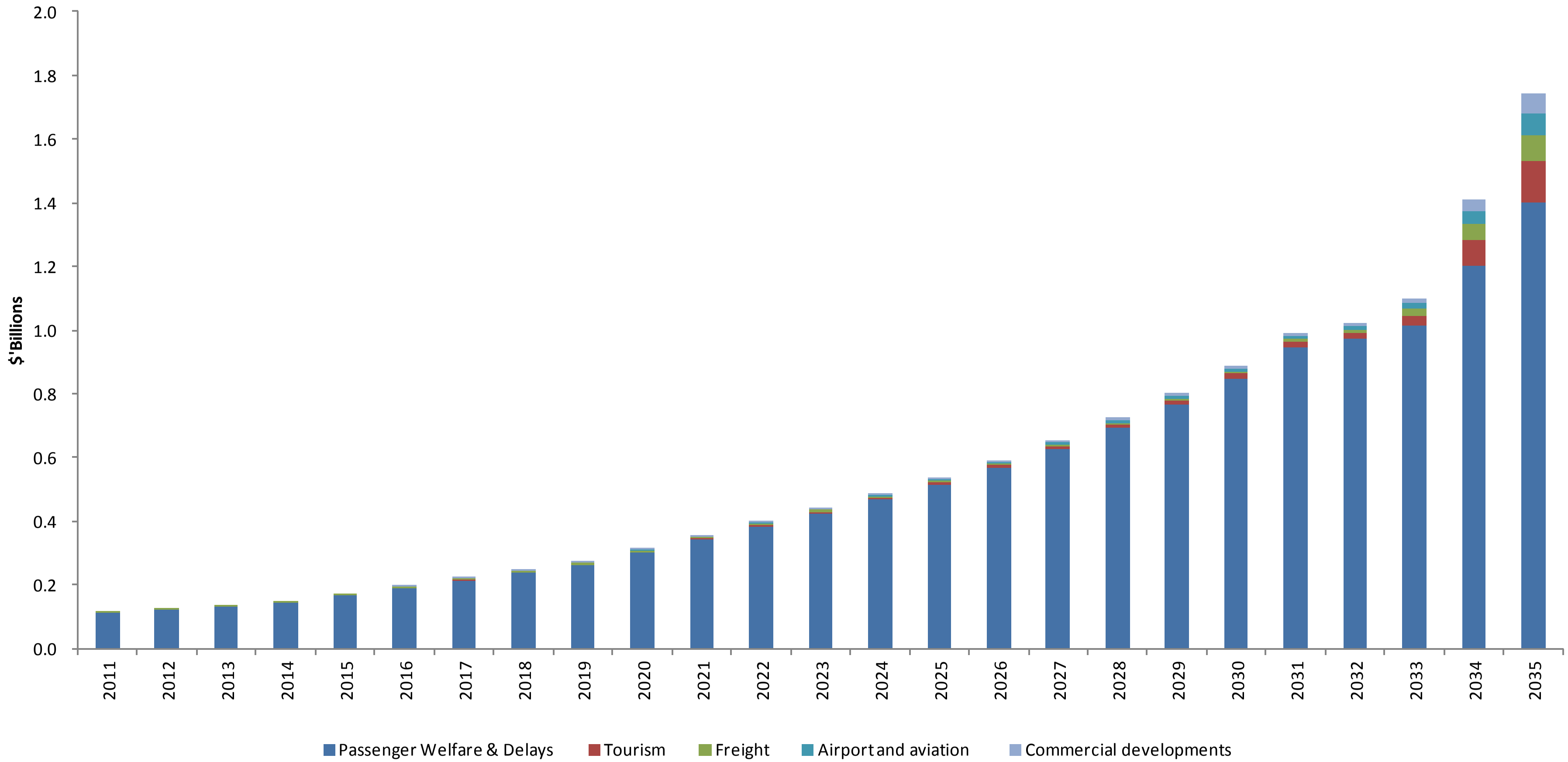
Figure 5: Direct low scenario (2011 – 2060)



The low direct expenditure outcomes between 2011 and 2035 are presented in the figures below. This period of analysis highlights the upfront costs to the economy, which are particularly driven by passenger delays and peak spreading. Based on the flow of direct expenditure, the:

- Total undiscounted expenditure from 2011 to 2035 is $ 14.1 billion; and
- Total present value from 2011 to 2035 is $4.6 billion.

Figure 6: Direct low scenario (2011 – 2035)

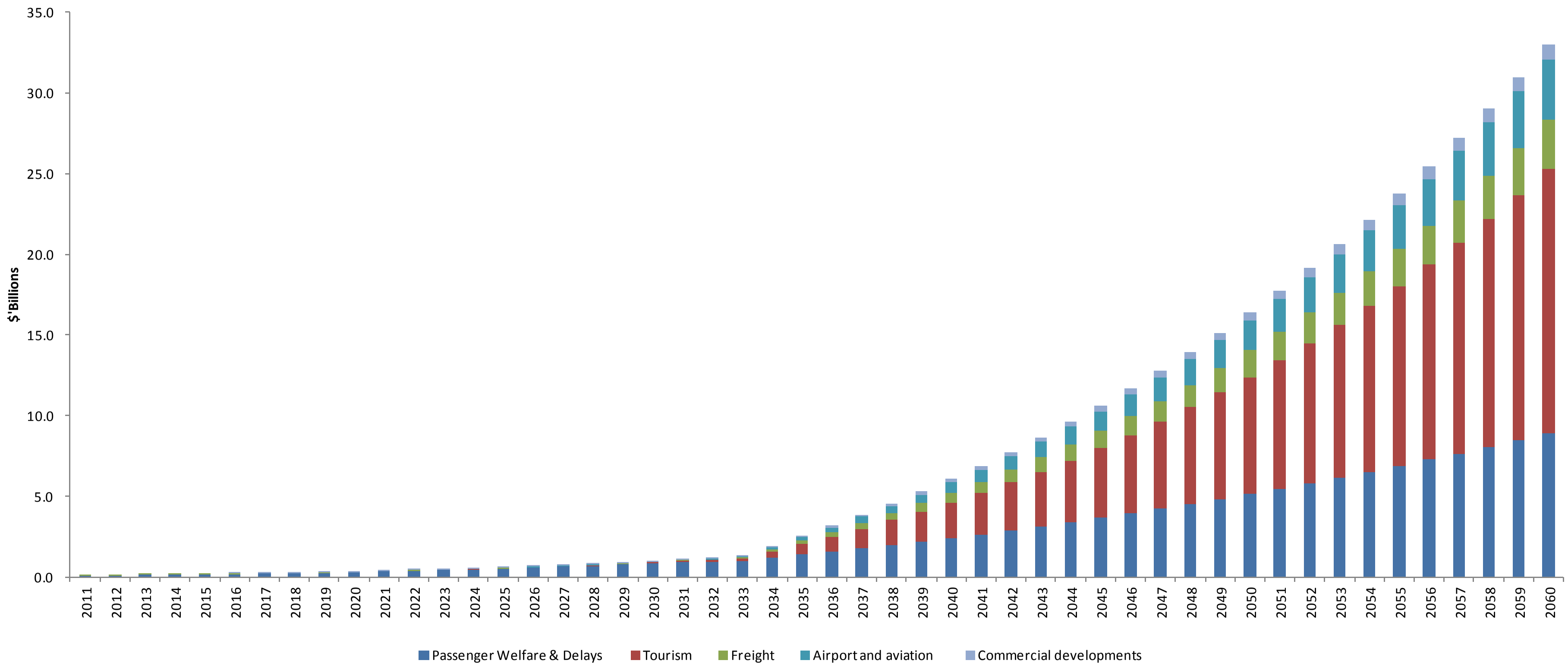


4.4.2 Medium scenario

The medium direct expenditure outcomes are presented in the figures below. Based on the flow of direct expenditure, the:

- Total undiscounted direct expenditure from 2011 to 2060 is $401.9 billion; and
- Total present value from 2011 to 2060 is $29.7 billion.

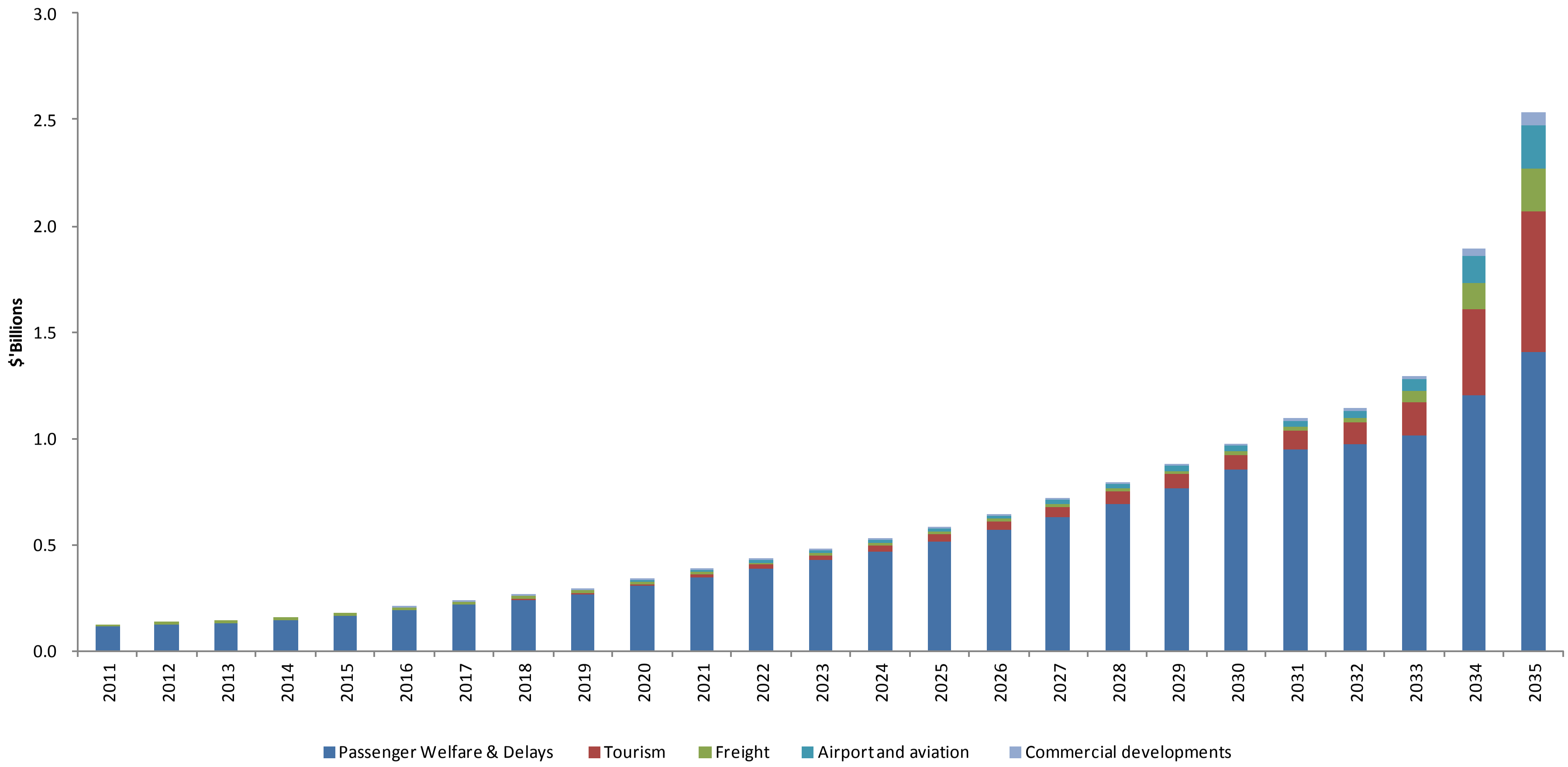
Figure 7: Direct medium scenario (2011 – 2060)



The medium direct expenditure outcomes between 2011 and 2035 are presented in the figures below. Based on the flow of direct expenditure, the:

- Total undiscounted direct expenditure from 2011 to 2035 equal to $16.4 billion; and
- Total present value from 2011 to 2035 is $5.1 billion.

Figure 8: Direct medium scenario (2011 – 2035)

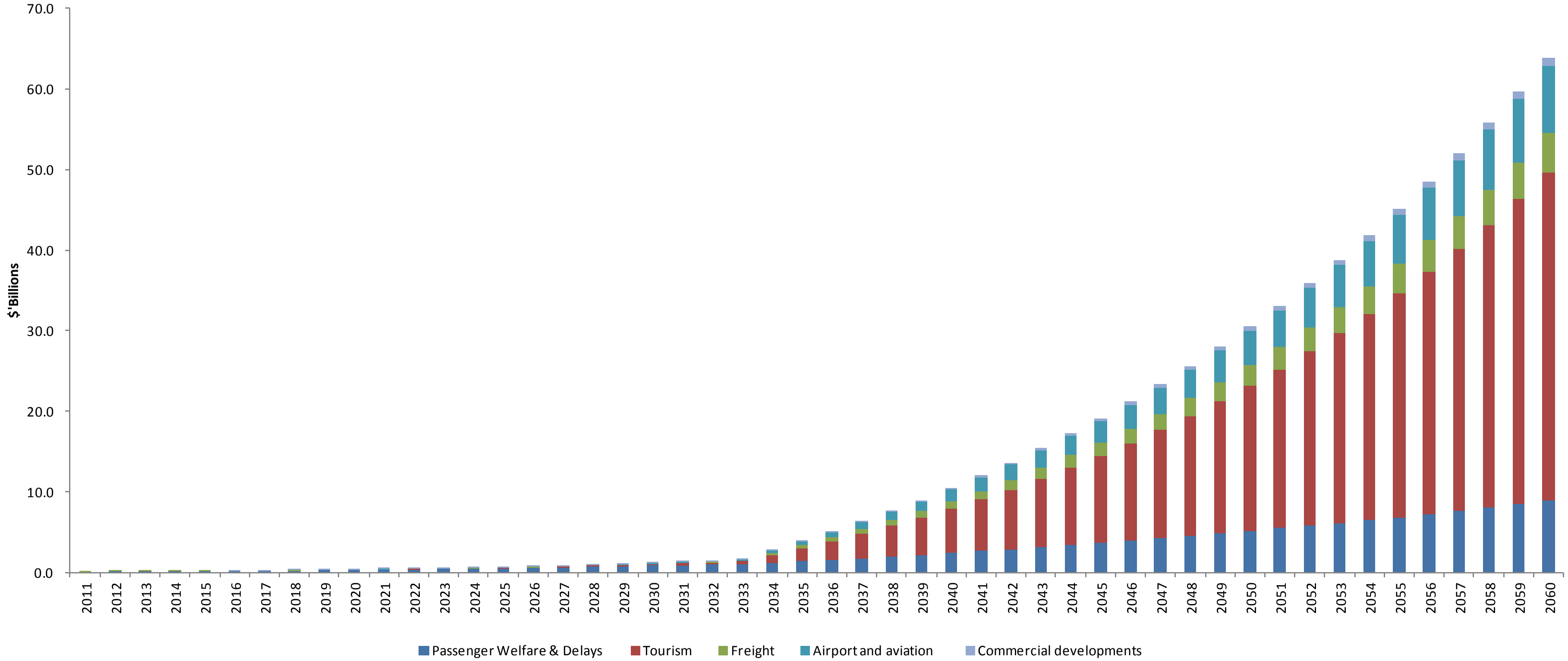


4.4.3 High scenario

The high direct expenditure outcomes are presented in the figures below. Based on the flow of direct expenditure, the:

- Total undiscounted direct expenditure from 2011 to 2060 to $739.3 billion; and
- Total present value of direct expenditure from 2011 to 2060 is $51.1 billion.

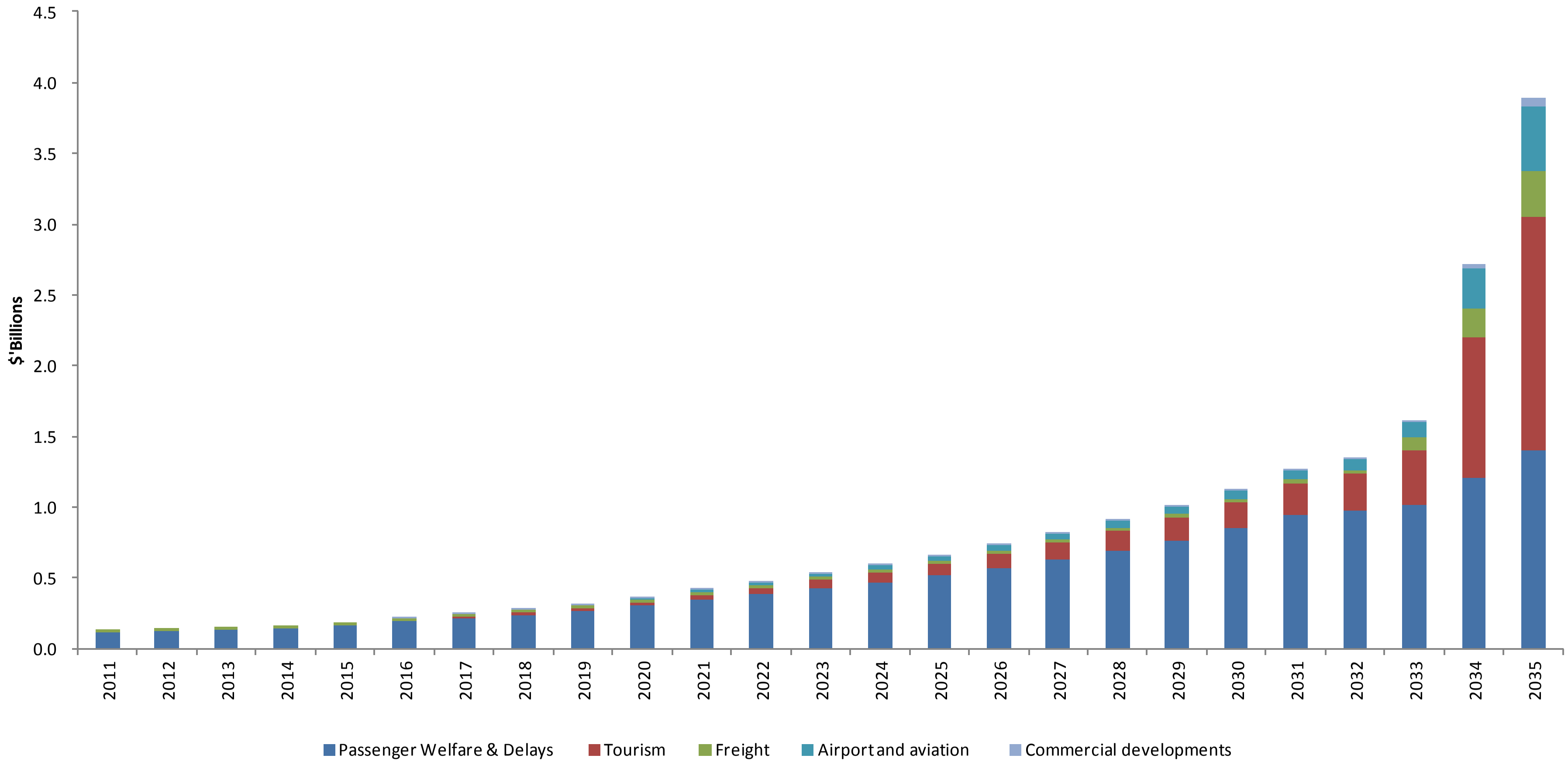
Figure 9: Direct high scenario (2011 – 2060)



The high direct expenditure outcomes between 2011 and 2035 are presented in the figures below. Based on the flow of direct expenditure, the:

- Total undiscounted direct expenditure from 2011 to 2035 is $20.3 billion; and
- Total present value of direct expenditure from 2011 to 2035 is $6.1 billion.

Figure 10: Direct high scenario (2011 – 2035)



4.5 Summary of direct impacts

The summary results are presented in the tables below, which present the gross expenditure and the value-added outcomes for each of the identified categories for NSW and Australia. Australian results include NSW.

The table presents the **undiscounted** flow of expenditure and value-added over the 50-year evaluation. The outcomes of the analysis show that for:

- Expenditure, the range of outcomes is a loss of:
  - between $208.6 billion and $739.3 billion for NSW; and
  - between $166.5 billion and $442.5 billion for Australia.
- Value-added, the range of outcomes is a loss of:
  - between $55.1 billion and $216.6 billion for NSW; and
  - between $42.3 billion and $126.8 billion for Australia.

Table 8: Undiscounted outputs of analysis (Australia includes NSW)

Result type (Undiscounted 2010 $)	Jurisdiction	Low (real 2010 $billions)	Medium (real 2010 $billions)	High (real 2010 $billions)
Expenditure	NSW	208.6	401.9	739.3
	Australia	166.5	268.5	442.5
Value-added	NSW	55.1	113.1	216.6
	Australia	42.3	73.2	126.8

The table below presents the **discounted** flow of expenditure and value-added over the 50-year evaluation. The outcomes of the analysis show that for:

- Expenditure, the range of outcomes is a loss of:
  - between $17.4 billion and $51.1 billion for NSW; and
  - between $14.6 billion and $32.2 billion for Australia.
- Value-added, the range of outcomes is a loss of:
  - between $4.4 billion and $14.6 billion for NSW; and
  - between $3.6 billion and $8.9 billion for Australia.

Table 9: Discounted outputs of analysis (Australia includes NSW)

Result type (Present value $)	Jurisdiction	Low variance (PV $billions)	Medium variance (PV $billions)	High variance (PV $billions)
Expenditure	NSW	17.4	29.7	51.1
	Australia	14.6	21.2	32.2
Value-added	NSW	4.4	8.1	14.6
	Australia	3.6	5.6	8.9

The analysis presented in the two tables above shows that the impact on Australian direct expenditure is lower than that of NSW. This result is to be expected. The analysis has shown that under a scenario where aviation capacity in NSW is reached, individuals will continue to travel to Australia and freight will continue to make its way into Australia, but will enter through different locations in other states. As such, the losses to the NSW economy will be greater than to the Australia economy as a whole, where other states are benefiting through:

- Additional tourism expenditure;
- Additional freight expenditure; and
- Investment in aviation and aviation related activities to cater for increases in throughput.

The summary of NSW employment outcomes under each of the scenarios are produced in the table below. It should be noted these are not net employment numbers; that is, they do not consider jobs which would be created in other industries if aviation capacity in the Sydney region is not increased.

Table 10: Employment outcomes

	Low variance	Medium variance	High variance
FTE jobs	28,000	44,700	74,300

The outputs presented in the table above are:

- Employment figures presented as an annual average over the 50-year evaluation period (2011 – 2060);
- Estimated based on pro-rating publicly available IBISWorld report estimates of employment per dollar of industry expenditure with estimated foregone expenditure, with the exception of business parks in the commercial developments category, which were calculated based on benchmarking other international airports.

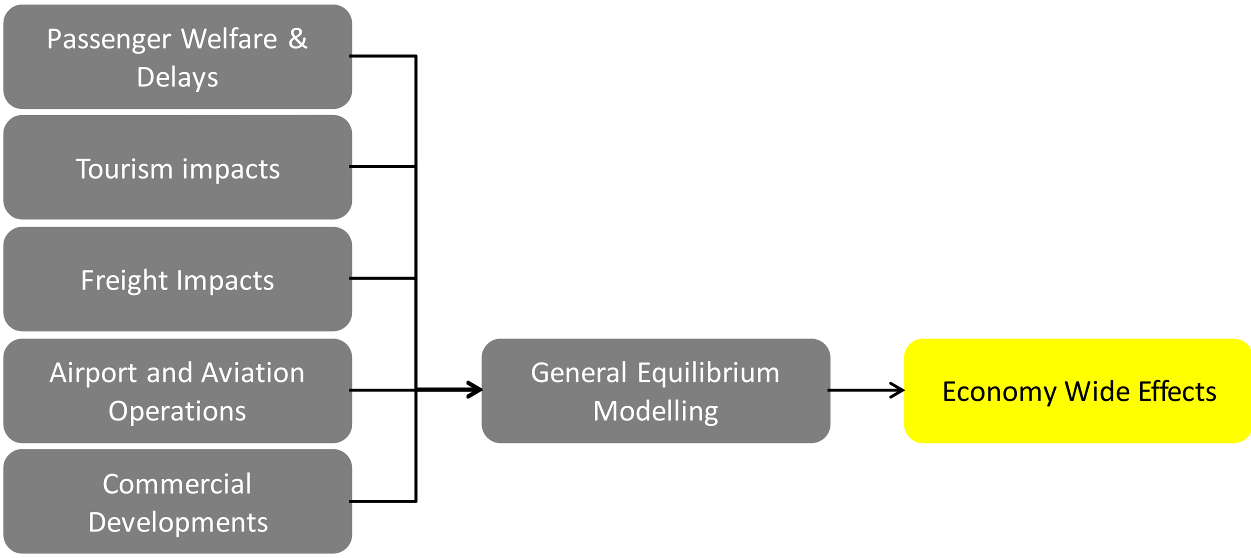
5. Foregone total quantifiable impacts

5.1 General equilibrium economic impact assessment

The economy wide study was undertaken using a general equilibrium modelling approach. Under a general equilibrium approach, the direct expenditure benefits and costs identified in the previous chapters are used as inputs that drive the results for the entire NSW and the rest of Australia (ROA) economies. Full details of the general equilibrium modelling are contained in this chapter of the report.

The approach to capturing the economy wide effects of a lack of aviation capacity in the Sydney region is shown in the simplified figure below.

Figure 11: General Equilibrium Modelling Inputs



Based on the direct expenditure impacts identified in Chapter 4 above (excluding passenger welfare and delays as they are not financial shocks), a broad economic impact study was conducted on the NSW and Australian economies. The economic impact assessment was undertaken using the MMRF model, developed at the Centre of Policy Studies (CoPS).

In effect, the MMRF model's treatment of production in the selected industries is turned off and replaced with Ernst & Young's estimates of the direct impacts (i.e. production becomes an exogenous, user-determined, variable and a variable allowing for a shift in unit cost becomes an endogenous, model-determined, variable. In effect, Ernst and Young changes in turnover for the affected industries are forced on the model via endogenous changes in unit costs).

5.2 Economic impact model and assumptions

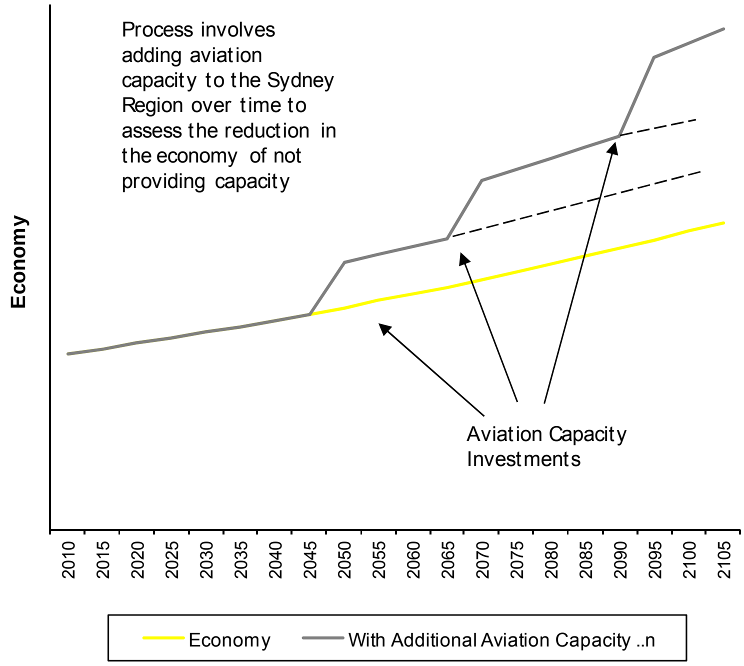
This chapter outlines the economic modelling process used in this study and presents the economic impact results generated from the modelling. The detailed modelling was undertaken by CoPS.

The approach is summarised in Appendix C.

5.2.1 Key assumptions

The general equilibrium modelling of Sydney's aviation capacity was undertaken using the process illustrated in the figure below. The economic impact was run over 50 years assuming no additional aviation capacity is added versus a model where additional aviation capacity is added to the economy to meet the unmet demand. The model produced an overall economic impact on the NSW and ROA economies. The input data was based on the low, medium and high scenarios for these purposes.

Table 11: General equilibrium model process



The simulation was conducted under the assumption that each household maintained its existing average propensity to consume. Households consequently reduced their share of purchases of other goods and services to fund their aviation expenditure. The other main macroeconomic assumptions relate to the other aggregate components of final demand. It is assumed that real expenditure by the Commonwealth, State and Local governments is not affected by the development of aviation assets.

The measures presented in the analysis include:

- Real private consumption – presents the changes in expenditure on goods and services intended for individual consumption or use;
- Real investment – presents the changes in investment in tangible and productive assets such as plant and machinery, as opposed to investment in securities or other financial instruments;
- International export volumes – a measure of the change in international trade of products and services from NSW and the ROA;
- International import volumes – a measure of the change in international trade of products and services into NSW and the ROA;
- Real Gross Domestic/State Product – a measure of the total market value of all final goods and services produced in NSW and Australia in a given year which is equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports; and
- Employment ('000 of persons) – the change in employment driven by changes in economic activity within the economy at the NSW and the ROA levels.

The assessment of aviation capacity economic impacts has been produced at the NSW and the ROA economy levels. The assessment has been produced for the period of 2011 to 2060.

5.3 Gross State Product or State Value-added

The estimated impacts of additional aviation capacity on NSW Gross State Product (GSP) are shown in Table 12. This impact is given as percentage deviations and as absolute deviations ($m) away from simulated values that would have applied if there were no additional aviation capacity (i.e. the status quo).

Table 12: NSW impact on GSP (real)

Scenario	NSW ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Real GSP ($m)	98	147	210	293	584	1,260	2,158	3,320	4,804	6,690
	Real GSP (% change from Base)	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.4%	0.6%	0.8%	1.1%
Medium	Real GSP ($m)	102	160	245	363	1,184	3,310	6,327	10,472	16,096	23,733
	Real GSP (% change from Base)	0.0%	0.0%	0.1%	0.1%	0.2%	0.6%	1.2%	1.8%	2.7%	3.8%
High	Real GSP ($m)	105	181	306	489	2,244	7,011	14,063	24,274	39,250	62,657
	Real GSP (% change from Base)	0.0%	0.0%	0.1%	0.1%	0.5%	1.4%	2.6%	4.2%	6.5%	10.0%

Source: CoPS and MMRF

The annual cost to the NSW economy of not enhancing aviation capacity is estimated to be between $210 million and $306 million in 2025 in real GSP terms. The cost gradually expands. By 2060, the annual effect of status quo aviation capacity is estimated to cost between $6,690 million and $52,657 to NSW real GSP. This is equivalent to a 1.1 to 10.0 per cent decrease in 2060.

The cost impacts of status quo aviation capacity on the regions of NSW are produced in Table 14. The variable reported here is real Gross Regional Product, which is analogous to real GSP at the state level. The largest economic cost impacts are produced in the Sydney metropolitan region, but there are general impacts in economic performance across NSW.

Table 13: NSW regional distribution of GSP

Scenario	Gross Regional Product ($m, 2010 prices)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Sydney	82	123	176	245	485	1,039	1,774	2,721	3,927	5,457
	Hunter	7	11	15	21	46	106	188	297	440	625
	Illawarra	5	8	11	16	33	74	130	202	296	417
	Richmond Tweed	3	4	6	8	18	39	68	105	153	213
	Mid North Coast	3	5	7	10	20	44	77	120	175	245
	Northern	2	3	4	5	11	24	42	66	95	132
	North West	1	1	2	3	6	14	26	40	59	83
	Central West	1	2	3	4	10	24	44	70	104	148
	South East	3	4	6	8	17	38	65	101	146	204
	Murrumbidgee	1	2	3	5	10	24	43	67	98	136
	Murray	1	2	3	4	8	18	32	50	73	102
	Far West	0	0	0	0	1	3	5	8	12	17
Medium	Sydney	85	134	205	302	972	2,705	5,153	8,505	13,036	19,168
	Hunter	7	12	18	28	104	305	598	1,015	1,597	2,408
	Illawarra	5	9	13	20	71	205	397	666	1,034	1,541
	Richmond Tweed	3	5	7	11	38	108	208	345	532	787
	Mid North Coast	3	5	8	12	43	124	239	399	617	916
	Northern	2	3	4	7	24	69	134	223	342	501
	North West	1	2	2	4	14	43	84	142	220	326
	Central West	1	2	4	6	24	75	148	250	392	587
	South East	3	4	7	10	36	103	199	330	508	748

	Murrumbidgee	2	3	4	6	24	71	138	230	353	519
	Murray	1	2	3	5	18	53	104	173	267	393
	Far West	0	0	0	1	3	8	16	28	44	68
High	Sydney	88	151	254	404	1,830	5,697	11,395	19,608	31,603	50,276
	Hunter	8	13	24	40	209	676	1,390	2,459	4,079	6,685
	Illawarra	6	10	17	28	138	444	902	1,576	2,581	4,178
	Richmond Tweed	3	5	9	15	74	236	475	822	1,333	2,139
	Mid North Coast	3	6	10	17	85	272	550	956	1,556	2,504
	Northern	2	3	6	10	48	154	311	536	864	1,372
	North West	1	2	3	6	30	97	198	346	564	908
	Central West	1	3	5	9	51	168	347	612	1,007	1,634
	South East	3	5	9	15	71	225	453	783	1,267	2,030
	Murrumbidgee	2	3	5	9	48	158	319	551	885	1,399
	Murray	1	2	4	7	36	118	240	416	670	1,062
	Far West	0	0	1	1	6	18	38	69	118	197
	Sydney	88	151	254	404	1,830	5,697	11,395	19,608	31,603	50,276

Source: CoPS and MMRF

The impacts of status quo aviation capacity on the main components of GSP from the expenditure side are reported in Table 14. At a state level, there is net reduction in real private consumption per annum ranging from $50 million to $54 million in 2015, and from $2,215 million to $19,472 million in 2060. In MMRF, real consumption in NSW is driven, in the main, by real GSP which accrues to NSW residents.

Table 14: NSW impact on real expenditure

Scenario	NSW ($'ms)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Real private consumption	5	15	32	54	265	800	1,530	2,499	3,763	5,398
	Real investment	50	59	77	103	243	521	831	1,200	1,653	2,215
	International export volumes	4	14	25	39	106	284	531	852	1,261	1,779
	International import volumes	24	32	45	62	143	315	523	780	1,102	1,505
Medium	Real private consumption	5	25	64	123	872	2,860	5,704	9,649	15,038	22,393
	Real investment	52	66	94	134	580	1,496	2,585	3,952	5,704	7,975
	International export volumes	6	18	35	58	259	836	1,666	2,777	4,213	6,006
	International import volumes	24	36	56	84	354	959	1,726	2,716	3,994	5,642
High	Real private consumption	4	43	124	252	2,002	6,739	13,709	23,816	38,875	63,063
	Real investment	54	78	124	189	1,168	3,209	5,699	8,922	13,261	19,472
	International export volumes	9	25	51	91	508	1,742	3,507	5,729	7,844	8,462
	International import volumes	24	43	76	123	736	2,126	3,910	6,234	9,262	13,299

Source: CoPS and MMRF
Note: in some years NSW total expenditure is lower than NSW GSP impacts; this is a result of the dynamic nature of the MMRF model.

The percentage equivalents of the dollar impact on the economy are presented in Table 16.

Table 15: NSW impact on real expenditure – percentage of economy

	NSW (% Change from Base)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Real private consumption	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.5%	0.8%	1.1%	1.5%
	Real investment	0.0%	0.1%	0.1%	0.1%	0.2%	0.4%	0.6%	0.8%	1.1%	1.4%
	International export volumes	0.0%	0.0%	0.0%	0.1%	0.2%	0.4%	0.7%	1.1%	1.5%	2.0%
	International import volumes	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.6%	0.8%	1.1%	1.4%
Medium	Real private consumption	0.0%	0.0%	0.0%	0.0%	0.3%	1.0%	1.9%	3.0%	4.5%	6.4%
	Real investment	0.0%	0.1%	0.1%	0.1%	0.4%	1.1%	1.8%	2.7%	3.7%	5.0%
	International export volumes	0.0%	0.0%	0.1%	0.1%	0.4%	1.2%	2.2%	3.5%	5.1%	6.9%
	International import volumes	0.0%	0.0%	0.1%	0.1%	0.4%	1.0%	1.8%	2.8%	3.9%	5.3%
High	Real private consumption	0.0%	0.0%	0.1%	0.1%	0.7%	2.3%	4.5%	7.4%	11.6%	18.0%
	Real investment	0.0%	0.1%	0.1%	0.2%	0.9%	2.4%	4.1%	6.1%	8.7%	12.2%
	International export volumes	0.0%	0.0%	0.1%	0.1%	0.8%	2.4%	4.7%	7.3%	9.4%	9.7%
	International import volumes	0.0%	0.1%	0.1%	0.1%	0.8%	2.3%	4.1%	6.3%	9.1%	12.5%

5.3.1 Employment

Changes in NSW employment due to a lack of expansion of aviation capacity are given in the table below. The first row of numbers shows changes in persons employed (in thousands) as measured by the ABS' labour force survey. The second row of numbers expresses these person-changes in percentage-change form against all employment. The number of additional jobs that are not created in NSW by a lack of expansion in the aviation capacity is estimated to be between approximately 23,000 and 136,900 by 2060.

Note that the employment figures need to be treated with some caution. They were calculated on the assumption that the aviation network will not change the ratio of hours worked per person. In reality, it is probable that the increased requirement for labour will be covered by increased working hours of existing employees as well as increased persons employed. To the extent that this does occur, the numbers in Table 16 will overstate the employment implications of the status quo aviation capacity.

Table 16: NSW estimated impact on employment

Scenario	NSW (Change from Base)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Employment ('000 of persons)	0.2	0.2	0.3	0.5	2.0	5.2	8.7	12.8	17.5	23.0
	Employment (% change in hours)	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.5%	0.7%	0.9%	1.1%
Medium	Employment ('000 of persons)	0.1	0.1	0.3	0.4	2.9	8.7	16.3	26.3	39.6	57.0
	Employment (% change in hours)	0.0%	0.0%	0.0%	0.0%	0.2%	0.5%	0.9%	1.4%	2.0%	2.8%
High	Employment ('000 of persons)	0.1	0.2	0.4	0.8	6.5	19.9	37.6	61.5	93.5	136.9
	Employment (% change in hours)	0.0%	0.0%	0.0%	0.1%	0.4%	1.2%	2.1%	3.2%	4.7%	6.6%

Source: CoPS and MMRF

From a regional perspective, the allocation of employment impacts is produced in the table below. The outputs show that a lack of expanded aviation capacity impacts on all regions negatively, particularly the Sydney metropolitan area.

Table 17: NSW Regional Impact on Employment

Scenario	Employment ('000s)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Sydney	0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	0.5%	0.8%	1.0%	1.4%
	Hunter	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.5%	0.7%	0.9%
	Illawarra	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.4%	0.7%	0.9%	1.2%
	Richmond Tweed	0.0%	0.0%	0.0%	0.0%	0.2%	0.5%	0.8%	1.2%	1.7%	2.2%
	Mid North Coast	0.0%	0.0%	0.0%	0.0%	0.1%	0.4%	0.7%	1.0%	1.4%	2.0%
	Northern	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.5%	0.7%
	North West	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.1%	0.2%	0.3%	0.5%
	Central West	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.1%	0.3%	0.4%	0.6%
	South East	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.5%	0.7%	1.1%	1.4%
	Murrumbidgee	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.4%	0.6%	0.9%
	Murray	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.4%	0.7%	0.9%
	Far West	0.0%	0.0%	-0.1%	-0.1%	-0.1%	0.0%	0.1%	0.1%	0.3%	0.4%
Medium	Sydney	0.0%	0.0%	0.1%	0.1%	0.4%	0.9%	1.6%	2.4%	3.4%	4.5%
	Hunter	0.0%	0.0%	0.0%	0.0%	0.2%	0.6%	1.1%	1.8%	2.7%	3.8%
	Illawarra	0.0%	0.0%	0.0%	0.0%	0.3%	0.8%	1.5%	2.3%	3.3%	4.5%
	Richmond Tweed	0.0%	0.0%	0.0%	0.1%	0.5%	1.5%	2.7%	4.2%	6.0%	8.2%
	Mid North Coast	0.0%	0.0%	0.0%	0.0%	0.4%	1.3%	2.4%	3.8%	5.5%	7.6%
	Northern	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.8%	1.3%	2.1%	3.1%
	North West	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.6%	1.0%	1.7%	2.5%
	Central West	0.0%	0.0%	0.0%	0.0%	0.1%	0.4%	0.8%	1.4%	2.1%	3.0%
	South East	0.0%	0.0%	0.0%	0.0%	0.3%	0.9%	1.7%	2.7%	3.9%	5.5%
	Murrumbidgee	0.0%	0.0%	0.0%	0.0%	0.1%	0.5%	1.1%	1.8%	2.7%	3.9%
	Murray	0.0%	0.0%	0.0%	0.0%	0.1%	0.6%	1.2%	1.9%	2.9%	4.2%
	Far West	0.0%	0.0%	-0.1%	-0.1%	0.0%	0.2%	0.4%	0.8%	1.3%	2.0%
High	Sydney	0.0%	0.1%	0.1%	0.1%	0.7%	2.0%	3.5%	5.3%	7.5%	10.4%
	Hunter	0.0%	0.0%	0.0%	0.0%	0.5%	1.5%	2.8%	4.5%	6.7%	9.6%
	Illawarra	0.0%	0.0%	0.0%	0.1%	0.6%	1.9%	3.4%	5.3%	7.7%	10.8%
	Richmond Tweed	0.0%	0.0%	0.1%	0.1%	1.2%	3.5%	6.3%	9.7%	13.9%	19.0%

Mid North Coast	0.0%	0.0%	0.0%	0.1%	1.1%	3.2%	5.8%	9.0%	12.9%	17.8%
Northern	0.0%	0.0%	0.0%	0.0%	0.2%	0.9%	2.0%	3.4%	5.3%	7.8%
North West	0.0%	0.0%	0.0%	0.0%	0.1%	0.7%	1.6%	2.7%	4.3%	6.5%
Central West	0.0%	0.0%	0.0%	0.0%	0.3%	1.0%	2.1%	3.5%	5.3%	7.8%
South East	0.0%	0.0%	0.0%	0.1%	0.7%	2.2%	4.1%	6.4%	9.3%	13.0%
Murrumbidgee	0.0%	0.0%	0.0%	0.0%	0.4%	1.4%	2.7%	4.5%	6.8%	9.8%
Murray	0.0%	0.0%	0.0%	0.0%	0.4%	1.5%	2.9%	4.8%	7.3%	10.5%
Far West	0.0%	0.0%	0.0%	0.0%	0.1%	0.6%	1.3%	2.2%	3.6%	5.2%

5.4 Rest of Australia (ROA) economy impacts

The total impacts for the ROA due to a lack of investment in aviation capacity within the Sydney region have also been calculated using MMRF. The difference between the outcomes of the NSW analysis and ROA analysis is determined by the impacts on other Australian States – which may be positive or negative depending on the economic transfers experienced through aviation capacity increases, on impacts caused as a result of the constrained aviation capacity such as depreciation in the exchange rates and on traveller's behavioural decisions, which have been determined in the direct expenditure analysis.

5.4.1 ROA

The estimated impacts of maintaining the status quo on Gross Domestic Product (GDP), excluding NSW, are shown in Table 18. Two rows of numbers are shown. The first gives the impacts in real dollar terms. The second shows the impacts in terms of percentage changes away from the simulated case of where there is no additional capacity created (i.e. the Base Case).

Table 18: Employment impact on ROA

Scenario	ROA ($m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Real GDP	175	268	381	525	830	1,436	2,225	3,229	4,496	6,092
	Real GDP (%)	0.01%	0.02%	0.03%	0.04%	0.05%	0.09%	0.13%	0.18%	0.24%	0.30%
Medium	Real GDP	179	280	411	581	1,294	2,998	5,354	8,541	12,836	18,672
	Real GDP (%)	0.01%	0.02%	0.03%	0.04%	0.08%	0.18%	0.31%	0.47%	0.68%	0.94%
High	Real GDP	183	298	458	675	2,085	5,734	11,035	18,703	30,135	48,569
	Real GDP (%)	0.01%	0.02%	0.03%	0.05%	0.13%	0.35%	0.64%	1.05%	1.62%	2.52%

Source: CoPS and MMRF

The annual impact of maintaining the status quo aviation capacity in the Sydney region on real GDP, excluding NSW, has been estimated to range from $175 million to $183 million in 2015, and from $6,092 million to $48,569 million in 2060. The impacts on the Australian economy as a result of status quo aviation are generally lower than the impact on the NSW economy at later dates. This indicates that some of the national resources underlying the activity in NSW have been drawn to other states, causing the ROA to contract significantly less. In the earlier years, the ROA outcomes in some cases and for some years are larger than the NSW impacts alone. To put it another way, for those cases and years, the ROA is also negatively impacted from no expansion in aviation capacity in Sydney.

There are two general influences on real GSP:

- real GSP in the ROA will increase as a result of resources moving from NSW to the ROA once aviation capacity in NSW is reached. Some of this increase is the result of the real depreciation in the exchange rate, as well as the labour and capital released by NSW which flows into the ROA.
- real GSP in the ROA will decrease as a result of the net decrease in foreign visitor expenditure in the ROA which imposes direct and indirect costs on non-NSW regions.

It is an empirical matter as to which of these two effects dominate. Based on the direct impacts, in some cases and for some years the second factor dominates.

The impacts of Sydney's aviation capacity network on the main expenditure-side components of ROA are reported in Table 22. A similar story emerges for each of these categories as explained above for ROA. In general, the ROA effects of the aviation network on each of the expenditure aggregates are less than the NSW effects in terms of dollar value changes. This is consistent with resources moving to the rest of Australia from NSW.

Table 19: ROA impact on real expenditures

Scenario	ROA($m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Real private consumption	92	152	225	316	586	1,171	1,948	2,955	4,243	5,883
	Real investment	80	97	122	158	251	409	571	751	960	1,207
	International export volumes	74	117	168	234	300	402	539	709	915	1,165
	International import volumes	65	88	118	158	262	458	686	964	1,305	1,729
Medium	Real private consumption	93	163	258	382	1,144	3,053	5,736	9,404	14,369	21,115
	Real investment	82	101	131	172	415	841	1,277	1,770	2,361	3,093
	International export volumes	75	118	170	237	310	456	661	913	1,208	1,533
	International import volumes	65	92	130	181	491	1,133	1,915	2,900	4,151	5,747
High	Real private consumption	94	182	314	500	2,152	6,507	12,855	22,033	35,773	58,186
	Real investment	84	108	146	195	682	1,535	2,415	3,446	4,766	6,615
	International export volumes	76	119	171	238	305	484	727	936	795	-654
	International import volumes	65	99	152	223	902	2,346	4,122	6,380	9,288	13,166

Source: CoPS and MMRF

The percentage impacts on the Australian economy, excluding NSW, of the variances in real expenditure are presented in the table overleaf.

Table 20: ROA impact on real expenditures – Percentage of ROA economy

Scenario	ROA($m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Real private consumption	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%	0.6%
	Real investment	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%
	International export volumes	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.3%
	International import volumes	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%	0.3%	0.4%	0.5%
Medium	Real private consumption	0.0%	0.0%	0.0%	0.0%	0.1%	0.4%	0.6%	1.0%	1.4%	2.0%
	Real investment	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	0.3%	0.4%	0.6%
	International export volumes	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.2%	0.3%	0.4%	0.4%
	International import volumes	0.0%	0.0%	0.0%	0.1%	0.2%	0.4%	0.6%	0.9%	1.2%	1.6%
High	Real private consumption	0.0%	0.0%	0.0%	0.1%	0.3%	0.7%	1.4%	2.3%	3.7%	5.8%
	Real investment	0.0%	0.0%	0.0%	0.0%	0.2%	0.3%	0.5%	0.7%	0.9%	1.2%
	International export volumes	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.3%	0.3%	0.3%	0.0%
	International import volumes	0.0%	0.0%	0.1%	0.1%	0.3%	0.8%	1.3%	2.0%	2.8%	3.8%

Source: CoPS and MMRF

5.4.2 Employment

The MMRF model produces employment outputs based on the changes in GDP, excluding NSW, and general expenditure levels. The estimated employment impacts of the status quo aviation capacity are shown in the table below. The first row of numbers show changes in persons employed (in thousands) as measured by the ABS' labour force survey. The second row of numbers expresses these person-changes in percentage-change form against all employment.

As with the NSW economy employment impacts, the figures need to be treated with some caution. They were computed on the assumption that aviation capacity issues will not change the ratio of hours worked per person. In reality, it is probable that the increased requirement for labour will be covered by increased working hours of existing employees as well as increased persons employed. To the extent that this occurs, the numbers in Table 21 will be overstated.

Table 21 will overstate the employment benefits of the aviation network.

Table 21: National Estimated Impact on Employment

Scenario	ROA	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Employment ('000 of persons)	0.0	0.1	0.1	0.1	0.4	0.9	1.5	2.4	3.6	5.1
	Employment (% change in hours)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium	Employment ('000 of persons)	0.0	0.1	0.1	0.2	1.0	3.0	5.7	9.4	14.3	20.8
	Employment (% change in hours)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
High	Employment ('000 of persons)	0.0	0.1	0.2	0.3	2.3	7.0	13.4	22.3	34.9	53.4
	Employment (% change in hours)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

5.5 Summary of foregone quantifiable impacts

An assessment of the economy wide impacts of lack of investment in aviation capacity in Sydney has been undertaken using the direct expenditure impacts produced in previous chapters of the report including:

- Passenger welfare and delays – Economic cost of passenger welfare and delays;
- Tourism – Losses to the tourism industry;
- Freight – Losses to the freight industry;
- Aviation and Airport – Losses to the aviation and airport industry; and
- Commercial developments – Losses resulting from commercial developments (e.g. business parks and hotels) not being developed.

The economic impact assessment was undertaken using general equilibrium analysis to estimate the historical and future growth in the economy as a result of the maintaining the status quo in aviation capacity in the Sydney region.

A summary of the results across the major output variables is produced in the table below.

Table 22: NSW and ROA impacts of Sydney's aviation network

Scenario		2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	NSW ($'ms)										
	Real private consumption	5	15	32	54	265	800	1,530	2,499	3,763	5,398
	Real investment	50	59	77	103	243	521	831	1,200	1,653	2,215
	International export volumes	4	14	25	39	106	284	531	852	1,261	1,779
	International import volumes	24	32	45	62	143	315	523	780	1,102	1,505
	Real GDP	98	147	210	293	584	1,260	2,158	3,320	4,804	6,690
	Employment ('000 of persons)	0.1	0.1	0.2	0.2	1.0	2.6	4.6	7.2	10.5	14.7
	ROA ($'ms)										
	Real private consumption	92	152	225	316	586	1,171	1,948	2,955	4,243	5,883
	Real investment	80	97	122	158	251	409	571	751	960	1,207
	International export volumes	74	117	168	234	300	402	539	709	915	1,165
	International import volumes	65	88	118	158	262	458	686	964	1,305	1,729
	Real GDP	175	268	381	525	830	1,436	2,225	3,229	4,496	6,092
	Employment ('000 of persons)	0.0	0.1	0.1	0.1	0.4	0.9	1.5	2.4	3.6	5.1
Medium	NSW ($'ms)										
	Real private consumption	5	25	64	123	872	2,860	5,704	9,649	15,038	22,393
	Real investment	52	66	94	134	580	1,496	2,585	3,952	5,704	7,975
	International export volumes	6	18	35	58	259	836	1,666	2,777	4,213	6,006
	International import volumes	24	36	56	84	354	959	1,726	2,716	3,994	5,642
	Real GDP	102	160	245	363	1,184	3,310	6,327	10,472	16,096	23,733
	Employment ('000 of persons)	0.1	0.1	0.3	0.4	2.9	8.7	16.3	26.3	39.6	57.0
	ROA ($'ms)										
	Real private consumption	93	163	258	382	1,144	3,053	5,736	9,404	14,369	21,115
	Real investment	82	101	131	172	415	841	1,277	1,770	2,361	3,093
	International export volumes	75	118	170	237	310	456	661	913	1,208	1,533
	International import volumes	65	92	130	181	491	1,133	1,915	2,900	4,151	5,747
	Real GDP	179	280	411	581	1,294	2,998	5,354	8,541	12,836	18,672
	Employment ('000 of persons)	0.0	0.1	0.1	0.2	1.0	3.0	5.7	9.4	14.3	20.8
High	NSW ($'ms)										
	Real private consumption	4	43	124	252	2,002	6,739	13,709	23,816	38,875	63,063
	Real investment	54	78	124	189	1,168	3,209	5,699	8,922	13,261	19,472
	International export volumes	9	25	51	91	508	1,742	3,507	5,729	7,844	8,462
	International import volumes	24	43	76	123	736	2,126	3,910	6,234	9,262	13,299
	Real GDP	105	181	306	489	2,244	7,011	14,063	24,274	39,250	62,657
	Employment ('000 of persons)	0.1	0.2	0.4	0.8	6.5	19.9	37.6	61.5	93.5	136.9
	ROA ($'ms)										

Real private consumption	94	182	314	500	2,152	6,507	12,855	22,033	35,773	58,186
Real investment	84	108	146	195	682	1,535	2,415	3,446	4,766	6,615
International export volumes	76	119	171	238	305	484	727	936	795	205
International import volumes	65	99	152	223	902	2,346	4,122	6,380	9,288	13,166
Real GDP	183	298	458	675	2,085	5,734	11,035	18,703	30,135	48,569
Employment ('000 of persons)	0.0	0.1	0.2	0.3	2.3	7.0	13.4	22.3	34.9	53.4

Source: CoPS and MMRF

The analysis presented in this chapter and in the table above shows that the economic impact on the ROA is lower than that of the NSW economy in later years, and higher in earlier years. As detailed in the direct expenditure analysis, this result is to be expected. The analysis has shown that under a scenario where aviation capacity in NSW is reached, individuals will continue to travel to Australia and freight will continue to make its way into Australia, but will enter through different locations, in other states. As such, the losses to the NSW economy will be greater than to the Australia economy as a whole, where other states are benefiting through:

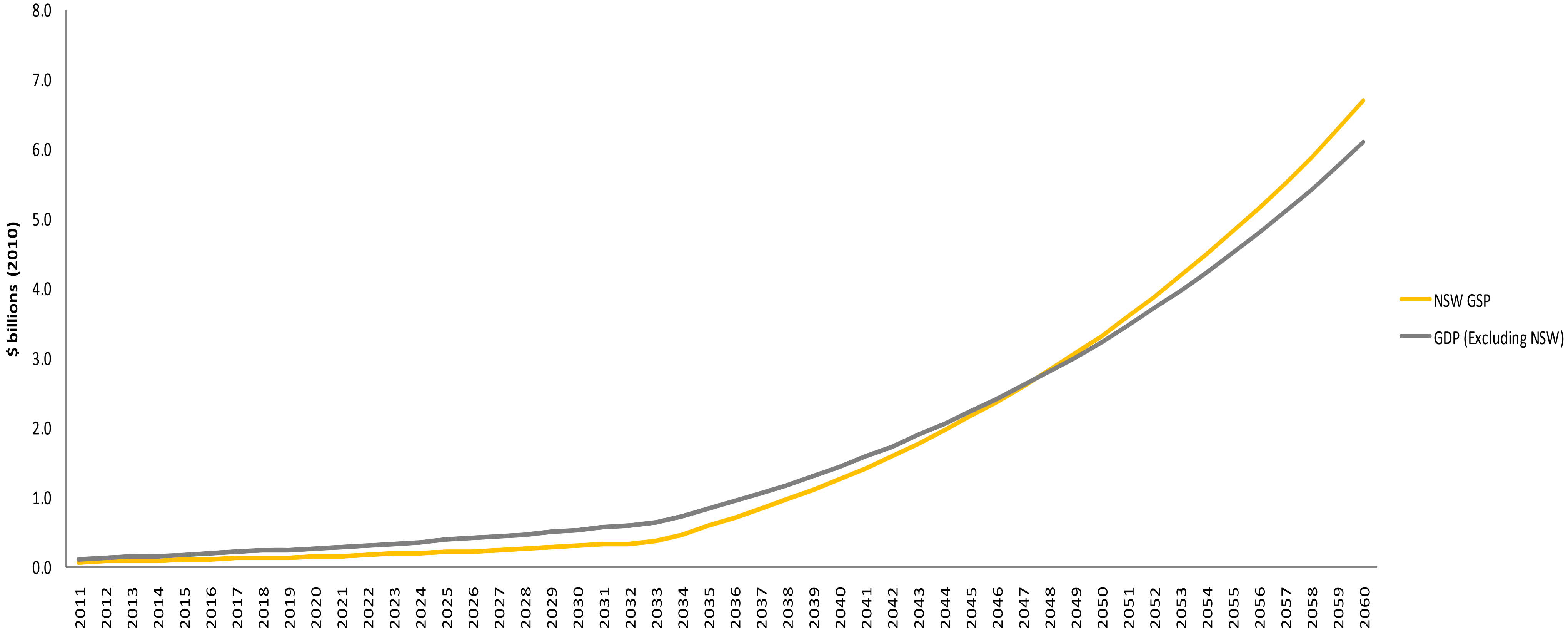
- Additional tourism expenditure;
- Additional freight expenditure; and
- Investment in aviation and aviation related activities to cater for increases in throughput.

In the short-term however, exchange rate impacts and their impacts dominate, resulting in ROA industries being impacted more severely than those in NSW.

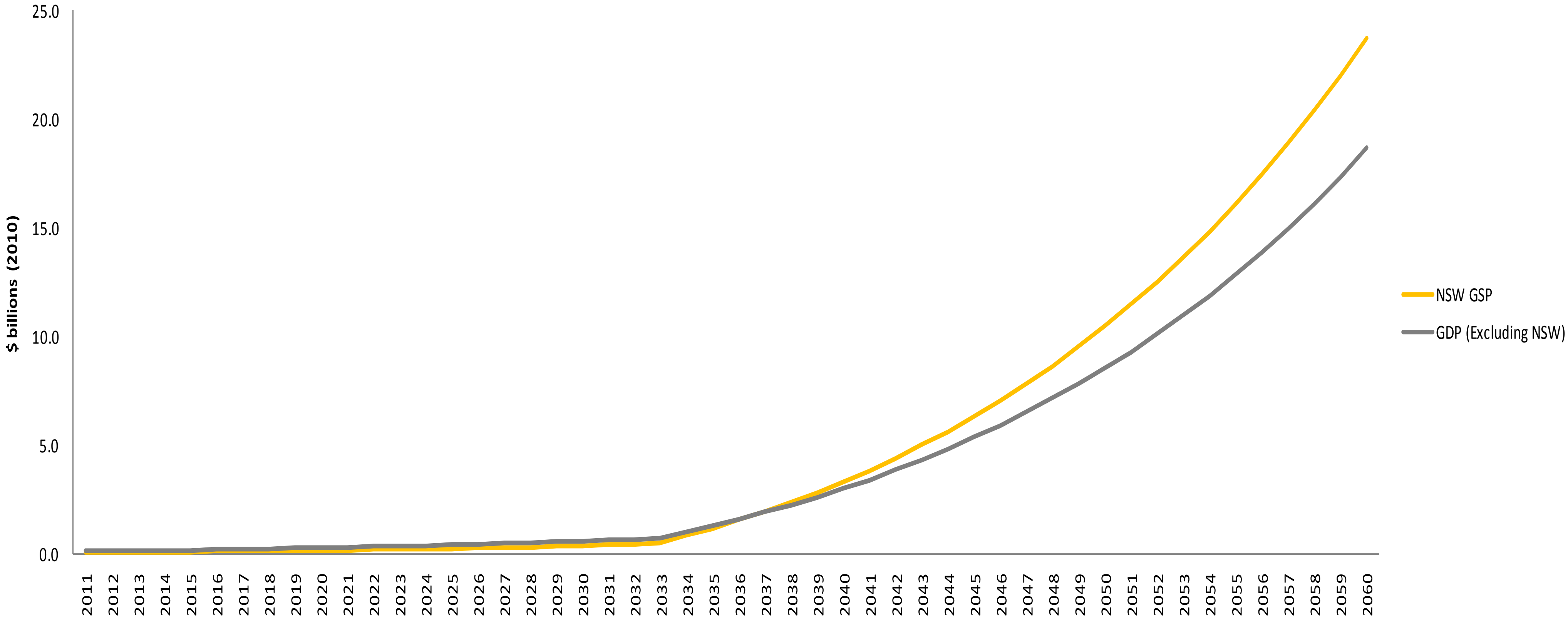
The GSP/GDP outcomes experienced at the NSW and ROA level are presented in the figure below. The changes projected for the NSW economy as a result of additional aviation capacity are greater than the changes projected for the Australian economy. This illustrates the extent to which the negative impacts on NSW are due to shifting resources into the ROA from NSW.

Figure 12: Total GSP / GDP (excluding NSW) outcomes

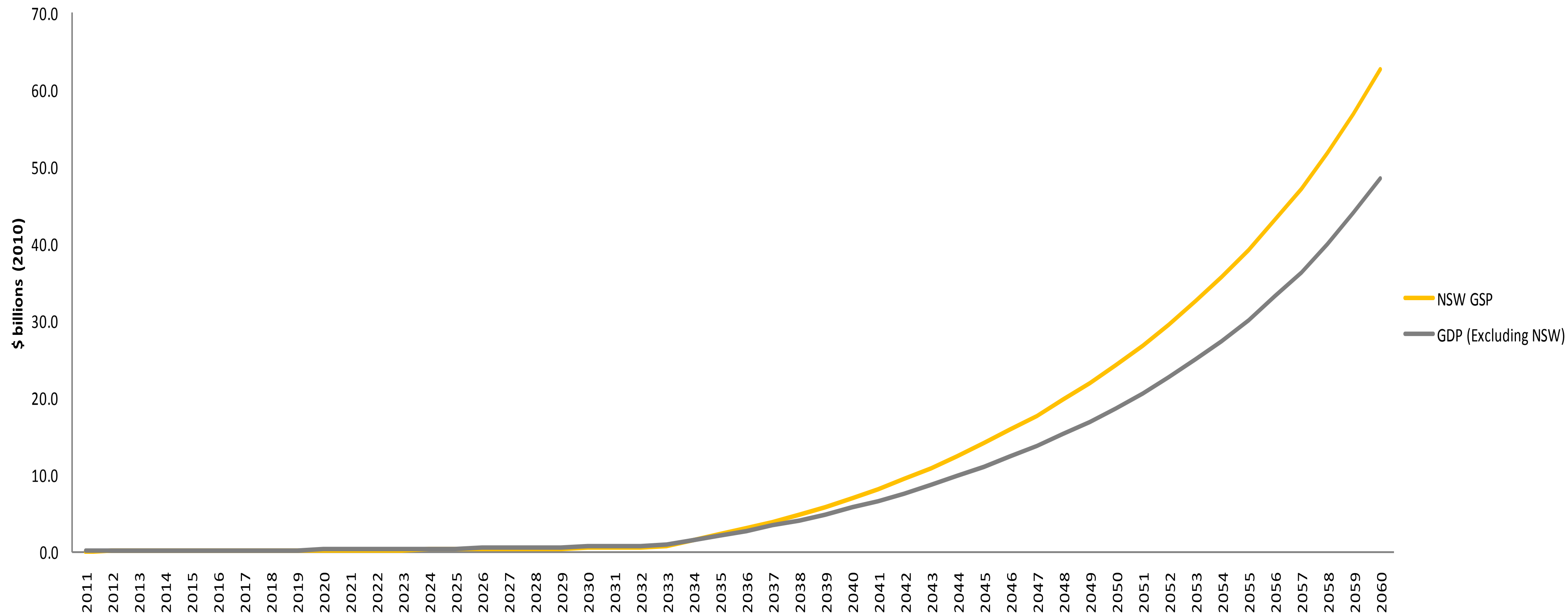
Scenario – Low



Scenario – Medium



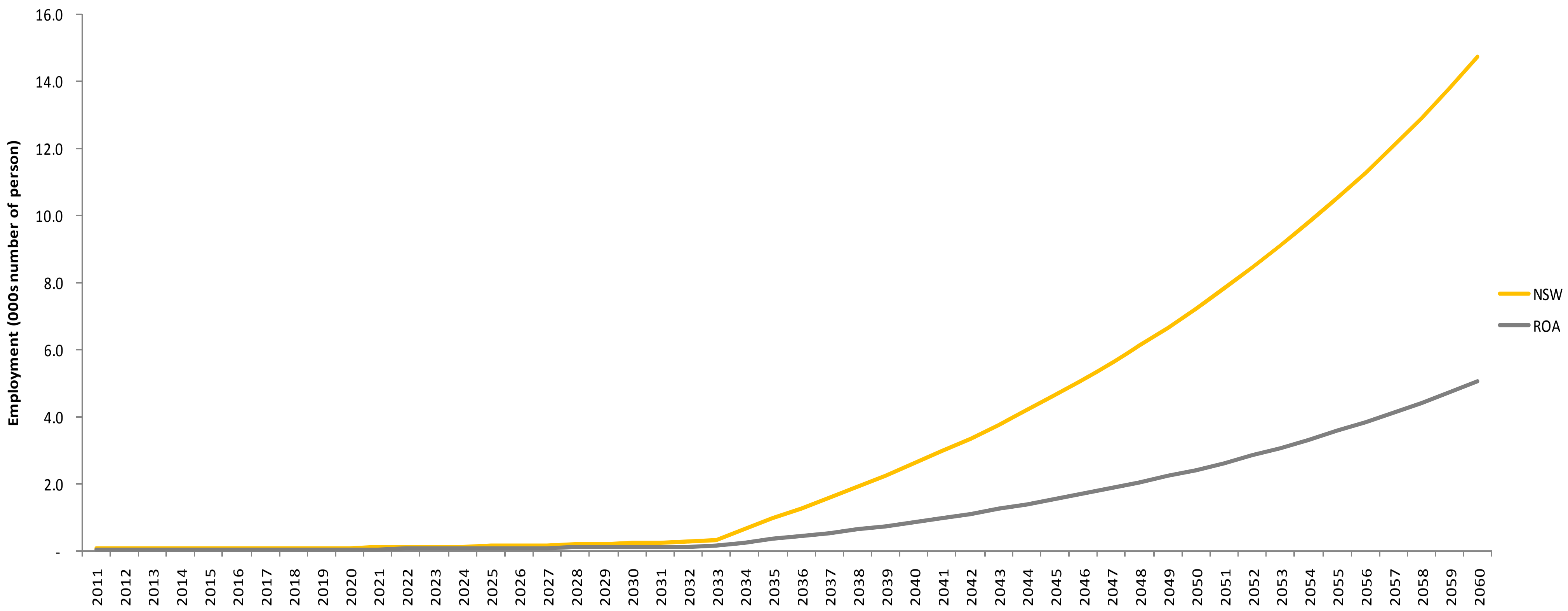
Scenario – High



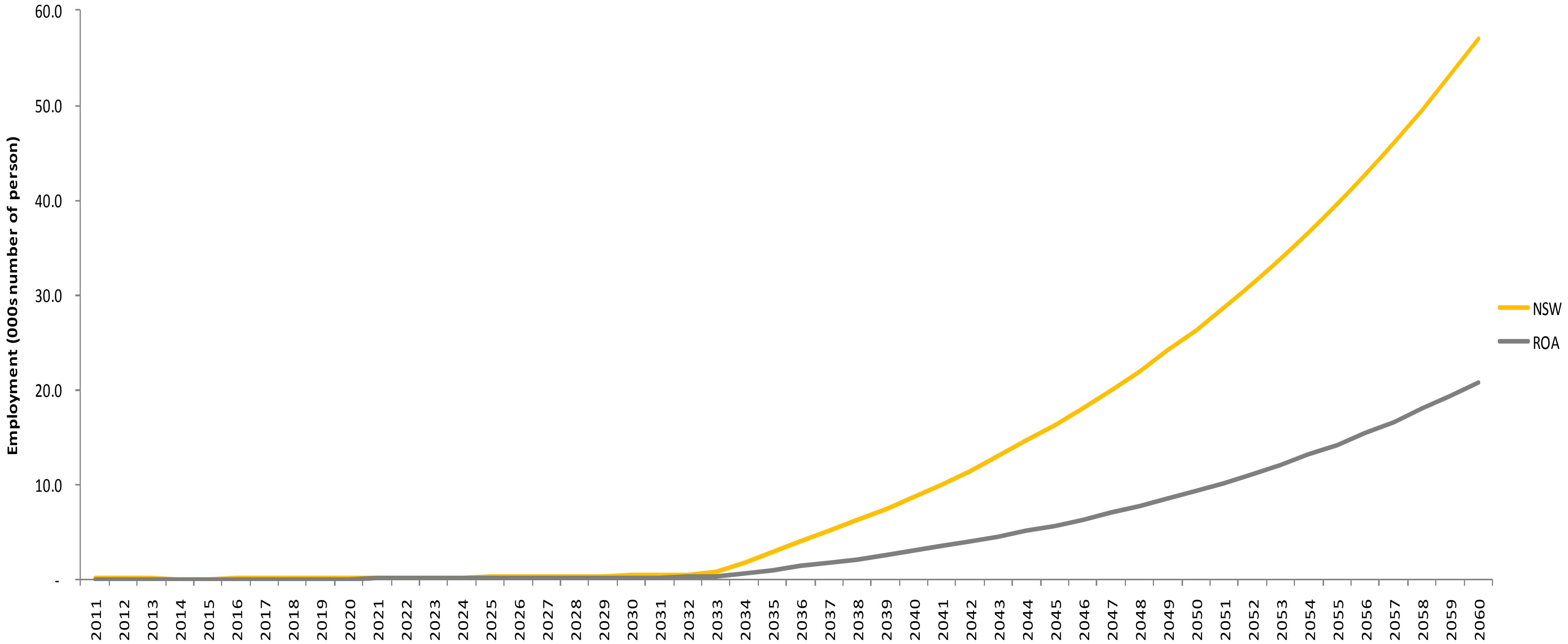
The summary employment results for NSW and ROA are presented in the figure below.

Figure 13: Total employment outcomes

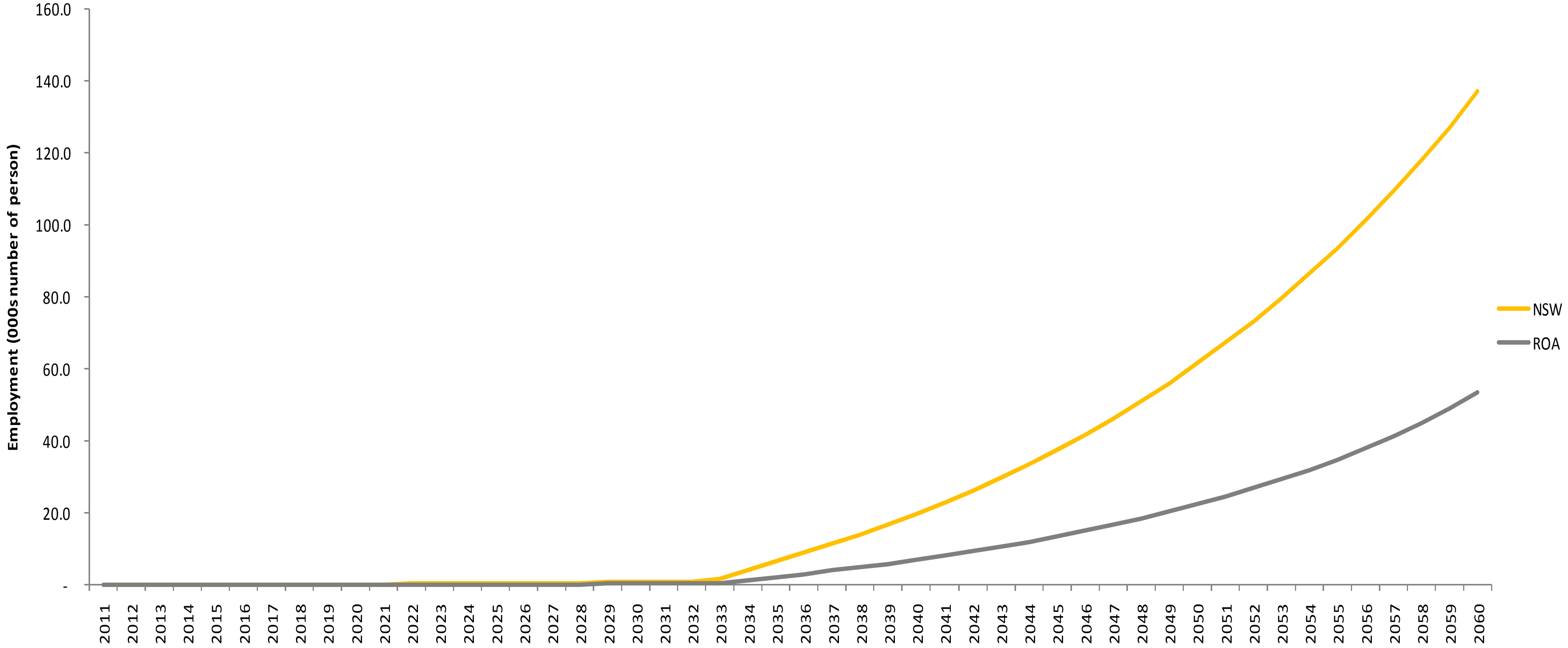
Scenario – Low



Scenario – Medium



Scenario – High



6. Qualitative impacts analysis

6.1 Introduction

'The air transport sector's contribution to the economy is much wider and further-reaching than the direct contribution.'[11]

Previous chapters in this report quantify the potential costs to the Australian and NSW economies of maintaining the status quo in terms of aviation infrastructure in the Sydney region. This analysis provides an important foundation for policy makers to understand the potential implications of decisions regarding Australia's future aviation strategy.

However, this analysis does not capture the full story. There is a wide range of impacts associated with aviation infrastructure that are difficult to monetise; an analysis that sets aside such non-monetised impacts is at risk of significantly understating or overstating the benefits of investment decisions.

Decisions to expand aviation capacity are always controversial and require a balanced assessment of the broader economic impacts, financial implications and the potential impacts on local communities and residents.

A number of research studies have been undertaken that consider the wider impacts associated with aviation capacity in different countries; this chapter sets out the key findings of these studies and considers how they might apply to the context of the Sydney region. These studies include persuasive arguments as to how good aviation services are an important enabler of economic growth, particularly for the services sector.

However, despite the importance of the issue, there is limited published literature on the direct quantifiable wider economic impacts of airports. This is largely driven by the fact it is difficult to show a precise link between certain levels of aviation activity and services and the wider economy, due to the inevitable complexity of factors that underpin events such as location or investment decisions by companies.

Given the challenges in quantifying these impacts, it is ultimately a matter of judgement as to the degree to which the likelihood of these impacts being realised is incorporated into decision making.

6.2 Connectivity

'A distinguishing feature of world cities is that they are part of a super-network of connectivity.'[12]

Air transport connects people and businesses to the global economy, thereby playing an increasingly important role in global economic activity. Indeed, global connectivity is regularly cited by international businesses as a reason for choosing a location.

A high degree of connectivity is critical to maintain both Australia's and Sydney's reputation as world-class destinations for business and leisure (i.e. 'Brand Australia' and 'Brand Sydney'), particularly given the geographical distance between Australia and many other world-class cities. Furthermore, in a county of Australia's size, frequent and affordable air transport links are important for ensuring access to and from other cities and regional/remote communities.

There is a risk that constrained aviation in the Sydney region will diminish Australia's ability to consistently attract business and leisure visitors to the region. While flights may continue to be available, operating the system at maximum capacity increases the risk that unexpected events, such as weather, safety or security issues, have a particularly detrimental impact on the quality and consistency of service. Capacity constraints are also likely to lead to higher airfares and constrain the number of destinations that are directly served from Sydney.

Connectivity generates wider economic benefits for businesses, both through the efficiency of direct linkages and by providing an environment that benefits businesses, including access to an international labour force, as well as customers, suppliers and knowledge-sharing around the world. Global connectivity is particularly important for those sectors characterised by internationalised, high-value products and services, dependent on mobile

[11] '*Aviation: The Real World Wide Web*', Oxford Economics (2009)
[12] '*A new airport for London*', Mayor of London (2011)

workforces and face-to-face relations. These include high-tech sectors, pharmaceuticals and financial and business services.[13]

Being part of a nationally and globally integrated transport network plays a particularly important role in enabling firms to access larger markets. For example, the UK Eddington Transport Study cited the widespread use of aviation and its falling costs as a key driver in the transformation of the connectivity of both the manufacturing and service sectors globally.[14]

In a detailed review undertaken by Oxford Economic Forecasting (OEF) for the International Air Transport Association (IATA), nearly 85% of firms reported that air services were important for their sales and over half of the businesses surveyed believed that their ability to compete internationally would be very badly or moderately affected by constraints on the availability of air transport.[15]

In particular, the ability to hold face-to-face meetings with overseas contacts is perceived as crucial to doing business effectively.[16] While it has been argued that developments in communication technology (e.g. the use of video conference facilities) should diminish the importance of air travel in business, a number of studies have concluded that this is not the case due to the importance of building strong personal relationships.[17]

6.3 Regional growth

' In the same way that the engine is the beating heart of an aircraft, an airport is the economic growth engine for communities large and small in today's global economy.'[18]

Sydney is widely recognised as one of the world's leading cities for both business and leisure travel and, whether correct or not, is often seen by international travellers as the 'gateway' to Australia. Maintaining this role and reputation is critical to Australia's continued success on the world stage and could be at risk if Sydney cannot meet the growing demand for aviation.

The development of an airport can have a 'game-changing' impact on the development of a country or region. For example, it has been argued that the Singaporean Government's decision to take 'bold infrastructure investment decisions' in the development of Changi International Airport has been a major contributor to Singapore's successful economic growth strategy.[19]

While a number of traditional cost benefit analyses concluded that Paya Lebar Airport should be expanded rather than developing a new civilian airport at Changi, the Government decided that this investment was needed to support Singapore's external competitiveness by providing an important 'signaling strategy in order to capture new demand and tilt the market share in the Southeast Asia region towards Changi'.[20]

However, it is empirically difficult to quantify or prove the impact of individual transport investments on overall long-term economic growth and development; hence, the exclusion of these impacts from traditional transport appraisal.

The degree of economic development in any given region must also be considered carefully as it has been argued that there are diminishing marginal impacts on economic growth as more capacity is added. For example, Banister and Berechman have argued that the evidence is mixed on the role of accessibility changes in generating economic development in advanced economies where the infrastructure is already well established, where more complex market systems are in operation, and where transport costs play a less important role in the total production costs.[21]

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13 *'Economic Impacts of Hub Airports'*, British Chambers of Commerce (2009)
14 *'The Eddington Transport Study, Main report: Transport's role in sustaining the UK's productivity and competitiveness'*, Eddington (2006)
15 *'Airline Network Benefits'*, International Air Transport Association (2007)
16 *'Connecting for growth: the role of Britain's hub airport in economic recovery'*, Frontier Economics (September 2011)
17 '*A new airport for London'*, Mayor of London (2011)
18 *'Priming the Airport Economic Engine: Stimulus funding sparks development while value is high '*, Pope (2009)
19 *'Strategic development of airport and rail infrastructure: the case of Singapore'*, Phang (2002)
20 Ibid
21 *'Strategic development of airport and rail infrastructure: the case of Singapore'*, Phang (2002)

6.4 Industry development

Investment in aviation infrastructure may generate a number of broader regional economic benefits that are not captured in a traditional costs benefits analysis. Most notably, these include access to emerging markets, agglomeration impacts and labour market impacts. These are discussed below.

6.4.1 Access to emerging markets

International trade is widely recognised as a key driver of economic growth, increasing prosperity and rising living standards, with world trade persistently growing more rapidly than global GDP.[22] The availability of both air freight and passenger services plays a vital role in facilitating trade and enabling businesses to serve a bigger market. The ability to serve a larger market is likely to have a significant impact on the ability of businesses to innovate and potentially leads to increased sales and profits, more scope to exploit economies of scale and increased competition. OEF's econometric research across 24 EU countries implies that, other things being equal, a 10% increase in output of air services will raise productivity and potential output by 0.56% in the longer term. [23]

In the UK, aviation services are particularly important for transporting exports to the fast-growing markets of Asia, including China and India. It has been argued that there is a direct correlation between connectivity through a hub airport and a country's trading performance and that in particular a lack of direct flights from London Heathrow to emerging markets (including Manila, Guangzhou and Jakarta) may already be costing the economy $1.2 billion each year as trade goes to better-connected competitors.[24]

However, a recent study conducted for the UK Government found that London has better connections to the key business centres of the world than any other European city (with 1,113 departure flights in the week studied to key business destinations compared with Paris' 499 flights, Frankfurt's 443 and Amsterdam's 282).[25] While a similar study has not been completed for Sydney, the implications for all modern, open economies are clear.

6.4.2 Agglomeration impacts

Airports can provide a strong regional economic anchor and are often magnets for economic activity. By locating near each other in airport precincts, firms can benefit from significant economies of scale and network effects. The development of Seoul, Atlanta and Memphis Airports has been cited as the catalyst for nearby clusters of development.[26] For example, a £15 billion development housing 65,000 residents and 300,000 office workers has been proposed upon reclaimed land near Seoul's Incheon Airport in South Korea.

Indeed, airports are increasingly being seen as more than transport interchanges, but as potential economic growth centres in their own right. For example, the Kenan Institute Centre for Air Commerce has argued that a new urban form is emerging – the Aerotropolis – creating an airport city with clusters of aviation-linked businesses and associated residential development.[27] An analysis of trends in airport cities in Hong Kong, South Korea and Taiwan has demonstrated that 'with the growth in passenger flows and related logistical activities, some airports have added intermodal functions, a wider array of organisations and enterprises and become the focus of a logistic economic zone'.[28]

6.4.3 Labour market impacts

As identified in this report, increasing aviation capacity can have significant employment impacts, both at airports that are large employers in their own right and in a range of activities supplying the airport. Beyond these direct and indirect employment benefits, aviation capacity can have potential implications for the wider labour market.

For example, in the context of London, it has been argued that the number of destinations accessible will widen the pool of talent from which businesses are able to recruit, thereby increasing London's productivity by allowing the city to attract more highly skilled workers.[29] Furthermore, research carried out by Oxer suggests that aviation

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[22] *'The Economic Contribution of the Aviation Industry in the UK'*, Oxford Economic Forecasting (October 2006)
[23] Ibid
[24] *'Connecting for growth: the role of Britain's hub airport in economic recovery'*, Frontier Economics (September 2011)
[25] *'International Air Connectivity for Business'*, AirportWatch (2011)
[26] '*A new airport for London'*, Mayor of London (2011)
[27] *'Global Airport Cities'*, Kasarda, Airports Council International, Kenan Institute of Private Enterprise, and Insight
[28] *'Strategic development trend and key factor analysis of Airport City in Taiwan'* (2011)
[29] '*A new airport for London'*, Mayor of London (2011)

sector workers are more productive than the average worker by approximately £17,100 (AU$27,500) per annum.[30]

The international labour force is particularly significant to Australia's economy in certain skilled sectors. As highlighted by the Productivity Commission, migration contributes to the economy in many ways, including the upskilling of the workforce, economies of scale and the development of new export markets. Indeed, the Productivity Commission concluded that increasing skilled migration will make a positive overall contribution to Australia's future per capita income levels. Maintaining strong aviation links will be important to enable the effective flow of international labour both in and out of Australia.[31]

6.5 Tourism

'There is a close relationship between the successful development of tourism and the strengthening of the cultural assets of the country.'[32]

Aviation has opened up the global economy to international tourism. With over 40% of international tourists travelling by air, air transport provides essential support to tourism.[33]

Australia's international reputation, as well as the economic and social benefits it generates, could be at risk if Sydney cannot meet the growing demand for aviation. At best, visitors may relocate their travel plans to other Australian cities, such as Melbourne and Brisbane. At worst, Australia will lose significant tourism and business activity to other parts of the globe.

While the direct benefits of increased tourism have been captured and monetised in this report (see Chapter 4), tourism also brings more intangible benefits. For example, it has been argued that tourism plays a key role in cultural exchange and education.[34]

International events are key drivers of increasing tourism and Australia has long been a prime destination for major sporting and cultural events (e.g. the 2000 Olympics and the 2003 Rugby World Cup). Particularly in light of Australia's distance from the rest of the world, maintaining strong network links and efficient and affordable air transport services are critical to ensuring Australia continues to be successful in attracting events of this nature.

6.6 Environmental impacts

'With respect to impacts in the locality of an airport, aircraft noise disturbance is probably the single most important issue affecting the operation and development of airports around the world, and hence their capacity.'[35]

While ensuring demand for aviation services is met can generate significant economic and social benefits, it is also important to consider the potentially negative environmental factors associated with air transport.

There are a number of adverse effects associated with aviation that warrant careful consideration – notably, aviation's contribution to climate change through greenhouse gas emissions, noise impacts and local air quality at airfields, in addition to land transport congestion.

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[30] *'What is the Contribution of Aviation to the UK Economy?'* Final Report Prepared for the Airport Operators Association, Oxera (2008)
[31] '*Economic impacts of Migration and Population Growth*', Productivity Commission (2006)
[32] *'Tomorrow's Tourism Today'*, UK Department of Culture, Media and Sport (2004)
[33] '*Aviation: The Real World Wide Web*', Oxford Economics (2009)
[34] *'The Economic Contribution of the Aviation Industry in the UK'*, Oxford Economic Forecasting (October 2006)
[35] '*Aviation: The Real World Wide Web*', Oxford Economics (2009)

6.6.1 Carbon emissions

Significant attention has been paid to the impact of the aviation sector on climate change, with a number of overseas governments regulating to reduce greenhouse gas emissions.

Overall, the aviation industry is currently responsible for 2% of global anthropogenic greenhouse gas emissions (particularly CO_2, nitrogen oxides and water vapour) through combustion of kerosene. [36] The Australian Government has committed to reducing greenhouse gas emissions by 5% by 2020 and the aviation industry will need to play its part if this target is to be reached.

While the scale of carbon emissions associated with additional aviation capacity can be monetised, it is important to also consider the wider implications of increasing emissions against the backdrop of a global drive to tackle climate change.

6.6.2 Aircraft noise impacts

The noise impacts associated with air travel are a particularly contentious issue among local communities, with noise complaints increasing in line with noise exposure.[37] In addition, there is recent evidence that noise causes far more annoyance than previously had been thought.[38]

As such, a critical issue for airport operators and governments is the need for effective land use planning to prevent noise sensitive uses, such as housing, being built in noise sensitive areas around airports.

6.6.3 Local air quality impacts

Air quality in the vicinity of an airport is affected by a number of sources, including ground transport, aircraft emissions and apron activities such as aircraft refuelling. In terms of the impact on humans, the importance of airport related emissions varies between sites depending upon the location of the airport relative to centres of human habitation.[39]

6.6.4 Impacts on transport networks

As airports gain additional passengers and traffic, a limiting factor is the off-airport roadway network which may not be able to accommodate the increase. The Tourism & Transport Forum has already highlighted that 'the major land transport issue for Sydney Airport is the significant congestion experienced on key access roads and the surrounding road network'.[40]

While it is important to consider these environmental impacts, they cannot be addressed in detail in the context of assessing the cost of doing nothing due to their localised nature. Instead, these factors are considered as part of the CBA of alternative localities and sites.

6.7 Social impacts

'Many of the benefits of sustained growth in the air transport industry are self-evident; increased living standards through trade, improved communications and security, travel and leisure benefits, cultural exchange and social connectivity.'[41]

It has also been argued that airports can generate significant positive social impacts. OEF highlight five specific benefits:[42]

- Cheap and frequent flights enabling most of the population to travel and holiday overseas;

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[36] *'Aviation Emissions and Climate Change Position Paper'*, Royal Aeronautical Society Australian Division (2009)

[37] *'Environmental capacity and airport operations: current issues and future prospects'*, Upham, Thomas, Gillingwater & Raper (2003)

[38] *'Attitudes to Noise from Aviation Sources in England (ANASE)'*, MVA Consulting for UK Department for Transport (2007)

[39] *'Environmental capacity and airport operations: current issues and future prospects'*, Upham, Thomas, Gillingwater & Raper (2003)

[40] *'Accessing Our Airports: Integrating city transport planning with growing air service demand*, Tourism & Transport Forum and Booz & Co

[41] *'Aviation: The Real World Wide Web'*, Oxford Economics (2009)

[42] Ibid

- Enabling contact between residents and friends and families overseas (research conducted by the Civil Aviation Authority has shown that 'Visiting Friends and Relatives' is the strongest component of the growing international passenger traffic at UK airports);

- Expansion of the choices available to consumers, in terms of the range of products (e.g. foods) and culture;

- Facilitation of immigrant labour; and

- The role of air transport links in helping countries to attract major international events.[43]

Oxford Economics highlight a number of related but different social benefits associated with the continued growth of the aviation industry:[44]

- Making global travel more accessible to more people than at any time in history;

- Diffusing the knowledge gained from investment in research and development, and multiplying the effects of innovation across economies;

- Helping to maintain social networks for the increasing number of migrants in modern, globalised economies;

- Fostering the protection of fragile ecosystems by increasing awareness of preservation initiatives and boosting sustainable ecotourism; and

- Amplifying the benefits of cross-cultural exchange, bringing visitors to countries with native cultures.

However, assessing the scale and causation of these benefits is challenging as the impacts are not measured and are highly subjective. Furthermore, it has been argued that the first four of these benefits are reflected in consumer surplus and therefore captured to a large extent by the value-added of the aviation industry – impacts that are captured in the monetised chapters of this report.

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[43] The report specifically referred to the UK's air transport links in helping to win the bid for the 2012 Olympics.

[44] '*Aviation: The Real World Wide Web*', Oxford Economics (2009)

Appendix A Industry outputs

NSW industry outcomes

The MMRF model produces the impact on GSP split into 56 aggregated industry levels. The industry-level deviations from the base case (no additional aviation capacity) as a percentage of the NSW economy are shown in the table below. Note some caution should be taken at this level of disaggregation given the nature of inputs to the modelling.

Table 23: NSW impacts on industry sectors

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Sheep and cattle	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.00	-0.00	0.00	0.01
	Dairy	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.01
	Other agriculture	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.01	0.01
	Agricultural services and fishing	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.00	-0.00	0.00
	Forestry and logging	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00
	Coal mining	-0.00	-0.00	-0.00	-0.00	-0.01	-0.02	-0.03	-0.04	-0.05	-0.07
	Oil mining	-	-	-	-	-	-	-	-	-	-
	Gas mining	-	-	-	-	-	-	-	-	-	-
	Iron ore mining	-	-	-	-	-	-	-	-	-	-
	Meat products	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.01	0.02	0.04	0.05
	Other food and drink products	-0.00	-0.00	-0.00	-0.00	0.00	0.02	0.04	0.07	0.10	0.15
	Textiles, clothing and footwear	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.00	0.00	0.01	0.02
	Wood products	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.02	0.03	0.04
	Paper products	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.01	0.01	0.02
	Printing and publishing	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.04	0.06	0.09
	Petroleum refinery	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.04
	Other chemicals	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.02	0.03
	Rubber and plastic products	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.01	0.01	0.02	0.03
	Non-metallic construction materials (not cement)	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Cement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Iron and steel	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.01
	Alumina	-	-	-	-	-	-	-	-	-	-
	Aluminium	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.02
	Other non-ferrous metals	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.02
	Other metal products	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.02	0.03	0.05	0.07
	Motor vehicle and parts	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.01	0.03	0.04
	Other manufacturing products	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.02	0.05	0.09	0.14
	Electricity - coal	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	Electricity - gas	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00
	Electricity - oil products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Electricity - nuclear	-	-	-	-	-	-	-	-	-	-
	Electricity - hydro	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	Electricity - non-hydro renewable	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	Electricity supply	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00
	Gas supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Water supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
	Construction services	0.02	0.03	0.03	0.04	0.12	0.28	0.44	0.64	0.87	1.16
	Trade services	-0.03	-0.04	-0.04	-0.05	0.05	0.32	0.66	1.11	1.72	2.52
	Accommodation and hotels	-0.01	-0.01	-0.01	0.00	0.26	0.83	1.52	2.38	3.48	4.86
	Road transport - passenger	0.01	0.01	0.01	0.02	0.03	0.07	0.12	0.17	0.24	0.33
	Road transport - freight	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.02	0.04	0.06	0.09
	Rail transport - passenger	-0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	Rail transport - freight	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.02	-0.02
	Other transport (includes water transport)	-0.00	-0.00	-0.00	-0.00	0.03	0.08	0.14	0.20	0.27	0.35
	Air transport	-0.00	-0.00	-0.00	-0.00	0.05	0.15	0.26	0.39	0.54	0.71
	Communication services	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.08	0.13	0.20
	Financial services	0.00	0.01	0.01	0.02	0.02	0.03	0.05	0.07	0.10	0.15

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Business services	0.14	0.18	0.24	0.31	0.41	0.56	0.73	0.90	1.10	1.32
	Dwelling ownership	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Public services	-0.01	-0.01	-0.01	-0.01	-0.02	-0.03	-0.03	-0.03	-0.04	-0.05
	Other services	-0.01	-0.02	-0.02	-0.02	0.06	0.29	0.61	1.04	1.62	2.39
	Private transport services	-	-	-	-	-	-	-	-	-	-
	Private electrical equipment services	-	-	-	-	-	-	-	-	-	-
	Private heating equipment services	-	-	-	-	-	-	-	-	-	-
Medium	Sheep and cattle	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.00	0.01	0.03	0.07
	Dairy	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.01	0.01	0.02
	Other agriculture	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.02	0.03	0.06
	Agricultural services and fishing	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.01	0.03	0.05	0.08
	Forestry and logging	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.01	0.02	0.03
	Coal mining	-0.00	-0.00	-0.00	-0.01	-0.02	-0.04	-0.07	-0.10	-0.15	-0.20
	Oil mining	-	-	-	-	-	-	-	-	-	-
	Gas mining	-	-	-	-	-	-	-	-	-	-
	Iron ore mining	-	-	-	-	-	-	-	-	-	-
	Meat products	-0.00	-0.00	-0.00	-0.00	0.01	0.03	0.06	0.10	0.15	0.22
	Other food and drink products	-0.00	-0.00	-0.00	-0.00	0.02	0.08	0.16	0.27	0.42	0.62
	Textiles, clothing and footwear	-0.00	-0.00	-0.00	-0.00	-0.00	0.01	0.04	0.07	0.13	0.20
	Wood products	-0.00	-0.00	-0.00	-0.00	0.00	0.02	0.04	0.08	0.13	0.19
	Paper products	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.02	0.03	0.05	0.07
	Printing and publishing	0.00	0.00	0.00	0.00	0.01	0.04	0.09	0.15	0.24	0.37
	Petroleum refinery	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.05	0.08	0.10
	Other chemicals	-0.00	-0.00	-0.00	-0.00	-0.00	0.01	0.04	0.08	0.13	0.20
	Rubber and plastic products	-0.00	-0.00	-0.00	0.00	0.00	0.01	0.03	0.05	0.08	0.12
	Non-metallic construction materials (not cement)	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.06	0.08
	Cement	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Iron and steel	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.02	0.04	0.07	0.12
	Alumina	-	-	-	-	-	-	-	-	-	-
	Aluminium	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.03	-0.04	-0.06
	Other non-ferrous metals	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.03	-0.04	-0.06
	Other metal products	-0.00	-0.00	-0.00	0.00	0.01	0.04	0.08	0.14	0.22	0.32
	Motor vehicle and parts	-0.00	-0.00	-0.00	-0.00	0.00	0.02	0.06	0.11	0.18	0.28
	Other manufacturing products	-0.01	-0.01	-0.01	-0.01	0.01	0.08	0.18	0.33	0.54	0.82
	Electricity - coal	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.00	-0.00	0.01	0.02
	Electricity - gas	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	Electricity - oil products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Electricity - nuclear	-	-	-	-	-	-	-	-	-	-
	Electricity - hydro	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01
	Electricity - non-hydro renewable	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	Electricity supply	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.01	0.02	0.03
	Gas supply	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.03
	Water supply	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.05
	Construction services	0.03	0.03	0.04	0.06	0.31	0.81	1.38	2.08	2.98	4.15
	Trade services	-0.03	-0.03	-0.02	-0.00	0.56	1.86	3.59	5.91	9.03	13.19
	Accommodation and hotels	-0.01	-0.00	0.02	0.06	0.80	2.49	4.67	7.55	11.33	16.27
	Road transport - passenger	0.01	0.01	0.01	0.02	0.07	0.19	0.33	0.51	0.73	1.01
	Road transport - freight	-0.00	-0.00	-0.00	-0.00	0.01	0.05	0.10	0.18	0.28	0.41
	Rail transport - passenger	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.02
	Rail transport - freight	-0.00	-0.00	-0.00	-0.00	-0.01	-0.02	-0.03	-0.04	-0.05	-0.07
	Other transport (includes water transport)	0.00	0.00	-0.00	-0.00	0.08	0.21	0.35	0.49	0.65	0.82
	Air transport	0.00	0.00	0.00	0.01	0.15	0.43	0.75	1.11	1.53	2.01
	Communication services	0.00	0.00	0.00	0.00	0.02	0.08	0.18	0.33	0.55	0.87
	Financial services	0.00	0.01	0.01	0.02	0.02	0.03	0.06	0.13	0.23	0.39
	Business services	0.14	0.18	0.23	0.31	0.41	0.53	0.63	0.72	0.76	0.76

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Dwelling ownership	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Public services	-0.01	-0.01	-0.01	-0.01	-0.03	-0.04	-0.04	-0.03	-0.02	0.02
	Other services	-0.01	-0.01	0.00	0.03	0.54	1.82	3.57	5.94	9.11	13.33
	Private transport services	-	-	-	-	-	-	-	-	-	-
	Private electrical equipment services	-	-	-	-	-	-	-	-	-	-
	Private heating equipment services	-	-	-	-	-	-	-	-	-	-

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
High	Sheep and cattle	0.14	0.29	0.58	1.04	3.58	12.83	28.22	50.30	79.77	117.02
	Dairy	0.00	0.04	0.10	0.20	0.79	3.07	6.67	11.72	18.72	29.41
	Other agriculture	0.15	0.29	0.49	0.78	2.79	8.39	16.28	26.70	40.31	59.05
	Agricultural services and fishing	-0.55	-0.60	-0.55	-0.36	1.85	12.75	32.01	60.13	97.52	142.80
	Forestry and logging	-0.02	-0.02	-0.01	0.03	0.37	1.93	4.69	8.78	14.40	21.94
	Coal mining	-0.73	-1.80	-3.29	-5.28	-12.26	-41.97	-77.74	-106.81	-120.15	-115.00
	Oil mining	-	-	-	-	-	-	-	-	-	-
	Gas mining	-	-	-	-	-	-	-	-	-	-
	Iron ore mining	-	-	-	-	-	-	-	-	-	-
	Meat products	-0.86	0.00	1.85	4.80	42.48	149.91	304.22	513.60	789.73	1,147.54
	Other food and drink products	-1.23	0.98	6.24	15.02	122.82	471.58	996.93	1,733.02	2,762.21	4,298.94
	Textiles, clothing and footwear	-1.59	-1.69	-1.55	-1.08	7.80	45.64	109.56	203.42	334.87	519.64
	Wood products	0.40	0.79	1.40	2.37	10.20	42.85	98.14	178.98	292.56	455.19
	Paper products	0.15	0.47	1.07	2.09	12.05	51.43	115.52	207.15	334.03	513.16
	Printing and publishing	2.77	4.89	8.21	13.21	48.30	169.55	363.37	645.29	1,050.53	1,665.05
	Petroleum refinery	3.12	4.56	6.47	9.11	48.16	171.10	346.61	574.89	863.75	1,234.32
	Other chemicals	-2.65	-2.42	-1.34	0.99	30.06	162.77	393.45	737.05	1,227.82	1,946.08
	Rubber and plastic products	0.20	0.66	1.55	2.99	18.44	69.93	149.78	263.59	422.42	649.87
	Non-metallic construction materials (not cement)	0.81	1.35	2.22	3.54	13.49	48.27	102.09	178.04	283.51	435.60
	Cement	0.82	1.22	1.87	2.80	11.45	35.50	68.53	112.83	173.05	259.81

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Iron and steel	-0.65	-0.48	0.04	1.17	9.65	64.36	166.91	324.14	550.55	873.79
	Alumina	-	-	-	-	-	-	-	-	-	-
	Aluminium	-0.61	-1.15	-1.90	-2.89	-9.57	-30.72	-55.56	-80.74	-105.12	-127.73
	Other non-ferrous metals	-2.44	-4.44	-7.26	-11.02	-26.17	-63.53	-107.60	-157.66	-215.29	-288.39
	Other metal products	0.87	1.77	3.46	6.12	36.22	128.46	267.98	466.85	748.55	1,168.08
	Motor vehicle and parts	-1.02	-0.97	-0.26	1.27	19.81	92.71	215.76	396.65	648.32	992.75
	Other manufacturing products	-3.33	-2.23	0.67	5.67	89.86	348.75	741.04	1,298.01	2,066.50	3,116.89
	Electricity - coal	-0.28	-0.43	-0.52	-0.45	0.08	5.42	23.58	62.91	136.57	273.68
	Electricity - gas	0.02	0.03	0.03	0.03	-0.05	-0.16	-0.17	-0.10	-0.06	-0.31
	Electricity - oil products	0.02	0.03	0.04	0.04	0.10	0.30	0.55	0.79	0.85	0.29
	Electricity - nuclear	-	-	-	-	-	-	-	-	-	-
	Electricity - hydro	-0.00	-0.00	-0.00	-0.00	-0.17	-0.83	-1.58	-2.26	-2.75	-2.99
	Electricity - non-hydro renewable	-0.00	0.00	0.00	0.00	-0.01	-0.06	-0.13	-0.18	-0.20	-0.19
	Electricity supply	0.39	1.05	2.24	4.15	13.52	45.49	106.75	206.46	357.85	587.92
	Gas supply	0.38	0.61	1.00	1.57	9.17	30.88	60.44	99.27	149.81	216.15
	Water supply	0.54	0.98	1.62	2.56	6.97	22.58	49.93	91.63	151.63	236.79
	Construction services	26.62	40.66	64.35	98.62	468.31	1,456.65	2,806.80	4,608.70	7,050.45	10,570.7
	Trade services	-	11.34	36.61	76.49	686.53	2,267.38	4,469.49	7,467.90	11,487.1	16,823.1
	Accommodation and hotels	-	11.40	36.52	75.72	679.42	2,225.06	4,362.03	7,253.04	11,106.5	16,197.0
	Road transport - passenger	0.57	0.93	1.50	2.30	10.85	31.36	57.64	89.39	121.70	146.88
	Road transport - freight	0.46	1.43	3.32	6.27	40.89	144.04	296.16	507.37	794.75	1,192.03
	Rail transport - passenger	0.04	0.08	0.09	0.10	-2.07	-5.69	-9.06	-12.65	-17.04	-23.23
	Rail transport - freight	0.02	0.04	0.03	0.02	-2.61	-7.60	-10.80	-11.08	-7.49	1.11
	Other transport (includes water transport)	6.95	7.75	8.64	9.58	128.09	385.78	690.69	1,047.23	1,462.26	1,945.19
	Air transport	10.41	15.02	22.91	33.24	340.19	1,026.90	1,843.03	2,800.82	3,917.52	5,216.91
	Communication services	3.41	6.09	10.65	17.97	69.55	247.50	566.67	1,078.80	1,872.77	3,154.37
	Financial services	13.18	23.60	37.85	57.74	119.24	330.18	709.39	1,306.67	2,204.10	3,578.26
	Business services	153.44	219.60	304.17	414.41	667.94	1,166.66	1,759.13	2,454.35	3,263.59	4,202.58

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Dwelling ownership	9.11	19.66	35.37	58.24	139.85	421.67	955.05	1,807.85	3,072.87	4,916.45
	Public services	6.83	10.93	17.20	26.06	90.78	272.09	537.25	912.75	1,455.33	2,326.69
	Other services	-	8.06	26.10	54.65	495.71	1,635.74	3,229.23	5,404.15	8,324.47	12,206.1
	Private transport services	2.71	4.62	7.86	12.77	38.17	141.75	310.79	550.41	878.55	1,336.01
	Private electrical equipment services	1.19	2.19	3.80	6.22	17.40	64.47	144.63	261.35	424.62	658.11
	Private heating equipment services	0.61	1.03	1.74	2.80	8.74	32.13	68.86	120.13	190.47	291.04

NSW employment outcomes

The table below provides an overview of the impact on employment by industry sector. Again, these figures should be used with some caution given the level of disaggregation.

Table 24: NSW employment impacts on industry sectors

Scenario	Industry ('000s)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Sheep and cattle	0.15	0.26	0.42	0.63	1.12	2.39	4.34	7.00	10.46	14.82
	Dairy	0.00	0.03	0.05	0.09	0.19	0.49	0.92	1.49	2.17	3.00
	Other agriculture	0.15	0.25	0.36	0.51	0.84	1.59	2.56	3.75	5.16	6.81
	Agricultural services and fishing	-0.51	-0.61	-0.73	-0.86	-1.03	-0.68	0.38	2.14	4.70	8.22
	Forestry and logging	-0.03	-0.03	-0.04	-0.05	-0.04	0.07	0.28	0.60	1.04	1.62
	Coal mining	-0.72	-1.66	-2.76	-4.13	-6.32	-12.11	-19.69	-27.72	-35.27	-41.44
	Oil mining	-	-	-	-	-	-	-	-	-	-
	Gas mining	-	-	-	-	-	-	-	-	-	-
	Iron ore mining	-	-	-	-	-	-	-	-	-	-
	Meat products	-0.78	-0.56	-0.27	0.15	4.55	16.90	34.08	56.63	85.54	122.19
	Other food and drink products	-1.46	-1.08	-0.47	0.48	14.03	56.28	116.38	195.18	295.76	422.99
	Textiles, clothing and footwear	-1.52	-1.81	-2.21	-2.74	-3.05	-1.45	2.10	7.66	15.58	26.45
	Wood products	0.25	0.49	0.72	1.01	2.34	6.84	13.82	23.27	35.51	51.20
	Paper products	-0.01	0.15	0.31	0.52	2.02	7.27	15.29	26.04	39.96	57.74
	Printing and publishing	2.60	4.12	5.91	8.20	14.23	30.77	55.01	87.38	129.29	183.02
	Petroleum refinery	1.82	2.66	3.59	4.76	13.48	38.77	73.85	118.49	173.74	241.42
	Other chemicals	-2.88	-3.18	-3.70	-4.43	-2.95	8.20	28.31	57.61	97.74	151.55
	Rubber and plastic products	0.11	0.31	0.55	0.86	3.00	9.42	18.68	31.05	47.15	67.95
	Non-metallic construction materials (not cement)	0.75	1.10	1.51	2.05	3.71	8.48	15.23	24.01	35.18	49.36
	Cement	0.75	1.01	1.33	1.77	3.27	6.86	11.40	16.98	23.87	32.40
	Iron and steel	-0.76	-0.78	-0.90	-1.07	-0.85	3.70	12.64	26.01	44.58	69.80
	Alumina	-	-	-	-	-	-	-	-	-	-
	Aluminium	-0.66	-1.08	-1.49	-1.96	-2.99	-5.53	-8.33	-11.05	-13.62	-16.05

Scenario	Industry ('000s)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Other non-ferrous metals	-2.88	-4.62	-6.56	-8.90	-11.91	-16.55	-21.38	-26.52	-31.99	-37.71
	Other metal products	0.70	1.10	1.61	2.30	6.36	17.69	33.55	54.52	81.75	116.94
	Motor vehicle and parts	-0.92	-1.22	-1.54	-1.91	-1.40	3.10	11.43	24.11	42.19	67.26
	Other manufacturing products	-3.62	-3.93	-4.42	-5.08	2.16	26.62	62.28	110.97	176.07	262.53
	Electricity - coal	-0.22	-0.37	-0.54	-0.74	-1.05	-1.31	-0.65	1.45	5.52	12.21
	Electricity - gas	0.01	0.01	0.02	0.03	0.04	0.11	0.27	0.52	0.86	1.30
	Electricity - oil products	0.01	0.02	0.03	0.03	0.05	0.09	0.17	0.27	0.38	0.52
	Electricity - nuclear	-	-	-	-	-	-	-	-	-	-
	Electricity - hydro	-0.00	0.01	0.01	0.03	0.01	-0.07	-0.17	-0.26	-0.34	-0.40
	Electricity - non-hydro renewable	0.00	0.00	0.00	0.00	0.00	-0.00	-0.01	-0.02	-0.02	-0.02
	Electricity supply	0.60	1.08	1.71	2.53	3.83	6.72	12.10	20.56	32.75	49.60
	Gas supply	0.27	0.39	0.54	0.75	2.13	5.78	10.49	16.36	23.60	32.51
	Water supply	0.53	0.89	1.33	1.87	2.88	5.30	9.05	14.32	21.36	30.54
	Construction services	24.50	32.16	42.05	55.52	114.04	252.88	426.79	640.17	902.47	1,227.03
	Trade services	-	1.29	4.05	8.22	65.68	217.94	422.00	691.65	1,044.64	1,504.50
	Accommodation and hotels	-	2.15	6.52	12.87	108.72	341.55	643.03	1,028.09	1,515.78	2,131.35
	Road transport - passenger	0.50	0.73	1.04	1.43	2.93	6.19	10.25	15.26	21.42	28.98
	Road transport - freight	0.33	0.72	1.22	1.90	6.33	18.83	36.21	58.96	88.17	125.42
	Rail transport - passenger	0.05	0.12	0.18	0.25	0.06	-0.28	-0.53	-0.77	-1.04	-1.38
	Rail transport - freight	0.02	0.09	0.15	0.22	-0.03	-0.54	-0.83	-0.83	-0.49	0.29
	Other transport (includes water transport)	1.75	1.95	2.17	2.41	32.03	96.45	172.68	261.81	365.56	486.30
	Air transport	2.60	3.33	4.52	6.02	64.74	197.10	353.12	534.92	745.70	989.92
	Communication services	3.12	4.90	7.09	9.95	18.16	41.28	79.35	135.69	214.25	320.25
	Financial services	13.00	22.46	33.84	48.19	69.15	110.48	172.12	257.23	370.26	517.35
	Business services	153.44	216.62	295.47	397.94	536.55	770.83	1,046.21	1,366.55	1,736.78	2,163.90
	Dwelling ownership	8.81	17.89	29.34	43.86	67.33	117.26	198.30	315.77	475.45	684.94
	Public services	6.54	9.53	13.36	18.39	30.80	59.00	95.96	142.54	200.42	272.14
	Other services	-	0.63	2.05	4.28	38.80	128.03	252.74	422.96	651.50	955.27

Scenario	Industry ('000s)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Private transport services	2.61	3.97	5.69	7.94	12.73	26.60	47.30	74.59	109.25	152.70
	Private electrical equipment services	1.13	1.90	2.84	4.03	6.39	13.12	23.50	37.48	55.41	78.02
	Private heating equipment services	0.58	0.87	1.25	1.75	2.89	6.17	10.90	17.02	24.67	34.19
Medium	Sheep and cattle	0.14	0.27	0.48	0.78	1.98	6.05	12.72	22.24	34.98	51.51
	Dairy	0.00	0.03	0.07	0.13	0.40	1.38	2.91	4.95	7.57	10.89
	Other agriculture	0.15	0.26	0.41	0.61	1.54	4.01	7.40	11.72	17.07	23.60
	Agricultural services and fishing	-0.53	-0.61	-0.67	-0.70	-0.13	3.69	10.87	21.68	36.67	56.62
	Forestry and logging	-0.02	-0.03	-0.03	-0.02	0.10	0.72	1.82	3.46	5.70	8.70
	Coal mining	-0.73	-1.71	-2.95	-4.54	-8.35	-22.77	-40.82	-57.08	-66.89	-65.20
	Oil mining	-	-	-	-	-	-	-	-	-	-
	Gas mining	-	-	-	-	-	-	-	-	-	-
	Iron ore mining	-	-	-	-	-	-	-	-	-	-
	Meat products	-0.82	-0.38	0.47	1.78	17.70	63.08	127.96	215.50	330.56	479.83
	Other food and drink products	-1.35	-0.32	1.94	5.65	52.67	203.11	425.67	729.28	1,132.47	1,663.84
	Textiles, clothing and footwear	-1.56	-1.78	-1.99	-2.17	0.53	14.30	38.25	73.63	122.97	190.02
	Wood products	0.33	0.63	0.99	1.53	5.41	20.53	45.31	80.46	128.16	192.02
	Paper products	0.07	0.29	0.61	1.11	5.85	23.84	52.42	92.37	146.05	217.26
	Printing and publishing	2.68	4.43	6.76	10.01	26.56	80.53	164.46	282.47	443.03	659.55
	Petroleum refinery	2.47	3.58	4.90	6.63	28.98	97.28	193.72	318.19	474.17	667.47
	Other chemicals	-2.77	-2.87	-2.83	-2.48	8.92	63.27	157.61	296.46	490.34	755.90
	Rubber and plastic products	0.16	0.45	0.92	1.63	8.59	31.23	65.62	113.62	178.68	265.97
	Non-metallic construction materials (not cement)	0.78	1.20	1.77	2.58	7.27	22.87	46.36	78.56	121.59	178.77
	Cement	0.78	1.09	1.53	2.14	6.30	17.43	32.26	51.51	76.40	108.76
	Iron and steel	-0.70	-0.65	-0.54	-0.25	2.96	25.42	67.41	131.00	221.44	347.13
	Alumina	-	-	-	-	-	-	-	-	-	-
	Aluminium	-0.64	-1.09	-1.62	-2.28	-5.21	-14.09	-24.41	-34.84	-44.86	-54.15
	Other non-ferrous metals	-2.66	-4.47	-6.70	-9.54	-16.10	-30.06	-45.97	-63.79	-83.00	-102.87

Scenario	Industry ('000s)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Other metal products	0.78	1.36	2.29	3.68	17.23	57.69	117.40	200.12	312.30	463.54
	Motor vehicle and parts	-0.97	-1.15	-1.12	-0.82	5.79	33.64	81.50	152.74	252.97	390.33
	Other manufacturing products	-3.47	-3.29	-2.58	-1.26	33.51	141.20	302.61	529.65	841.21	1,263.88
	Electricity - coal	-0.25	-0.40	-0.55	-0.66	-0.80	0.39	6.13	19.07	42.37	80.39
	Electricity - gas	0.01	0.02	0.03	0.03	0.03	0.11	0.33	0.72	1.24	1.86
	Electricity - oil products	0.02	0.02	0.03	0.04	0.07	0.20	0.39	0.61	0.86	1.09
	Electricity - nuclear	-	-	-	-	-	-	-	-	-	-
	Electricity - hydro	-0.00	0.00	0.01	0.02	-0.06	-0.36	-0.72	-1.05	-1.31	-1.45
	Electricity - non-hydro renewable	0.00	0.00	0.00	0.00	-0.00	-0.03	-0.06	-0.08	-0.10	-0.09
	Electricity supply	0.49	1.03	1.85	3.05	6.75	18.36	41.07	78.07	133.36	212.70
	Gas supply	0.32	0.48	0.73	1.07	4.89	15.60	29.95	48.47	72.06	102.05
	Water supply	0.54	0.93	1.43	2.12	4.36	11.48	23.56	41.57	66.84	101.24
	Construction services	25.57	35.48	50.22	71.03	244.09	692.18	1,287.57	2,056.85	3,048.50	4,334.50
	Trade services	-	4.81	15.49	32.21	283.85	938.13	1,844.33	3,072.91	4,714.29	6,887.70
	Accommodation and hotels	-	5.39	17.06	34.96	309.27	1,003.45	1,949.96	3,215.65	4,886.12	7,074.26
	Road transport - passenger	0.53	0.82	1.22	1.76	5.92	15.69	28.26	44.16	63.99	88.18
	Road transport - freight	0.39	0.99	1.98	3.46	18.75	63.65	128.79	217.62	336.01	492.44
	Rail transport - passenger	0.05	0.10	0.15	0.20	-0.73	-2.28	-3.69	-5.18	-6.89	-8.93
	Rail transport - freight	0.02	0.07	0.11	0.15	-0.97	-3.14	-4.57	-4.88	-3.62	-0.20
	Other transport (includes water transport)	4.34	4.84	5.40	5.99	80.05	241.11	431.68	654.53	913.92	1,215.74
	Air transport	6.51	8.75	12.44	17.20	182.95	553.19	992.15	1,506.24	2,104.74	2,800.49
	Communication services	3.27	5.39	8.43	12.89	36.98	115.80	252.95	465.26	774.56	1,211.91
	Financial services	13.08	22.89	35.30	51.63	87.43	189.27	361.72	621.00	990.40	1,503.39
	Business services	153.44	217.66	298.52	403.73	582.74	909.95	1,296.77	1,748.84	2,273.33	2,880.32
	Dwelling ownership	8.96	18.61	31.62	49.15	94.00	227.97	470.97	847.81	1,387.63	2,130.11
	Public services	6.69	10.09	14.80	21.19	52.56	135.38	251.31	406.42	611.18	882.34
	Other services	-	3.24	10.49	21.97	199.37	657.87	1,298.72	2,173.43	3,347.90	4,908.97
	Private transport services	2.66	4.22	6.49	9.69	22.00	68.13	141.57	243.19	377.69	553.15

Scenario	Industry ('000s)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Private electrical equipment services	1.16	2.02	3.19	4.82	10.42	31.74	67.02	116.98	184.00	272.21
	Private heating equipment services	0.59	0.93	1.43	2.13	5.04	15.63	31.81	53.72	82.39	119.61
Scenario	Industry ('000s)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
High	Sheep and cattle	0.14	0.29	0.58	1.04	3.58	12.83	28.22	50.30	79.77	117.02
	Dairy	0.00	0.04	0.10	0.20	0.79	3.07	6.67	11.72	18.72	29.41
	Other agriculture	0.15	0.29	0.49	0.78	2.79	8.39	16.28	26.70	40.31	59.05
	Agricultural services and fishing	-0.55	-0.60	-0.55	-0.36	1.85	12.75	32.01	60.13	97.52	142.80
	Forestry and logging	-0.02	-0.02	-0.01	0.03	0.37	1.93	4.69	8.78	14.40	21.94
	Coal mining	-0.73	-1.80	-3.29	-5.28	-12.26	-41.97	-77.74	-106.81	-120.15	-115.00
	Oil mining	-	-	-	-	-	-	-	-	-	-
	Gas mining	-	-	-	-	-	-	-	-	-	-
	Iron ore mining	-	-	-	-	-	-	-	-	-	-
	Meat products	-0.86	0.00	1.85	4.80	42.48	149.91	304.22	513.60	789.73	1,147.54
	Other food and drink products	-1.23	0.98	6.24	15.02	122.82	471.58	996.93	1,733.02	2,762.21	4,298.94
	Textiles, clothing and footwear	-1.59	-1.69	-1.55	-1.08	7.80	45.64	109.56	203.42	334.87	519.64
	Wood products	0.40	0.79	1.40	2.37	10.20	42.85	98.14	178.98	292.56	455.19
	Paper products	0.15	0.47	1.07	2.09	12.05	51.43	115.52	207.15	334.03	513.16
	Printing and publishing	2.77	4.89	8.21	13.21	48.30	169.55	363.37	645.29	1,050.53	1,665.05
	Petroleum refinery	3.12	4.56	6.47	9.11	48.16	171.10	346.61	574.89	863.75	1,234.32
	Other chemicals	-2.65	-2.42	-1.34	0.99	30.06	162.77	393.45	737.05	1,227.82	1,946.08
	Rubber and plastic products	0.20	0.66	1.55	2.99	18.44	69.93	149.78	263.59	422.42	649.87
	Non-metallic construction materials (not cement)	0.81	1.35	2.22	3.54	13.49	48.27	102.09	178.04	283.51	435.60
	Cement	0.82	1.22	1.87	2.80	11.45	35.50	68.53	112.83	173.05	259.81
	Iron and steel	-0.65	-0.48	0.04	1.17	9.65	64.36	166.91	324.14	550.55	873.79
	Alumina	-	-	-	-	-	-	-	-	-	-
	Aluminium	-0.61	-1.15	-1.90	-2.89	-9.57	-30.72	-55.56	-80.74	-105.12	-127.73
	Other non-ferrous metals	-2.44	-4.44	-7.26	-11.02	-26.17	-63.53	-107.60	-157.66	-215.29	-288.39

Scenario	Industry ('000s)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Other metal products	0.87	1.77	3.46	6.12	36.22	128.46	267.98	466.85	748.55	1,168.08
	Motor vehicle and parts	-1.02	-0.97	-0.26	1.27	19.81	92.71	215.76	396.65	648.32	992.75
	Other manufacturing products	-3.33	-2.23	0.67	5.67	89.86	348.75	741.04	1,298.01	2,066.50	3,116.89
	Electricity - coal	-0.28	-0.43	-0.52	-0.45	0.08	5.42	23.58	62.91	136.57	273.68
	Electricity - gas	0.02	0.03	0.03	0.03	-0.05	-0.16	-0.17	-0.10	-0.06	-0.31
	Electricity - oil products	0.02	0.03	0.04	0.04	0.10	0.30	0.55	0.79	0.85	0.29
	Electricity - nuclear	-	-	-	-	-	-	-	-	-	-
	Electricity - hydro	-0.00	-0.00	-0.00	-0.00	-0.17	-0.83	-1.58	-2.26	-2.75	-2.99
	Electricity - non-hydro renewable	-0.00	0.00	0.00	0.00	-0.01	-0.06	-0.13	-0.18	-0.20	-0.19
	Electricity supply	0.39	1.05	2.24	4.15	13.52	45.49	106.75	206.46	357.85	587.92
	Gas supply	0.38	0.61	1.00	1.57	9.17	30.88	60.44	99.27	149.81	216.15
	Water supply	0.54	0.98	1.62	2.56	6.97	22.58	49.93	91.63	151.63	236.79
	Construction services	26.62	40.66	64.35	98.62	468.31	1,456.65	2,806.80	4,608.70	7,050.45	10,570.7
	Trade services	-	11.34	36.61	76.49	686.53	2,267.38	4,469.49	7,467.90	11,487.1	16,823.1
	Accommodation and hotels	-	11.40	36.52	75.72	679.42	2,225.06	4,362.03	7,253.04	11,106.5	16,197.0
	Road transport - passenger	0.57	0.93	1.50	2.30	10.85	31.36	57.64	89.39	121.70	146.88
	Road transport - freight	0.46	1.43	3.32	6.27	40.89	144.04	296.16	507.37	794.75	1,192.03
	Rail transport - passenger	0.04	0.08	0.09	0.10	-2.07	-5.69	-9.06	-12.65	-17.04	-23.23
	Rail transport - freight	0.02	0.04	0.03	0.02	-2.61	-7.60	-10.80	-11.08	-7.49	1.11
	Other transport (includes water transport)	6.95	7.75	8.64	9.58	128.09	385.78	690.69	1,047.23	1,462.26	1,945.19
	Air transport	10.41	15.02	22.91	33.24	340.19	1,026.90	1,843.03	2,800.82	3,917.52	5,216.91
	Communication services	3.41	6.09	10.65	17.97	69.55	247.50	566.67	1,078.80	1,872.77	3,154.37
	Financial services	13.18	23.60	37.85	57.74	119.24	330.18	709.39	1,306.67	2,204.10	3,578.26
	Business services	153.44	219.60	304.17	414.41	667.94	1,166.66	1,759.13	2,454.35	3,263.59	4,202.58
	Dwelling ownership	9.11	19.66	35.37	58.24	139.85	421.67	955.05	1,807.85	3,072.87	4,916.45
	Public services	6.83	10.93	17.20	26.06	90.78	272.09	537.25	912.75	1,455.33	2,326.69
	Other services	-	8.06	26.10	54.65	495.71	1,635.74	3,229.23	5,404.15	8,324.47	12,206.1
	Private transport services	2.71	4.62	7.86	12.77	38.17	141.75	310.79	550.41	878.55	1,336.01

Scenario	Industry ('000s)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Private electrical equipment services	1.19	2.19	3.80	6.22	17.40	64.47	144.63	261.35	424.62	658.11
	Private heating equipment services	0.61	1.03	1.74	2.80	8.74	32.13	68.86	120.13	190.47	291.04

ROA industry outcomes

The MMRF model also produces the impact on GDP split into 56 aggregated industry levels. The results are shown in the table below. The industry GDP (excluding NSW) table shows the industry level impact within the economy as a result of the status quo aviation capacity. Table 25 shows the impact aviation capacity is estimated to have at an industry level. Again, caution should be applied to these figures given the level of disaggregation.

Table 25: ROA estimated economic impact at industry level

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Sheep and cattle	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	-0.03	-0.03	-0.03	-0.02
	Dairy	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.00
	Other animals	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.01	0.02	0.03
	Grains	-0.01	-0.01	-0.01	-0.01	-0.02	-0.03	-0.04	-0.04	-0.05	-0.05
	Other agriculture	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.01
	Agricultural services and fishing	-0.01	-0.01	-0.01	-0.01	-0.02	-0.03	-0.04	-0.05	-0.06	-0.08
	Forestry and logging	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.02	-0.02
	Coal mining	-0.00	-0.00	-0.01	-0.01	-0.02	-0.04	-0.07	-0.10	-0.14	-0.20
	Oil mining	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.02
	Gas mining	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.03	-0.04
	Iron ore mining	-0.00	-0.00	-0.00	-0.00	-0.01	-0.02	-0.04	-0.06	-0.09	-0.12
	Non-ferrous metal ores	-0.01	-0.01	-0.01	-0.01	-0.03	-0.05	-0.09	-0.13	-0.19	-0.26
	Other mining	-0.00	-0.00	-0.01	-0.01	-0.02	-0.04	-0.06	-0.09	-0.13	-0.18
	Meat products	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.00	-0.00	0.00
	Other food and drink products	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.01
	Textiles, clothing and footwear	-0.01	-0.01	-0.01	-0.01	-0.02	-0.04	-0.05	-0.07	-0.09	-0.12
	Wood products	-0.00	-0.00	-0.00	-0.00	-0.01	-0.02	-0.03	-0.04	-0.06	-0.07
	Paper products	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.02
	Printing and publishing	-0.00	-0.00	-0.00	-0.00	-0.01	-0.02	-0.03	-0.04	-0.05	-0.07
	Petroleum refinery	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.04
	Other chemicals	-0.00	-0.00	-0.01	-0.01	-0.01	-0.02	-0.03	-0.05	-0.06	-0.07

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Rubber and plastic products	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.02	-0.03
	Non-metallic construction materials (not cement)	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.02	-0.03
	Cement	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.02
	Iron and steel	-0.00	-0.00	-0.00	-0.00	-0.01	-0.02	-0.04	-0.06	-0.08	-0.11
	Alumina	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.03	-0.04	-0.05
	Aluminium	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.03	-0.05	-0.06
	Other non-ferrous metals	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.04	-0.05	-0.07	-0.10
	Other metal products	-0.00	-0.00	-0.00	-0.00	-0.01	-0.02	-0.03	-0.05	-0.07	-0.10
	Motor vehicle and parts	-0.01	-0.01	-0.01	-0.01	-0.02	-0.05	-0.08	-0.11	-0.16	-0.21
	Other manufacturing products	-0.01	-0.01	-0.01	-0.02	-0.04	-0.07	-0.11	-0.16	-0.22	-0.29
	Electricity - coal	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.03	-0.03
	Electricity - gas	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01
	Electricity - oil products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Electricity - nuclear	-	-	-	-	-	-	-	-	-	-
	Electricity - hydro	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01
	Electricity - non-hydro renewable	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	Electricity supply	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.03	-0.04	-0.05
	Gas supply	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01
	Water supply	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01
	Construction services	0.03	0.03	0.03	0.03	0.04	0.02	-0.04	-0.14	-0.28	-0.47
	Trade services	-0.03	-0.04	-0.04	-0.05	-0.08	-0.13	-0.17	-0.21	-0.24	-0.26
	Accommodation and hotels	0.09	0.12	0.17	0.23	0.58	1.30	2.19	3.30	4.70	6.46
	Road transport - passenger	0.03	0.04	0.05	0.06	0.10	0.17	0.26	0.36	0.49	0.65
	Road transport - freight	-0.00	-0.00	-0.00	-0.01	-0.01	-0.03	-0.05	-0.08	-0.11	-0.15
	Rail transport - passenger	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01
	Rail transport - freight	-0.00	-0.00	-0.00	-0.01	-0.01	-0.03	-0.05	-0.08	-0.11	-0.16
	Other transport (includes water transport)	-0.00	-0.00	-0.00	-0.01	0.01	0.04	0.07	0.09	0.11	0.13
	Air transport	0.05	0.07	0.09	0.12	0.21	0.39	0.59	0.85	1.15	1.52

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Communication services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Financial services	0.00	0.00	0.01	0.01	0.00	-0.02	-0.04	-0.07	-0.11	-0.16
	Business services	-0.01	-0.02	-0.03	-0.03	-0.05	-0.09	-0.14	-0.19	-0.26	-0.33
	Dwelling ownership	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00
	Public services	-0.04	-0.06	-0.08	-0.11	-0.21	-0.42	-0.67	-0.99	-1.39	-1.90
	Other services	0.02	0.02	0.03	0.04	0.12	0.31	0.58	0.95	1.46	2.16
	Private transport services	-	-	-	-	-	-	-	-	-	-
	Private electrical equipment services	-	-	-	-	-	-	-	-	-	-
	Private heating equipment services	-	-	-	-	-	-	-	-	-	-
Medium	Sheep and cattle	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.00	0.01	0.03	0.07
	Dairy	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.01	0.01	0.02
	Other animals	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.03	0.06	0.09	0.15
	Grains	-0.00	-0.00	-0.00	-0.00	-0.01	-0.02	-0.02	-0.01	-0.00	0.02
	Other agriculture	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.02	0.03	0.06
	Agricultural services and fishing	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.01	0.03	0.05	0.08
	Forestry and logging	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.01	0.02	0.03
	Coal mining	-0.00	-0.00	-0.00	-0.01	-0.02	-0.04	-0.07	-0.10	-0.15	-0.20
	Oil mining	-	-	-	-	-	-	-	-	-	-
	Gas mining	-	-	-	-	-	-	-	-	-	-
	Iron ore mining	-	-	-	-	-	-	-	-	-	-
	Non-ferrous metal ores	-0.00	-0.00	-0.00	-0.00	-0.01	-0.02	-0.03	-0.04	-0.05	-0.07
	Other mining	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.02	-0.03
	Meat products	-0.00	-0.00	-0.00	-0.00	0.01	0.03	0.06	0.10	0.15	0.22
	Other food and drink products	-0.00	-0.00	-0.00	-0.00	0.02	0.08	0.16	0.27	0.42	0.62
	Textiles, clothing and footwear	-0.00	-0.00	-0.00	-0.00	-0.00	0.01	0.04	0.07	0.13	0.20
	Wood products	-0.00	-0.00	-0.00	-0.00	0.00	0.02	0.04	0.08	0.13	0.19
	Paper products	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.02	0.03	0.05	0.07

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Printing and publishing	0.00	0.00	0.00	0.00	0.01	0.04	0.09	0.15	0.24	0.37
	Petroleum refinery	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.05	0.08	0.10
	Other chemicals	-0.00	-0.00	-0.00	-0.00	-0.00	0.01	0.04	0.08	0.13	0.20
	Rubber and plastic products	-0.00	-0.00	-0.00	0.00	0.00	0.01	0.03	0.05	0.08	0.12
	Non-metallic construction materials (not cement)	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.06	0.08
	Cement	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03
	Iron and steel	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.02	0.04	0.07	0.12
	Alumina	-	-	-	-	-	-	-	-	-	-
	Aluminium	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.03	-0.04	-0.06
	Other non-ferrous metals	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.03	-0.04	-0.06
	Other metal products	-0.00	-0.00	-0.00	0.00	0.01	0.04	0.08	0.14	0.22	0.32
	Motor vehicle and parts	-0.00	-0.00	-0.00	-0.00	0.00	0.02	0.06	0.11	0.18	0.28
	Other manufacturing products	-0.01	-0.01	-0.01	-0.01	0.01	0.08	0.18	0.33	0.54	0.82
	Electricity - coal	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.00	-0.00	0.01	0.02
	Electricity - gas	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	Electricity - oil products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Electricity - nuclear	-	-	-	-	-	-	-	-	-	-
	Electricity - hydro	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01
	Electricity - non-hydro renewable	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	Electricity supply	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.01	0.02	0.03
	Gas supply	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.03
	Water supply	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.05
	Construction services	0.03	0.03	0.04	0.06	0.31	0.81	1.38	2.08	2.98	4.15
	Trade services	-0.03	-0.03	-0.02	-0.00	0.56	1.86	3.59	5.91	9.03	13.19
	Accommodation and hotels	-0.01	-0.00	0.02	0.06	0.80	2.49	4.67	7.55	11.33	16.27
	Road transport - passenger	0.01	0.01	0.01	0.02	0.07	0.19	0.33	0.51	0.73	1.01
	Road transport - freight	-0.00	-0.00	-0.00	-0.00	0.01	0.05	0.10	0.18	0.28	0.41
	Rail transport - passenger	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.02

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Rail transport - freight	-0.00	-0.00	-0.00	-0.00	-0.01	-0.02	-0.03	-0.04	-0.05	-0.07
	Other transport (includes water transport)	0.00	0.00	-0.00	-0.00	0.08	0.21	0.35	0.49	0.65	0.82
	Air transport	0.00	0.00	0.00	0.01	0.15	0.43	0.75	1.11	1.53	2.01
	Communication services	0.00	0.00	0.00	0.00	0.02	0.08	0.18	0.33	0.55	0.87
	Financial services	0.00	0.01	0.01	0.02	0.02	0.03	0.06	0.13	0.23	0.39
	Business services	0.14	0.18	0.23	0.31	0.41	0.53	0.63	0.72	0.76	0.76
	Dwelling ownership	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Public services	-0.01	-0.01	-0.01	-0.01	-0.03	-0.04	-0.04	-0.03	-0.02	0.02
	Other services	-0.01	-0.01	0.00	0.03	0.54	1.82	3.57	5.94	9.11	13.33
	Private transport services	-	-	-	-	-	-	-	-	-	-
	Private electrical equipment services	-	-	-	-	-	-	-	-	-	-
	Private heating equipment services	-	-	-	-	-	-	-	-	-	-
High	Sheep and cattle	-0.01	-0.01	-0.01	-0.01	-0.06	-0.13	-0.18	-0.21	-0.21	-0.21
	Dairy	-0.00	-0.00	-0.00	-0.00	-0.03	-0.06	-0.08	-0.09	-0.08	-0.05
	Other animals	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	0.02	0.07	0.15	0.29
	Grains	-0.01	-0.01	-0.01	-0.01	-0.07	-0.15	-0.22	-0.27	-0.31	-0.34
	Other agriculture	-0.00	-0.00	-0.00	-0.01	-0.04	-0.08	-0.10	-0.10	-0.08	-0.02
	Agricultural services and fishing	-0.01	-0.01	-0.01	-0.01	-0.07	-0.14	-0.21	-0.29	-0.40	-0.57
	Forestry and logging	-0.00	-0.00	-0.00	-0.00	-0.01	-0.03	-0.05	-0.07	-0.11	-0.16
	Coal mining	-0.00	-0.01	-0.01	-0.02	-0.07	-0.22	-0.43	-0.71	-1.09	-1.66
	Oil mining	-0.00	-0.00	-0.00	-0.00	-0.01	-0.03	-0.06	-0.10	-0.16	-0.26
	Gas mining	-0.00	-0.00	-0.00	-0.00	-0.02	-0.05	-0.10	-0.16	-0.25	-0.39
	Iron ore mining	-0.00	-0.00	-0.00	-0.01	-0.04	-0.13	-0.27	-0.46	-0.75	-1.17
	Non-ferrous metal ores	-0.01	-0.01	-0.01	-0.02	-0.11	-0.33	-0.62	-1.01	-1.57	-2.38
	Other mining	-0.00	-0.01	-0.01	-0.01	-0.07	-0.22	-0.43	-0.71	-1.11	-1.71
	Meat products	-0.00	-0.00	-0.00	-0.00	-0.02	-0.03	-0.03	-0.02	-0.00	0.02
	Other food and drink products	-0.00	-0.00	-0.01	-0.01	-0.04	-0.06	-0.06	-0.03	0.05	0.26

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Textiles, clothing and footwear	-0.01	-0.01	-0.01	-0.01	-0.07	-0.17	-0.28	-0.41	-0.59	-0.86
	Wood products	-0.00	-0.00	-0.00	-0.01	-0.05	-0.12	-0.20	-0.31	-0.46	-0.68
	Paper products	-0.00	-0.00	-0.00	-0.00	-0.01	-0.03	-0.05	-0.07	-0.10	-0.15
	Printing and publishing	-0.00	-0.00	-0.00	-0.00	-0.04	-0.10	-0.18	-0.27	-0.40	-0.58
	Petroleum refinery	0.00	0.00	0.00	0.00	0.01	0.03	0.06	0.09	0.14	0.20
	Other chemicals	-0.00	-0.00	-0.01	-0.01	-0.05	-0.11	-0.17	-0.24	-0.34	-0.48
	Rubber and plastic products	-0.00	-0.00	-0.00	-0.00	-0.02	-0.05	-0.09	-0.14	-0.20	-0.29
	Non-metallic construction materials (not cement)	-0.00	-0.00	-0.00	-0.00	-0.02	-0.05	-0.09	-0.14	-0.21	-0.31
	Cement	-0.00	-0.00	-0.00	-0.00	-0.01	-0.03	-0.05	-0.09	-0.13	-0.20
	Iron and steel	-0.00	-0.00	-0.01	-0.01	-0.05	-0.14	-0.26	-0.41	-0.63	-0.95
	Alumina	-0.00	-0.00	-0.00	-0.00	-0.02	-0.07	-0.13	-0.22	-0.34	-0.51
	Aluminium	-0.00	-0.00	-0.00	-0.01	-0.03	-0.09	-0.16	-0.26	-0.39	-0.58
	Other non-ferrous metals	-0.00	-0.00	-0.01	-0.01	-0.05	-0.13	-0.24	-0.39	-0.60	-0.90
	Other metal products	-0.00	-0.00	-0.00	-0.01	-0.05	-0.14	-0.25	-0.40	-0.59	-0.87
	Motor vehicle and parts	-0.01	-0.01	-0.01	-0.02	-0.11	-0.31	-0.54	-0.84	-1.25	-1.85
	Other manufacturing products	-0.01	-0.01	-0.02	-0.03	-0.17	-0.43	-0.73	-1.11	-1.65	-2.49
	Electricity - coal	-0.00	-0.00	-0.00	-0.00	-0.02	-0.05	-0.08	-0.11	-0.15	-0.20
	Electricity - gas	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.02	-0.03	-0.05	-0.08
	Electricity - oil products	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	Electricity - nuclear	-	-	-	-	-	-	-	-	-	-
	Electricity - hydro	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.04	-0.05
	Electricity - non-hydro renewable	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01
	Electricity supply	-0.00	-0.00	-0.00	-0.00	-0.02	-0.07	-0.12	-0.18	-0.26	-0.36
	Gas supply	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.02	-0.04	-0.06	-0.10
	Water supply	-0.00	-0.00	-0.00	-0.00	-0.01	-0.02	-0.03	-0.04	-0.06	-0.09
	Construction services	0.04	0.03	0.03	0.02	-0.03	-0.44	-1.19	-2.30	-3.82	-5.72
	Trade services	-0.03	-0.04	-0.04	-0.04	0.07	0.26	0.51	0.84	1.15	1.17
	Accommodation and hotels	0.09	0.15	0.27	0.43	2.47	7.19	13.48	22.09	34.39	53.06

Scenario	Industry Output ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Road transport - passenger	0.03	0.04	0.06	0.08	0.28	0.71	1.28	2.04	3.06	4.57
	Road transport - freight	-0.00	-0.01	-0.01	-0.01	-0.08	-0.22	-0.40	-0.64	-0.96	-1.43
	Rail transport - passenger	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.02	-0.04	-0.05	-0.08
	Rail transport - freight	-0.00	-0.00	-0.01	-0.01	-0.06	-0.18	-0.36	-0.61	-0.96	-1.47
	Other transport (includes water transport)	0.00	0.00	-0.00	-0.01	0.03	0.04	-0.00	-0.11	-0.32	-0.69
	Air transport	0.05	0.08	0.11	0.16	0.63	1.66	2.96	4.63	6.87	10.06
	Communication services	0.00	0.00	0.00	0.00	0.02	0.03	0.05	0.08	0.16	0.34
	Financial services	0.00	0.00	0.00	0.00	-0.09	-0.29	-0.54	-0.87	-1.33	-1.92
	Business services	-0.01	-0.02	-0.03	-0.04	-0.09	-0.21	-0.37	-0.62	-1.07	-2.06
	Dwelling ownership	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	Public services	-0.04	-0.07	-0.11	-0.17	-0.79	-2.21	-4.08	-6.57	-9.91	-14.37
	Other services	0.01	0.04	0.09	0.17	1.39	4.41	8.56	14.24	22.01	32.65
	Private transport services	-	-	-	-	-	-	-	-	-	-
	Private electrical equipment services	-	-	-	-	-	-	-	-	-	-
	Private heating equipment services	-	-	-	-	-	-	-	-	-	-

Source: CoPS and MMRF

ROA employment outcomes

The cumulative impact of providing aviation capacity on employment is positive over the course of the evaluation period based on the general equilibrium model outcomes for the ROA, as shown in the table below.

Table 26: Australian employment impacts on industry sectors

Scenario	Employment ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Low	Sheep and cattle	0.76	1.30	1.96	2.82	4.05	7.07	11.92	18.77	27.88	39.67
	Dairy	-0.35	-0.76	-1.19	-1.71	-2.44	-4.22	-6.98	-10.68	-15.40	-21.29
	Other animals	0.13	-0.10	-0.36	-0.67	-1.12	-2.87	-6.29	-11.56	-19.04	-29.30
	Grains	-0.19	-0.57	-1.04	-1.63	-1.85	-2.83	-5.51	-9.96	-16.38	-25.15
	Other agriculture	-0.98	-1.61	-2.32	-3.20	-4.76	-8.06	-12.58	-18.32	-25.38	-33.92
	Agricultural services and fishing	0.69	0.43	0.22	-0.02	1.13	2.70	2.94	2.08	0.14	-2.94
	Forestry and logging	0.06	-0.01	-0.07	-0.12	0.33	1.33	2.39	3.62	5.10	6.90
	Coal mining	1.46	3.33	5.33	7.73	13.33	35.26	72.01	123.28	190.32	275.50
	Oil mining	-0.80	-1.49	-2.74	-4.74	-8.46	-12.85	-17.23	-22.22	-28.27	-35.73
	Gas mining	-1.78	-3.07	-4.92	-7.38	-11.68	-14.89	-15.46	-13.77	-9.71	-2.91
	Iron ore mining	0.39	1.20	2.03	2.97	5.86	23.82	57.23	106.54	173.86	262.78
	Non-ferrous metal ores	4.77	8.31	11.98	16.30	29.05	67.54	124.58	200.11	296.32	417.32
	Other mining	1.63	2.77	4.01	5.49	11.26	28.52	53.64	87.07	130.18	185.11
	Meat products	0.11	-1.11	-2.36	-3.90	-5.77	-12.23	-23.71	-40.09	-61.93	-90.22
	Other food and drink products	-2.95	-7.77	-12.83	-18.94	-31.71	-66.81	-120.21	-191.91	-284.14	-400.73
	Textiles, clothing and footwear	2.32	2.44	2.84	3.48	7.72	15.02	21.91	29.19	37.39	47.00
	Wood products	-0.39	-0.97	-1.46	-2.03	-1.19	0.36	1.23	1.89	2.56	3.38
	Paper products	-0.30	-0.94	-1.58	-2.32	-2.95	-5.31	-9.97	-16.73	-25.76	-37.46
	Printing and publishing	-3.98	-6.28	-8.90	-12.21	-16.86	-27.87	-44.24	-66.05	-94.13	-129.89
	Petroleum refinery	-8.25	-12.78	-18.02	-24.72	-38.31	-68.52	-109.92	-163.16	-230.18	-313.98
	Other chemicals	3.53	2.99	2.95	3.18	8.23	13.88	14.03	9.76	0.98	-13.22
	Rubber and plastic products	-0.88	-1.73	-2.60	-3.66	-4.52	-7.15	-11.96	-18.76	-27.77	-39.43

Scenario	Employment ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Non-metallic construction materials (not cement)	-1.50	-2.23	-3.01	-3.99	-4.75	-6.42	-9.01	-12.34	-16.43	-21.41
	Cement	-1.30	-1.73	-2.23	-2.90	-4.19	-6.64	-9.45	-12.71	-16.53	-21.07
	Iron and steel	0.51	0.14	-0.07	-0.26	2.40	6.78	10.32	13.62	16.86	20.04
	Alumina	1.28	2.13	2.90	3.75	6.61	16.90	31.98	51.31	75.25	104.80
	Aluminium	1.63	2.61	3.52	4.59	7.76	17.77	31.50	48.34	68.57	92.98
	Other non-ferrous metals	7.33	11.62	16.25	21.80	36.90	79.38	137.48	211.44	303.50	417.38
	Other metal products	-1.89	-2.99	-4.18	-5.70	-6.42	-8.44	-12.37	-17.97	-25.41	-35.14
	Motor vehicle and parts	2.35	2.26	2.41	2.71	12.02	32.04	54.00	79.22	109.05	145.01
	Other manufacturing products	0.64	-1.78	-3.86	-6.18	-2.31	0.95	-2.24	-10.33	-23.47	-42.87
	Electricity - coal	-0.17	-0.44	-0.75	-1.16	-0.94	0.42	1.61	2.30	2.25	1.21
	Electricity - gas	-0.11	-0.23	-0.36	-0.52	-0.59	-0.40	-0.02	0.55	1.36	2.50
	Electricity - oil products	-0.04	-0.07	-0.09	-0.12	-0.16	-0.24	-0.35	-0.48	-0.64	-0.82
	Electricity - nuclear	-	-	-	-	-	-	-	-	-	-
	Electricity - hydro	-0.02	-0.05	-0.10	-0.15	-0.14	0.06	0.35	0.74	1.21	1.80
	Electricity - non-hydro renewable	-0.01	-0.01	-0.02	-0.04	-0.04	-0.02	0.02	0.08	0.15	0.25
	Electricity supply	-0.62	-1.43	-2.38	-3.57	-3.29	0.06	3.72	7.14	10.04	12.19
	Gas supply	-0.58	-0.86	-1.23	-1.70	-3.20	-6.49	-10.54	-15.45	-21.37	-28.52
	Water supply	-1.42	-2.19	-3.09	-4.22	-6.19	-10.31	-15.92	-23.12	-32.18	-43.53
	Construction services	-53.78	-70.05	-88.92	-113.81	-164.00	-258.45	-365.43	-486.59	-626.04	-789.20
	Trade services	-24.79	-38.70	-55.53	-77.03	-117.78	-207.06	-329.95	-491.50	-699.80	-966.26
	Accommodation and hotels	-44.25	-65.57	-92.65	-127.72	-268.93	-585.30	-994.45	-1,515.18	-2,172.14	-2,998.41
	Road transport - passenger	-2.45	-3.45	-4.69	-6.28	-9.64	-16.23	-24.48	-34.71	-47.33	-62.90
	Road transport - freight	-2.24	-3.85	-5.62	-7.84	-8.29	-8.42	-9.78	-11.90	-14.59	-17.80
	Rail transport - passenger	-0.03	-0.09	-0.15	-0.21	0.18	0.92	1.68	2.60	3.77	5.26
	Rail transport - freight	0.26	0.41	0.60	0.82	3.17	11.21	23.77	41.36	64.83	95.44
	Other transport (includes water transport)	-5.89	-8.76	-11.99	-15.96	-41.67	-92.87	-153.21	-223.29	-304.28	-397.83
	Air transport	-70.70	-101.17	-138.17	-185.36	-306.67	-550.79	-853.77	-1,224.96	-1,677.15	-2,227.81
	Communication services	-10.47	-15.81	-22.16	-30.22	-46.02	-79.20	-123.34	-179.52	-249.99	-338.06

Scenario	Employment ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Financial services	-22.18	-35.80	-51.80	-71.89	-98.42	-147.79	-216.67	-305.66	-417.22	-555.49
	Business services	-53.07	-77.13	-107.04	-145.75	-219.37	-369.63	-566.14	-814.92	-1,126.14	-1,514.14
	Dwelling ownership	-22.68	-45.11	-73.17	-108.24	-163.13	-258.44	-391.22	-567.91	-795.61	-1,083.73
	Public services	-11.79	-17.74	-24.59	-33.16	-38.52	-47.60	-61.58	-78.49	-97.45	-118.01
	Other services	-16.97	-25.02	-35.12	-48.22	-93.02	-196.77	-341.09	-536.42	-796.62	-1,140.24
	Private transport services	-8.07	-12.50	-17.76	-24.35	-36.50	-61.80	-94.90	-136.01	-186.36	-247.97
	Private electrical equipment services	-3.44	-5.93	-8.79	-12.30	-18.20	-30.45	-47.17	-68.38	-94.64	-126.97
	Private heating equipment services	-2.03	-3.10	-4.40	-6.04	-9.07	-15.27	-23.11	-32.65	-44.20	-58.24
Medium	Sheep and cattle	0.76	1.31	2.03	3.02	5.00	12.69	26.65	47.69	77.10	116.67
	Dairy	0.34	0.76	1.23	1.83	2.86	7.06	14.51	25.36	40.14	59.79
	Other animals	-0.14	0.09	0.38	0.80	1.44	6.38	17.09	34.54	60.42	97.29
	Grains	0.20	0.55	0.99	1.59	0.44	1.54	8.27	21.25	41.62	71.15
	Other agriculture	0.99	1.66	2.48	3.54	7.23	17.14	31.47	50.64	75.32	106.59
	Agricultural services and fishing	-0.73	-0.54	-0.40	-0.21	-4.95	-10.83	-12.46	-10.33	-4.48	5.16
	Forestry and logging	-0.07	-0.02	-0.01	-0.02	-1.93	-5.93	-10.52	-16.10	-23.09	-32.03
	Coal mining	-1.50	-3.64	-6.45	-10.43	-26.07	-101.69	-234.90	-428.12	-689.55	-1,033.36
	Oil mining	0.83	1.56	2.81	4.70	10.48	13.52	9.58	-1.57	-21.07	-50.96
	Gas mining	1.85	3.20	5.01	7.23	14.52	12.76	-4.78	-38.62	-91.31	-167.19
	Iron ore mining	-0.44	-1.45	-3.00	-5.48	-15.77	-85.09	-218.62	-422.74	-710.81	-1,104.09
	Non-ferrous metal ores	-4.86	-8.96	-14.18	-21.25	-60.07	-196.20	-409.77	-705.30	-1,096.82	-1,608.69
	Other mining	-1.68	-3.09	-5.02	-7.71	-26.80	-89.97	-186.81	-321.23	-501.27	-739.64
	Meat products	-0.18	1.05	2.46	4.38	6.64	24.07	58.53	110.67	183.27	280.94
	Other food and drink products	2.93	8.04	14.04	21.93	47.74	145.27	307.30	539.13	854.79	1,277.47
	Textiles, clothing and footwear	-2.39	-2.64	-3.27	-4.16	-16.93	-38.34	-58.10	-78.69	-102.05	-130.54
	Wood products	0.42	0.93	1.30	1.70	-3.65	-12.74	-20.84	-29.57	-39.98	-53.18
	Paper products	0.33	0.97	1.63	2.46	2.25	7.40	20.22	40.49	69.21	108.30
	Printing and publishing	4.04	6.47	9.42	13.29	22.34	53.66	104.03	175.01	271.09	399.46

Scenario	Employment ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Petroleum refinery	8.67	13.46	19.26	26.89	54.23	130.77	241.60	389.60	582.17	830.59
	Other chemicals	-3.54	-3.15	-3.25	-3.45	-18.59	-29.55	-18.58	12.58	66.12	146.75
	Rubber and plastic products	0.90	1.74	2.65	3.80	3.33	8.06	19.92	38.75	65.65	102.67
	Non-metallic construction materials (not cement)	1.52	2.25	3.04	4.05	3.77	5.47	9.59	15.57	23.52	33.91
	Cement	1.34	1.79	2.36	3.10	5.79	11.67	18.50	26.58	36.38	48.59
	Iron and steel	-0.53	-0.26	-0.21	-0.21	-9.76	-24.48	-36.63	-47.94	-59.01	-70.29
	Alumina	-1.32	-2.33	-3.53	-5.13	-14.47	-52.24	-110.34	-187.98	-288.01	-416.28
	Aluminium	-1.63	-2.77	-4.12	-5.91	-16.08	-52.69	-105.47	-172.99	-257.19	-362.37
	Other non-ferrous metals	-7.32	-12.28	-18.72	-27.35	-73.37	-224.20	-442.71	-733.51	-1,109.78	-1,593.18
	Other metal products	1.94	3.02	4.19	5.71	3.74	4.83	11.50	23.24	41.09	66.93
	Motor vehicle and parts	-2.50	-2.84	-3.83	-5.31	-39.01	-112.80	-198.30	-300.76	-426.75	-585.26
	Other manufacturing products	-0.61	1.63	3.51	5.75	-12.70	-26.61	-17.96	9.65	57.88	130.50
	Electricity - coal	0.12	0.35	0.63	1.02	-0.59	-5.49	-9.45	-11.00	-8.70	-0.66
	Electricity - gas	0.11	0.22	0.34	0.47	0.20	-1.28	-3.80	-7.59	-13.05	-20.80
	Electricity - oil products	0.04	0.07	0.10	0.12	0.19	0.36	0.60	0.88	1.16	1.42
	Electricity - nuclear	-	-	-	-	-	-	-	-	-	-
	Electricity - hydro	0.02	0.05	0.08	0.12	-0.09	-0.98	-2.30	-4.04	-6.29	-9.17
	Electricity - non-hydro renewable	0.00	0.01	0.02	0.03	0.02	-0.10	-0.31	-0.60	-1.00	-1.53
	Electricity supply	0.51	1.25	2.09	3.13	-0.90	-15.08	-30.96	-46.46	-60.09	-70.16
	Gas supply	0.63	0.95	1.38	1.94	5.51	14.08	24.73	37.83	53.96	73.90
	Water supply	1.45	2.27	3.29	4.60	8.74	19.94	36.14	57.94	86.63	124.15
	Construction services	55.05	72.73	93.90	121.72	228.42	457.57	719.97	1,022.03	1,380.11	1,818.63
	Trade services	25.06	40.49	60.72	87.68	202.06	499.46	925.69	1,505.51	2,273.55	3,275.30
	Accommodation and hotels	44.36	70.09	106.95	157.39	530.14	1,453.40	2,715.07	4,403.92	6,641.47	9,604.19
	Road transport - passenger	2.49	3.58	5.02	6.92	15.31	34.50	59.63	92.09	133.80	187.44
	Road transport - freight	2.25	3.78	5.42	7.47	2.39	-6.88	-15.22	-24.50	-35.95	-51.04
	Rail transport - passenger	0.02	0.07	0.08	0.10	-1.56	-4.74	-8.31	-12.76	-18.49	-26.01
	Rail transport - freight	-0.29	-0.57	-1.10	-1.94	-10.90	-42.17	-93.01	-166.64	-268.05	-404.67

Scenario	Employment ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Other transport (includes water transport)	8.00	11.00	14.26	18.16	73.12	186.16	316.48	464.16	630.22	816.20
	Air transport	73.54	107.25	150.87	207.89	512.25	1,209.70	2,109.35	3,250.55	4,688.34	6,501.74
	Communication services	10.73	16.56	23.93	33.59	71.42	169.22	306.36	489.03	728.36	1,041.17
	Financial services	22.47	36.60	53.73	75.66	116.21	224.42	391.38	621.62	926.99	1,326.74
	Business services	54.38	80.38	114.41	159.53	327.05	741.97	1,314.91	2,071.91	3,054.11	4,318.16
	Dwelling ownership	23.08	46.52	76.87	115.77	213.13	436.04	776.61	1,260.42	1,918.03	2,791.83
	Public services	12.00	17.96	24.74	33.24	27.91	25.77	31.98	39.90	46.32	49.96
	Other services	17.17	28.14	44.61	67.73	264.25	764.84	1,465.58	2,421.58	3,706.34	5,420.33
	Private transport services	8.23	13.01	19.08	26.92	53.81	126.67	228.12	359.89	528.02	742.28
	Private electrical equipment services	3.52	6.15	9.37	13.46	25.24	58.64	107.69	173.07	257.70	366.61
	Private heating equipment services	2.07	3.23	4.71	6.62	13.25	30.59	53.61	82.74	119.44	166.01
High	Sheep and cattle	0.76	1.32	2.13	3.37	6.70	22.79	52.97	98.91	162.58	244.33
	Dairy	-0.34	-0.77	-1.30	-2.04	-3.72	-12.46	-28.67	-53.28	-89.13	-144.08
	Other animals	0.16	-0.08	-0.44	-1.05	-2.23	-13.41	-37.77	-77.78	-137.90	-225.79
	Grains	-0.21	-0.49	-0.86	-1.49	2.24	1.03	-12.95	-41.12	-85.45	-150.75
	Other agriculture	-1.00	-1.74	-2.74	-4.12	-11.52	-33.00	-64.94	-108.81	-167.44	-246.36
	Agricultural services and fishing	0.78	0.70	0.71	0.61	11.28	23.98	27.62	24.14	17.58	19.28
	Forestry and logging	0.07	0.07	0.15	0.28	4.74	14.08	25.10	39.08	58.34	87.96
	Coal mining	1.55	4.11	8.37	15.26	49.25	219.91	523.66	972.27	1,606.32	2,527.56
	Oil mining	-0.85	-1.62	-2.83	-4.46	-13.27	-12.02	10.14	56.15	134.64	268.52
	Gas mining	-1.91	-3.33	-5.01	-6.69	-18.39	-5.74	47.00	143.45	296.93	541.41
	Iron ore mining	0.48	1.83	4.65	9.90	33.57	193.46	504.74	989.47	1,699.72	2,748.86
	Non-ferrous metal ores	4.97	10.03	18.07	30.16	115.29	424.50	919.01	1,620.16	2,594.69	3,999.11
	Other mining	1.74	3.60	6.78	11.67	54.35	198.81	424.45	745.61	1,198.12	1,861.89
	Meat products	0.25	-0.99	-2.66	-5.26	-9.10	-47.65	-124.51	-241.60	-405.34	-624.34
	Other food and drink products	-2.91	-8.50	-16.12	-27.21	-77.60	-290.48	-655.17	-1,196.64	-1,983.78	-3,205.90
	Textiles, clothing and footwear	2.45	2.97	4.01	5.36	32.47	77.40	119.07	164.72	226.49	330.15

Scenario	Employment ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Wood products	-0.45	-0.82	-0.94	-1.04	12.74	36.46	59.38	86.11	124.18	189.38
	Paper products	-0.37	-0.98	-1.66	-2.65	-0.61	-9.95	-36.22	-79.12	-139.97	-221.87
	Printing and publishing	-4.09	-6.73	-10.24	-15.12	-31.71	-98.57	-209.56	-370.47	-595.02	-911.30
	Petroleum refinery	-9.09	-14.25	-20.96	-30.14	-76.52	-221.50	-437.93	-733.21	-1,128.80	-1,674.37
	Other chemicals	3.55	3.45	3.83	3.98	36.30	54.80	22.48	-55.29	-171.95	-313.91
	Rubber and plastic products	-0.91	-1.74	-2.67	-3.99	-1.09	-9.25	-33.24	-72.89	-129.65	-206.44
	Non-metallic construction materials (not cement)	-1.55	-2.27	-3.07	-4.11	-1.76	-2.85	-8.95	-18.88	-31.79	-47.00
	Cement	-1.37	-1.88	-2.54	-3.40	-8.21	-19.35	-32.57	-48.84	-69.87	-99.68
	Iron and steel	0.55	0.47	0.74	1.09	22.55	55.04	82.44	110.51	150.21	229.78
	Alumina	1.36	2.65	4.62	7.57	28.32	114.38	249.08	433.45	682.57	1,034.38
	Aluminium	1.63	3.06	5.21	8.32	31.22	115.87	239.51	400.66	610.18	896.13
	Other non-ferrous metals	7.29	13.48	23.26	37.53	139.99	487.46	999.47	1,696.64	2,644.24	3,993.69
	Other metal products	-1.99	-3.02	-4.14	-5.64	1.56	3.18	-7.27	-28.87	-61.28	-106.12
	Motor vehicle and parts	2.64	3.78	6.33	9.95	85.80	253.29	452.04	699.11	1,031.05	1,521.98
	Other manufacturing products	0.58	-1.29	-2.72	-4.78	39.73	73.92	59.60	10.34	-49.92	-48.78
	Electricity - coal	-0.06	-0.25	-0.49	-0.86	2.63	11.47	16.42	13.22	-2.91	-41.81
	Electricity - gas	-0.11	-0.21	-0.30	-0.37	0.54	4.36	11.00	21.39	37.63	64.67
	Electricity - oil products	-0.04	-0.07	-0.10	-0.13	-0.23	-0.50	-0.83	-1.11	-1.14	-0.32
	Electricity - nuclear	-	-	-	-	-	-	-	-	-	-
	Electricity - hydro	-0.01	-0.04	-0.05	-0.06	0.48	2.52	5.57	9.74	15.53	24.31
	Electricity - non-hydro renewable	-0.00	-0.01	-0.02	-0.02	0.03	0.32	0.81	1.53	2.58	4.24
	Electricity supply	-0.41	-1.03	-1.67	-2.45	7.19	36.67	68.02	96.02	117.70	128.62
	Gas supply	-0.68	-1.06	-1.60	-2.30	-8.97	-25.34	-45.71	-71.05	-102.96	-143.67
	Water supply	-1.48	-2.39	-3.59	-5.22	-12.92	-36.00	-70.39	-117.98	-182.67	-271.34
	Construction services	-56.31	-76.30	-101.58	-134.30	-327.46	-766.04	-1,279.12	-1,897.17	-2,689.59	-3,834.78
	Trade services	-25.35	-43.36	-69.52	-106.18	-351.56	-1,013.12	-1,960.94	-3,242.90	-4,909.56	-7,030.14
	Accommodation and hotels	-44.48	-78.14	-132.67	-210.92	-1,004.77	-3,036.98	-5,880.00	-9,814.61	-15,399.37	-23,745.87
	Road transport - passenger	-2.53	-3.78	-5.57	-8.00	-24.83	-65.44	-119.75	-191.88	-289.99	-433.08

Scenario	Employment ($'m)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
	Road transport - freight	-2.26	-3.63	-4.99	-6.68	8.43	35.37	62.98	97.12	148.48	239.58
	Rail transport - passenger	-0.02	-0.02	0.03	0.10	3.96	11.43	20.06	31.10	46.39	69.62
	Rail transport - freight	0.32	0.83	1.96	3.92	24.60	96.96	216.16	392.45	646.88	1,024.81
	Other transport (includes water transport)	-10.13	-13.14	-16.17	-19.59	-97.26	-256.70	-435.64	-630.16	-833.75	-1,030.54
	Air transport	-76.38	-115.54	-170.55	-244.69	-837.21	-2,261.38	-4,135.37	-6,570.20	-9,796.62	-14,319.97
	Communication services	-10.98	-17.62	-26.76	-39.21	-113.81	-321.49	-620.84	-1,032.53	-1,598.25	-2,410.66
	Financial services	-22.79	-37.68	-56.61	-81.62	-143.79	-348.94	-684.61	-1,169.11	-1,839.74	-2,784.24
	Business services	-55.68	-84.89	-125.99	-182.31	-503.79	-1,355.72	-2,553.19	-4,154.52	-6,241.11	-8,877.03
	Dwelling ownership	-23.48	-48.49	-82.57	-128.01	-296.31	-734.19	-1,430.72	-2,453.87	-3,896.56	-5,917.24
	Public services	-12.20	-18.01	-24.53	-32.68	-5.35	23.97	37.02	43.65	47.01	14.34
	Other services	-17.34	-33.56	-61.64	-103.01	-575.92	-1,801.47	-3,526.75	-5,902.81	-9,151.00	-13,581.17
	Private transport services	-8.39	-13.76	-21.19	-31.21	-82.83	-236.55	-456.16	-748.94	-1,136.32	-1,661.96
	Private electrical equipment services	-3.59	-6.47	-10.28	-15.37	-36.96	-106.00	-210.58	-354.34	-548.85	-820.01
	Private heating equipment services	-2.12	-3.41	-5.20	-7.57	-20.15	-56.04	-104.86	-168.61	-253.07	-370.67

Appendix B Sources of data for analysis

6.8 Publicly available information

Where information was not obtained through existing sources, additional data for determining the direct impacts of not proceeding with increasing aviation capacity in the Sydney region was sourced from publicly available information. The sources of the information used, by category, are presented in the table below.

Publicly available information utilised

Category	Publicly available information utilised

Tourism (including business travel)	► BITRE's Airport Traffic Data 1985/86 – 2009/10
	  ► Number of inbound and outbound passengers for major domestic airlines, regional airlines and international airlines, 2009/10
	► Australian Bureau of Statistics (ABS) Catalogue 3401.1 (Overseas Arrivals and Departures (long and short-term), Australia, April 2011
	  ► Number of visitors (long and short-term) arriving, May 2010 – April 2011
	  ► Total number of arrivals, May 2010 – April 2011
	► Tourism NSW Travel to New South Wales, Year ended June 2011
	  ► Percentage of domestic visitors whose purpose for travel was business
	  ► Percentage of domestic visitors whose purpose for travel was non-business
	  ► Percentage of international visitors whose purpose for travel was business
	  ► Percentage of international visitors whose purpose for travel was non-business
	  ► Average length of stay for domestic visitors
	  ► Average length of stay for international visitors
	  ► Average expenditure per day for domestic visitors
	  ► Average expenditure per day for international visitors
	► ABS Catalogue 6401.0, Tables 1 and 2: CPI: All Groups, Index numbers and percentage changes, March 2011

Category	Publicly available information utilised
	► Index numbers, all groups, Australia, March 2001 – March 2011 ► ABS Catalogue 6302.0, Table 3: Average weekly earnings, Australia (dollars) – Original, February 2011 ► Earnings, persons, total earnings, Australia, February 2001 – February 2011 ► ABS Catalogue 6202.0, Table 3: Average weekly earnings, Australia (dollars) – Original, May 2011 ► Employed – full-time (persons), May 2011 ► Employed – part-time (persons), May 2011 ► IBISWorld Industry Report X0003, Tourism in Australia, 4 March 2011 ► Profit as a percentage of industry costs (2011) ► Wages as a percentage of industry costs (2011) ► Employment numbers (2009/10) ► Wages (2009/10) ► Revenue (2009/10)
Delays and passenger welfare	► BITRE's Sydney Airport: Indicative estimate of cost of doing nothing report ► BITRE's on-time running performance data 2003 – 2010 ► CASA Value of Time ► Publicly available information on airline ticket pricing
Freight	► ABS Catalogue 6202.0, Table 3: Average weekly earnings, Australia (dollars) – Original, May 2011 ► Employed – full-time (persons), May 2011 ► Employed – part-time (persons), May 2011 ► IBISWorld Industry Report H4832-GL, Global logistics – Air Freight, 22 December 2010 ► Profit as a percentage of industry costs (2010) ► Wages as a percentage of industry costs (2010) ► Employment numbers (2010) ► Wages (2010) ► Revenue (2010)

Category	Publicly available information utilised
Aviation & airports	► ABS Catalogue 6202.0, Table 3: Average weekly earnings, Australia (dollars) – Original, May 2011 ► Employed – full-time (persons), May 2011 ► Employed – part-time (persons), May 2011 *Airlines* ► IBISWorld Industry Report I6402, Domestic Airlines in Australia, February 2011 ► Profit as a percentage of industry costs (2011) ► Wages as a percentage of industry costs (2011) ► Passenger numbers (2009/10) ► Employment numbers (2009/10) ► Wages (2009/10) ► Revenue (2009/10) ► IBISWorld Industry Report I6402, International Airlines in Australia, March 2011 ► Profit as a percentage of industry costs (2011) ► Wages as a percentage of industry costs (2011) ► Passenger numbers (2009/10) ► Employment numbers (2009/10) ► Wages (2009/10) ► Revenue (2009/10) *Airports* ► IBISWorld Industry Report I6630, Airports in Australia, April 2011 ► Profit as a percentage of industry costs (2011) ► Wages as a percentage of industry costs (2011) ► Aircraft movements (2009/10) ► Employment numbers (2009/10)

Category	Publicly available information utilised

	► Wages (2009/10)
	► Revenue (2009/10)
	Airport retail
	► Moodie's The Airport Commercial Revenues Study 2010/11
	  ► Duty free spend in US$
	  ► Food and beverage spend in US$
	  ► Retail spend in US$
	  ► Currency change spend in US$
	  ► Car parking spend in US$
	► ABS Catalogue 6401.0, Tables 1 and 2: CPI: All Groups, Index numbers and percentage changes, March 2011
	  ► Index numbers, all groups, Australia Dec 2002 – March 2011
	► ABS Catalogue 6401.0, Tables 1 and 2: CPI: All Groups, Index numbers and percentage changes, March 2011
	  ► Index numbers, all groups, Australia March 2001 – March 2011
	► ABS Catalogue 6302.0, Table 3: Average weekly earnings, Australia (dollars) – Original, February 2011
	  ► Earnings, persons, total earnings, Australia, February 2001 – February 2011
	► Exchange rate (SDR / AUD) http://coinmill.com/AUD_SDR.html#SDR=1
	  ► Accessed 28 June, 2011
	► IBISWorld Industry Report G5256, Duty-Free Stores in Australia, October 2010
	  ► Profit as a percentage of industry costs (2011)
	  ► Wages as a percentage of industry costs (2011)
	  ► Aircraft movements (2009/10
	  ► Employment numbers (2009/10)
	  ► Wages (2009/10)
	  ► Revenue (2009/10)
	► IBISWorld Industry Report G5125a, Fast Food in Australia, April 2011

Category	Publicly available information utilised
	► Profit as a percentage of industry costs (2011) ► Wages as a percentage of industry costs (2011) ► Aircraft movements (2009/10) ► Employment numbers (2009/10) ► Wages (2009/10) ► Revenue (2009/10) ► IBISWorld Industry Report G5221, Clothing Retailing in Australia, June 2011 ► Profit as a percentage of industry costs (2011) ► Wages as a percentage of industry costs (2011) ► Aircraft movements (2009/10) ► Employment numbers (2009/10) ► Wages (2009/10) ► Revenue (2009/10)
Commercial developments	► Changi Airport Data (Singapore), 2010 (http://www.changiairportgroup.com/cag/html/the-group/passenger_movement.html and http://www.jtc.gov.sg/Product/BsnsParkLand/CBP/Pages/index.aspx) ► Passenger movements (2010) ► Size of Changi Business Park (2010) ► Beijing Airport Data, 2010 (http://www.caac.gov.cn/I1/K3/201103/P020110315385388029023.xls and http://www.airport56.com/english/jl.html) ► Passenger movements (2010) ► Size of Beijing Airport logistics lark (2010) ► Hong Kong Airport Data, 2010 (http://www.hongkongairport.com/eng/business/about-the-airport/facts-figures/facts-sheets.html and http://www.hongkongairport.com/eng/pdf/business/airport-authority/MP2020.pdf) ► Passenger movements (2010) ► Size of Hong Kong mixed land use and planned SkyCity (2010) ► Incheon Airport Data (South Korea), 2010 (http://www.airport.kr/iiacms/pageWork.iia?_scode=C2401010000, http://www.globalairportcities.com/incheon-

Category	Publicly available information utilised
	international-airport and http://www.airport.kr/iiacms/pageWork.iia?_scode=C0305020101&fake=1303880664457) ► Passenger movements (2010) ► Size of International Business Centre 1 and 2 (2010) ► Gatwick Airport Data (United Kingdom), 2010 (http://www.gatwickairport.com/business/about/facts-figures/ and http://www.baa.com/assets/B2CPortal/Static%20Files/lgw_interim_masterplan.pdf) ► Passenger movements (2010) ► Size of Ancillary Area (2010) ► Frankfurt Airport Data, 2010 (http://www.frankfurt-airport.com/content/frankfurt_airport/en/business_location/facts_figures.html, http://www.frankfurt-airport.com/content/frankfurt_airport/en/business_location/cargo_hub/facts_figures.html, http://www.frankfurt-airport.com/content/frankfurt_airport/en/business_location/real_estate_development/cargocity_south.html, http://www.frankfurt-airport.com/content/frankfurt_airport/en/business_location/real_estate_development/gateway_gardens.html and http://www.frankfurt-airport.com/content/frankfurt_airport/en/business_location/real_estate_development/moenchhof_site.html#fratab_d341432) ► Passenger movements (2010) ► Size of Cargo City, Cargo City South, Gateway Gardens and Monchhof Site business parks (2010)
Delays and passenger welfare	► BITRE's Sydney Airport: Indicative estimate of cost of doing nothing report ► BITRE's on-time running performance data 2003 – 2010 ► CASA Value of Time ► Publicly available information on airline ticket pricing

Appendix C Approach to calculating total impacts

Modelling the Costs of not Expanding the Sydney Airport using MMRF: Notes

As provided by Monash University's Centre of Policy Studies

INTRODUCTION

Using the Monash Multi-Regional Forecasting (MMRF) model and inputs for various aspects of airport operations from Ernst and Young, four scenarios are run:

- Reference case (or Base case): A business-as-usual projection for the NSW and national economies in which there are no restrictions on Sydney airport capacity;
- Scenario 1 Low: Base case plus deviations from base due to the effects of restrictions on Sydney airport capacity - low assumption case;
- Scenario 2 Medium: Base case plus deviations from base due to the effects of restrictions on Sydney airport capacity - medium assumption case; and
- Scenario 3 High: Base case plus deviations from base due to the effects of restrictions on Sydney airport capacity - high assumption case.

A brief general description of MMRF is given in Section 2. Aspects of simulation design are given in Section 3. The effects of the three alternative scenarios are given in Section 4 as deviations between the values of variables in the policy scenarios and their values in the base case.

MMRF

Overview

MMRF is a dynamic, multi-sectoral, multi-regional model of Australia. The current version of the model distinguishes 58 industries (see Table 1), 63 products produced by the 58 industries, 8 states/territories and 56 sub-state regions. At the state/territory level it is a fully-specified bottom-up system of interacting regional economies. To allow estimates of the effects of policy at the sub-state level, a top-down approach is added.

Of the 58 industries, three produce primary fuels (coal, oil and gas), one produces refined fuel (petroleum products), six generate electricity and one supplies electricity to final customers. The six generation industries are defined according to primary source of fuel: *Electricity-coal* includes all coal-fired generation technologies; *Electricity–gas* includes all plants using gas turbines, cogeneration and combined cycle technologies driven by burning gas; *Electricity-oil products* covers all liquid-fuel generators; *Electricity-hydro* covers hydro generation; while *Electricity-other* covers the remaining forms of renewable generation from biomass, biogas, wind etc. Nuclear power generation is not currently used in Australia but *Electricity–nuclear* is included and could be triggered, if desired, at a specified CO2 price.

Apart from *Grains* (industry 4) and *Petroleum products* (industry 20), each industry produces a single product. *Grains* produces grains for animal and human consumption and biofuel used as feedstock by *Petroleum products*. *Petroleum products* produces five products – gasoline (includes gasoline-based biofuel blends), diesel (includes diesel-based biofuel blends), LPG, aviation fuel, and other refinery products (mainly heating oil).

General equilibrium core

The nature of markets

MMRF determines regional supplies and demands of commodities through optimising behaviour of agents in competitive markets. Optimising behaviour also determines industry demands for labour and capital. Labour supply at the national level is determined by demographic factors, while national capital supply responds to rates of return. Labour and capital can cross regional borders in response to relative regional employment opportunities and relative rates of return.

The assumption of competitive markets implies equality between the basic price and marginal cost in each regional sector. Demand is assumed to equal supply in all markets other than the labour market (where excess supply conditions can hold). The government intervenes in markets by imposing ad valorem sales taxes on commodities. This places wedges between the prices paid by purchasers and basic prices received by producers. The model recognises margin commodities (e.g., retail trade and road transport freight) which are required for each market transaction (the movement of a commodity from the producer to the purchaser). The costs of the margins are included in purchasers' prices but not in basic prices of goods and services.

Demands for inputs to be used in the production of commodities

MMRF recognises two broad categories of inputs: intermediate inputs and primary factors. Firms in each regional sector are assumed to choose the mix of inputs that minimises the costs of production for their levels of output. They are constrained in their choice by a three-level nested production technology. At the first level, intermediate-input bundles, primary-factor bundles and other costs are used in fixed proportions to output. These bundles are formed at the second level. Intermediate-input bundles are combinations of goods imported from overseas and domestic goods. The primary-factor bundle is a combination of labour, capital and land. At the third level, inputs of domestic goods are formed as combinations of goods sourced from each of the eight domestic regions, and the input of labour is formed as a combination of inputs of labour from nine different occupational categories.

Household demands

In each region, the household buys bundles of goods to maximise a utility function subject to a household expenditure constraint. The bundles are combinations of imported and domestic goods, with domestic goods being combinations of goods from each domestic region. A Keynesian consumption function is usually used to determine aggregate household expenditure as a function of household disposable income.

Demands for inputs to capital creation and the determination of investment

Capital creators for each regional sector combine inputs to form units of capital. In choosing these inputs, they minimise costs subject to a technology similar to that used for current production; the only difference being that they do not use primary factors directly.

Governments' demands for commodities

Commodities are demanded from each region by regional governments and by the Federal government. In MMRF, there are several ways of handling these demands, including:

- by a rule such as moving government expenditures with household consumption expenditure or with domestic absorption or with GDP;
- as an instrument which varies to accommodate an exogenously determined target such as a required level of government deficit; and
- exogenously.

Foreign demand (international exports)

MMRF adopts the ORANI specification of foreign demand. Each export-oriented sector in each state faces its own downward-sloping foreign demand curve. Thus, a shock that reduces the unit costs of an export sector will result in increased export volume, but a lower foreign-currency price. By assuming that the foreign demand schedules are specific to product and region of production, the model allows for differential movements in foreign-currency prices across domestic regions.

Regional labour markets

The response of regional labour markets to policy shocks depends on the treatment of three key variables – regional labour supplies, regional unemployment rates and regional wage differentials. The main alternative treatments are:

- to set regional labour supplies and unemployment rates exogenously and determine regional wage differentials endogenously;

- to set regional wage differentials and regional unemployment rates exogenously and determine regional labour supplies endogenously (*via* interstate migration or changes in regional participation rates); and
- set regional labour supplies and wage differentials exogenously and determine regional unemployment rates endogenously.

The second treatment 2 is the one adopted for the current modelling, with regional participation rates exogenous. Under this treatment, workers move freely (and instantaneously) across state borders in response to changes in relative regional unemployment rates. With in regional wage rates indexed to the national wage rate, regional employment is demand determined.

Physical capital accumulation

Investment undertaken in year t is assumed to become operational at the start of year t+1. Under this assumption, capital accumulates according to (industry and region indexes dropped for convenience):

$$K(t+1) = (1 - DEP) \times K(t) + Y(t) \qquad (0)$$

where:
K(t) is the quantity of capital available in industry at the start of year t;
Y(t) is the quantity of new capital created during year t; and
DEP is the rate of depreciation, which is treated as a fixed parameter.
Given a starting point value for capital in t=0, and with a mechanism for explaining investment through time, equation (1) can be used to trace out the time paths of industry capital stocks.
Following the approach taken in the MONASH model, investment in year t is explained via a mechanism of the form

$$\frac{K(t+1)}{K(t)} - 1 = F^t \left[\frac{EROR(t)}{RROR(t)} \right] \qquad (0)$$

where
EROR(t) is the expected rate of return in year t;
RROR(t) is the required rate of return on investment; and
$F^t[\ ]$ is an increasing function of the ratio of expected to required rate of return with a finite slope.
In the current version of MMRF, it is assumed that investors take account only of current rentals and asset prices when forming current expectations about rates of return (static expectations).

Lagged adjustment process in the national labour market

The airport simulations are year-to-year recursive-dynamic simulations, not comparative-static simulations. In the year-to-year simulations it is assumed that deviations in the national real wage rate from its base-case level increase through time in proportion deviations in the national unemployment rate. The coefficient of adjustment is chosen so that effects of a shock on the unemployment rate are largely eliminated after about ten years. This is consistent with macroeconomic modelling in which the NAIRU is exogenous.

This treatment of the national labour market differs from the treatment of regional labour markets outlined in Section 2.2.7. If the national real wage rate rises in response to a fall in the national unemployment rate, then wage rates in all regions rise by the same percentage amount, and regional employment adjusts immediately, with regional labour supplies adjusting to stabilise relative regional unemployment rates.

Simulation Design

Introduction

The effects of Scenarios 1, 2 and 3 are reported as deviations away from values in the base case projection. The inputs to the MMRF policy simulations are sourced from Ernst and Young.

Assumptions for the Macroeconomy in the policy scenarios

The following assumptions are made for key aspects of the macro-economy in the deviations simulations.

Labour markets

At the national level, it is assumed that there are no employment consequences associated with restrictions on Sydney airport capacity. This means that the costs of capacity restrictions are realised almost entirely as a fall in the national real wage rate, rather than as a fall in national employment.

At the regional level, labour is assumed to be mobile between state economies. Labour moves between regions so as to maintain inter-state unemployment-rate differentials at their levels in the base case projection. Accordingly, regions that are relatively unfavourably affected by Sydney airport restrictions will experience relative reductions in their labour forces as well as in employment.

Private consumption and investment

Private consumption expenditure is determined via a Keynesian consumption function which links nominal consumption to Household Disposable Income (HDI). HDI is the sum of payments to domestic labour and capital and government transfer payments net of direct taxation.

Investment in all but a few industries is allowed to deviate from values in the base case scenario in line with deviations in expected rates of return. Investors are assumed to be myopic, implying that expected rates of return move with contemporaneously observed rates of return. The exceptions to this rule are the electricity generators, for which changes in capital (generation capacity) are imposed exogenously using information from the detailed electricity modelling. The changes are imposed by allowing the required rates of return on investment to shift endogenously.

Rates of return on capital

In the policy scenarios, MMRF allows for short-run divergences in rates of return on industry capital stocks from their levels in the base case. Such divergences cause divergences in investment and hence capital stocks. The divergences in capital stocks gradually erode the initial divergences in rates of return, so that, provided there are no further shocks to the system, in the long run rates of return revert to their base case levels.

Government consumption and fiscal balances

MMRF contains no theory to explain changes in real public consumption. In these simulations, public consumption is simply indexed to nominal GDP. The fiscal balances of each jurisdiction (federal, state and territory) as a share of nominal GDP are fixed at their values in the base case. Budget-balances constraints are accommodated by endogenous movements in lump-sum payments to households.

Production technologies and household tastes

MMRF contains many types of technical-change and household-preference-change variables. Under the policy scenarios, it is assumed that most technology and preference variables are exogenous and have the same values as in the base case projection.

Imposing inputs from Ernst and Young

Ernst and Young provides data used as input for:

1. Reductions in turnover of certain industries in NSW due to restrictions on Sydney airport capacity; and
2. At the national level, reductions in total inbound tourism spending due to the restrictions in Sydney.

Item-1 data are input to MMRF via closure changes[45] that in effect turn off MMRF's treatment of production (turnover) in the selected NSW industries and replaces it with the story from Ernst and Young. Production becomes an exogenous (user-determined) variable and a variable allowing for a shift in unit cost becomes an endogenous (model-determined) variables. In effect, the Ernst and Young changes in turnover for the affected industries are forced on the model via endogenous changes in unit costs.

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[45] "Closure" is a modelling MMRF used to describe the choice of exogenous and endogenous variables underlying a simulation. MMRF contains more variables than equations. Thus in conducting a simulation a specific number of variables (equal to the number of equations) must be declared to be endogenous. The remainder are exogenous and their values are set by the model user.

Item-2 data are input to MMRF via exogenous shifts in foreign tourist demand for Australian tourist services. An exogenously specified reduction in foreign tourist expenditure is forced on the model via an endogenous shift in the position of the foreign tourist demand schedule.

Industries in MMRF*

Name	Description of major activity
1. Sheep & beef cattle	Primary agricultural activities related to sheep and cattle production
2. Dairy cattle	Primary agricultural activities associated with dairy cattle
3. Other livestock	Primary agricultural activities associated with other animals
4. Grains	Grains production
5. Other agriculture	Other primary agricultural production
6. Agricultural services, fishing and hunting	Provision of agricultural services, fishing and hunting
7. Forestry	Logging and forestry services
8. Coal mining	Mining of coal
9. Oil mining	Mining of oil
10. Gas mining	Production of natural gas at well
11. Iron ore mining	Mining of iron ore
12. Non-ferrous ore mining	Mining of ore other than iron
13. Other mining	Other mining activity
14. Meat & meat products	Processed food related to animal
15. Other food, beverages & tobacco	Other food and drink products
16. Textiles, clothing & footwear	Textiles, clothing and footwear
17. Wood products	Manufacture of wood (including pulp) products
18. Paper products	Manufacture of paper products
19. Printing and publishing	Printing and publishing
20. Petroleum products	Manufacture of petroleum (refinery) products
21. Basic chemicals	Manufacture of basic chemicals and paints
22. Rubber & plastic products	Manufacture of plastic and rubber products
23. Non-metal construction products	Manufacture of non-metallic building products excl. cement
24. Cement	Manufacture of cement
25. Iron & steel	Manufacture of primary iron and steel.
26. Alumina	Manufacture of alumina
27. Aluminum	Manufacture of aluminium

28. Other non-ferrous metals	Manufacture of other non-ferrous metals
29. Metal products	Manufacture of metal products
30. Motor vehicles and parts	Manufacture of motor vehicles and parts
31. Other manufacturing	Manufacturing non elsewhere classified
32. Electricity generation - coal	Electricity generation from coal (black and brown) thermal plants
33. Electricity generation - gas	Electricity generation from natural gas thermal plants
34. Electricity generation – oil products	Electricity generation from oil products thermal plants
35. Electricity generation - nuclear	Electricity generation from nuclear plants
36. Electricity generation – hydro	Electricity generation from renewable sources – hydro
37. Electricity generation – other	Electricity generation from all other renewable sources
38. Electricity supply	Distribution of electricity from generator to user
39. Gas supply	Urban distribution of natural gas
40. Water supply	Provision of water and sewerage services
41. Construction services	Residential building and other construction services

42. Trade services	Provision of wholesale and retail trade services
43. Accommodation, hotels & cafes	Provisions of services relating to accommodation, meals and drinks
44. Road passenger transport	Provision of road transport services – passenger
45. Road freight transport	Provision of road transport services - freight
46. Rail passenger transport	Provision of rail transport services – passenger
47. Rail freight transport	Provision of rail transport services - freight
48. Water, pipeline & transport services	Provision of water transport services
49. Air transport	Provision of air transport services
50. Communication services	Provision of communication services
51. Financial services	Provision of financial services
52. Business services	Provision of business services
53. Dwelling services	Provision of dwelling services
54. Public services	Provision of government and community services
55. Other services	Provision of services not elsewhere classified
56. Private transport services	Provision of services to households from the stock of motor vehicles
57. Private electricity equipment services	Provision of services to households from the stock of electrical equipment
58. Private heating services	Provision of services to households from the stock of heating equipment

* For most of the industries identified in this table there is an obvious correspondence to one or more standard categories in the Australian and New Zealand Standard Industrial Classification (ANZSIC), 2006 version. The exceptions are: industries 32 to 38, which together comprise ANZSIC 26 *Electricity Supply*; industry 53, which is equivalent to the *Ownership of dwellings* industry in the industrial classification of the official Input/output statistics; and industries 56 to 58 which relate to the provision of services from the private stocks of motor vehicles, electrical equipment (not heating) and heating equipment.

Appendix D Summary of results

Foregone direct expenditure and value-added (2010 dollars, $ billions)

Economic indicator	Jurisdiction	2011-2035		2011-2060	
		Undiscounted	Discounted	Undiscounted	Discounted
Expenditure	NSW	16.4	5.1	401.9	29.7
	Australia	14.7	4.7	268.5	21.2
Value-added	NSW	3.9	0.1	113.1	8.1
	Australia	3.5	0.1	73.2	5.6

Note: Low, medium and high scenarios were developed to illustrate a range of possible futuresiIn relation to the demand for travel to Sydney. This report presents the medium scenario.
Note: Australia includes NSW
Source: Ernst & Young

Employment

The direct employment outcomes under the same medium scenario are presented below.

Foregone NSW direct employment 2011-2060

Economic indicator	2011 2035		2011 2060	
	Annual average	Cumulative total	Annual average	Cumulative total
FTE jobs	1,490	n/a	44,700	n/a

Source: Ernst & Young, medium scenario

Total impacts on the broader economy

Economic activity

Total (direct and indirect) economic impacts

Long-term total impacts on GSP and GDP (2010 dollars, $ billions)

Jurisdiction and economic indicator	2011-2035		2011-2060	
	Undiscounted	Discounted	Undiscounted	Discounted
NSW GSP	7.1	2.3	258.8	17.5
Australia GDP	17.7	6.0	747.5	34.0

Note: Low, medium and high scenarios were developed to illustrate a range of possible futures in relation to the demand for travel to Sydney. This report presents the medium scenario.
Note: Australia includes NSW
Source: Ernst & Young analysis of CoPS and MMRF, medium scenario

Long-term total impacts on real expenditure (2010 dollars, $ billions)

Jurisdiction and economic indicator	2011-2035		2011-2060	
	Undiscounted	Discounted	Undiscounted	Discounted
NSW	8.7	2.6	463.7	30.6
Australia GDP	26.9	8.9	838.6	59.5

Note: Australia includes NSW
Source: Ernst & Young analysis of CoPS and MMRF, medium scenario

NSW total economic impacts

Impact on foregone NSW expenditure and GSP (2010 dollars, $ millions)

	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Real expenditure	87	146	249	399	2,065	6,151	11,681	19,094	28,950	42,016
Real GSP	102	160	245	363	1,184	3,310	6,327	10,472	16,096	23,733

Source: Ernst & Young analysis of CoPS and MMRF, medium scenario
Note: Australia includes NSW

Australia-wide total economic impacts

Impact on foregone Australian expenditure and GDP (2010 dollars, $ millions)

	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Real expenditure	403	621	938	1,371	4,423	11,635	21,270	34,081	51,039	73,504
Real GDP (excluding NSW)	281	440	656	944	2,478	6,308	11,681	19,013	28,932	42,405

Note: negative results in the table above indicates years with a loss would not be experienced nationally
Note: Australia includes NSW
Source: Ernst & Young analysis of CoPS and MMRF, medium scenario

Employment

Foregone total employment 2011-2060

Economic indicator	2011 2035		2011 2060	
	Annual average	Cumulative total	Annual average	Cumulative total
NSW	400	n/a	12,700	n/a
Australia	600	n/a	17,300	n/a

Source: Ernst & Young analysis of CoPS and MMRF, medium scenario
Note: Australia includes NSW

Foregone NSW and Australian employment 2015-2060 (FTEs)

	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	80	139	257	431	2,938	8,731	16,302	26,329	39,583	57,048
Australia	124	213	382	628	3,975	11,757	22,015	35,681	53,834	77,879

Source: Ernst & Young analysis of CoPS and MMRF, medium scenario
Note: Australia includes NSW

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Flow-on impact of delay based on passenger, aircraft and associated services at Sydney (Kingsford-Smith) Airport

B8

FINAL REPORT

Joint Study on Aviation Capacity for the Sydney Region

Flow on Impact of Delay Based on Passenger, Aircraft and Associated Services at Sydney (Kingsford-Smith) Airport

Canberra

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Glossary of Terms

Expression	Definition
Airservices Australia data	Provides aircraft movements at specified airports
Airport Interconnectivity	The connectivity between airports; usually measured as the correlation between delays at different airports over the same period of time
Connecting Passenger	Passenger movements that stopover at an intermediary airport on route to their intended destination
GAT (Gate Arrival Time)	Time an aircraft arrives at an airport gate
GDT (Gate Departure Time)	Time an aircraft departs an airport gate
Hub Airport	An airport that offers multiple onward flight connections and is often a larger/capital city airport
Line of Flying	An aircraft's line of flying shows what the aircraft is doing over a schedule period
MCT	Minimum connect time which varies between airports and operations types (i.e. an international operation has a higher MCT as it physically takes longer to turn than a domestic aircraft)
MIDT	Market Information Data Tapes provides passenger ticketing data captured by the Global Distribution Systems (GDS), i.e. indirect passenger bookings
OAG	Official Airline Guide provides commercial airline schedule data
O-D Direct Passengers	Passenger movements that travel directly to their intended destination and do not stop on route (Direct Services)
O-D Market	Origin and Destination market is the country or city pairs where a passenger starts and ends their journey; any intermediary stops are not considered
Off-schedule Operation	Occurs when an aircraft arrives or departs an airport at a time other than the scheduled time and usually occurs due to a delay
Originating Delay	The first occurrence of a delay
OTP	On Time Performance; the measure of flight departures than are over 15 minutes late
Passenger movements	The arrival or departure of a passenger at an airport

Propagating Delay	The subsequent delay occurrences that are related to a specific Originating Delay
Recovery Module	A subset of a Delay Model that is dedicated to reducing the delay at subsequent scheduled rotations
Split Crewing (or Split Crew Scheduling)	Occurs when: ▪ The aircraft and crew do not follow one another on the next sector ▪ The pilots and the cabin crew split to fly on different aircraft on their next sector
SRS	SRS Analyser is an online tool allowing access to IATA's Schedule Reference Service (SRS). SRS is a neutral source of schedule data that collects, validates, consolidates and distributes airline flight schedules and related data for over 900 airlines worldwide.
Sydney (Kingsford-Smith) Airport	Kingsford Smith Airport (Sydney Airport)
Tail Number	Registration number of an aircraft

Important Note

Booz & Company has devoted its best professional efforts to this assignment and our findings represent our best judgment based on the information available.

In undertaking our analysis for Sydney (Kingsford Smith) Airport and other capital city airports, we have relied upon the information provided by all entities. While we have checked our sources of information, data and assumptions, we will not assume responsibility for the accuracy of such data, information and assumptions received from any entity.

This report was prepared for the exclusive use of the Department of Infrastructure and Transport, in advising the Steering Committee on the Joint Study on Aviation Capacity in the Sydney Region and in their advice to Government. The Report may be relied upon solely by Department of Infrastructure and Transport, Booz & Company disclaims all liability to any persons other than Department of Infrastructure and Transport for all costs, loss, damage and liability that the third party may suffer or incur arising from or relating to or in any way connected with the provision of the Report to a third party. You have agreed that you will not amend the Report without prior written approval from Booz & Company. If any person, company or Government Department or Agency, other than the Department of Infrastructure and Transport chooses to rely on the Report in any way, they do so entirely at their own risk.

Executive Summary

Sydney (Kingsford-Smith) Airport is strongly interconnected to other major Australian airports meaning that delays incurred at Sydney impact more broadly on the capacity of the national aviation system. Network delays can be caused by a number of factors such as bad weather conditions, mechanical problems and congestion. Delays at Sydney (Kingsford-Smith) Airport are reflected at other airports through connecting passenger journeys and the impact on daily aircraft rotations or aircraft 'lines of flying'. This interconnectivity means that Sydney (Kingsford-Smith) Airport is closer to its theoretical capacity than Sydney aircraft movements alone can show. Therefore, as Sydney (Kingsford-Smith) Airport nears capacity, instability in the system increases and the chance of recovering system delays is further reduced.

Passenger Connectivity at Sydney (Kingsford-Smith) Airport

The importance of Sydney (Kingsford-Smith) Airport as both an international gateway and a domestic transit point is shown in the levels of connecting passenger traffic; with 65% of international traffic travelling to/from Canberra flying over Sydney (Kingsford-Smith) Airport, 22% to/from Adelaide, 9% on both Melbourne and Brisbane and 5% on Perth. From a domestic perspective, 9% of the traffic travelling to/from Canberra flies over Sydney (Kingsford-Smith) Airport, 7% to/from Brisbane, and 4% to/from Melbourne, Perth and Adelaide.[1] This connectivity indicates that delays affecting Sydney (Kingsford-Smith) Airport will also affect other connecting airports and have compounding impacts on passengers. The effect to a passenger of missing a domestic-to-domestic connection at Sydney (Kingsford-Smith) Airport on average is an 86 minute delay.[2]

Interconnectivity of Airports due to Aircraft Rotations

Historical delay data shows there is a high level of correlation between delays at Sydney (Kingsford-Smith) Airport and the five other capital city airports modelled (Adelaide, Brisbane, Canberra, Melbourne and Perth). The 10 worst off-schedule days (i.e. in terms of delayed services) at Sydney (Kingsford-Smith) Airport for 2010 produced delay correlation levels ranging from 0.44 to 0.92 between Sydney and the other five capital city airports. The weighted average correlation across the five airports was 0.88; where a correlation level of 1.00 shows perfect correlation and 0.00 shows no correlation.[3] This demonstrates that the six Australian capital city airports are intrinsically linked.

The 'line of flying' model developed showed that simulated originating delays are reflected across the five other capital city airports. A simulated 30 minute delay incurred on a flight departing Sydney (Kingsford-Smith) Airport at different hours across the day generated additional delays of 6 to 60 minutes. This results in total delays of 118% and 210% of the originating delay minutes. For example, originating delays of 30 minutes per flight were simulated on each of the 24 flights departing between 0800 and 0900, which is 840 minutes (28 flights x 30 minute delays) of originating delays. The ripple effect of these delays through the network generates 1,764 total delay minutes or 210% of the 840 originating delay

1 Market Information Data Tapes (MIDT) data for 2010
2 Based on weighted average delay minutes for the top 5 O-D domestic markets connecting through Sydney KSA on 12 November 2010; MIDT and OAG data used
3 Airservices Australia departure data for the 10 worst off-schedule days at Sydney KSA in 2010 and the same days at Adelaide, Brisbane, Canberra, Melbourne and Perth airports was used to calculate the correlation coefficients

minutes. Therefore, we can now say when Sydney (Kingsford-Smith) Airport experiences 30 minute originating delays across one hour of operation, the full system of airports would generate 118% to 210% total delay minutes of the originating delay minutes.[4] Furthermore, if all the airports were at capacity then the total delays generated would increase to between 127% and 382% of the originating delay minutes at Sydney.

Alternative Operational Options for Sydney (Kingsford-Smith) Airport

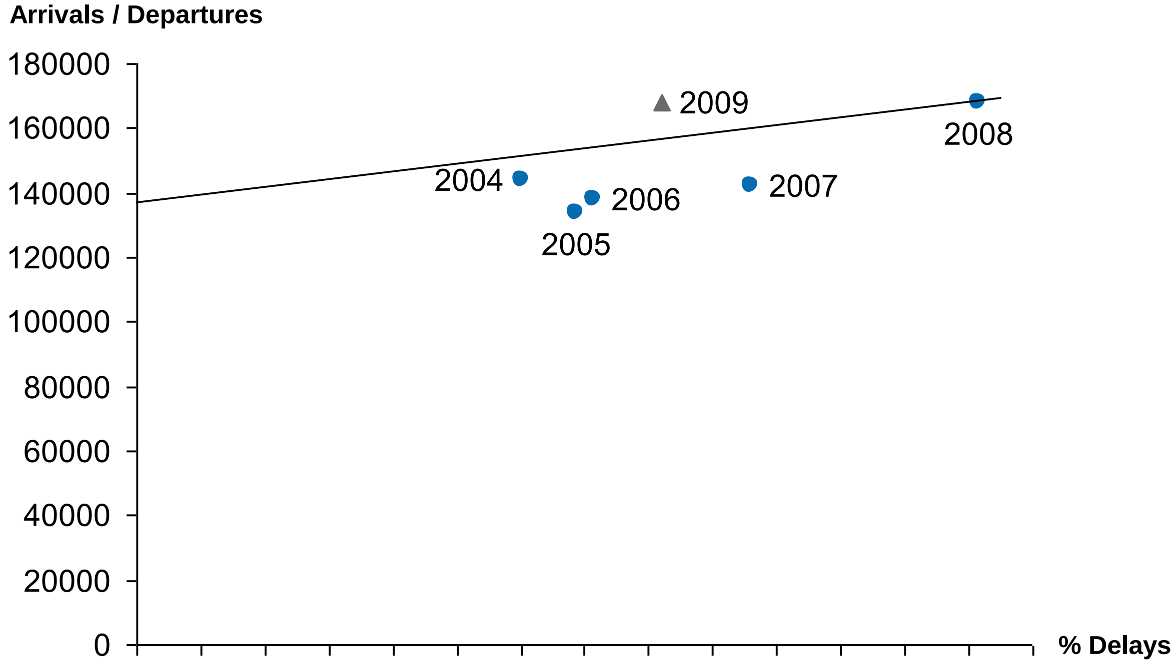
Hubs generate a concentration of traffic, which provides customer and operational benefits in terms of network connectivity and traffic consolidation, but as airports around the world become more congested hubs produce delays which can be more costly than offering direct point-to-point services. Therefore, as Sydney (Kingsford-Smith) Airport nears capacity, congestion will increase. Given airlines' immediate focus is on cost reductions in driving to more efficient operations, this will encourage airlines to convert hub services into direct point-to-point services to avoid the additional costs associated with the congested airport. Naturally, a number of other factors will drive the airline's decision to introduce new point-to-point services, with market demand being the key driver. Other benefits associated with non-stop flights that bypass hubs include faster turnaround time at airports, which would improve aircraft utilisation, and cost reductions as a result of not having to provide through service for connecting passengers, including baggage transfer and transit passenger assistance.

[4] *Airservices Australia data arrival and departure data by aircraft registration for a 'good' day (8 August) in 2010*

1. Introduction

With the exception of 2009, the proportion of aircraft movements experiencing delays at Sydney (Kingsford-Smith) Airport has steadily increased since the mid-2000s (see Figure 1 below). Therefore, as the airport continues to grow, congestion is expected to increase and become more of an issue. This operational impact on travel in and out of Sydney (Kingsford-Smith) Airport filters throughout the rest of the Australian airport network as flights are delayed. These delays, both on arrivals and departures, affect flights across the country and can mean an airport reaches practical capacity much sooner than when calculated with reference to forecasted passenger movements. Consequently, as Sydney (Kingsford-Smith) Airport becomes more congested, the airport could be expected to lose market share to other Australian airports due to airlines wishing to avoid delays at Sydney in additional to the unavailability of slots.

Figure 1 - Proportion of Delays vs. Number of Movements
Sydney Airport Domestic Operations, 2004 to 2009



Source: BITRE

Note: 2009 does not include all routes that were included in the data for the previous years

1.1 Delay impacts on secondary airports

The major capital city airports in Australia are intrinsically linked, meaning that delays accrued at Sydney (Kingsford-Smith) Airport impact other airports. These secondary impacts occur due to three possible operational effects:

1. **Aircraft delays** – with tight airline scheduling and high airport infrastructure utilisation rates, there is little room to absorb delays throughout the day, which causes further delays from aircraft running off-schedule and can potentially affect multiple airports;

2. **Passenger connections –** passengers on aircraft running off-schedule can miss connections or delay their connecting services which has the potential to affect multiple onwards services;

3. **Crew connections** (non-unit crew scheduling) – airlines often schedule crew and aircraft to split to gain productivity efficiencies, meaning that both the crew and aircraft can lead to multiple onwards delays.

Understanding the impact of delays on the existing aviation infrastructure and the role of other airports is essential to investigating the potential impacts of Sydney (Kingsford-Smith) Airport not being able to provide sufficient capacity to meet future demand.

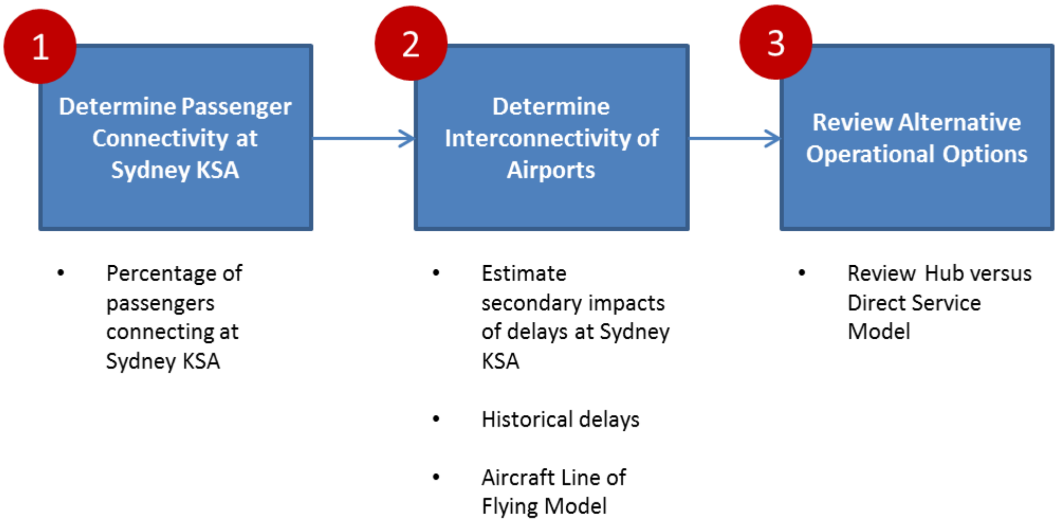
This analysis explores the flow on impact of delay based on passenger, aircraft and associated services at Sydney (Kingsford-Smith) Airport and focuses on understanding passenger connectivity levels at Sydney (Kingsford-Smith) Airport; the interconnectivity between six of the major capital city airports in Australia, by measuring the level of the correlation of delays between the airports; and tests this further by developing an aircraft rotation or 'line of flying' model to estimate the secondary impact of delays across the airport system. Options for reducing hub and interlinking activity at Sydney (Kingsford-Smith) Airport are also identified, taking into consideration the underlying operational and commercial drivers for hub operations and expected future trends in direct versus hub operations.

2. Approach

2.1 Overview

The approach adopted to investigate flow on delay impacts based on passenger, aircraft and associated services at Sydney (Kingsford-Smith) Airport , consisted of the following three major elements (see Figure 2 below):

Figure 2 - Overview of Approach



Source: Booz & Company

2.2 Scope of analysis

Our assessment of the flow on impact of delay based on passenger, aircraft and associated services at Sydney (Kingsford-Smith) Airport was conducted on the following dimensions:

- Historical delays were taken from Airservices Australia data for the 10 worst 'off - schedule' days at Sydney (Kingsford-Smith) Airport in 2010. Those days were:
  - 1 March 2010
  - 29 March 2010
  - 4 May 2010
  - 24 May 2010
  - 30 May 2010
  - 8 July 2010
  - 20 July 2010
  - 1 September 2010
  - 15 October 2010
  - 19 December 2010

- A 'line of flying' model of the combined individual aircraft rotations was built using Airservices Australia arrival and departure data for a 'good' operational day, which was defined as 8 August 2010. This model shows what each individual aircraft is doing on a daily basis (this is defined as a 'line of flying'), so a simulated delay that starts on one operation of an aircraft can be attributed to the rest of that aircraft's operations during the day.

The analysis included the following airports:

- Sydney (as an input to this analysis)
- Other capital city airports in Australia
  - Adelaide
  - Brisbane
  - Canberra
  - Melbourne
  - Perth

2.3 Passenger connectivity at Sydney (Kingsford-Smith) Airport

To understand the effect of passenger connectivity on delays, Marketing Information Data Tapes (MIDT) 2010 passenger data was analysed to determine the proportion of passenger connections that could be reflected in delays at the five capital city airports of Adelaide, Brisbane, Canberra, Melbourne and Perth from an originating delay at Sydney (Kingsford-Smith) Airport. The higher the proportion of passengers that use Sydney (Kingsford-Smith) Airport as a connection point, the larger the effect delays will have on the system.

To further the understanding of the impact of passenger delays due to congestion at Sydney (Kingsford-Smith) Airport, the effect on passengers missing a connection was investigated. The top five domestic O-D markets connecting over Sydney (Kingsford-Smith) Airport were analysed by analysing Official Airline Guide (OAG) schedule data to identify the next available flight for a missed connection, over a 24 hour period for 12 November 2010. The analysis assumed that a passenger who missed a connecting flight to their destination would have to wait for the next connecting flight to the same destination on the same airline[5]. The delay minutes were taken as the time difference between the two flights identified. Passengers having to overnight due to a missed connection were not included in this analysis.

An example is shown in Table 1 below, where the first possible connecting flight for the Qantas 0500 departure from Brisbane is the 0830 flight to Melbourne, if this is missed the passenger is delayed 30 minutes before being reaccommodated onto the Qantas 0900 flight departure to Melbourne (subject to seat capacity being available).

[5] *Airlines typically reaccommodate passengers on themselves to avoid the cost of purchasing a seat on another airline. Qantas and Jetstar were assumed to be the same airline for the purpose of this analysis.*

Table 1 - Example of Connection Times at Sydney (Kingsford-Smith) Airport

O D Market:	Brisbane Melbourne (via Sydney (Kingsford Smith) Airport)
Brisbane – Sydney	▪ 0500 departs Brisbane – 0735 arrives Sydney
Sydney – Melbourne	▪ 0830 departs Sydney to Melbourne = 55 min connection ▪ 0900 departs Sydney to Melbourne = 125 min connection ▪ 0930 departs Sydney to Melbourne = 155 min connection

Source: OAG data for 12 November 2010 and Booz & Company Analysis

2.4 Impact of delays at Sydney (Kingsford-Smith) Airport on other airports

2.4.1 Historical delays

The first step in understanding the impact of delays at Sydney (Kingsford-Smith) Airport on other airports was to investigate historical cases where significant delays have occurred and review these same days at the other airports to see if there is any connection.

Airservices Australia arrival and departure data for the 10 worst off-schedule days at Sydney (Kingsford-Smith) Airport were compared to the same 10 days at five other capital city airports in Australia. Ground delay minutes were calculated for each flight by taking the scheduled gate departure time from the actual gate departure time. The flights and their associated delay minutes were collated into hourly time bands across the day and the 10 days were added together by airport to give total delay minutes by hour and by airport.

To determine if the delays at Sydney (Kingsford-Smith) Airport impact the other airports, the level of correlation between airports was measured. A high correlation will show there is a strong connection between delays at the airport pair, whereas a low correlation will show a weak connection between delays for that airport pair.

2.4.2 Interconnectivity of airports

To understand the interconnectivity of airports, a 'line of flying' model was developed that utilised Airservices Australia arrival and departure data by aircraft tail number. The model built up each aircraft's line of flying by linking arrival and departure occurrences over the six capital city airports for a 24 hour period. This allowed simulated originating delays to be added at Sydney (Kingsford-Smith) Airport, which could then be reflected through each aircraft's line of flying to the other interconnected airports. These delays were measured to show the extent to which a delay at Sydney (Kingsford-Smith) Airport can affect other Australian airports.

Ground base delays are recovered by utilising 'spare' time on the ground at airports when the aircraft is turning to fly the next sector. Therefore, a 'recovery module' was also developed to simulate real world ground based recovery practices. It was assumed that the possible recovery time was the actual turn time of the aircraft less the higher of the average turn time for that airport and type of operation (i.e. international or domestic operations) or the industry standard 'Minimum Connect Time' (MCT). The MCT was used as this is a minimum standard that airlines and airports use; so the time between the MCT and the departure time is not available to reduce delays.

The difference between the flow on delays without any recovery (i.e. an airport with no capacity to turn an aircraft around in less time than the scheduled ground time) and those with recovery provide an indication of the future effect Sydney (Kingsford-Smith) Airport could have on other airports as it nears capacity.

2.5 Review options for alternative airline operations and assess their impact on Sydney (Kingsford-Smith) Airport

Alternative options for reducing hub and interlinking activity at Sydney (Kingsford-Smith) Airport were reviewed. Consideration was given to the underlying operational and commercial drivers for hub operations and recent trends in direct service versus hub operations.

3. Outcomes of Analysis

3.1 Introduction

This chapter is split into three sections:

- An examination of passenger connectivity at Sydney (Kingsford-Smith) Airport;
- An analysis of airport interconnectivity (i.e. airline schedule connectivity and the impact of delays at Sydney (Kingsford-Smith) Airport on other airports); and
- A consideration of alternative options for airline operations at Sydney (Kingsford-Smith) Airport.

3.2 Passenger connectivity at Sydney (Kingsford-Smith) Airport

To understand the effect of passenger connectivity on delays, MIDT full year 2010 traffic data was analysed to determine the proportion of passengers using Sydney (Kingsford-Smith) Airport as a connection point. This identified the extent to which passenger delays occurring at Sydney (Kingsford-Smith) Airport would affect other Australian airports.

In 2010, there were 2.5 million domestic passenger connections through Sydney (Kingsford-Smith) Airport.[6]

3.2.1 Domestic to Domestic connecting traffic

The importance of Sydney (Kingsford-Smith) Airport as a transit point for domestic passengers is shown in Table 2 below. Some 4% of passengers travelling domestically to or from Adelaide will travel through Sydney (Kingsford-Smith) Airport, while there is 7% travelling to or from Brisbane, 9% travelling to or from Canberra, and both Melbourne and Perth have 4% travelling through Sydney (Kingsford-Smith) Airport.

Table 2 - Domestic Passengers Connecting over Sydney (Kingsford-Smith) Airport, 2010

Airport	ADL	BNE	CBR	MEL	PER
Percentage of Passenger on route connecting over Sydney (Kingsford Smith) Airport	4%	7%	9%	4%	4%

Source: MIDT and Booz & Company Analysis

3.2.2 International to domestic connecting traffic

The importance of Sydney (Kingsford-Smith) Airport as a gateway to Australia for international passengers can be shown by determining the percentage of passenger traffic going to other Australian airports that connect over Sydney (Kingsford-Smith) Airport. Table 3 below shows the flows of international passenger traffic to five capital city airports in Australia via Sydney (Kingsford-Smith) Airport; with 65% of international traffic travelling to

[6] *MIDT data for full year 2010*

or from Canberra flying over Sydney (Kingsford-Smith) Airport, 22% to or from Adelaide, 9% on both Melbourne and Brisbane and 5% on Perth.

Table 3 - International Passenger Traffic Travelling to Capital City Airports via Sydney (Kingsford-Smith) Airport, 2010

Airport	ADL	BNE	CBR	MEL	PER
Percentage of Passenger on route connecting over Sydney (Kingsford Smith) Airport	22%	9%	65%	9%	5%

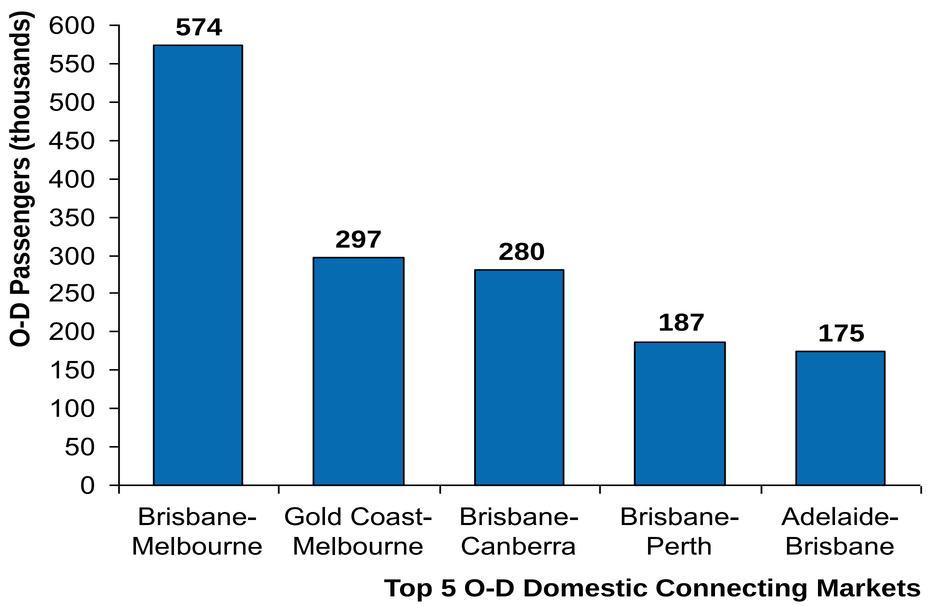
Source: MIDT and Booz & Company Analysis

Overall, this represents a high level of passenger connectivity at Sydney (Kingsford-Smith) Airport, indicating that passenger delays occurring at Sydney (Kingsford-Smith) Airport will affect the other capital city airports. Cities with more extensive international route networks, such as Melbourne, Brisbane and Perth have lower percentages of passengers travelling via Sydney (Kingsford-Smith) Airport as passengers are able to fly directly into these cities from outside of Australia.

3.3 Effect of missed connections on passengers

The top five domestic O-D markets connecting over Sydney (Kingsford-Smith) Airport (see Figure 3), which represent 61% of total domestic connecting traffic[7], were analysed over a 24 hour period (12 November 2010) to determine the effect of a missed connection on a passenger.

Figure 3 -Top 5 Domestic O-D Markets Connecting through Sydney KSA



Source: MIDT 2010 and Booz & Company Analysis

[7] *MIDT data for full year 2010*

The results of the analysis of missed connections at Sydney are shown in Table 4 below. The average effect of a passenger missing a connection in Sydney (Kingsford-Smith) Airport is a delay of 93 minutes. This is the weighted average of delay minutes over all the airlines and the top 5 domestic O-D markets connecting through Sydney (Kingsford-Smith) Airport.

Table 4 - Average Delay Minutes for Passenger Missed Connections [(1)]

O D Markets	Qantas & Jetstar	Virgin Australia	Tiger Airways	Average
Brisbane – Melbourne	37	58	(2)	48
Melbourne – Brisbane	60	60	160	93
Gold Coast – Melbourne	61	83	130	91
Melbourne – Gold Coast	92	60		76
Brisbane – Canberra	73	314		194
Canberra – Brisbane	53	60		56
Brisbane – Perth	158	190		174
Perth – Brisbane	69	60		65
Adelaide – Brisbane	64	60		62
Brisbane – Adelaide	101	175		138
Average weighted by O-D passengers	**69**	**100**	**145**	**93**

Source: OAG data for 12 November 2010 and Booz & Company Analysis

Notes:

(1)The analysis does not include passengers that had to stay overnight as a result of missing a connection

(2)Tiger Airways had no Brisbane-Sydney service on our analysis date of 12-Nov-2010

3.4 Airline schedule connectivity and the impact of delays at Sydney (Kingsford-Smith) Airport on other airports

3.4.1 Historical delays

To understand the impact of delays at Sydney (Kingsford-Smith) Airport on other major Australian airports the ten worst ‘off-schedule’ days in 2010 across six capital city airports in Australia was investigated.

Figure 4 below shows the delay minutes for the 10 worst ‘off-schedule’ days in 2010, by time-of-day across six capital city Australian airports (i.e. Adelaide, Brisbane, Canberra, Melbourne, Perth and Sydney). Similar delay patterns are apparent across all airports indicating that the interconnectivity of aircraft scheduling intrinsically links the airports together.

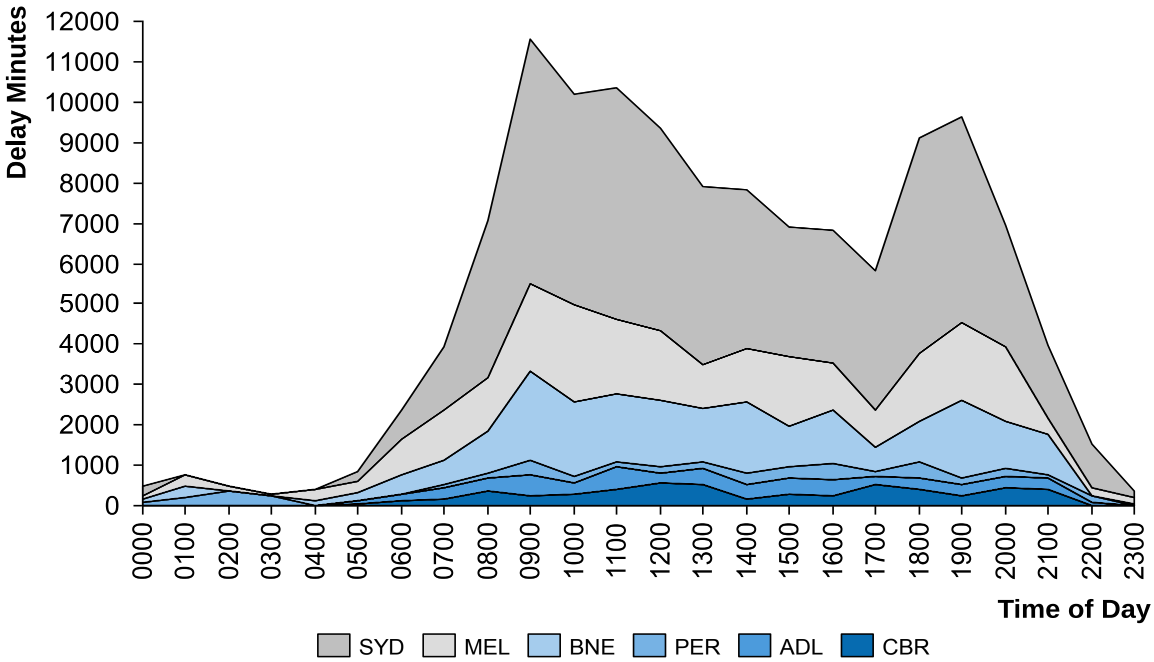


Figure 4 - Delay Minutes for 6 Capital City Airports over the Worst 10 Off-Schedule Days in 2010

Source: Airservices Australia and Booz & Company Analysis

This interrelationship can be measured by calculating the correlation between the hourly delay minutes at Sydney (Kingsford-Smith) Airport and the five other capital city airports, showing the level of impact that delays from one airport may have on the others. Correlation levels range from 0.00 to 1.00 on a sliding scale, where 0.00 indicates no impact and 1.00 indicates a total knock on effect of delays from Sydney to the other airport.

There is a high correlation between the delay minutes of Sydney (Kingsford-Smith) Airport and Brisbane (0.92), Melbourne (0.90), Adelaide (0.86) and Canberra (0.77) airports (see Table 5 below). Perth shows a relatively weak correlation (0.42). This is not unexpected as Perth is considerably further away than the other airports and has less connecting traffic travelling through Sydney than the other airports.

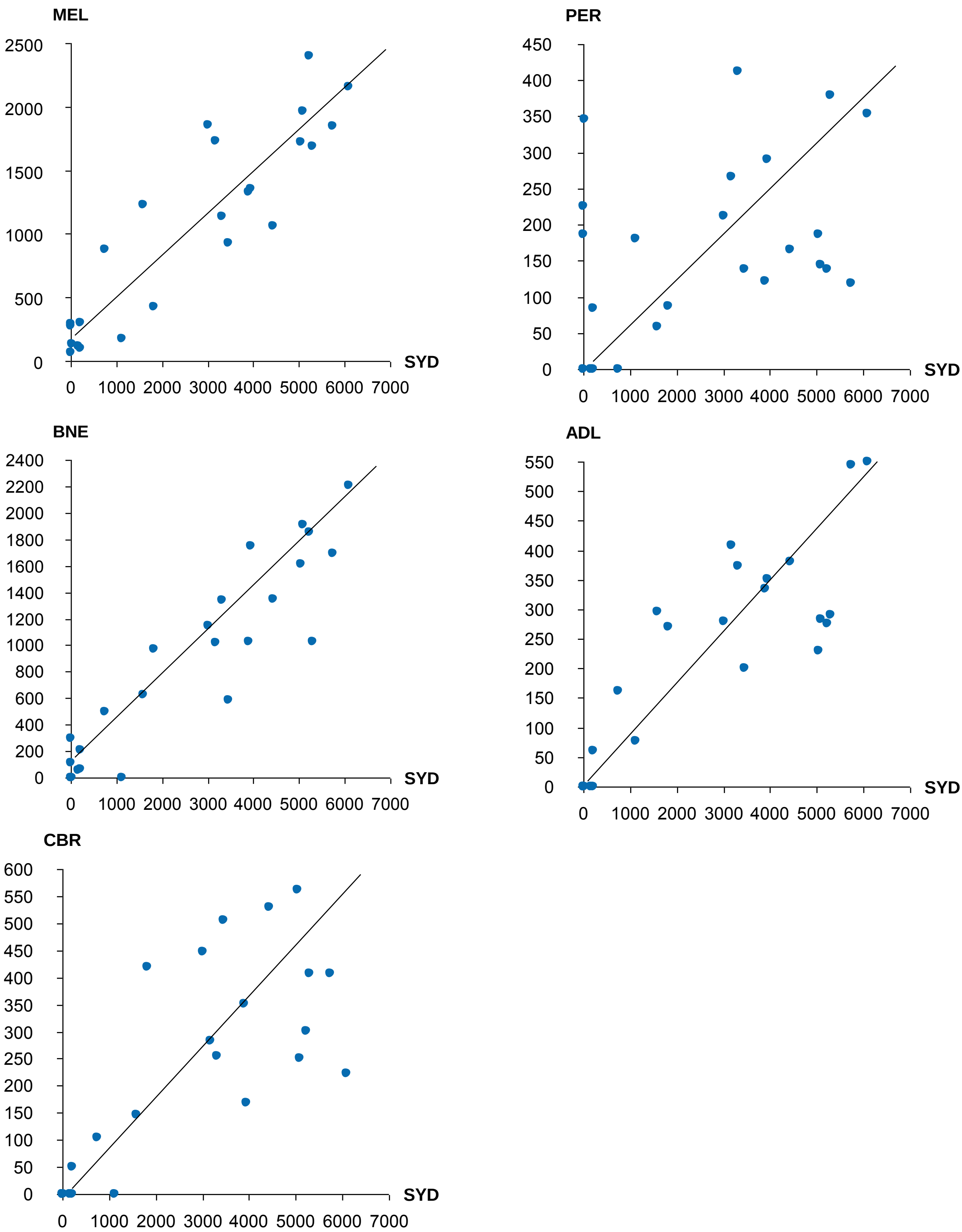
Table 5 - Summary of Correlation of Delays between SYD and other Capital City Airports

Airport	ADL	BNE	CBR	MEL	PER
Correlation	0.86	0.92	0.77	0.90	0.42

Source: Airservices Australia and Booz & Company Analysis

The correlation charts shown in Figure 5 plot the correlation between each of the five capital city airports and Sydney (Kingsford-Smith) Airport.

Figure 5 - Correlation between Sydney (Kingsford-Smith) Airport and other Capital City Airports



Source: Airservices Australia and Booz & Company Analysis

3.4.2 *Interconnectivity of airports*

With tight airline scheduling and high airport infrastructure utilisation rates, there is little room to absorb delays throughout the day. As an airport nears capacity it is more likely that delays originating at that airport will have a knock on effect through the entire system of airports. To understand this interconnectivity, a 'line of flying' model was developed where Airservices Australia airport arrival and departure data was linked together by tail number to create the system of aircraft rotations or the entire network of aircraft lines of flying for the six major capital city airports in Australia (i.e. Sydney, Adelaide, Brisbane, Canberra, Melbourne and Perth) over a 24 hour period.

Applying this 'line of flying' model, the impacts of simulated originating delays at Sydney (Kingsford-Smith) Airport are reflected through the network of airports modelled by tail number. So a delay that starts on an aircraft departing Sydney (Kingsford-Smith) Airport will follow that aircraft throughout the day to other airports in its line of flying, until the delay time can be recovered (where possible).

The recovery module reduces delay minutes through any surplus ground time and it is assumed that delays cannot be reduced from flying faster, as flight plan and air traffic management was not modelled. Table 6 below provides an example for an aircraft commencing operations with a Sydney to Brisbane (SYD-BNE) sector on 8 August 2010.

Table 6 - Illustrative Example of the Recovery Module in the Line of Flying Model

Flight Number	Sector	Gate Departure Time Actual	Gate Arrival Time Actual	Aircraft Turn Time	Delays without recovery		Delays with recovery	
					Originating	Propagating	Originating	Propagating
Units		**UTC**	**UTC**	**Minutes**	**Minutes**	**Minutes**	**Minutes**	**Minutes**
QF516	SYD-BNE	0003	0141	0	30	**0**	30	**0**
QF525	BNE-SYD	0250	0422	69	0	**30**	0	**27**
QF443	SYD-MEL	0608	0749	106	0	**30**	0	**0**
QF496	MEL-SYD	0832	0953	43	0	**30**	0	**0**
				Total Delays	**120**		**57**	

Source: Airservices Australia and Booz & Company Analysis

Table 6 shows an originating delay of 30 minutes on QF516's first sector of the day out of Sydney (Kingsford-Smith) Airport. Without the recovery module this 30 minute delay has a knock on effect through all the airports that this aircraft flies to during this day, giving a total of 120 minutes on the four rotations it makes and affects Sydney (30 minutes), Brisbane (30 minutes) and Melbourne (30 minutes) airports.

With the recovery module, the 30 minute originating delay still occurs out of Sydney (Kingsford-Smith) Airport, the aircraft makes a 69 minute ground turn in Brisbane before heading back to Sydney. The average turn time in Brisbane for a domestic sector is 66 minutes[8], so assuming the aircraft can improve the 69 minute turn time to the average for a

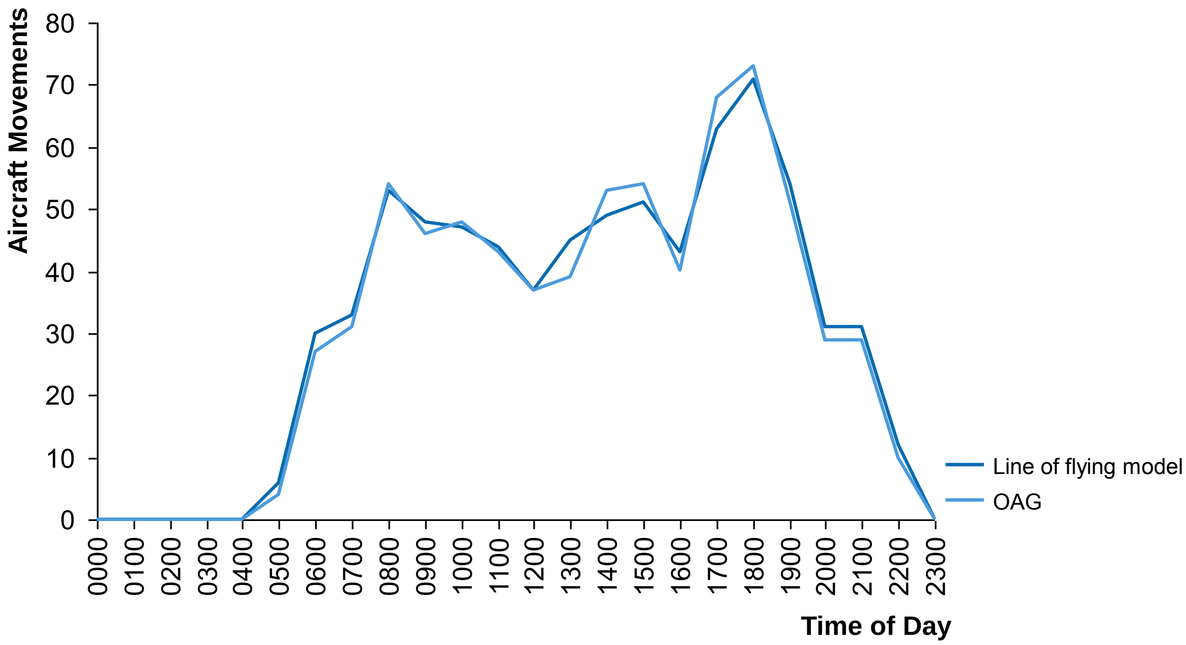
[8] *Booz & Company's Line of Flying Model using Airservices Australia data for 8 August 2010*

domestic Brisbane sector the aircraft can make up 3 minutes of the delay (69 minutes less 66 minutes). Now the aircraft is running 27 minutes 'off-schedule'. On the next ground turn in Sydney (Kingsford-Smith) Airport, the aircraft has a scheduled turn time of 106 minutes, and Sydney (Kingsford-Smith) Airport has an average domestic turn time of 63 minutes, so the aircraft can recover up to 43 minutes of delay. This means the 27 minutes of delay that this aircraft has been carrying can be made up by shortening this turn in Sydney and the aircraft is now back on schedule.

The modelling undertaken shows the knock on effect of delays in Sydney (Kingsford-Smith) Airport and their impact on other airports. What the modelling does not cover is the further knock on effects of delays due to passenger connections and airline non-unit crewing (where the aircraft and crew might split, potentially doubling the knock on delays through the system).

The accuracy of the Airservices Australia data and the 'line of flying' model can be shown by matching the number of movements calculated by the model to the number of movements shown in the industry standard data set for airline schedules, the Official Airline Guide (OAG). Figure 6, shows Sydney (Kingsford-Smith) Airport's modelled movements for 8 August 2010 versus the movements for the same day from OAG. The number of movements the model calculates across the day very closely approximates OAG indicating that it closely predicts the 'real world'.

Figure 6 - Comparison between Aircraft Movements Generated by the Line of Flying Model and Sourced from OAG



Source: Airservices Australia data and Booz & Company Model versus OAG data and Booz & Company Analysis

3.4.3 *Scenario analysis based on delays at Sydney (Kingsford-Smith) Airport between 0800 and 0900*

To determine the range of knock on delays, the following scenarios were analysed based on simulated originating delays at Sydney (Kingsford-Smith) Airport, where it was assumed that there were widespread delays across the airport between 0800 and 0900:

- Scenario 1 – 15 minute delays on all arriving and departing flights
- Scenario 2 – 30 minute delays on all arriving and departing flights
- Scenario 3 – 45 minute delays on all arriving and departing flights

The analysis captured all minutes of delay, not just delay minutes greater than 15 as in On Time Performance (OTP) metrics.

3.4.3.1 Scenario 1 – 15 minute delays

Table 7 below shows the impact of 15 minute flight delays out of Sydney (Kingsford-Smith) Airport on the 28 flights between 0800 and 0900. There is a total of 420 minutes simulated originating flight delays, which are reflected through the system and create an additional 1,185 delay minutes; spread over Adelaide (4%), Brisbane (9%), Canberra (9%), Melbourne (16%), Perth (3%) and Sydney (59%) airports. This means that the total system delay of 1,605 minutes is 382% of the originating delay. This would be representative if Sydney (Kingsford-Smith) Airport was already at capacity, however, with recovery available the knock on delay minutes can be reduced by 693 to 492 minutes or 117% of the originating delay minutes. This is consistent with total delay minutes (including recovery) of 912 which is 217% of the originating delay minutes at Sydney (Kingsford-Smith) Airport.

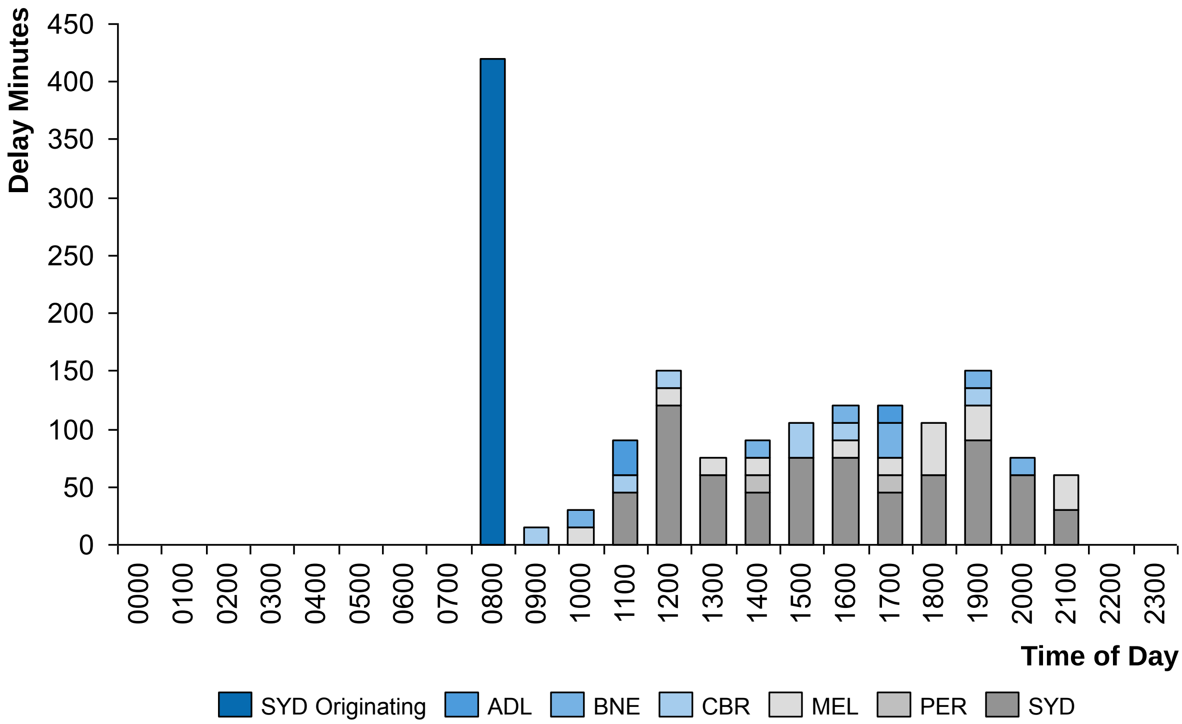
Table 7 - Delay Minutes from 15 Minute Originating Delays at Sydney (Kingsford-Smith) Airport between 0800 and 0900

PORT	Originating Delay Minutes (ODM)	Propagating Delay Minutes (PDM)	PDM with Recovery (PDMW)	Recovery Minutes	PDM Split by Port	PDMW Split by Port
SYD	420	705	366	339	59%	74%
ADL	0	45	0	45	4%	0%
BNE	0	105	55	50	9%	11%
CBR	0	105	13	92	9%	3%
MEL	0	195	58	137	16%	12%
PER	0	30	0	30	3%	0%
TOTAL	**420**	**1,185**	**492**	**693**	**100%**	**100%**
% of ODM		**282%**	**117%**			

Source: Airservices Australia data and Booz & Company Analysis

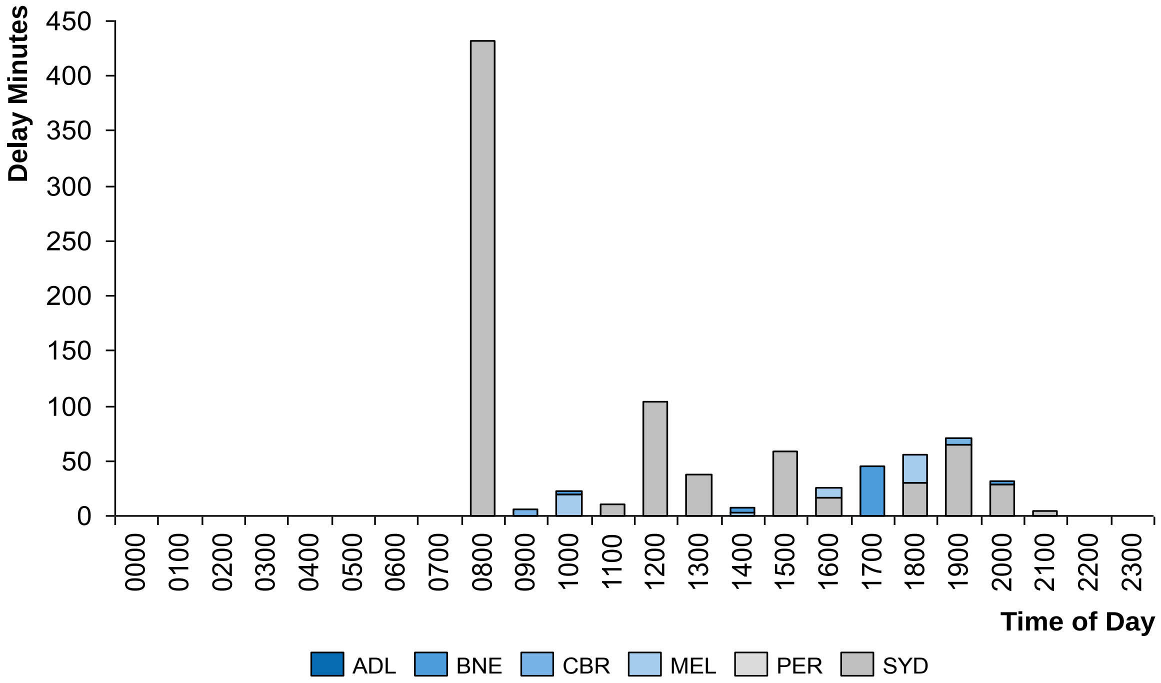
Figure 7 and Figure 8 show these delays graphically. 15 minute delays on flights between 0800 and 0900 produce knock on delays until 2200 and affect four of the six modelled airports: Brisbane (11% of originating Sydney delay minutes with recovery), Canberra (3%), Melbourne (12%) and Sydney (Kingsford-Smith) Airport (74%). Interestingly, all airports are able to reduce their delays significantly with Sydney (Kingsford-Smith) Airport and Brisbane recovering 48% of their delay minutes, Canberra 88%, Melbourne 70% and Adelaide and Perth 100%.

Figure 7 - Delay Minutes from 15 Minute Originating Delays at Sydney (Kingsford-Smith) Airport between 0800 and 0900



Source: Airservices Australia data and Booz & Company Analysis

Figure 8 - Delay Minutes with Recovery from 15 Minute Originating Delays at Sydney (Kingsford-Smith) Airport between 0800 and 0900



Source: Airservices Australia data and Booz & Company Analysis

3.4.3.2 Scenario 2 – 30 minute delays

Table 8 below shows the impact of 30 minute flight delays out of Sydney (Kingsford-Smith) Airport on the 28 flights between 0800 and 0900.

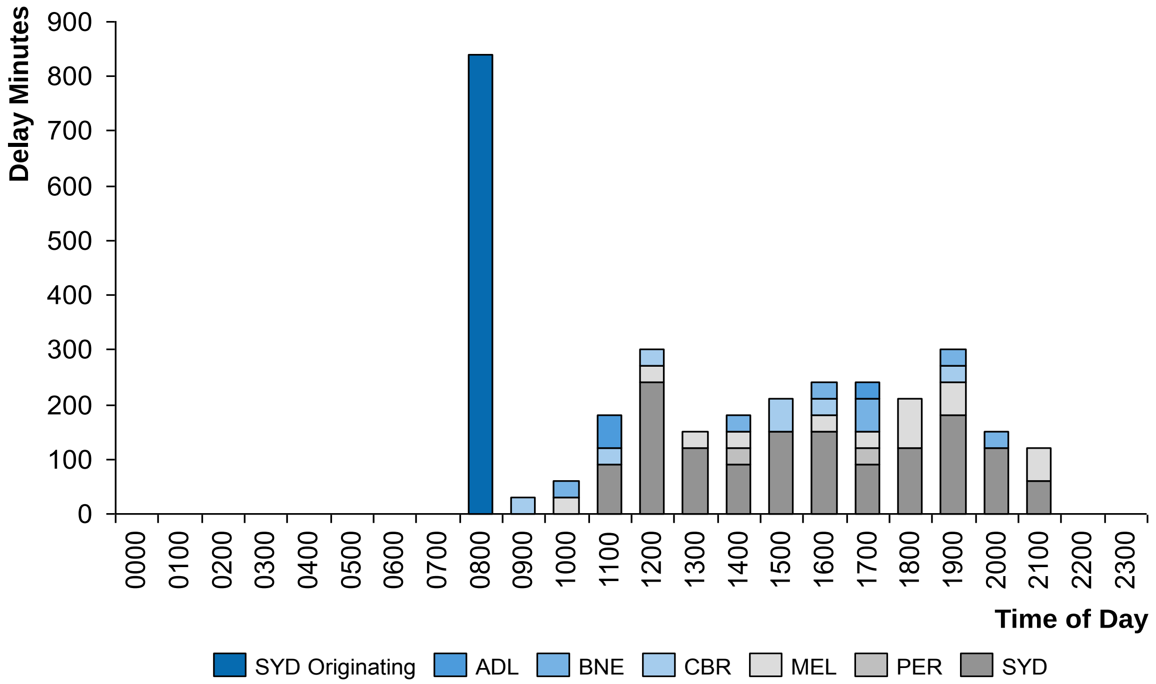
Table 8 - Line of Flying Model – 30 Minute Originating Delays at Sydney (Kingsford-Smith) Airport between 0800 and 0900

PORT	Originating Delay Minutes (ODM)	Propagating Delay Minutes (PDM)	PDM with Recovery (PDMW)	Recovery Minutes	PDM Split by Port	PDMW Split by Port
SYD	840	1,410	658	752	59%	71%
ADL	0	90	15	75	4%	2%
BNE	0	210	100	110	9%	11%
CBR	0	210	46	164	9%	5%
MEL	0	390	105	285	16%	11%
PER	0	60	0	60	3%	0%
TOTAL	**840**	**2,370**	**924**	**1,446**	**100%**	**100%**
% of ODM		**282%**	**110%**			

Source: Airservices Australia data and Booz & Company Analysis

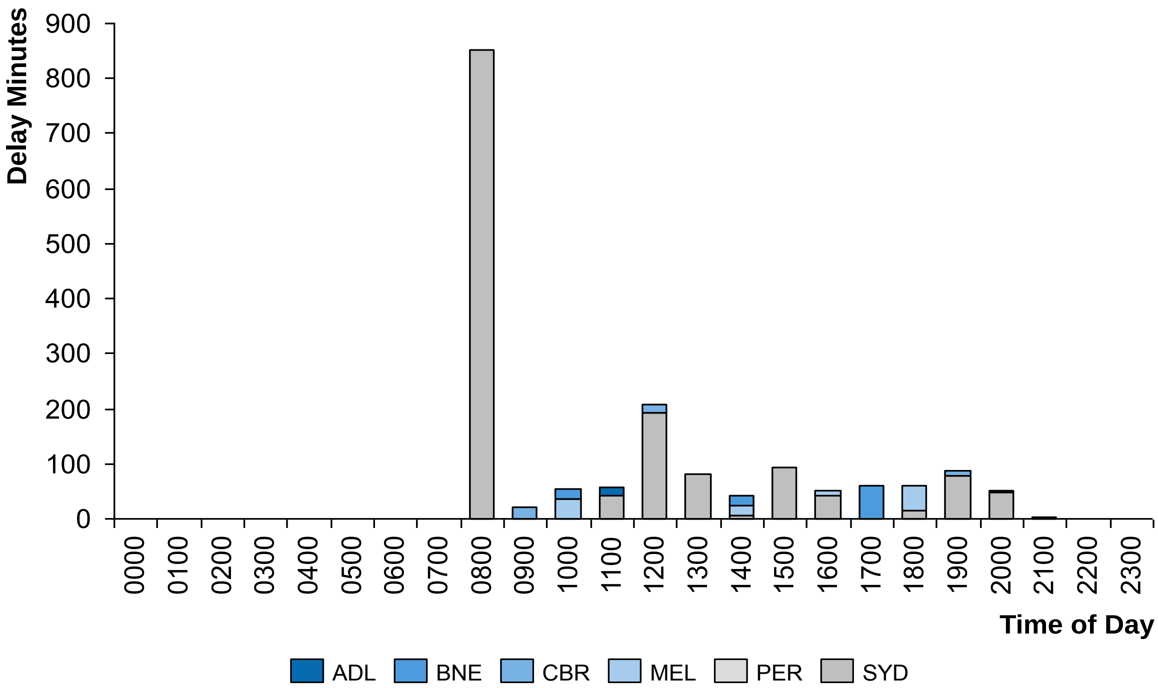
Figure 9 and Figure 10 show these delays graphically.

Figure 9 - Delay Minutes from 30 Minute Originating Delays at Sydney (Kingsford-Smith) Airport between 0800 and 0900



Source: Airservices Australia data and Booz & Company Analysis

Figure 10 - Delay Minutes with Recovery from 30 Minute Originating Delays at Sydney (Kingsford-Smith) Airport between 0800 and 0900



Source: Airservices Australia data and Booz & Company Analysis

3.4.3.3 Scenario 3 – 45 minute delays

Table 9 below shows the impact of 45 minute flight delays out of Sydney (Kingsford-Smith) Airport on the 28 flights between 0800 and 0900.

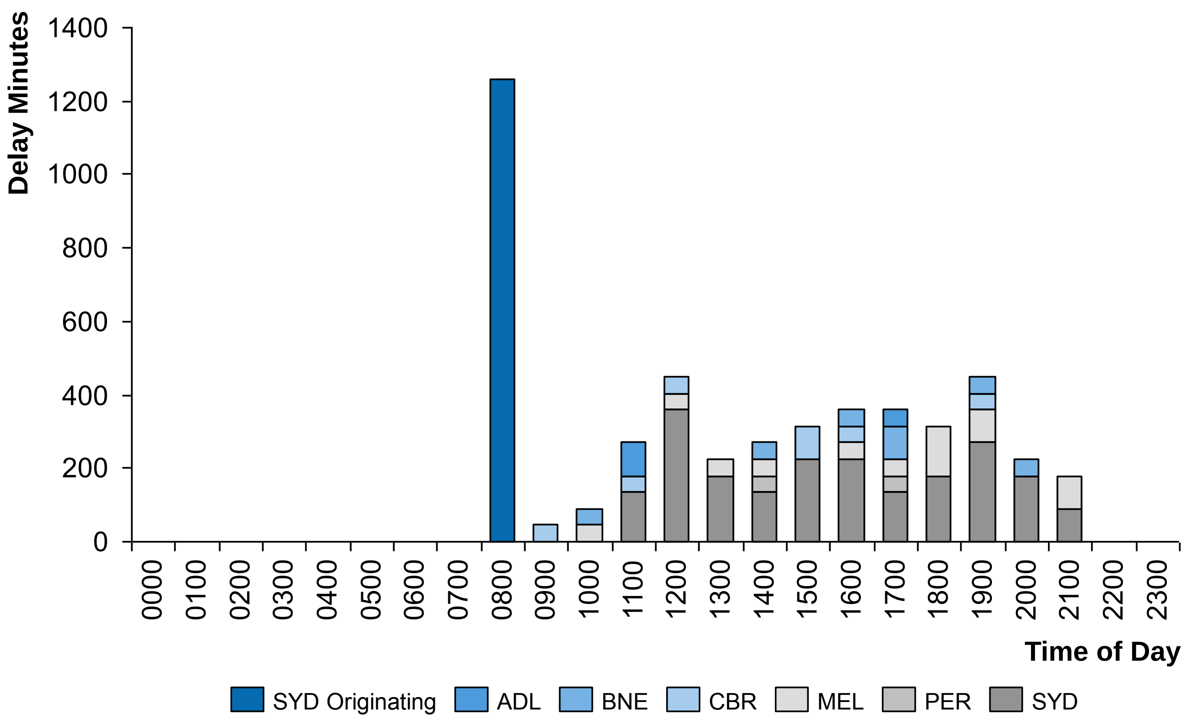
Table 9 - Line of Flying Model – 45 Minute Originating Delays at Sydney (Kingsford-Smith) Airport between 0800 and 0900

PORT	Originating Delay Minutes (ODM)	Propagating Delay Minutes (PDM)	PDM with Recovery (PDMW)	Recovery Minutes	PDM Split by Port	PDMW Split by Port
SYD	1,260	2,115	1,088	1,027	59%	70%
ADL	0	135	42	93	4%	3%
BNE	0	315	148	167	9%	10%
CBR	0	315	102	213	9%	7%
MEL	0	585	165	420	16%	11%
PER	0	90	0	90	3%	0%
TOTAL	**1,260**	**3,555**	**1,544**	**2,011**	**100%**	**100%**
% of ODM		**282%**	**123%**			

Source: Airservices Australia data and Booz & Company Analysis

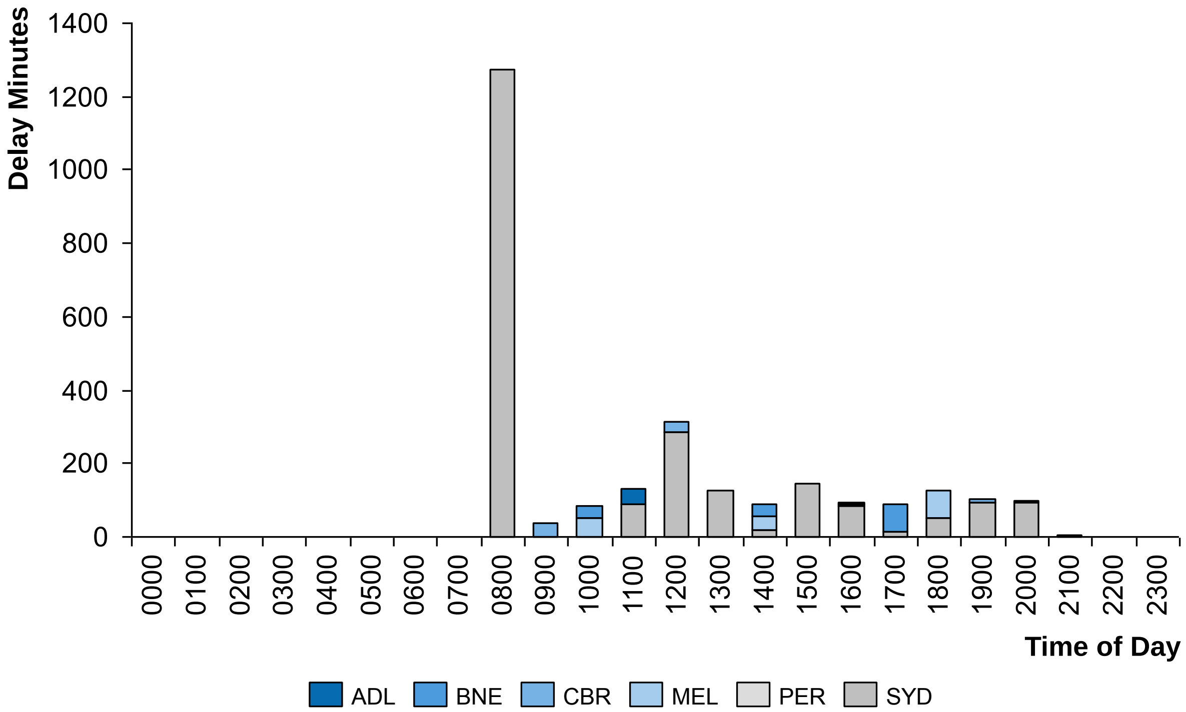
Figure 11 and Figure 12 below show these delays graphically.

Figure 11 - Delay Minutes from 45 Minute Originating Delays at Sydney (Kingsford-Smith) Airport between 0800 and 0900



Source: Airservices Australia data and Booz & Company Analysis

Figure 12 - Delay Minutes with Recovery from 45 Minute Originating Delays at Sydney (Kingsford-Smith) Airport between 0800 and 0900



Source: Airservices Australia data and Booz & Company Analysis

3.4.4 Effect of originating delays over a day

By analysing a number of scenarios across a day the impact from delays at Sydney (Kingsford-Smith) Airport to other Australian airports were estimated. Table 10 below indicates that total system delay minutes range from 118% to 210% of the originating delay at Sydney.

What is also shown is that if airports are at already at capacity and therefore have no chance to recover delays then this range increases to 127% to 382%.

For example: 1,000 minutes of originating delays across the day at Sydney (Kingsford-Smith) Airport would generate between 1,118 and 2,100 delay minutes across all airports (or 118% to 210% of the originating delay minutes). As Sydney (Kingsford-Smith) Airport nears capacity delay minutes could increase up to 3,820 delay minutes.

Table 10 - Scenario Analysis: 30 Minute Originating Delays on Flights Departing Sydney (Kingsford-Smith) Airport at Different Points During the Day

Time of Day	SYD Originating Delay	Propagating Delay Minutes with Recovery (PDMWR)						Total System Delay	Delay Minutes per Originating Delay	Delay Minutes with No Recovery
		ADL	BNE	CBR	MEL	PER	SYD			
0800-0900	840	15	100	46	105	0	658	1,764	**210%**	**382%**
1000-1100	780	0	102	87	96	0	174	1,239	**159%**	**258%**
1200-1300	720	52	35	53	156	0	458	1,474	**205%**	**279%**
1400-1500	780	7	100	25	59	0	262	1,232	**158%**	**208%**
1600-1700	600	10	54	30	42	0	114	850	**142%**	**160%**
1800-1900	1,110	0	62	21	92	0	24	1,309	**118%**	**127%**

Source: Airservices Australia data and Booz & Company Analysis

3.5 Alternative options for airline operations at Sydney (Kingsford-Smith) Airport

Airlines build hub networks to generate operational efficiencies and give passengers a larger choice of destinations. Hubs work on economies of scale and concentrate traffic by connecting flights together over a single point where there is the opportunity to fill flights with a few passengers coming off many other flights. Concentrating traffic is a good use of scarce resources under uncongested conditions. However, as airports become more and more congested, the hub model can become increasingly commercially unattractive from an airline perspective at the margin due to the cost of delays and the cost of delays can outweigh the benefits of a hub. The major benefits and drawbacks are:

(a) Benefits

- Increased options for passengers, for example: in a system with 10 destinations, the hub design requires only 9 routes to connect all destinations, while a true point-to-point system would require 45 routes;
- Aircraft are more likely to fly at full capacity, and can often fly routes more than once a day;
- Complicated operations may be centralised at the hub, rather than at every node – e.g. aircraft maintenance and crew basing;
- New service additions to the hub are simple, and can be created easily;
- Passengers may find the network more intuitive. Scheduling is convenient for them since there are few routes, with frequent services.

(b) Drawbacks

- Centralisation builds relative inflexibility into day-to-day operations. Changes at the hub, or even in a single route, could have unexpected consequences throughout the network.

It may be difficult or impossible to handle occasional periods of high demand between two nodes;

- Route scheduling is complicated for the airline. Scarce resources must be used carefully to avoid starving the hub. Careful traffic analysis and precise timing are required to keep the hub operating efficiently;

- The hub constitutes a bottleneck or a single point of failure in the network. Total capacity of the network is limited by the hub's capacity. Delays at the hub (caused, for example, by bad weather conditions) can result in delays throughout the network. Delays at a spoke (from mechanical problems with an aircraft, for example) can also affect the network;

- Passenger journeys must pass through the hub before reaching their destination, requiring longer than direct point-to-point trips. This trade-off may be desirable for freight, which can benefit from sorting and consolidating operations at the hub, but not for time-critical cargo and passengers;

- Two flights are required to reach most of the destinations. Landing on the hub and spending some time there increases the duration of the journey (safety screening may be necessary again before boarding the second plane). It also introduces the risk of passengers' missing the connecting flight and this may be more troublesome than just a flight delay.[9]

Recent studies have shown that there are significant monetary gains to be obtained from cutting back on hub flights in favour of direct services, and that the additional costs and lost revenue from delays contribute significantly to this effect. As hub congestion increases, delays will increase.[10]

Therefore, this acts as a natural foil as airports near capacity in that airlines will attempt to find ways to reduce costly delays. For Sydney (Kingsford-Smith) Airport, this is likely to mean that airlines may seek to reduce the proportion of connecting flights and introduce more direct services. This would be a commercial decision for airlines based on the commercial sustainability of direct routes based on demand and subject to a variety of factors including those identified above; for example, the connectivity needs of regional or international services may differ from the analysis of domestic services identified here. These issues have been considered to the extent possible in the analysis by Booz & Company.

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[9] *Babcock, B. A., 2002, Making Sense of Cities: A Geographical Survey, London: Arnold, pp. 63–94; Lawrence, H., 2004, "Aviation and the Role of Government", pp. 227–230; and Markusen, A., 1996, "Sticky Places in Slippery Space: A Typology of Industrial Districts", in Economic Geography, 72: 293–313.*

[10] *Terran Melconian, Effects of Increased Nonstop Routing on Airline Cost and Profit, MIT Masters paper, September 2001*