

Heathrow Airport

R3 NW MDL Easterly TAAM Modelling

Modelling Results

Version 2.0

13 June 2014

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Version History:

Version 1.0	Original Document (8 th April 2014)
Version 1.1	Apron names updated on Slides 32 and 34 (17 th April 2014)
Version 2.0	All results updated following simulation re-runs with revised apron allocations

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Caveats

- Simulation tools offer a 'first cut' assessment of operational scenarios. Changes to operations must not be implemented without first completing all appropriate actions, which may include further analytical assessment, real-time simulation, operational trials, safety assessment and obtaining regulatory approval
- When interpreting results from simulation models, please note that models generally present an optimistic view of operations because events such as aircraft technical problems, pilot-ATC communication errors, variation in pilot performance, weather and slot compliance are not modelled
- It should be noted that whilst every effort has been made to ensure that the modelled scenarios are as representative of real life as is possible, fast-time computer simulations can never predict future ATM operations with 100% certainty. Any business decisions made based on the outputs of such modelling need to take these uncertainties into account as well as all assumptions made during the modelling process

Executive Summary

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Executive Summary (1)

- > This study was carried out to investigate Heathrow operations with a 3rd runway located to the North-West in Easterly MDL mode
- > A schedule with 740k movements per year was modelled
- > The key findings of this study are:
 - > Runway throughput rates consistently over 120 movements per hour were achieved, averaging 127 per hour between 07:00 and 21:59
 - > In order to achieve these levels of throughput, runway balancing and demand smoothing measures were applied to the schedule:
 - > Almost all Super and many Heavy departures were moved from 09C to 09L in order to reduce the number of wake turbulence separations applied
 - > In hour smoothing was applied to 09C and 09L departures in order to ensure an even level of demand in each half hour and in each ten minute period
 - > An imbalance of departure delay between 09C (lower) and 09L (higher) suggests that further departure balancing could be carried out to achieve similar levels of delay on both runways
 - > Arrival and departure taxi times varied widely depending on the terminal and runway combination. There may be opportunities to change runway assignments to reduce taxi times
 - > Traffic generally flowed well around the layout, but a number of areas that showed relatively high interaction counts and high delays have been identified
 - > In this configuration (MDL, E) it is important to manage the allocation of traffic to the north and south holding points on 09C depending on demand
 - > 09C northern holding points can obstruct some T6 apron stands

Executive Summary (2)

Comparing the Easterly 740k and Westerly 740k models showed:

- › Taxi times and arrival delay were largely similar
- › Runway 09C departure delay was lower and departure throughput higher in the Easterly mode of operation. This was due to the increased flexibility offered by more holding points

Comparing the Easterly 740k models with the T5N stands (stands 501, 502, 503 and 505) open and closed showed:

- › Overall, the effects of opening the T5N stands were slight
- › The most substantial differences in performance metrics were confined to the T5A Apron, where the T5N stands are present
- › Arrival and departure taxi times for the T5A Apron decreased slightly when the T5N stands were opened
- › The number of conflicts in the 09C holding point did not increase
- › The level of delay on taxiway Bravo adjacent to the T5N stands increased due to aircraft pushing back; however this did not effect runway throughput
- › T5A Apron gate delay decreased from opening the T5N stands. However, Stands 503 and 505 had the highest level of pushback delay in the T5N stand group as they were closest to taxiway Bravo and the A13 hold queue

Modelling Configuration - Easterly with T5N Stands closed

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Modelling Assumptions

- The assumptions are inherited from the Westerly model
(LHR_TAAM_R3_NW_MDL_W_Results_v2.0.pdf)
- The following slides show the runway performance, taxi flow and ATM procedure assumptions that differ for the Easterly models

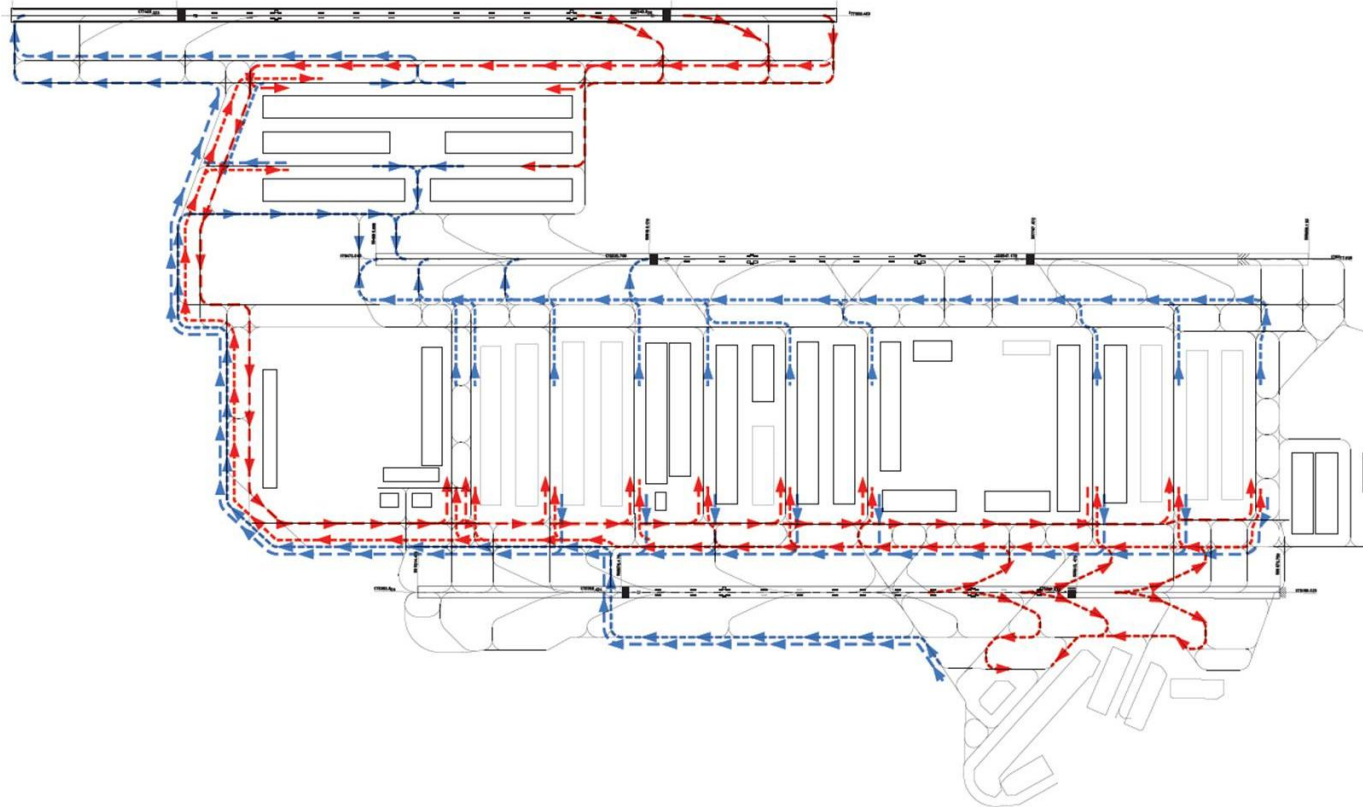
Expected Taxiway Flows

Diagram supplied by Mott MacDonald

Departures (Blue)

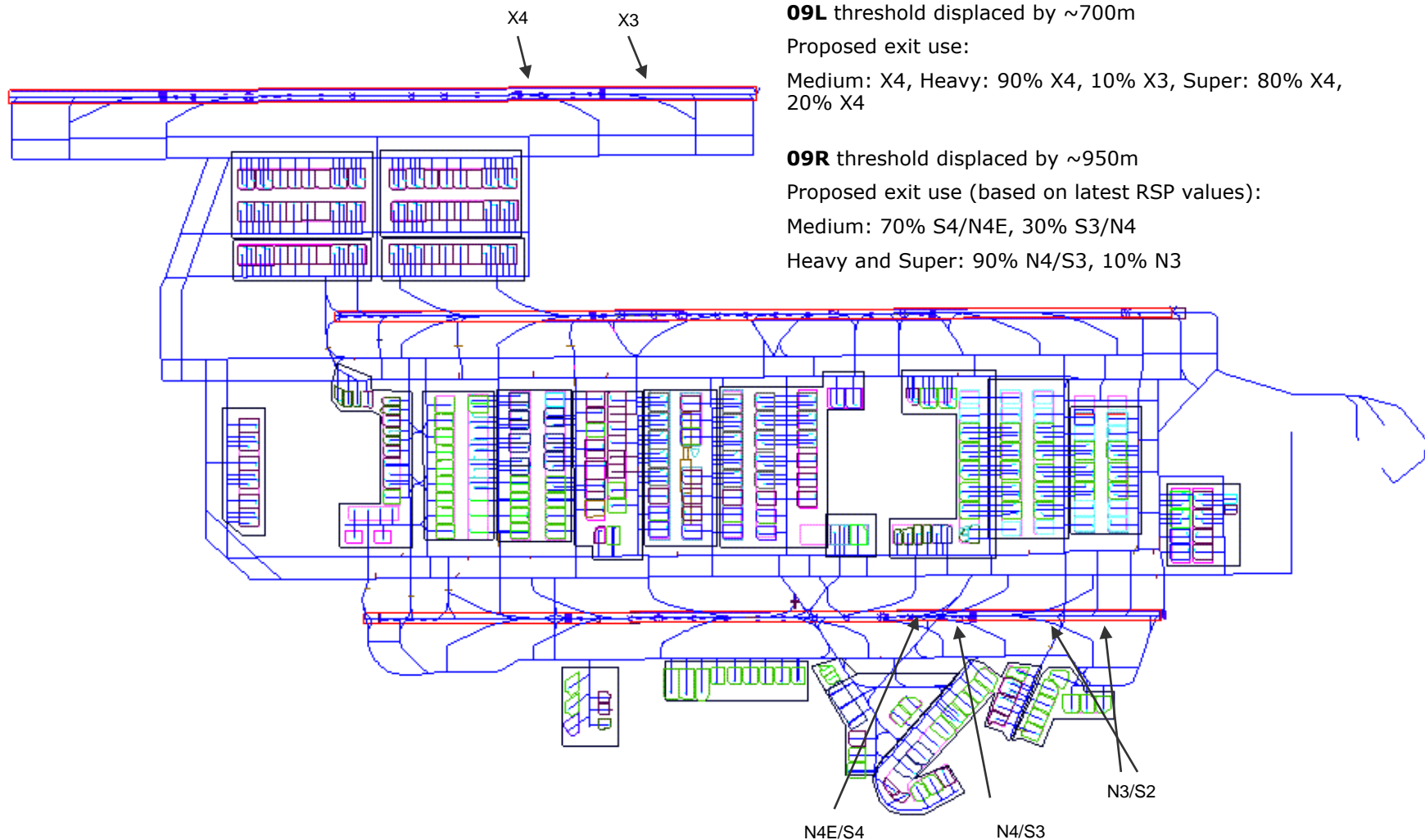
Arrivals (Red)

Taxiway flows may be modified if necessary following initial simulation runs



LHR 3R Northwest V3 Taxiway
Flow Diagram - MDL Easterlies
Scenario 1

Runways: Displaced Thresholds and Exit Use



Departure Separations

Minimum departure separations

- > SIDs provided by Heathrow Airport (via Anderson Acoustics)
- > The SID and runway allocations provided in the schedule assume that the following combinations will be available:
 - > 09C: BPK-South, CPT, DVR, MID, SAM, BUZ-West
 - > 09L: BPK, CPT-North, DVR-N, SAM-North, BUZ
 - > No consideration has been given to the airspace structure required to support these routes
 - > Please note that the London Airspace Management Programme (LAMP) assumes no new runway development
 - > Implementation of Departure Enhancement Project (DEP) has not been assumed
- > 09L - 2 mins (or wake turbulence minima if greater)
- > 09C SID Separation Matrix – provided by NATS ATC

Lead	BPK	DVR	MID	SAM	CPT	WOB/BUZ
Follower						
BPK	120	90	60	60	60	60
DVR	90	120	60	60	60	60
MID	60	60	120	90	90	90
SAM	60	60	90	120	90	90
CPT	60	60	90	90	120	90
WOB/BUZ	60	60	90	90	90	120

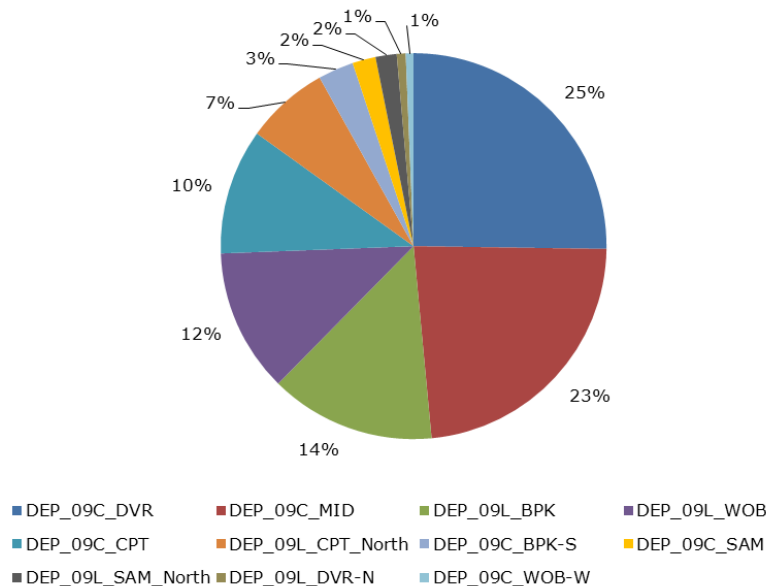
Arrival Separations Minimum arrival separations

- > 09L – 6NM, but reduce to 3NM when there is no departure queue (pack and gap on mixed mode runway)
- > 09R – 3NM (or wake turbulence minima if greater)
- > Time Based Separation (TBS) has not been assumed

Traffic – 740k Schedule – Departure Routes

Route	Count	Percentage
DEP_09C_DVR	271	25.2%
DEP_09C_MID	250	23.3%
DEP_09L_BPK	149	13.9%
DEP_09L_WOB	129	12.0%
DEP_09C_CPT	113	10.5%
DEP_09L_CPT_North	75	7.0%
DEP_09C_BPK-S	32	3.0%
DEP_09C_SAM	21	2.0%
DEP_09L_SAM_North	19	1.8%
DEP_09L_DVR-N	8	0.7%
DEP_09C_WOB-W	7	0.7%
Total	1074	100.0%

Departure Route Distribution for 740k Schedule



Results

Slide 16
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Results

- The simulation results are presented in two sections:
 1. High level summary table for the 740K schedule (Easterly vs. Westerly operations with T5N stands closed)
 2. Results for the 740K schedule (Easterly operations with T5N stands closed)

High level comparison of results for the 740K schedule

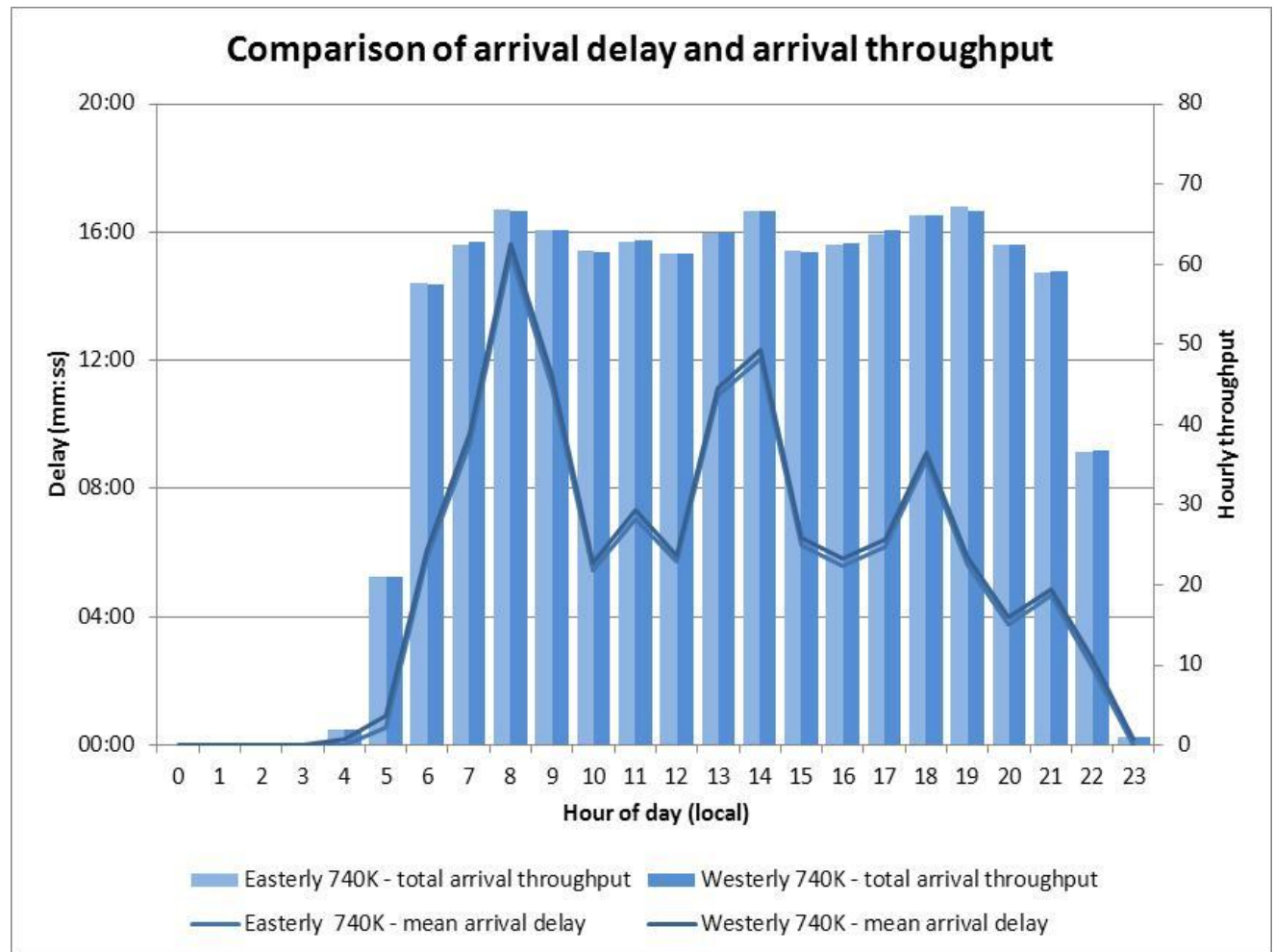
Comparison of overall mean values (mm:ss) for the Westerly and Easterly 740k schedules:

	Easterly 740K Schedule T5N closed	Westerly 740K Schedule T5N closed	Difference (mm:ss)
Arrival Delay	07:29	07:44	00:15
Departure Delay	04:13	09:12	04:59
Arrival Taxi Time	07:58	07:37	-00:21
Departure Taxi Time	13:56	16:01	02:05
Departure Gate Delay	01:24	04:11	02:47

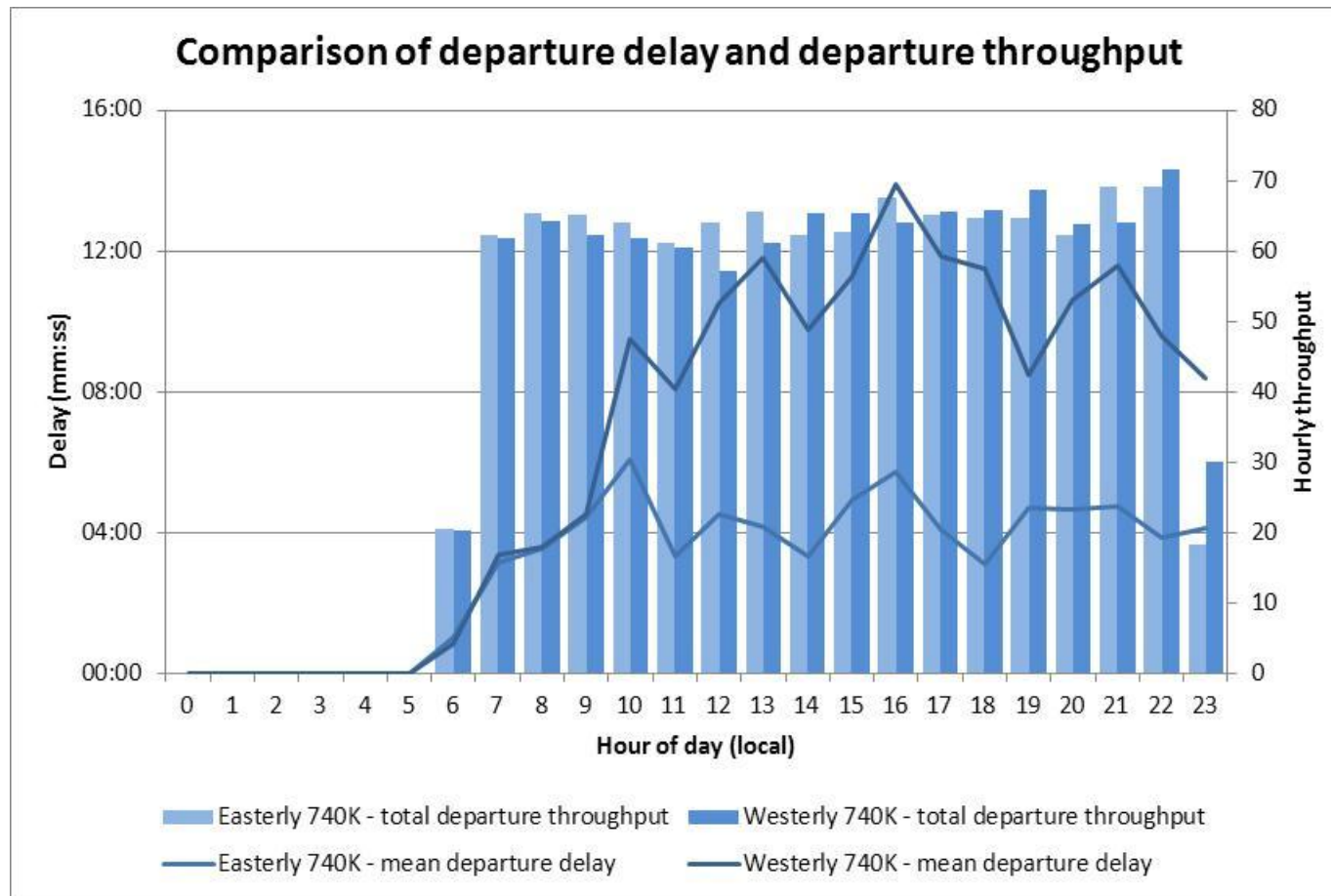
- > Delays were lower for the Easterly mode of operation
- > The lower departure taxi time for Easterly was due to 09C being closer to the T6 and T5 aprons (which account for over 50% of the traffic)
- > Arrival taxi time increased for Easterly due to the position of runway exit points in relation to the terminals

High level comparison of results for Westerly and Easterly 740K schedules

- > Arrival throughput and delays are virtually identical for the Easterly and Westerly models



High level comparison of results for Westerly and Easterly 740K schedules



The Easterly model has lower average departure delay throughout the day due to it having a higher departure throughput in several hours

Higher departure throughput is achieved by 09C having a total of 5 holding points feeding the runway from opposite sides

Results – 740K Schedule - Easterly with T5N Stands closed

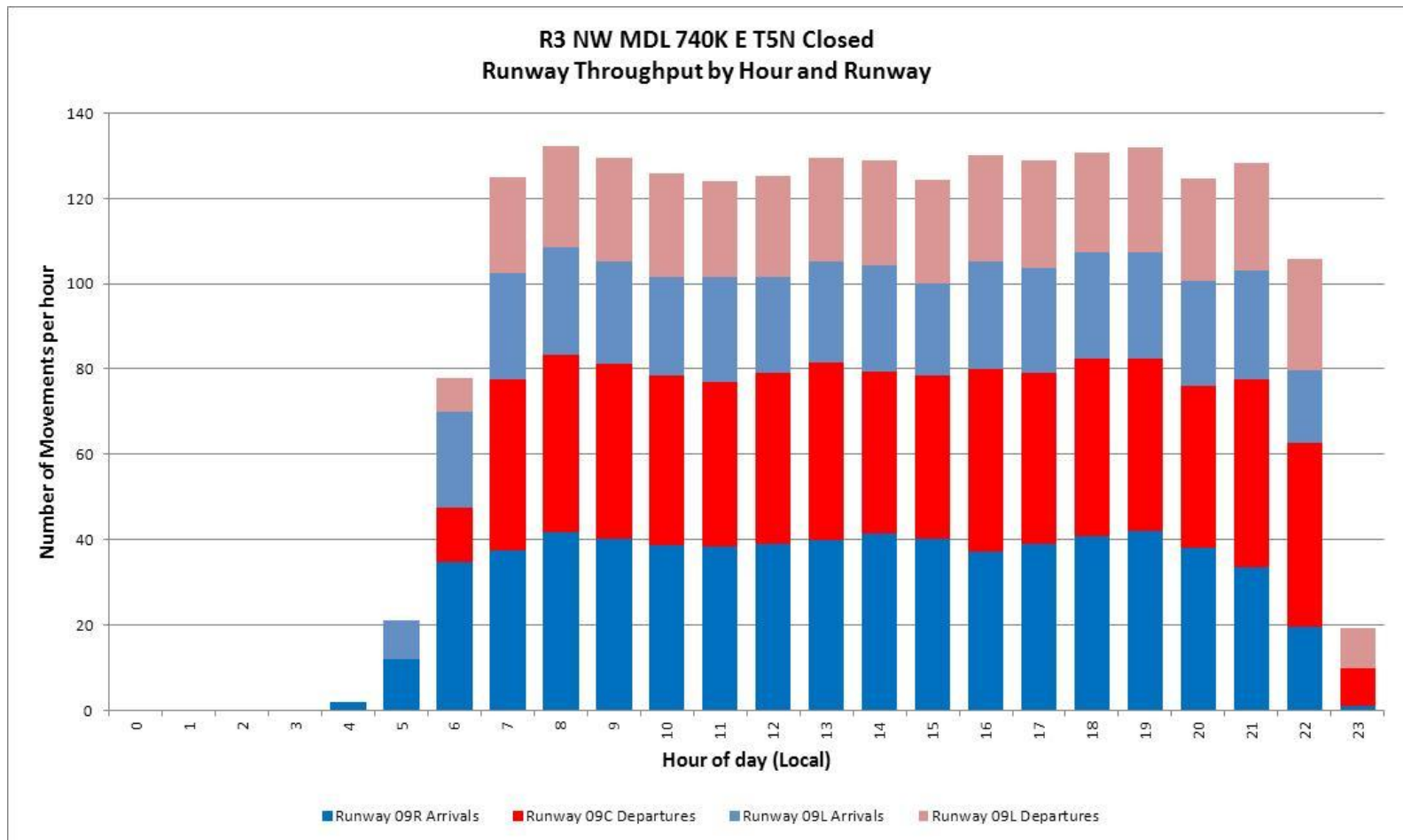
Slide 21
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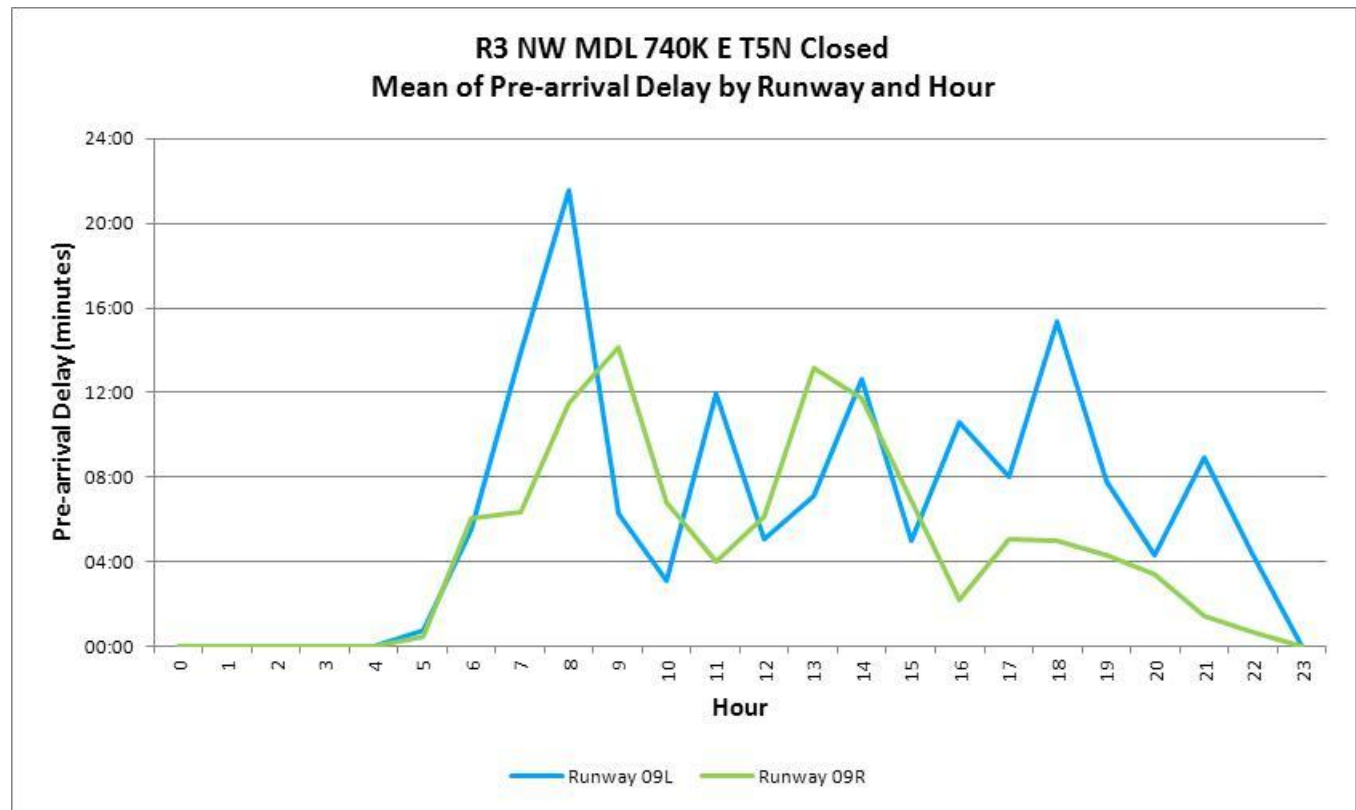
Runway Throughput

- Achieved runway throughput consistently over 120 movements per hour, averaged 127 per hour between 07:00 and 21:59
- Achieved throughput peaked at 132 movements (08:00 hour)



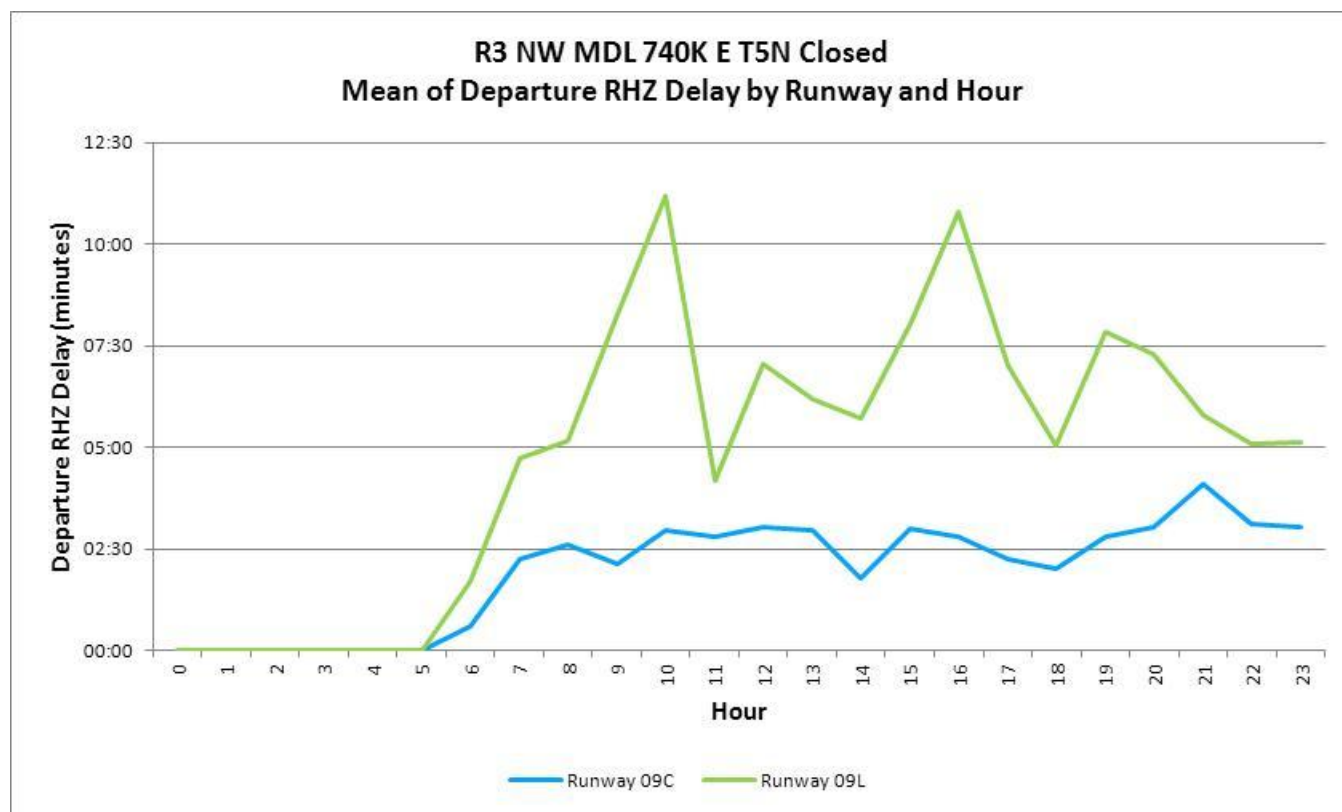
Arrival Delays

- > Mean arrival delay is 7 minutes 29 seconds
- > Peaks and troughs suggest that runway balancing and demand smoothing could be applied to the schedule to achieve a more even delay profile



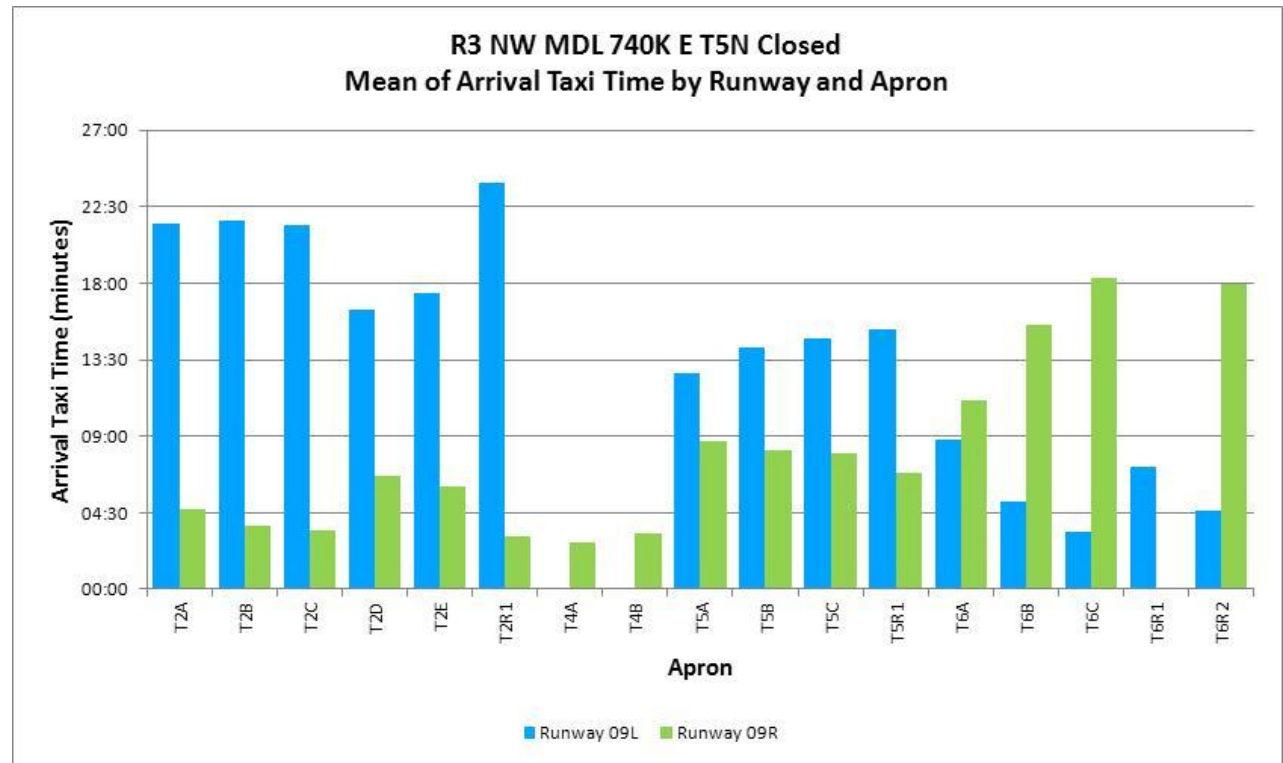
Departure Delays

- Departure delay on both runways is below 10 minutes for most of the day
- Departure delay on 09L is slightly higher, peaking at just over 10 minutes. This is due to the mixed mode operations on 09L
- An imbalance of departure delay between 09C (lower) and 09L (higher) suggests that further departure balancing could be carried out to achieve similar departure delays



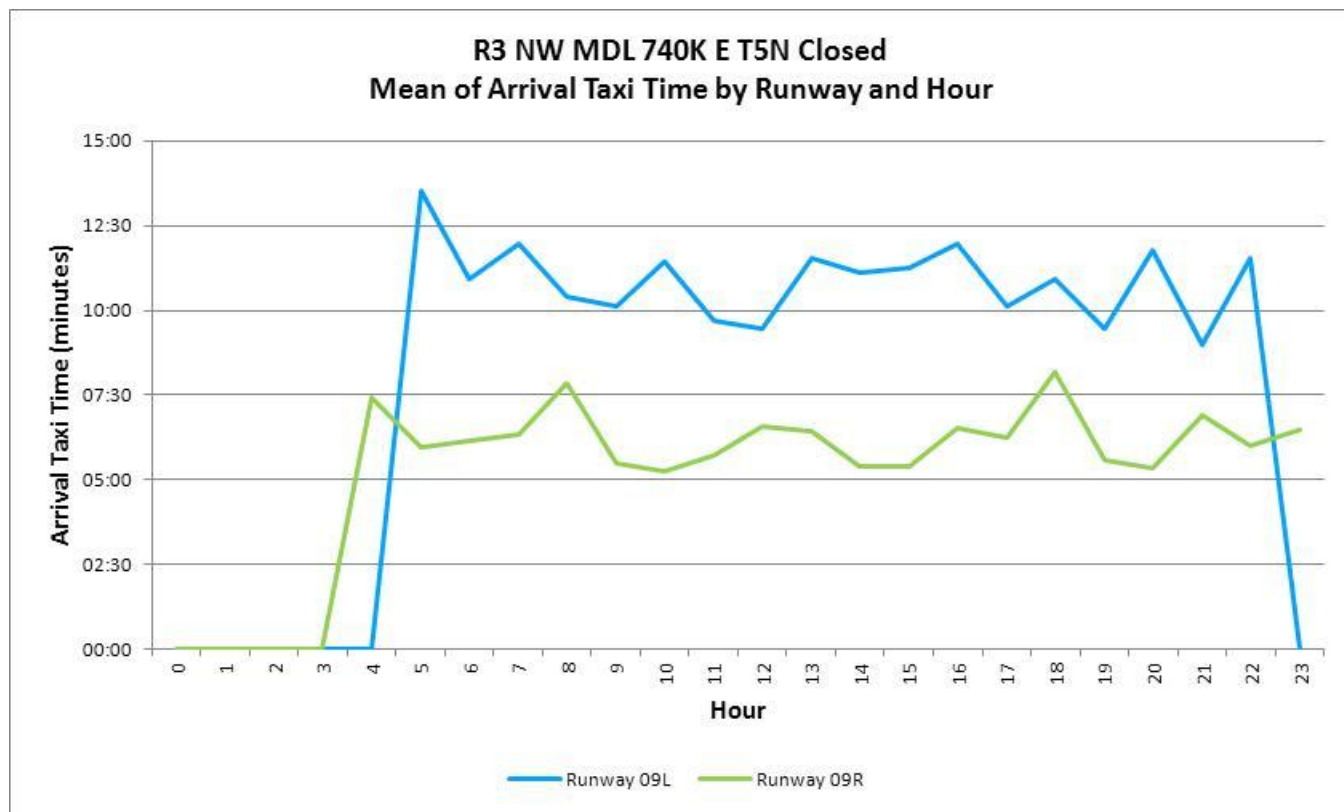
Arrival Taxi times – by Runway and Apron

- › This is the taxi time from the runway exit to stand
- › Overall mean arrival taxi time is 9 minutes, but varies widely
- › E.g. 09R to T2C (short taxi) ~3 minutes, whereas 09L to T2C (long taxi) average is ~21 minutes
- › Similar situation in reverse for T6B/C
- › Note that the majority of T2 arrivals use 09R (short taxi), the majority of T6 arrivals use 09L (short taxi) and most T5 arrivals use 09L (long taxi)



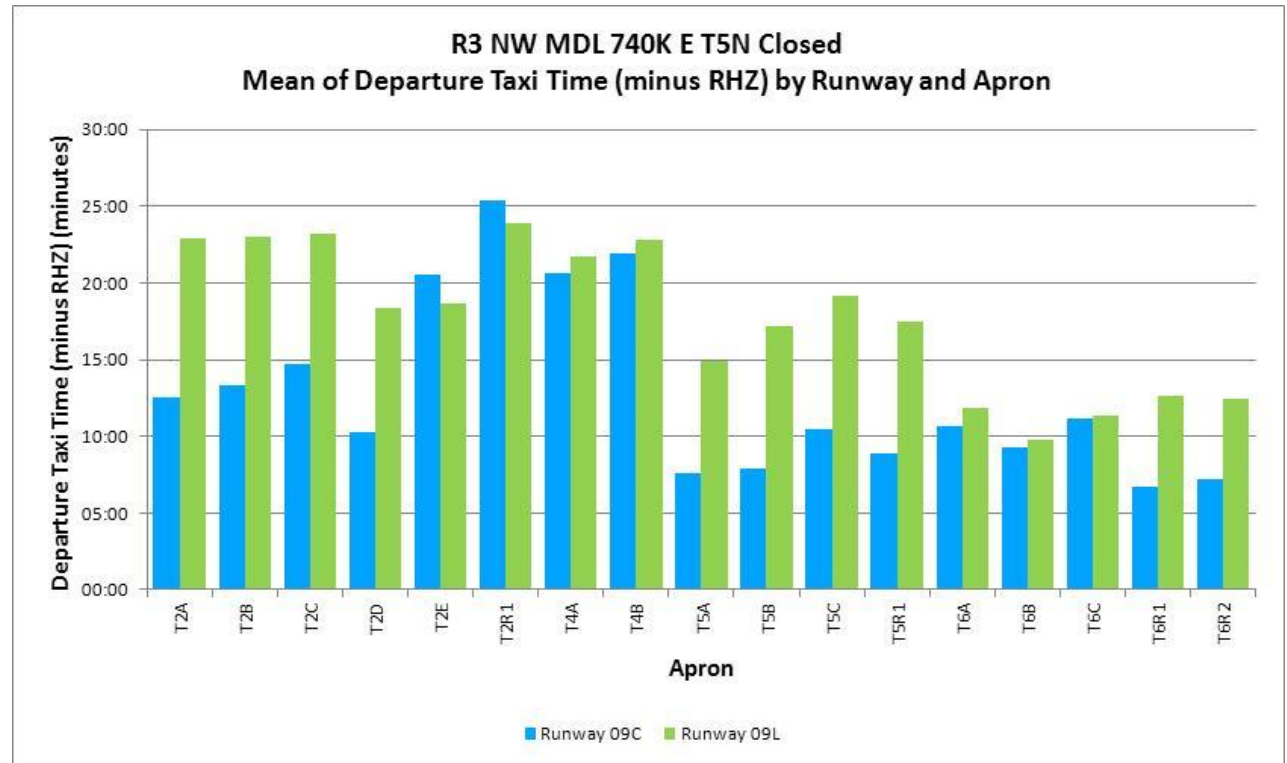
Arrival Taxi times – by hour of day

- This is the taxi time from the runway exit to stand
- Average arrival taxi times are broadly consistent across the day



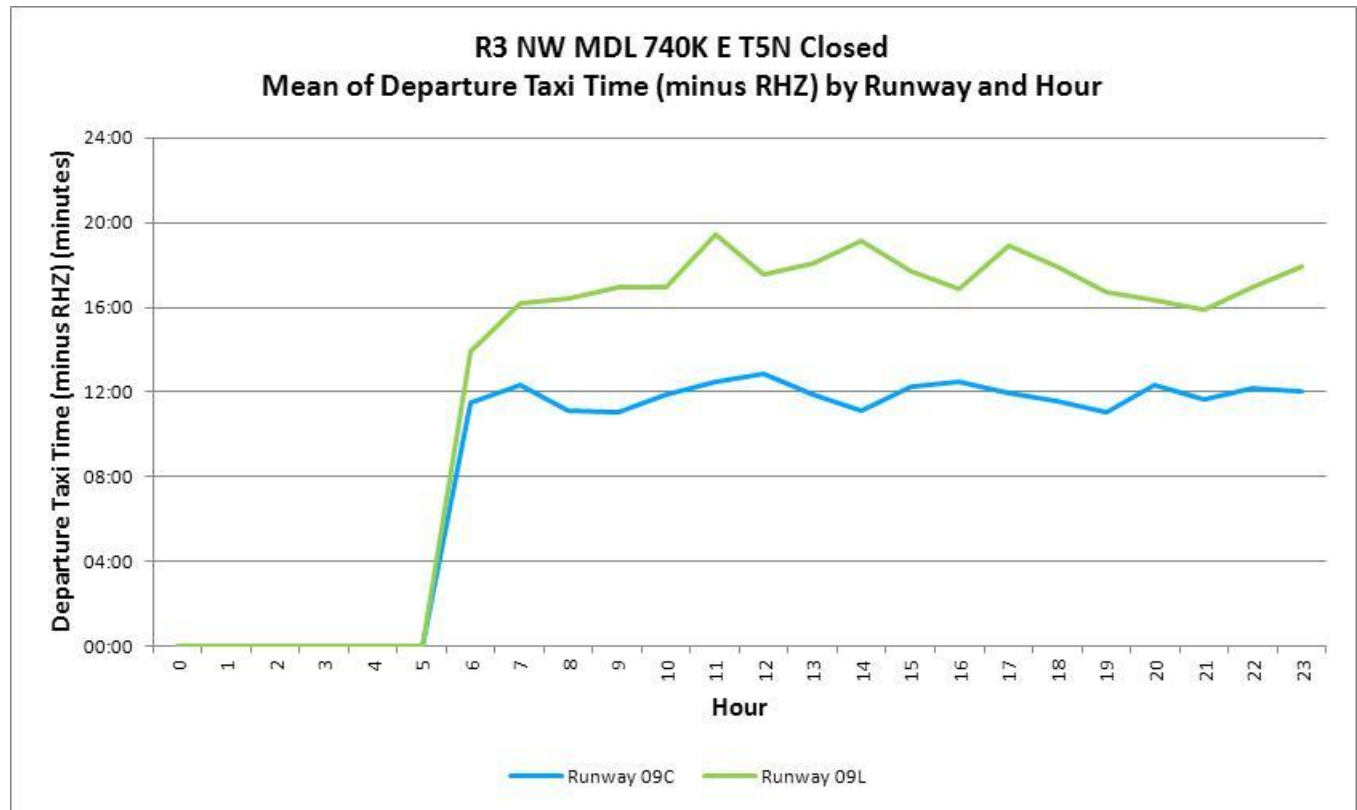
Departure Taxi times – by Runway and Apron

- › Departure Taxi Time is the time from an aircraft leaving the stand to reaching the Runway Hold Zone (RHZ). It includes the pushback pause
- › Overall mean departure taxi time is ~14 minutes, but varies widely
- › E.g. T5 to 09L (long taxi) ~18 minutes, whereas T5 to 09C (short taxi) ~8 minutes



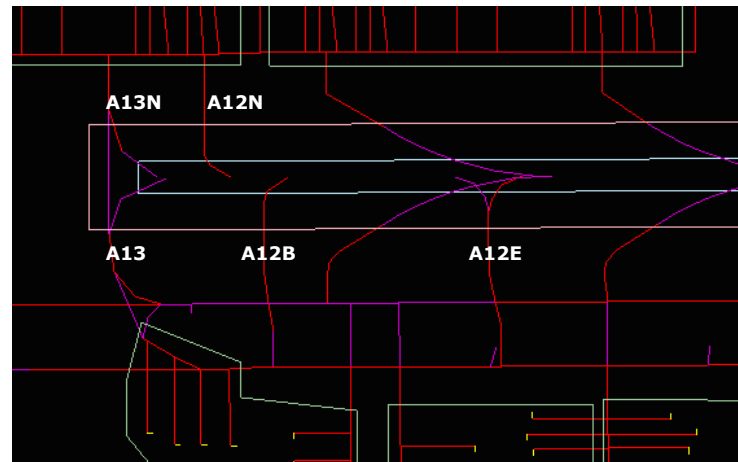
Departure Taxi times – by hour of day

- › Departure Taxi Time is the time from an aircraft leaving the stand to reaching the Runway Hold Zone (RHZ). It includes the pushback pause
- › Departure taxi times are broadly consistent over the day
- › Departure taxi times to 09L are on average between 5 and 6 minutes higher than 09C



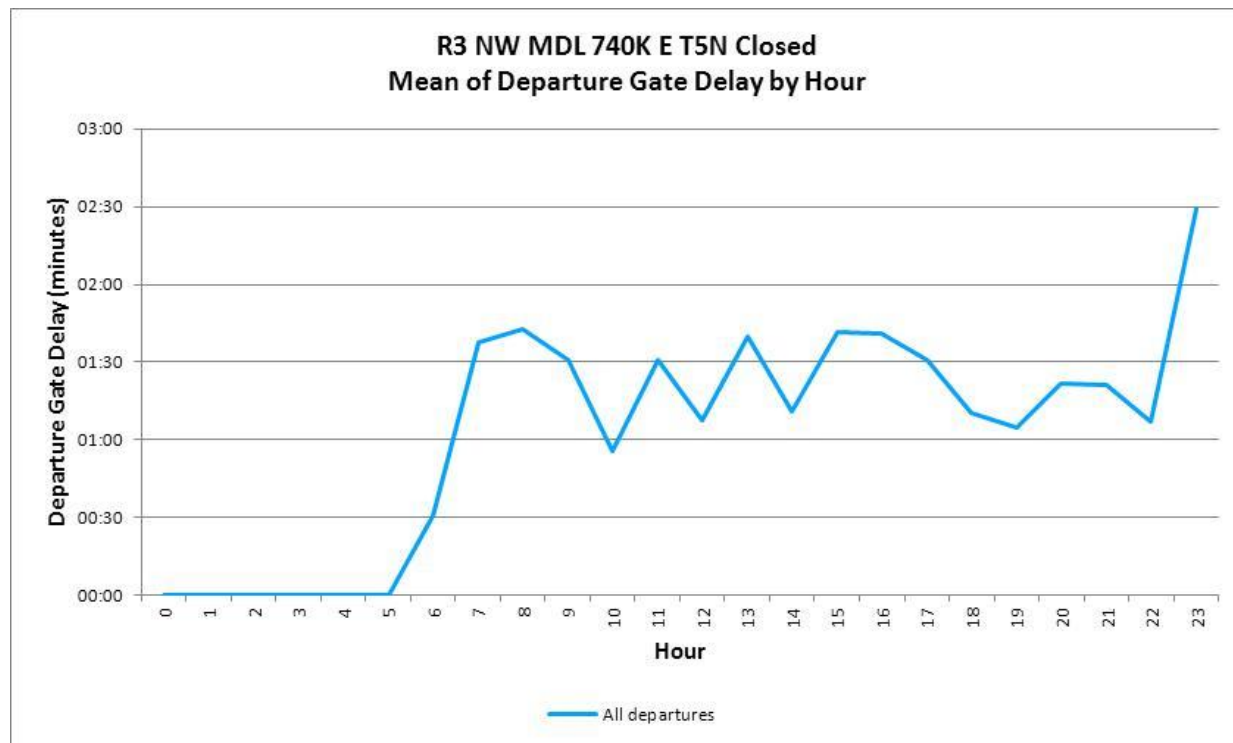
Departure Taxi times 09C Holding Points

- > Runway 09C has 5 holdings points (2 North and 3 South of the runway)
- > As shown earlier, Departure Taxi Time can vary substantially depending on whether a departure goes to the northern or southern holding points.
- > To ensure a balanced split of departure movements to each holding point and manageable taxi times, the holding point assignment within the simulation is listed below;
 - > **Southern holding points** (A13/A12B/A12E); T5 T2 A-D
 - > **Northern holding points** (A13N & A12N); T4, T2F and all T6



Average Departure Gate Delay – All Aircraft by Hour

- > This is the delay prior to pushback due to taxiway congestion, the maximum number of aircraft taxiing for departure at any one time having been reached, or a late inbound aircraft
- > Average Gate delay remains below 2 minutes for most of the day



Runway Crossings

- > Departures from T4: All cross 09R (79 flights per day)
- > Current number of runway crossings (2013-14 mean) is 46 flights per day

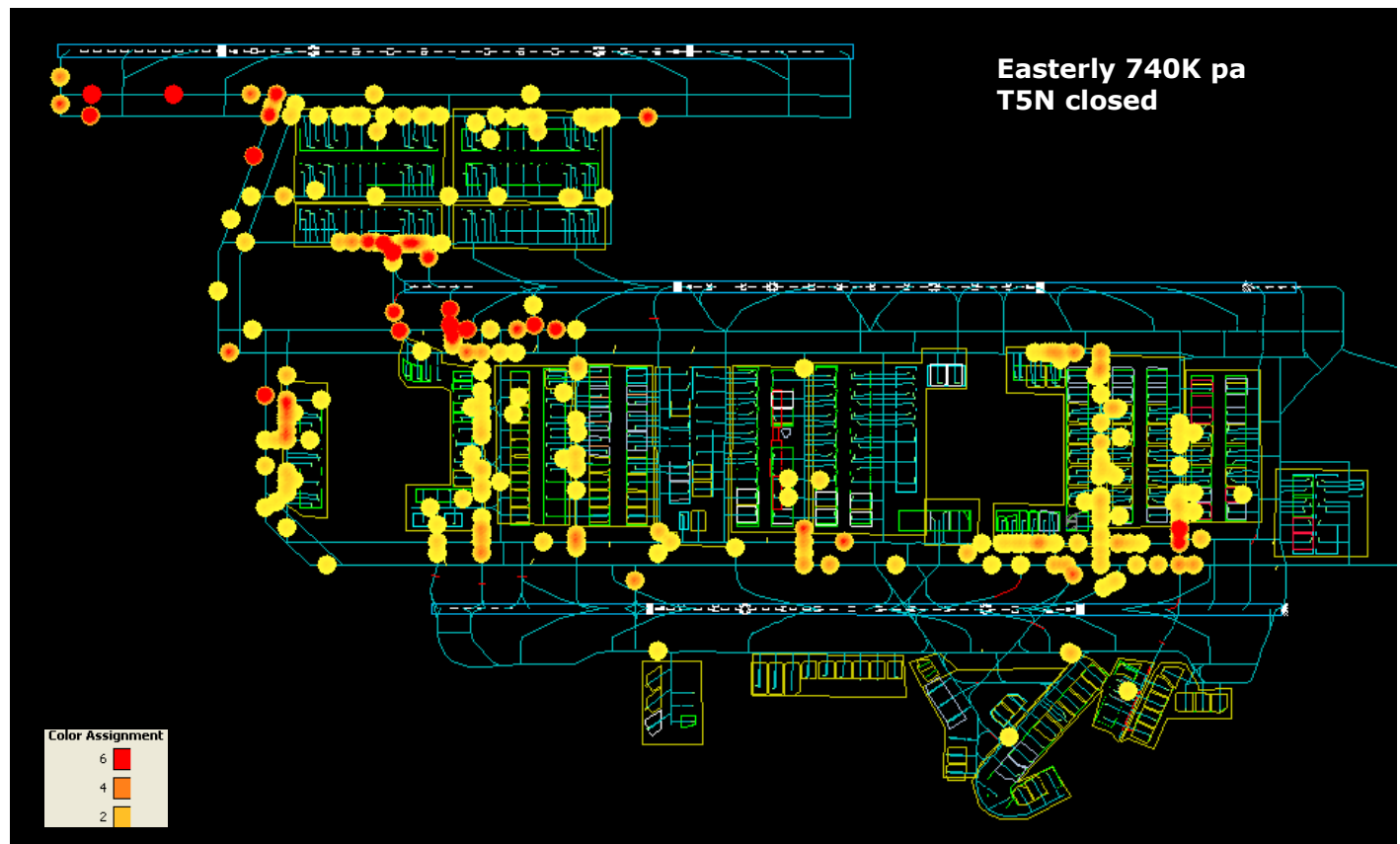
Ground Interaction and Taxiway Delay Plots

- The ground interaction and taxiway delay plots on the following slides show the effects of the 740K pa traffic schedule on the layout
- It should be noted that the models do not test resilience of the layout (i.e. the effect of taxiway closures)

A ground interaction is recorded in TAAM whenever an aircraft is required to wait for another, or when the speed of an aircraft is reduced to allow for another

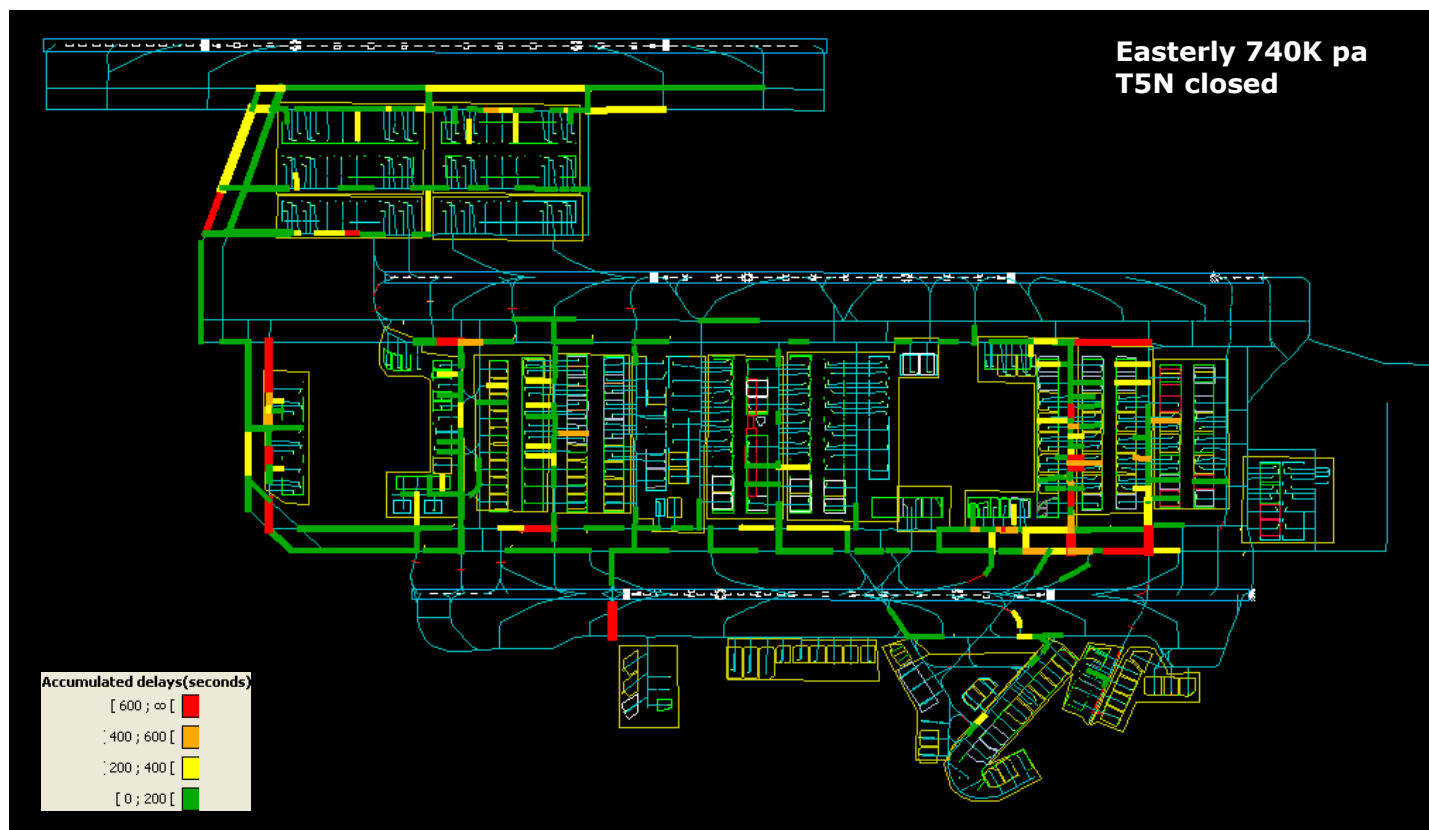
Colour (yellow, orange, red) shows an increasing number of interactions

The plots are indicative and highlight potential hotspots that can occur across the infrastructure. The plots presented show all recorded interactions from a single simulated run for each scenario



Taxiway Delays

The plots show all recorded taxiway delays from a single simulated run for each scenario
 Colour (green, yellow, orange, red) shows increasing taxiway delays. The thickness of the line increases with the number of aircraft affected



Taxiway Delays

09C holding point:

Aircraft holding for 09C to the north can obstruct T6 stands backing on to the taxiway

Merging flows:

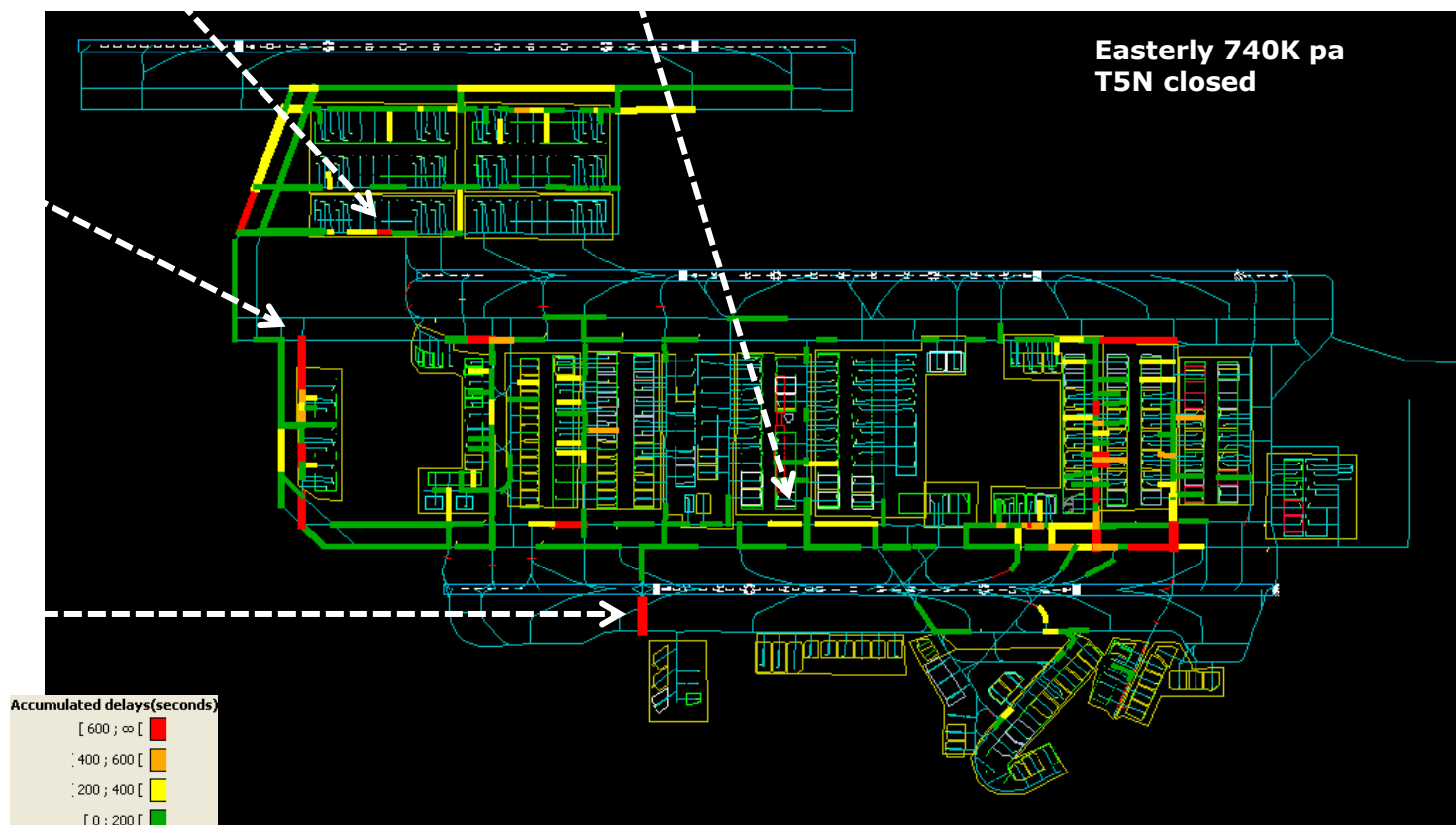
09R arrivals for T5 waiting for T5 departures from 09L to taxi out of the apron

Taxiway Congestion:

Arrivals from 09L delayed by departing aircraft pushback from T6A

Runway Crossing:

T4 departures (non-A380) waiting to cross 09R



Modelling Configuration - Easterly with T5N Stands open

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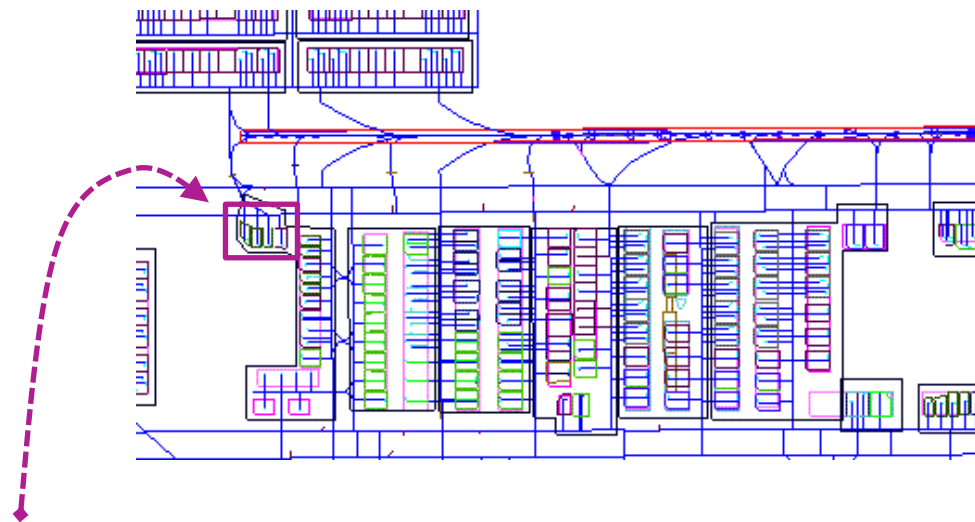
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Modelling Assumptions

- All assumptions are inherited from the Easterly model with T5N stands closed (covered earlier in this document)
- T5N Stands (501, 502, 503, 505) in the T5A Apron have been opened in this simulation
- The following slides show the taxi flows that differ

T5N Stands in T5A Apron



- T5N Stands (501, 502, 503, 505) in the T5A Apron have been opened in this simulation to model the impact on gate delay, taxi time and the Runway 09C holding point
- Utilisation of the T5N stands has been modelled as outlined below;

A = Arrivals & D = Departures

- 501 = 10A + 10D
- 502 = 9A + 10D
- 503 = 8A + 11D
- 505 = 9A + 10D

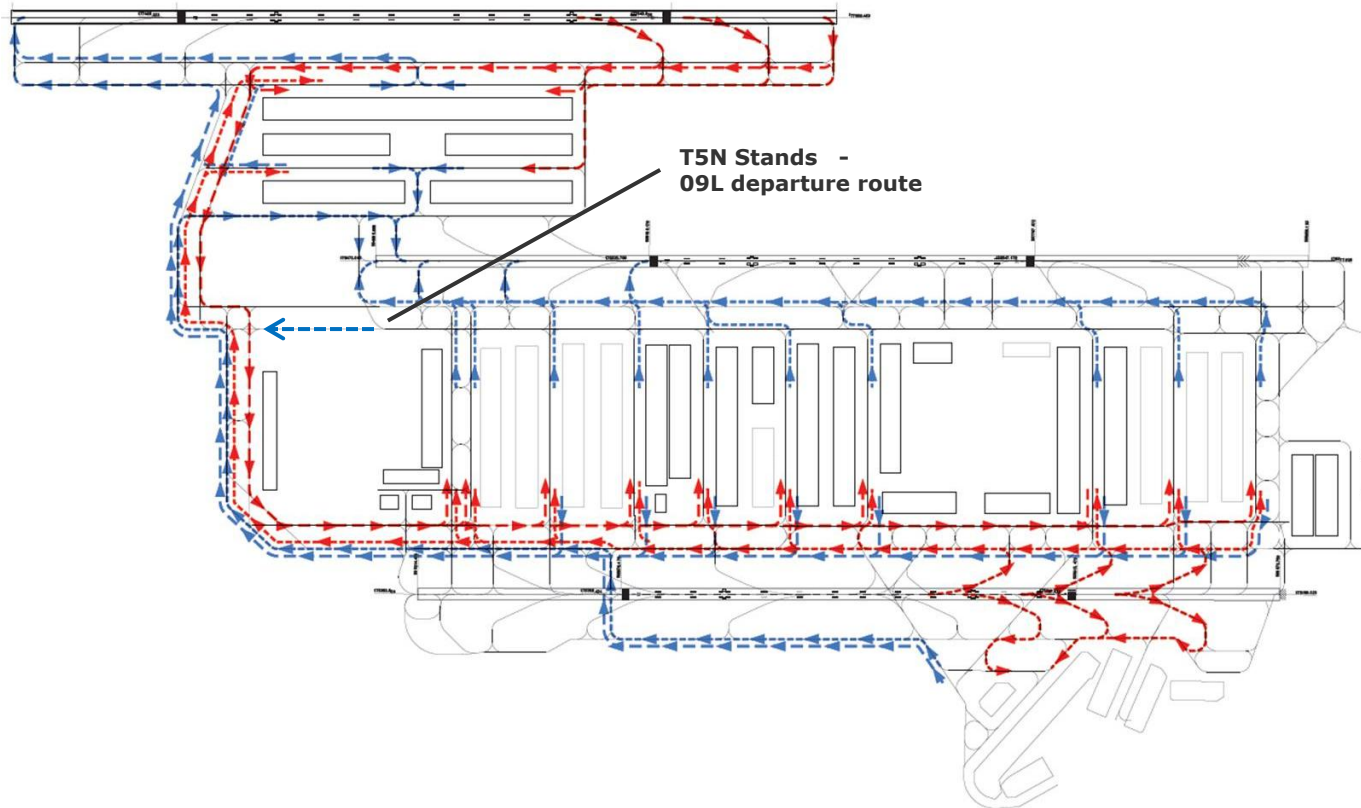
Expected Taxiway Flows with T5N stands open

Diagram supplied by Mott MacDonald

Departures (Blue)

Arrivals (Red)

Taxiway flows may be
modified if necessary
following initial simulation
runs



LHR 3R Northwest V3 Taxiway
Flow Diagram - MDL Easterlies
Scenario 1

Results

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Results

- The simulation results are presented in two sections:
 1. High level results summary for Easterly 740k R3 NW MDL with and without T5N stands open
 2. Detailed results comparison between T5N stands open/closed

High level comparison of results for T5N stands open

Comparison of overall mean values (mm:ss) and runway throughput for the Easterly 740k schedule with T5 stands open and closed:

	Easterly 740K Schedule T5N Stands closed	Easterly 740K Schedule T5N Stands open	Difference (seconds)
Runway Throughput (average 0700-2159)	127 ATMs	127 ATMs	--
Departure Delay	04:13	04:18	+5
Arrival Taxi Time	07:58	07:50	-8
Departure Taxi Time	13:56	13:47	-9
Departure Gate Delay	01:24	01:22	-2

- > Negligible difference in Departure Delay suggests only a minor negative impact on 09C holding point from having T5N stands open
- > The proximity of the T5N stands to Runway 09L (compared to the rest of T5) appears to have contributed to the lower departure and arrival taxi times when the T5N stands are open

Results – 740K Schedule Easterly Operations

with T5N Stands (501, 502, 503, 505) Open

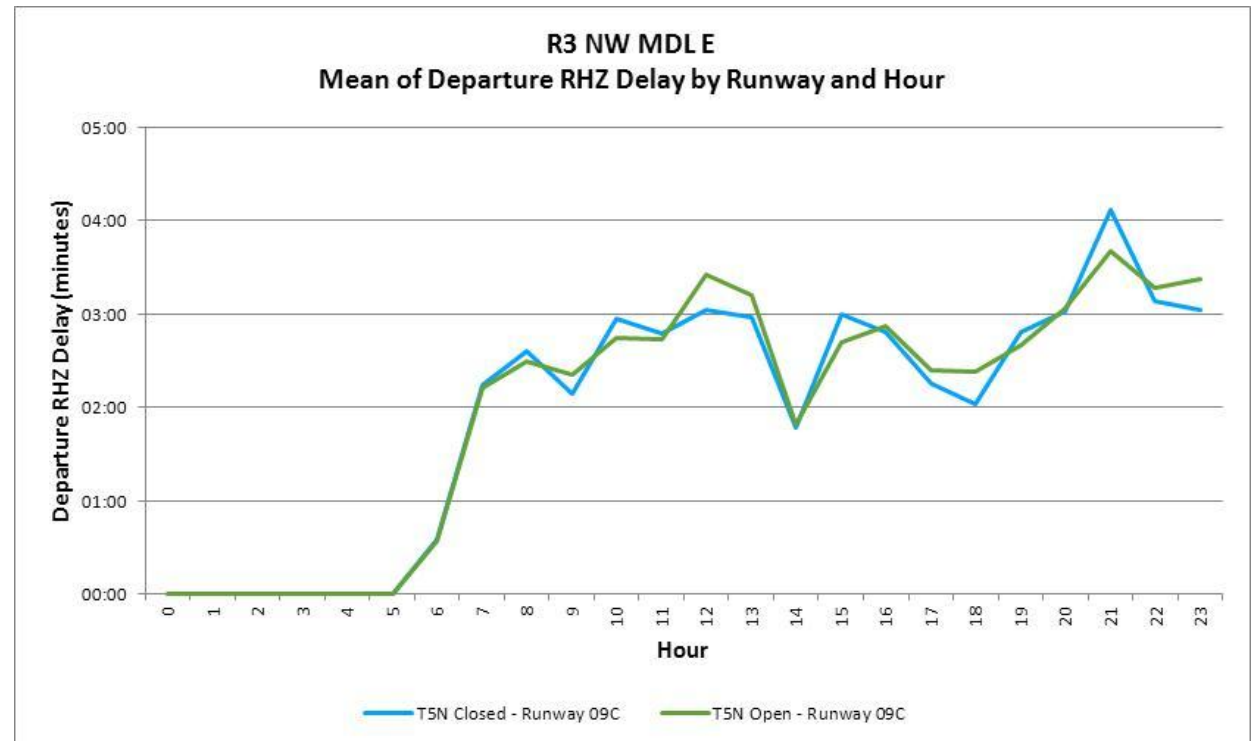
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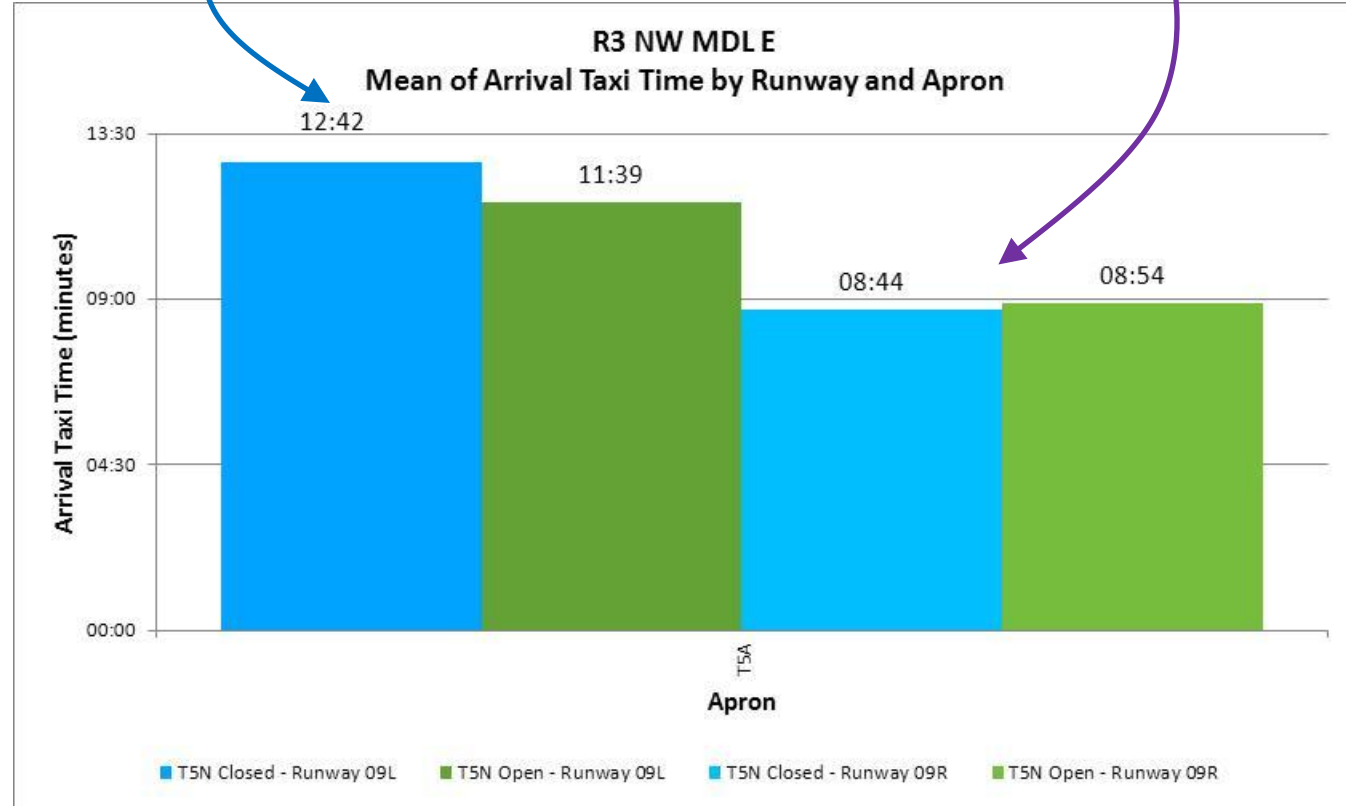
Departure Delays Runway 09C

- Departure delay for both models on Runway 09C is below 5 minutes
- Comparing the levels of departure delay on Runway 09C for both models shows only minor differences and no clear evidence to suggest that delays are worse when the T5N stands are open
- Runway throughput was also unaffected
- Depending on the demand at the runway hold point, departures from T5N stands (in particular 505 & 503) have potential to conflict with aircraft taxiing to A13 for Runway 09C



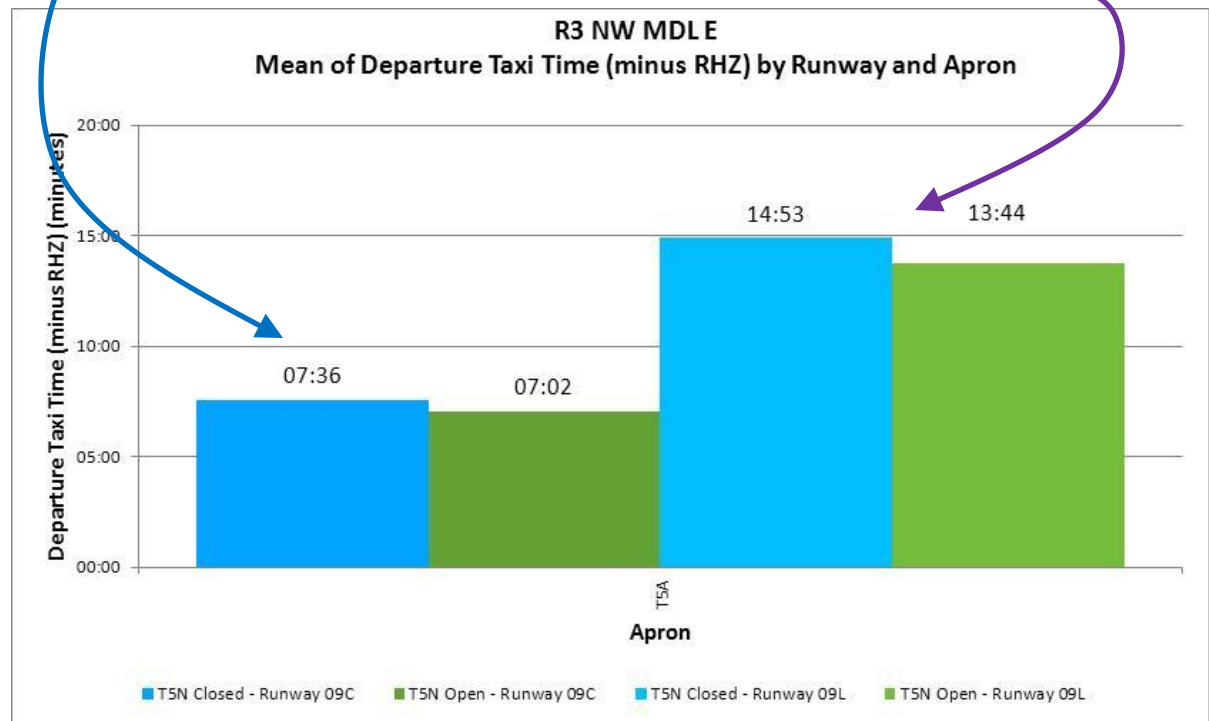
Arrival Taxi times – T5A Apron

- > This is the taxi time from the runway exit to stand
- > There is a 43 second decrease in T5A Apron arrival taxi time from opening the T5N stands
- > Taxi times from 09L to T5A reduced by 63 seconds
- > Taxi times from 09R to T5A increased by 10 seconds



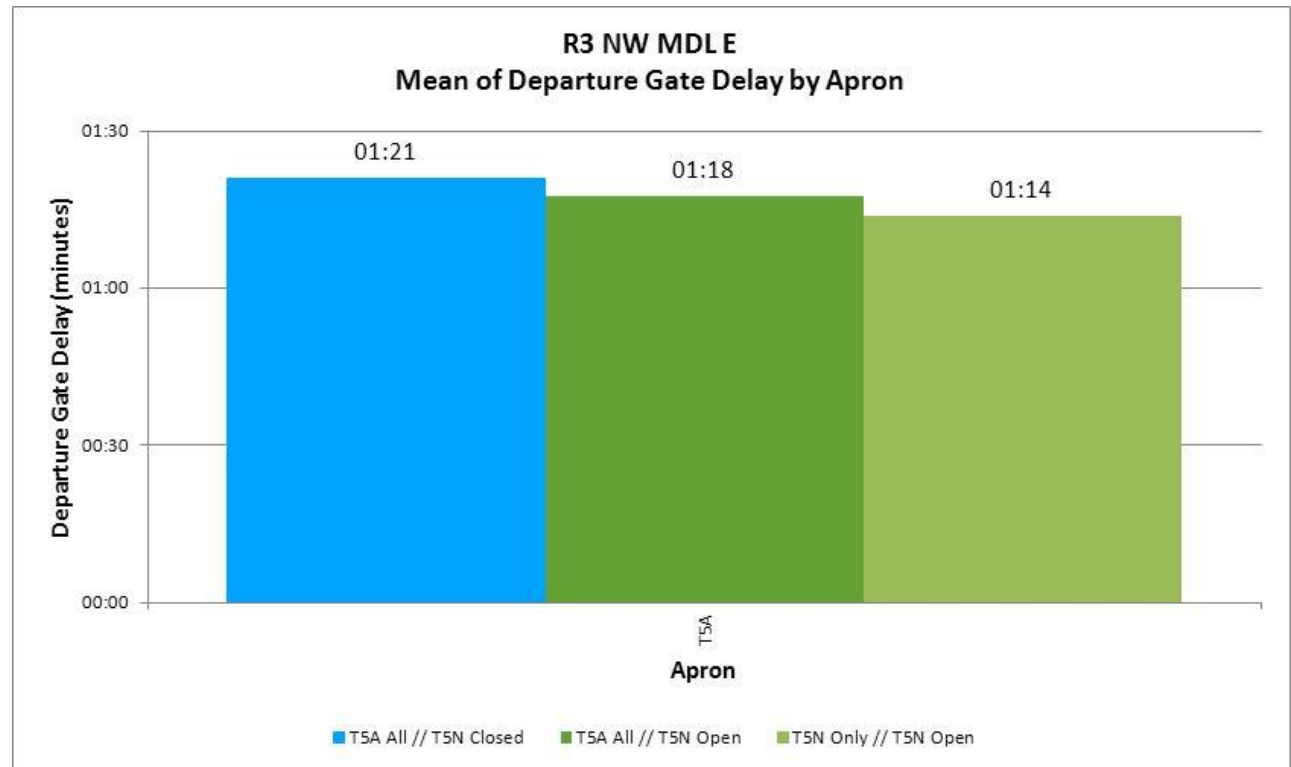
Departure Taxi times – T5A Apron

- > Departure Taxi Time is the time from an aircraft leaving the stand to reaching the Runway Hold Zone (RHZ). It includes the pushback pause
- > Departure taxi time for the T5A Apron reduced following the opening of T5N stands
- > Departure taxi time to 09C reduced by 34 seconds
- > Departure Taxi time to 09L reduced by 69 seconds

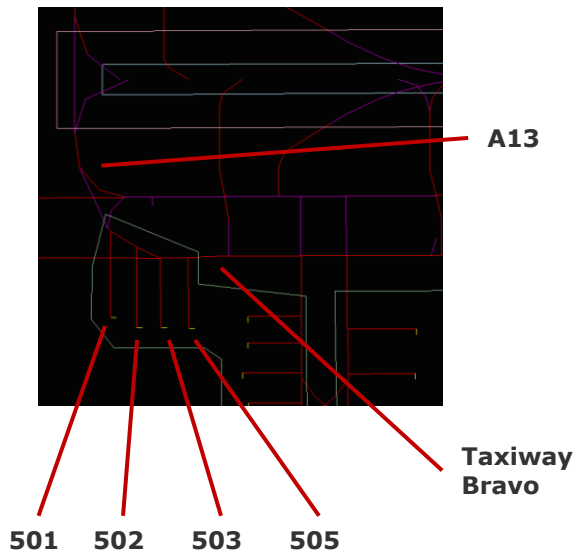


Average Departure Gate Delay – T5A Apron and T5N Stands

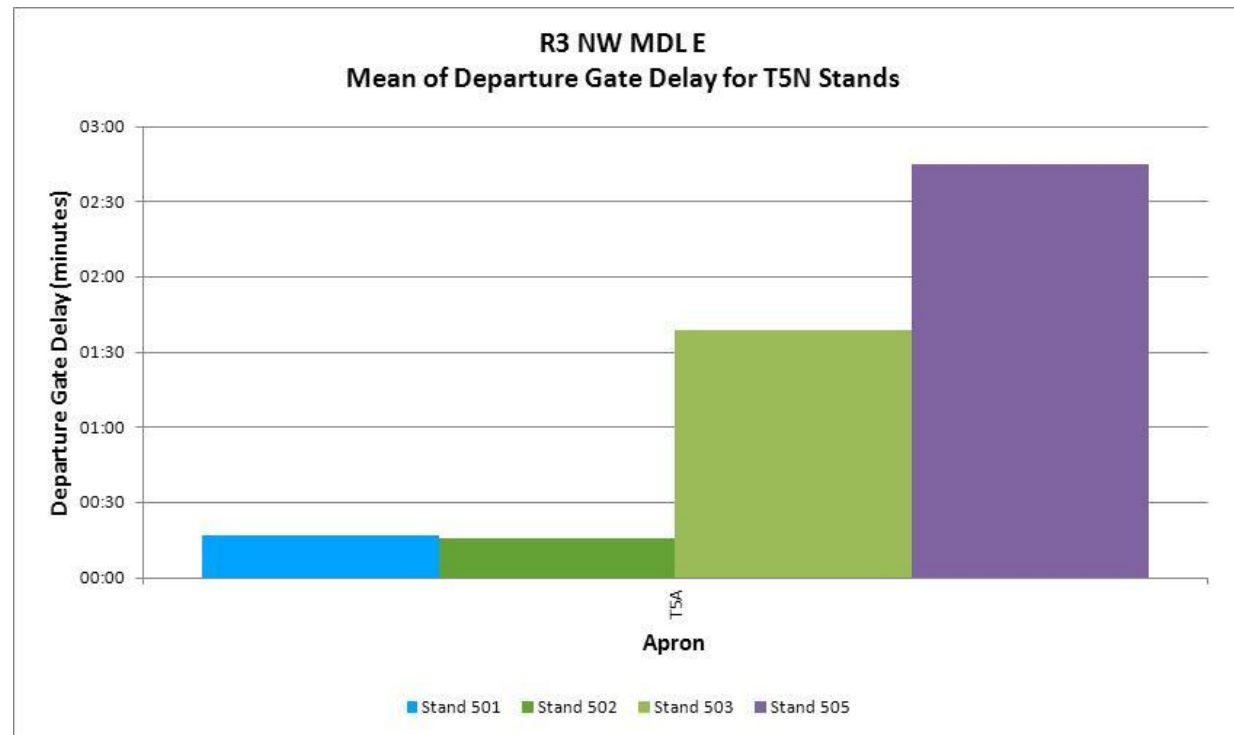
- > This is the delay prior to pushback due to taxiway congestion, the maximum number of aircraft taxiing for departure at any one time having been reached, or a late inbound aircraft
- > Gate delay for the T5N Stands (501, 502, 503 and 505) is 1 minute 14 seconds, which is lower than the previous average gate delay for 'T5A all' with T5N stands closed
- > Average Gate delay for T5A Apron reduced from 1 minute 21 seconds with the T5N stands closed to 1 minute 18 seconds with the T5N stands open



Average Departure Gate Delay – T5N Stands



- > Stands 503 and 505 of the T5N stand group have the highest average gate delay and are closest to the holding point queue for A13 along taxiway Bravo
- > The availability of runway entry points to the north and south of 09C helped to keep the runway queues short during model runs. However, if queues were to build up on the south side of the runway, access to and from the T5N stands could become difficult



Ground Interaction and Taxiway Delay Plots

- > The ground interaction and taxiway delay plots on the following slides show the effects of opening the T5N stands
- > It should be noted that the models do not test resilience of the layout (i.e. the effect of taxiway closures)
- > There was no substantial increase in the number of conflicts surrounding the T5N stands and the 09C holding point



Taxiway Delays

The plots show all recorded taxiway delays from a single simulated run for each scenario
 Colour (green, yellow, orange, red) shows increasing taxiway delays. The thickness of the line increases with the number of aircraft affected

Taxiway
 Congestion:

Increased taxiway
 delay on Bravo
 approaching stands
 503/505 towards
 A13 holding point

Taxiway Usage:

09L Departures from
 T5N Stands now
 using Bravo west of
 T5A

