CIVIL AVIATION AUTHORITY

Gatwick delay root cause analysis - Final Report

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EXECUTIVE SUMMARY

Gatwick Airport is growing but punctuality is reducing and delays are increasing

Gatwick Airport's punctuality and delay performance has degraded both in absolute terms and relative to peer airports. Figure 1 (LHS) shows that punctuality at Gatwick Airport has deteriorated overall, with summer punctuality performance progressively worsening across successive years from 2013 to 2015. Figure 1 (RHS) shows average delay increasing, where it stood at nearly 25 mins in Q2 2016 compared to 15 for Heathrow.

This reduction in performance has coincided with growth in traffic at the airport where from summer 2014 to summer 2016 Gatwick Airport's air traffic volume increased by 6%. In the peak summer months of June - September Gatwick Airport's runway operates at very high utilisation, typically 95% on average and up to 100% for short periods.

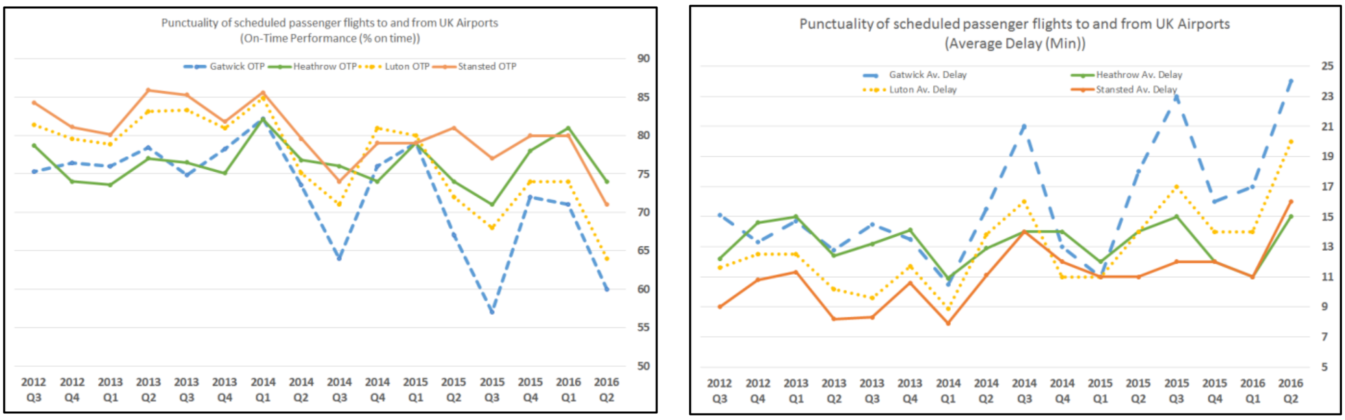


Figure 1: Punctuality and delay performance since Q3 2012 to Q2 2016 of London's main airports

Both Gatwick Airport and its main airlines have sponsored studies to identify causes of this reduced performance. However, these studies have reached different conclusions and place different emphasis on the dominant causes, all of which appear, at face value, to be credible and realistic.

To understand the root cause of the reduction in performance at Gatwick Airport, the Civil Aviation Authority (CAA), in conjunction with Gatwick Airport Limited (GAL) and the Airport Consultative Committee (ACC) sponsored an independent study to investigate key aspects of delay.

To categorise causes, we adopted analytically robust methods to examine the main arrivals and departure processes

We interrogated data sets associated with both air traffic flow/control and aircraft handling processes at Gatwick Airport (Figure 2) to assess key contributing factors associated with the deterioration in on-time performance.

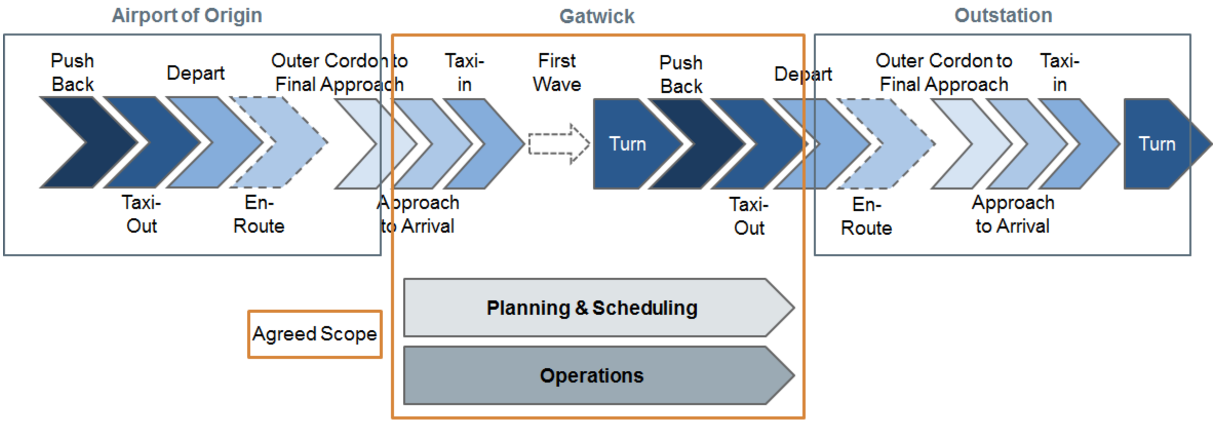


Figure 2: Overall scope of the root cause analysis

The study consisted of four main phases 1) Definitions & Data; 2a) Planning & Scheduling; 2b) Operational; and 3) Insights & Understanding, which together were designed to meet the requirements as defined by the CAA, GAL and ACC to:

- Agree a common dataset and definitions concerning delays at Gatwick Airport.
- Reach a common understanding of certain key aspects of planning and operations and their influence on the downturn in on-time performance and increase in average delay for departing and arriving aircraft at Gatwick Airport during the summer season since 2013.
- Provide suggestions based on this evidence on how to improve on-time performance at the airport in future years and prevent further deterioration.

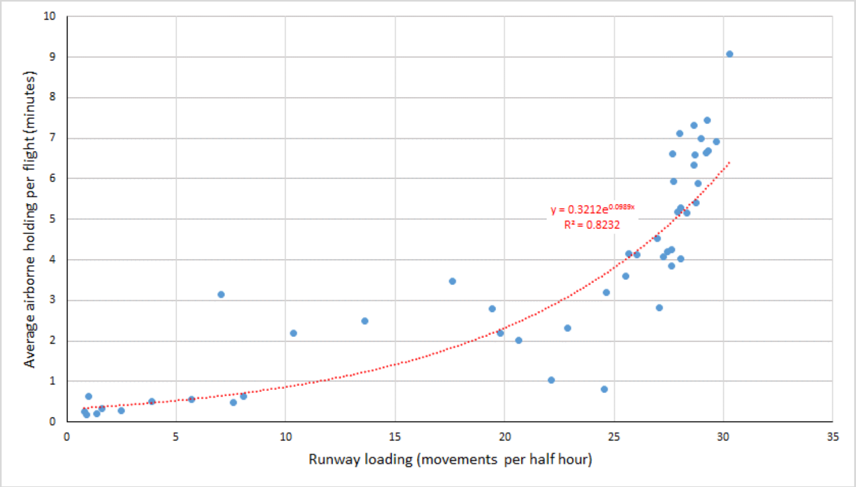
With its current infrastructure, Gatwick Airport’s utilisation is near, and at times, exceeds capacity

Significant causes of delays are driven by runway capacity constraints, airborne holding, turn and first-wave performance, application of outbound ATFM/CTOTs and start delays

Our analysis indicates that the theoretical level of utilisation resulting from the pure summer schedule would exceed available runway capacity. However, optimisation of the arrival and departure flows by air traffic control increases the efficiency of runway use, by up to 16%, to enable the demand to be met. However, at peak times runway utilisation is approaching 100%. Airborne and departure taxi holding are two of the consequences of flow optimisation by air traffic control.

The analysis, performed over the summer 2016 season in its entirety, indicates that season-wide airborne holding has reached the limits applied in capacity declaration. Departure holding performance is worse than arrivals and has degraded over time to the point that the capacity declaration limits are being breached consistently across the season. The policy of push-and-hold for departures that are subject to outbound ATFM regulation results in increased departure taxi holding although it frees up stands for arrivals and provides benefits in helping achieve departure punctuality.

The correlations between airfield loading and airborne holding delay indicate, in general, exponential queuing type relationships. The data graph below provides an early analytical signal of an area of planning and performance that should be further investigated. The graph shows that loading above 25-27 movements per half hour can result in increased delays. Movements maintained at these levels is likely to mean that OTP will be significantly more challenging to recover.



The graph illustrates the statistical correlation between the number of movements (per half hour) occurring on the runway and the average time (in minutes), an aircraft was held in airborne holding. The data covers the summer 2016 period. The line of best fit is drawn using a statistical package.

The data provides initial evidence that suggests it can be difficult to manage and limit delays above a certain range of runway movements. The data provides an initial analytical signal that should be further investigated.

The presence of statistical association between the *y* and *x* variables does not necessarily prove a scientific linkage or a cause-and-effect relationships between them.

As such, the analytical robustness of this insight needs to be improved through additional analytical exploration.

Short turns are very challenging

A significant proportion of Gatwick Airport's traffic is accounted for by airlines whose scheduling and planning is predicated on short turns: the most common arrival-departure turn time is 30 minutes. Operational data for summer 2016 shows that achieving such short turns is very challenging with a success rate of around only 25%. This success rate increases to approximately 70% as the scheduled turn time increases up to a turn time of approximately one hour after which it decreases to approximately 50%.

Further ground operations investigation was unable to be investigated further within the timescales of this study and we recommend this as an area for further analysis and examination.

First wave performance underpins performance for the remainder of the day

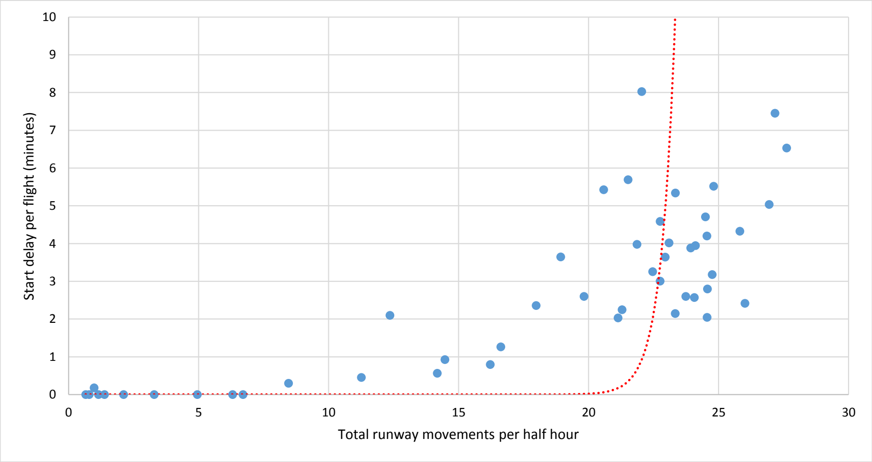
There is a statistical relationship between first wave departure punctuality and subsequent, downstream arrival and departure punctuality. Similarly, there is a relationship between first wave arrival punctuality and subsequent downstream arrival and departure punctuality. However, in both cases the statistical significance of the correlations indicate that there are other factors influencing downstream punctuality: absolutely perfect first wave punctuality would still only result in an average of 80% punctuality downstream.

Holding on stand is severely affecting punctuality, especially first wave

Two of the principal causes of the observed degradation in first wave departure punctuality are outbound air traffic flow management (ATFM) holding and start delay:

- **ATFM Holding** – is imposed by the European Network Manager on flights departing Gatwick Airport to ameliorate capacity constraints within European airspace or at European destination airports. First wave departures subject to ATFM regulation have punctuality performance reduced by 15% compared to unregulated flights/Non-CTOT flights (i.e. punctuality for non-CTOT first wave flights is 81.8% while punctuality is reduced to 67.1% where ATFM regulations are applied). The application of ATFM regulation can increasingly be seen as becoming the new 'normal' operating regime for Gatwick Airport. For instance, its application to first wave departures more than doubled from summer 2014 to summer 2016 where it stood at a level of 40% of flights being regulated at a level of 30 minutes holding per delayed flight.
- **Start Delay** - is the elapsed time between the pilot asking permission to start and air traffic control granting that permission. It is usually associated with a demand-capacity imbalance. Start delay at Gatwick Airport does not appear to be route dependent and is therefore unlikely to be related to the imposition of minimum departure intervals (MDIs) to moderate traffic on specific routes. Start delay does, however, appear to be associated with airfield loading, as shown in the figure below. It has

not been possible to understand whether the constraints are due to infrastructure, processes or air traffic controller workload based on the data made available within the duration of this study.



The graph illustrates the statistical correlation and best line fit between start delay and airfield loading for summer 2016..

The data provides initial evidence that suggests it can be difficult to manage and limit delays above a certain range of runway movements. However, the best-fit line illustrates that the analytical robustness of this insight needs to be improved through additional analytical exploration. We therefore recommend the initial analytical signal should be further investigated.

It has not been possible to assess fully the impact of Gatwick Airport attributable inbound ATFM delay due to a lack of access to data available in this area. However the trend for ATFM regulation appears to be increasing based on reproducing Eurocontrol analysis of Gatwick Airport attributed ATFM arrival holding from 2008-2014.

Improving on-time performance through resilience-based planning, better metrics and collaborative exploration of frontline data sets to drive new insights

High levels of utilisation need optimised planning and operations

At busy times of the year Gatwick Airport is at high risk of disruption to first wave departures. There is a strong correlation between first wave and subsequent performance; therefore when there is disruption this is likely to propagate through the day.

In addition, in busy periods, Gatwick Airport is operating at very high levels of utilisation and very tightly scheduled operations with no headroom for recovery. In particular, the achievement of planned short turns by the airlines appears very challenging and may be exacerbating the situation. In addition, the effects of disruption to the first wave persist throughout the day. The recommendations arising from the study are aimed building resilient schedules through optimising planning and operations by both Gatwick Airport and its airlines.

1. **Improve the planning process**. The scheduling process should be reviewed by both the airlines and GAL to avoid OTP impacts and improve the resilience of the schedule within available capacity. This process should acknowledge the new operating norm of a heavily CTOT regulated environment. **GAL** should improve the capacity declaration process to:
    a. Include all Gatwick Airport associated holding delays in the process, including inbound ATFM, any holding applied through XMAN/AMAN and start delay that are currently not included.
    b. Ensure that any assumptions used in the process, e.g. the 20 minute average taxi out time, are validated and/or updated to reflect the current reality of operations at Gatwick.
    c. Improve the modelling baseline so that it avoids the potential optimism bias arising from only calibrating the model against the performance achieved on good, busy days.
    d. Explore the potential for expanding the KPIs used in the modelling to: (i) reflect risks as well as average holding delays; and (ii) apply some simple form of cost benefit analysis to understand the economic and financial implications of the wish-list scenarios being explored.

   e. Make the process more transparent and inclusive, including balancing of commercial and operational considerations for both the Airport and the airlines.

   The **airlines** should explore whether it is feasible to use forward looking forecast data as well as historical performance in their block time and network planning activities to anticipate and mitigate issues that could potentially be foreseen and reflect this in the wish-list.

2. **Build headroom into the schedule**. Gatwick Airport is very tightly scheduled both in terms of its runway capacity declaration, the time allowed for aircraft turns and, potentially, block times between Gatwick Airport and outstation airports. Meeting scheduled times is very challenging and when things go wrong there is no resilience in the system for recovery.

   The **airlines** should review the capability to adhere to schedules such as turn times, including associated ground handling resources, scheduled block times and outstation performance to identify where headroom can be usefully built in: (i) to increase the probability of being able to meet scheduled times; and (ii) to allow space for recovery.

   Any extension of turn times needs to take into consideration the impact on stand occupancy and pier service requirements. The treatment of block times also needs careful consideration. For example, simple buffering (e.g. addition of a 15 minute turn buffer on turns) may reduce the number of flights arriving late but increase the number of flights arriving early with its own consequences on holding delay and congestion whereas reduction in the variability in block times would increase the proportion of flights operating on time. Given the current infrastructure constraints, in parallel **GAL** should:

   a. Explore operational and long-term slot management options as part of an overall approach to resilience-based scheduling and planning. Local rules on slot usage and performance should be evaluated to assess available options including 1) the feasibility and trade-offs of not re-allocating slots at busy times that are handed back to reserve the additional capacity as headroom for resilience and 2) mechanisms for temporary retirement of slot use which balances rights to use later on.

   b. Continue with its process improvement activities, such as integrated arrival and departure managers (AMAN-DMAN) with examination of how additional capacity generated could support resilience-based planning.

3. **Drill down to the detailed causes of CTOTs and start delay**, especially for first wave departures. It is clear that outbound ATFM regulation and start delay, especially in the first wave, are prejudicing punctuality performance both in the first wave and throughout the remainder of the day. However, further work, beyond just the data analysis, such as lean process investigation, is required to identify and improve the robustness of the defined root causes of ATFM regulation and start delay:

   a. GAL, in conjunction with the airlines, should work with the Eurocontrol Network Manager to identify the location and cause of ATFM regulation as well as forecasts for future levels of regulation, especially those affecting the first departure wave. Based on the information obtained, work should be done to explore the potential for potential re-routing or other mitigation for affected flights to ameliorate the impact of ATFM regulation.

   b. Further analysis should be undertaken by GAL and ANS to understand the root causes of start delay and explore mechanisms through which these can be addressed.

4. **Enhance monitoring metrics (e.g. Idaho)**. Idaho coupled with A-CDM provides the best platform for a common data source and dictionary, building on the work from this study. This platform should combine airport, airspace and airline data to improve subsequent performance monitoring, analysis and improvement. We recommend GAL and the airlines should explore with ANS and potentially NATS, the scope for importing additional operational data into Idaho. This data could include elements of EFPS to address airfield air traffic issues; data from London Terminal Control to enable airborne holding to be assessed; tow data to understand how aircraft towing affects airfield performance and airline data to, for example, allow validation of different

measurements of pushback and to allow turn performance to be better monitored by incorporating addition turn milestones consistently, such as doors closed, which is already partially available.

Gaining insight from summer 2017 on-time performance needs a new collaborative approach which adopts formal problem-solving methodologies

Through the approach taken in this study, we have categorised a number of significant causes of delay. However, we acknowledge there is an additional level of analytical rigour and on-the ground engagement required, that wasn't possible to achieve within the timescales and constraints of this study, to reach indisputably robust and empirical definitions of delay root causes.

We acknowledge also that both GAL and ACC have welcomed the analysis undertaken within the parameters of the provided data and the time available. Within these constraints, the evidence base thus far constructed now provides GAL and the ACC with the foundation to adopt highly data-driven ways of collaborative working. This will help generate quantified, statistically tested and operationally relevant insights that can be built upon, or challenge the current understanding of the inter-linked root causes of punctuality held by key stakeholders.

Significant effort was made to review and reach consensus on the definitions used in performance measurement and improvement as well as identify and agree the sources of data. This step forward from the status quo has been viewed as a valuable benefit of the study by stakeholders.

It was the foremost challenge of the study to obtain an agreed common data set which has resulted in the absence of data from airlines and the wider system (e.g. Eurocontrol) as well as the restriction of its use and publication within the final report. This has been the rate limiting step in reaching stronger and statistically robust insights on root causes and advancing beyond the initial signals from the exploratory analysis undertaken. For example, we were specifically unable to obtain IATA delay code and description in the time allotted for the study from GAL. Although this was in the context of overall timely and cooperative responses to requests for data from GAL.

The study's stated requirement was the examination of key aspects of planning and operations at Gatwick Airport, as detailed in the originating ITT. However, poor on-time performance is often a symptom of wider-system complexity and is affected by decisions and issues made in multiples areas both within and outside of Gatwick.

We recognise further actionable insights are required to develop 'COO ready' initiatives which enhance and protect on-time performance in the future. We believe the study has demonstrated the limitations of a desk-top analytics approach.

Therefore, further work should adopt a joint iterative analytics approach with access and transparency of the full range of datasets to allow an analytical synthesis of the contributing factors across the 'system'. This approach will provide the best opportunity to convert the initial analytical signals that we have found from the data made available into further on-site exploratory analytical exercises that provide greater understanding of root causes that weren't necessarily widely understood before.

The key advantages of this approach includes the flexibility to frame problems with both a data-driven component and people/process-related aspects offering the flexibility for the conversation to be moved 'top-down' (e.g. system view) or 'bottom-up' (e.g. individual process components).

We therefore greatly value Gatwick Airport's suggestion on creating a collaborative and joint 'On-Time Performance Analysis Group' to develop further the common dataset building on airport, air traffic, airlines and European network manager datasets and a supporting analytics programme to develop shared root cause and improvement recommendations.

We have seen this approach be successfully adopted in other sectors with infrastructure provider and user models. In one example this has seen the implementation of an operating model that maintains an integrated control centre and joint planning and integrated performance teams.

We think there is significant benefits to be gained from fairly rapidly establishing elements (e.g. analytics capability) of a joint ‘Insights and Performance Analysis Unit’ which would have better access to the spectrum of stakeholder data to help carry out analysis on summer 2017 performance. This, together with the other recommendations within this report, help provide at least the first steps to build sustainable improvements in OTP.

CONTENTS

FIGURES AND TABLES

FIGURES

TABLES

1 INTRODUCTION

1.1 General

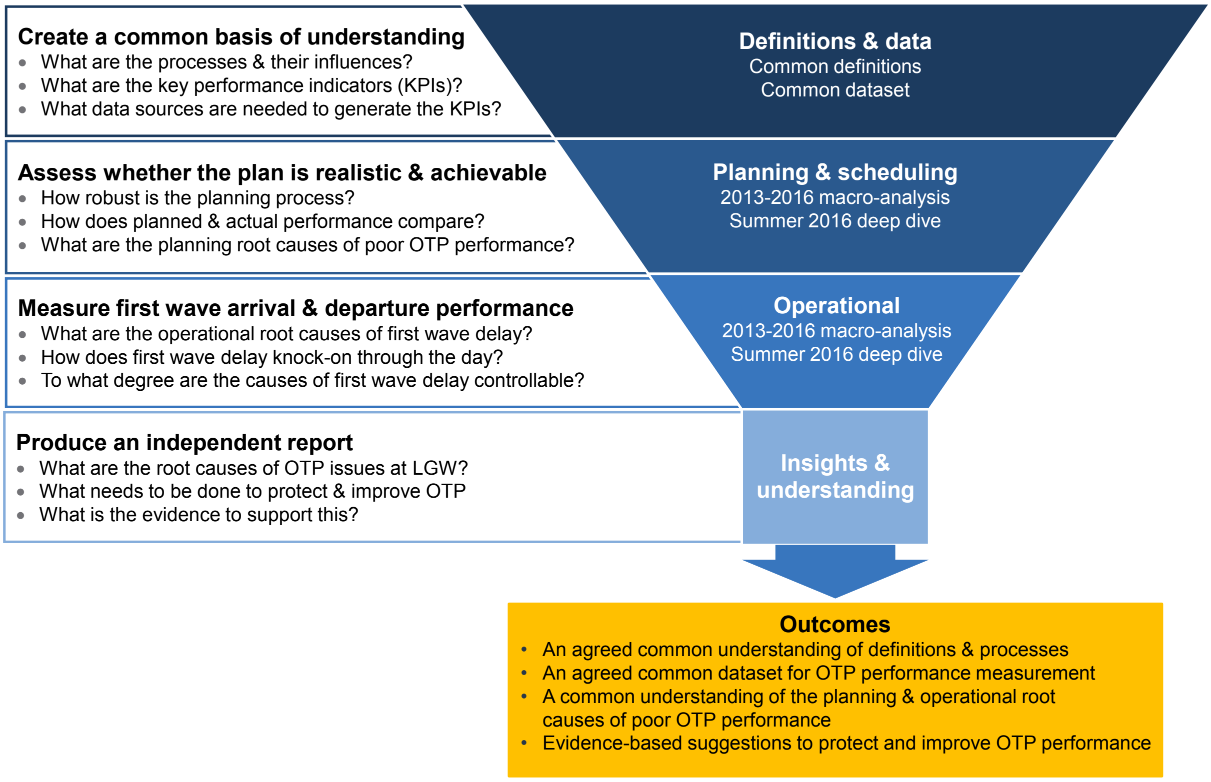
This document has been produced for the Civil Aviation Authority (CAA), Gatwick Airport Limited (GAL) and the Gatwick Airport Operators Committee (AOC) by PA Consulting Limited. It is the final report of a study on the causes of delay at Gatwick Airport.

1.2 Context

Gatwick's punctuality and delay performance has degraded recently both in absolute terms and relative to peer airports. This reduction in performance has coincided with growth in traffic at the airport and, to a degree, some external factors, such as poor air traffic control performance in continental Europe and a shift in summer holiday traffic from the east (Greece and Turkey) to the west (Spain and Portugal). Both Gatwick and its main airlines have sponsored studies to identify the causes of this reduced performance. However, these studies have reached different conclusions and emphases, all of which appear, at face value, to be credible and realistic.

The CAA, therefore, in conjunction with Gatwick Airport Limited (GAL) and the Airport Consultative Committee (ACC) have sponsored this independent study to investigate key aspects of delay at Gatwick. The objectives of and key questions to be answered by this study are illustrated in Figure 3.

Figure 3: Study objectives



Create a common basis of understanding
- What are the processes & their influences?
- What are the key performance indicators (KPIs)?
- What data sources are needed to generate the KPIs?

Assess whether the plan is realistic & achievable
- How robust is the planning process?
- How does planned & actual performance compare?
- What are the planning root causes of poor OTP performance?

Measure first wave arrival & departure performance
- What are the operational root causes of first wave delay?
- How does first wave delay knock-on through the day?
- To what degree are the causes of first wave delay controllable?

Produce an independent report
- What are the root causes of OTP issues at LGW?
- What needs to be done to protect & improve OTP
- What is the evidence to support this?

Outcomes
- An agreed common understanding of definitions & processes
- An agreed common dataset for OTP performance measurement
- A common understanding of the planning & operational root causes of poor OTP performance
- Evidence-based suggestions to protect and improve OTP performance

The study excludes so-called disaster days where factors such as weather, systems failure or infrastructure outage cause massive disruption and need proactive management for mitigation and recovery.

1.3 Structure of the report

The structure of this report is as follows:

- Section 2 describes the evolution over the past two years to Gatwick's current operating environment covering traffic volume, traffic characteristics, punctuality performance, descriptions of the processes used for air traffic management and identification of the factors that influence performance
- Section 3 highlights the definitions agreed during the project and the sources of data used
- Section 4 analyses the planning and scheduling process, and its impacts on runway utilisation, how well the arrival and departure criteria are met as well as assessing the degree to which aircraft turns comply with the plan
- Section 5 reports on analysis of Gatwick operations with focus on the first wave, the impact of air traffic flow management (ATFM) regulation applied in the form of calculated take-off times (CTOTs) and start delay on departure punctuality, the impact of ATFM regulation on arrival performance and taxi in performance for arrivals
- Section 6 highlights the conclusions and recommendations of the study.

2 GATWICK’S CURRENT OPERATING ENVIRONMENT

2.1 Introduction

This section provides an overview of the evolution of Gatwick’s operating environment from summer 2014 through to summer 2016 in terms of the volume of traffic, its characteristics and punctuality performance. The section also provides high level descriptions of the processes used to manage Gatwick’s air traffic. The section is organised as follows:

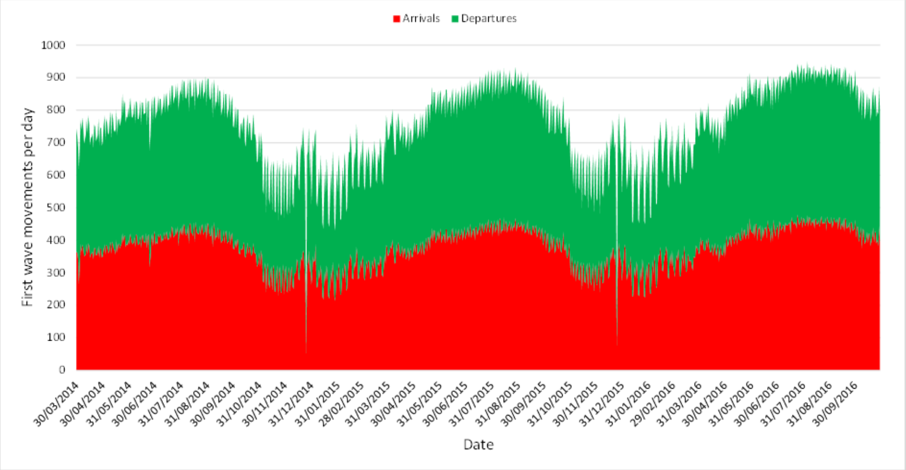
- Section 2.2 describes traffic volume and illustrates how it has evolved from 2014. Overall traffic is described in terms of number of movements at a monthly, daily and half-hourly resolution; this is then segmented into arrivals and departures to compare and contrast the different patterns and understand how they contribute to the overall loading
- Section 2.3 highlights the principal characteristics of Gatwick’s air traffic in terms of aircraft size and loadings, and origins and destinations
- Section 2.4 illustrates the development of punctuality performance from summer 2014 to summer 2016 at seasonal, daily and half-hourly resolution
- Section 2.5 provides high level descriptions of Gatwick’s air traffic management processes to set the operational context for the analysis described in the remainder of the report
- Section 2.6 uses simple fishbone diagrams to identify and understand the potential influences on Gatwick’s performance to add focus to the analysis.

2.2 Traffic volume

2.2.1 Overall traffic

Figure 4 illustrates the development of Gatwick’s air traffic in movements per day from the beginning of the 2014 summer season to the end of the 2016 summer season. Arrivals (red) and departures (green) are differentiated in the figure.

Figure 4: Evolution of daily traffic volume from summer season 2014 to summer season 2016

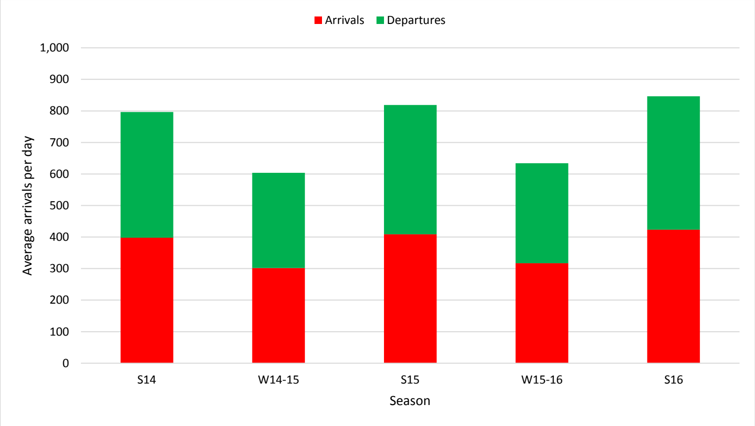


The figure clearly shows the summer-winter cyclical pattern, with much higher volumes, typically by 50% in the summer than winter. This cyclical pattern is overlaid on an underlying general increase. During the summer, traffic builds up through April, May and June, peaks during July, August and

September and then starts to fall off during October. There is a sharp reduction in traffic at the change from summer to winter seasons at the end of October. Volume continues to fall during November then increases to a peak of winter traffic in December, falls again in January and then starts to increase through February and March. There is a step change increase in traffic at the change from the winter to summer seasons at the end of March. There is considerable day-to-day variation superimposed on these general trends, indicated by the spikiness of the chart.

Figure 5 consolidates the data shown above to show average daily traffic volume by season. The total volume has increased by approximately 6% from summer 2014 to summer 2016.

Figure 5: Average daily traffic volume by season



To add more detail and to explore the variation of traffic across the day, Figure 6 is a traffic volume heatmap for summer 2014. Figure 7 is a similar heatmap for summer 2016. The heatmaps have three parts:

- The central, main part that shows traffic volume at half-hourly resolution for the whole season. The horizontal axis defines the time of day in universal time coordinated (UTC) equivalent to Greenwich Mean Time (GMT) in half-hour intervals and the vertical axis defines the day
- The right hand bar, which illustrates the daily average traffic volume, referring to the vertical, daily axis
- The bottom bar that shows the monthly average traffic volume, segmented into half-hour intervals.

The unit of volume used throughout is the number of flights per half-hour.

The heatmap shows the variation in intensity of traffic with hotspots in the morning from April through to September and across the afternoon, again most prevalent in July, August and September. The daily variation also shows the greatest traffic volumes in August, increasing through July and tailing off through September.

Figure 6: Heatmap showing summer 2014 traffic volume

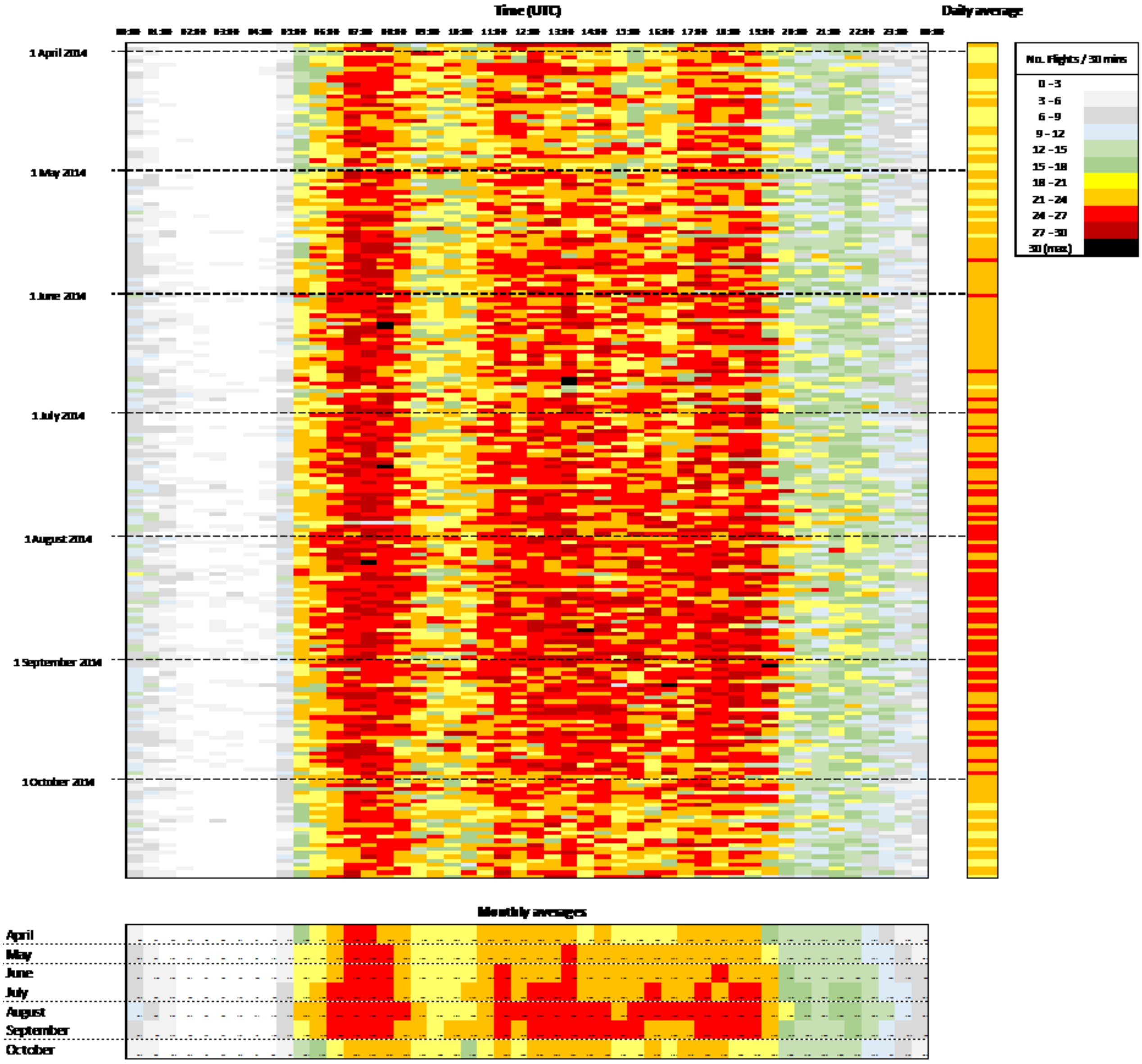
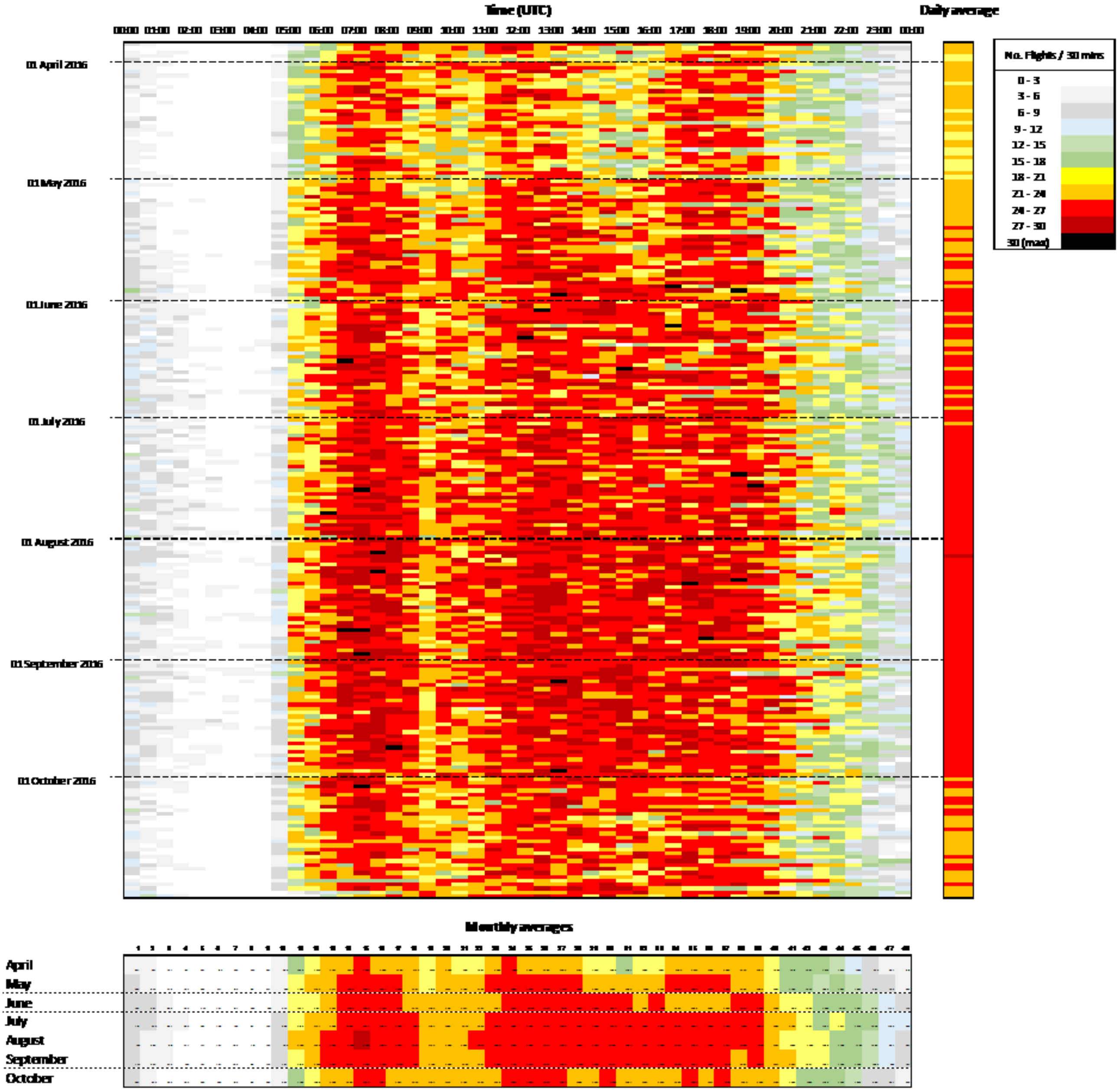


Figure 7: Heatmap showing summer 2016 traffic volume



Comparison of summer 2014 and summer 2016 heatmaps, Figure 6 and Figure 7 respectively, clearly illustrates the increase in traffic from 2014 to 2016. Summer 2016 has the same basic traffic pattern as summer 2014 but with a higher intensity. This is particularly apparent in the daily averages for July, August and September, which have increased from mixed pattern of amber and red through to a solid pattern of red. The periods of high traffic in the morning and afternoon have also extended.

2.2.2 Arrivals

Figure 8 and Figure 9 show traffic volume heatmaps for arrival traffic for summer 2014 and summer 2016 respectively. These heatmaps are the same format as those above for total traffic but the scale has been compressed, reflecting that arrival traffic is clearly approximately half of total traffic.

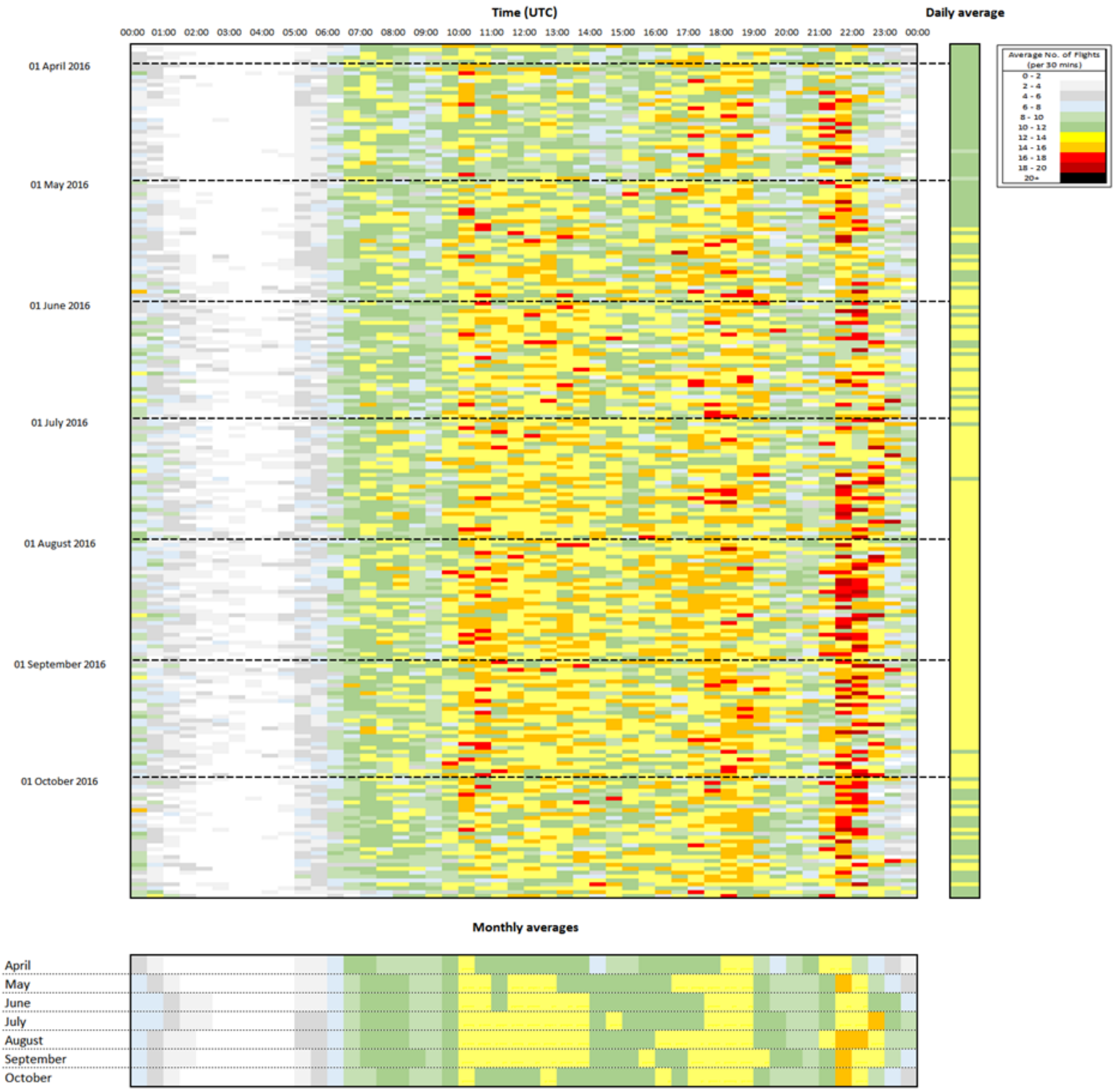
As with total traffic, the heatmaps have the same basic structure but with summer 2016 arrivals traffic being higher than summer 2014. There is an underlying wave pattern of arrivals, most apparent in the monthly averages at the bottom of each chart. These waves have extended from summer 2014 to 2016 and cover the following approximate time windows:

- Early morning from 07:30 to 09:30 local time (06:30 to 08:30 hours UTC)
- Late morning to mid-afternoon from 11:00 to 15:00 hours local time (10:00 to 14:00 UTC)
- Early evening from 18:00 to 20:00 hours local time (17:00 to 19:00 UTC)
- Late evening from 22:30 to 24:00 hours local time (21:30 to 23:00 UTC).

The last wave is the most intense and the first the least intense.

Figure 8: Heatmap showing summer 2014 arrival traffic volume

Figure 9: Heatmap showing summer 2016 arrival traffic volume



2.2.3 Departures

Figure 10 and Figure 11 are heatmaps for summer 2014 and summer 2016 departure traffic respectively.

Figure 10: Heatmap showing summer 2014 departure traffic volume

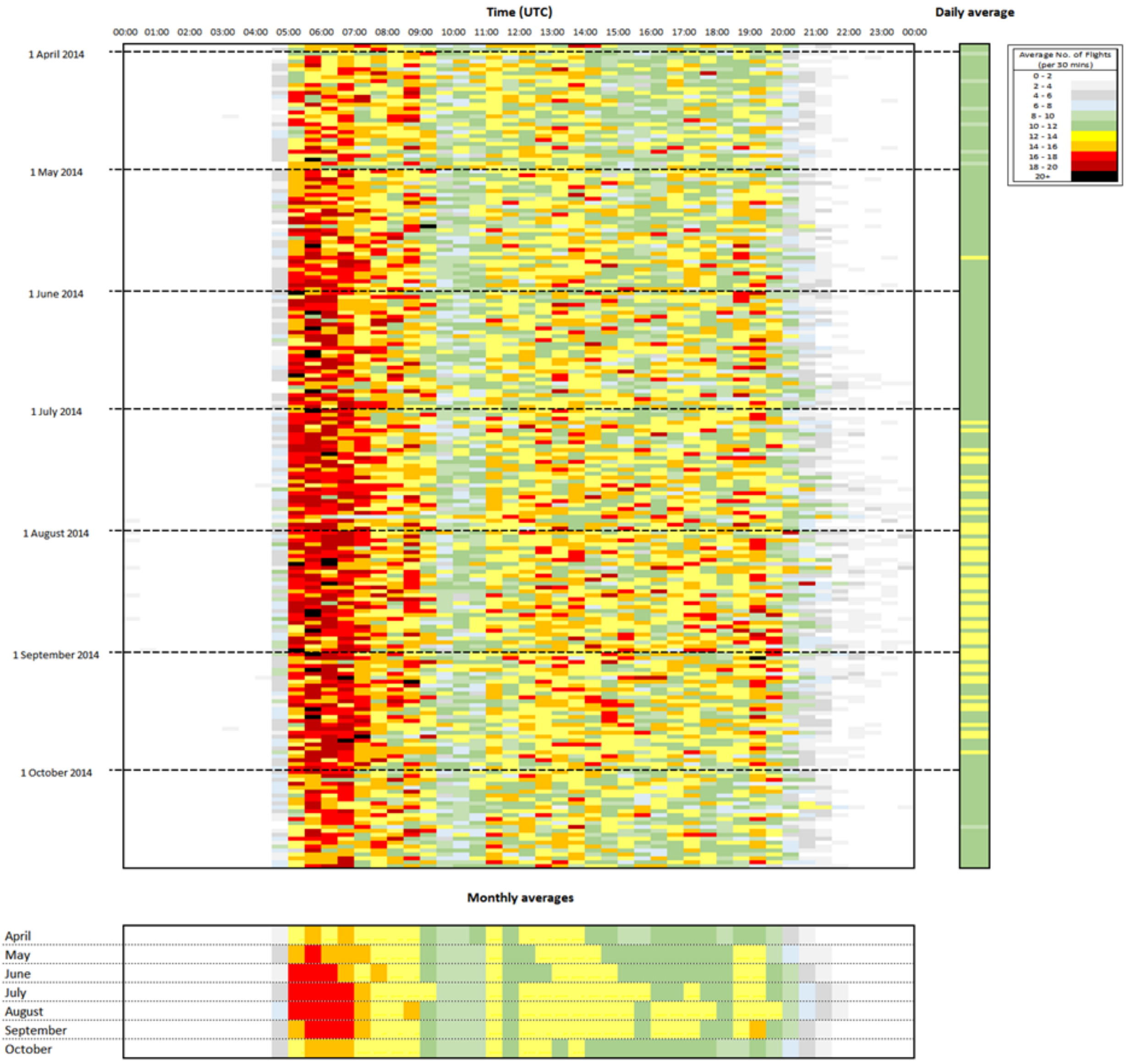
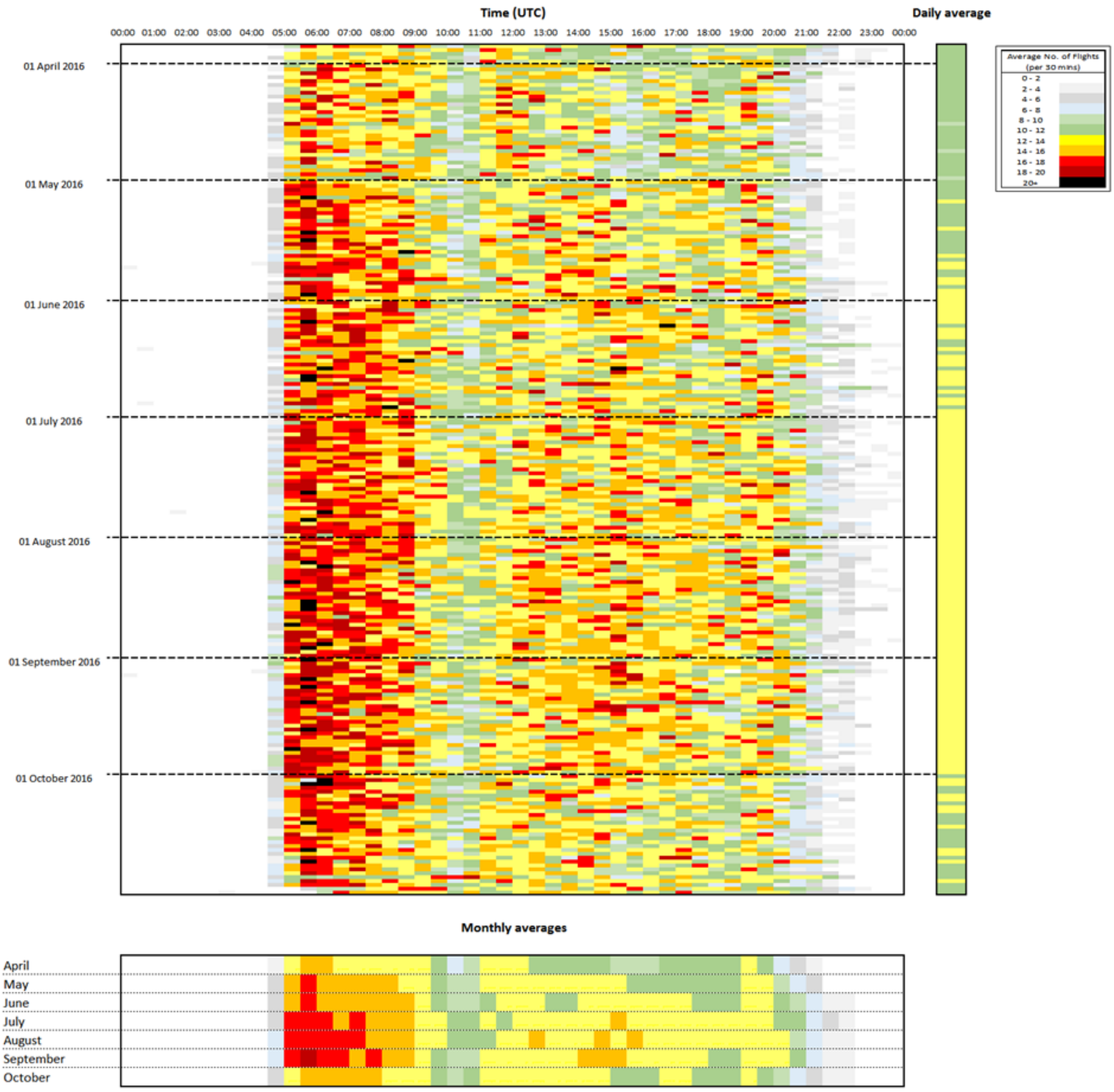


Figure 11: Heatmap showing summer 2016 departure traffic volume

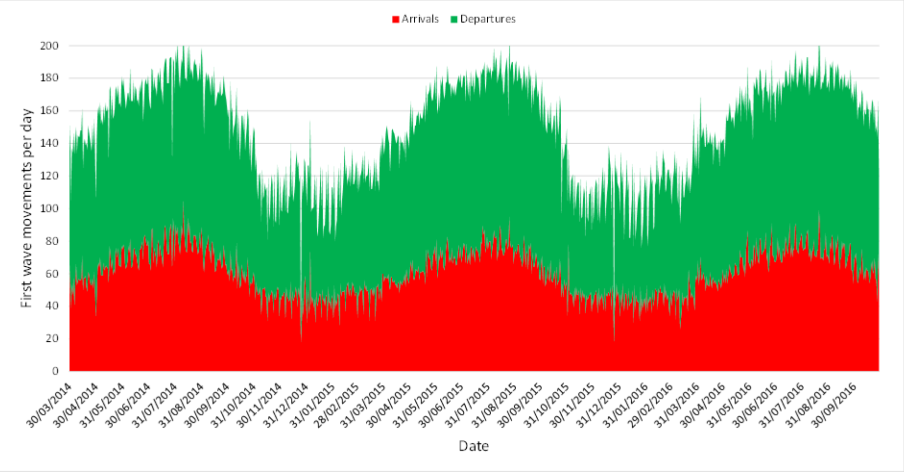


Again these heatmaps illustrate the increase in traffic volume from 2014 to 2016. The also emphasise the strong departure wave in the early morning and also show how the afternoon departure waves apparent in summer 2014 have merged in summer 2016, especially during the busier months.

2.2.4 First wave

Figure 12 shows the volume of traffic that can be approximately described as first wave, operating between 04:00 and 08:00 hour's local time. The full definition of first wave traffic is provided in section 3.2. However, with the data available it is only possible to apply the strict definition to summer 2016 traffic so the above approximation has been used for the other seasons.

Figure 12: Evolution of first wave traffic volume



The figure shows that that first wave traffic pattern is similar to the overall traffic pattern and makes up approximately 20% of the overall volume. On average, the first wave traffic comprises 30 to 40% arrivals and 60 to 70% departures.

2.3 Traffic characteristics

2.3.1 Aircraft size and loading

Figure 13 and Figure 14 show the average passengers per flight, the average gauge of the aircraft using Gatwick in terms of seats per flight and the average load factor for arrivals and departures respectively. Data to derive load factor and seats per flight were only available from summer 2015.

Figure 13: Evolution of passengers per arrival and arrival load factor from summer 2014 to summer 2016

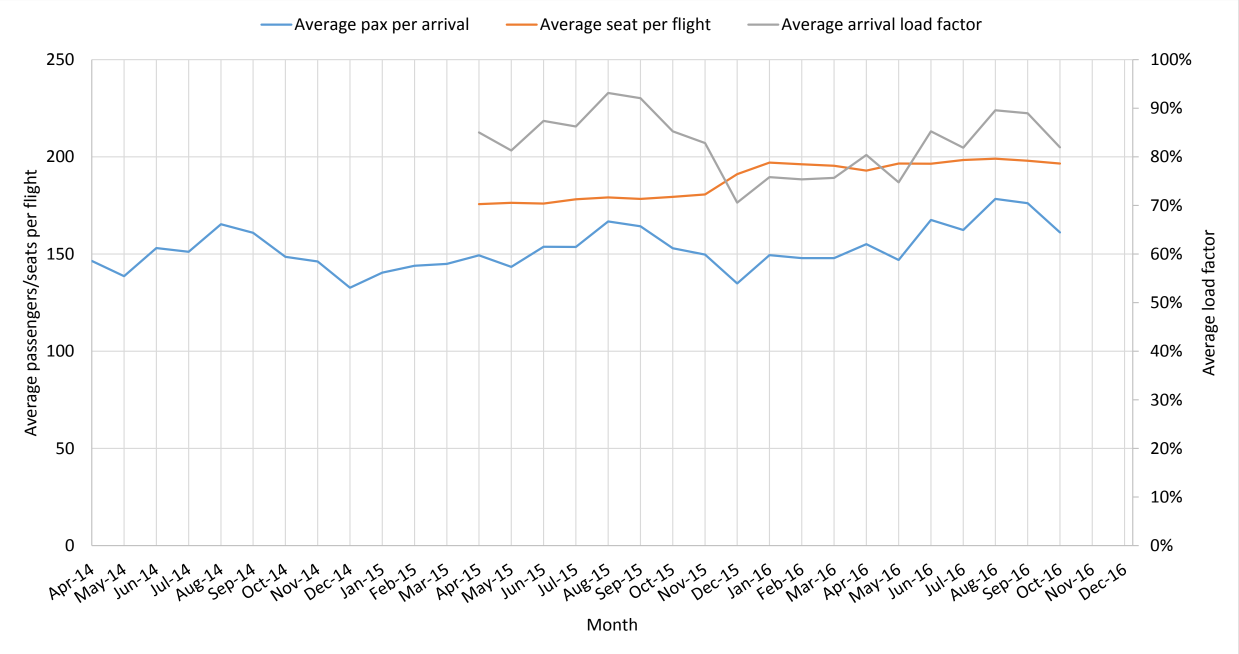
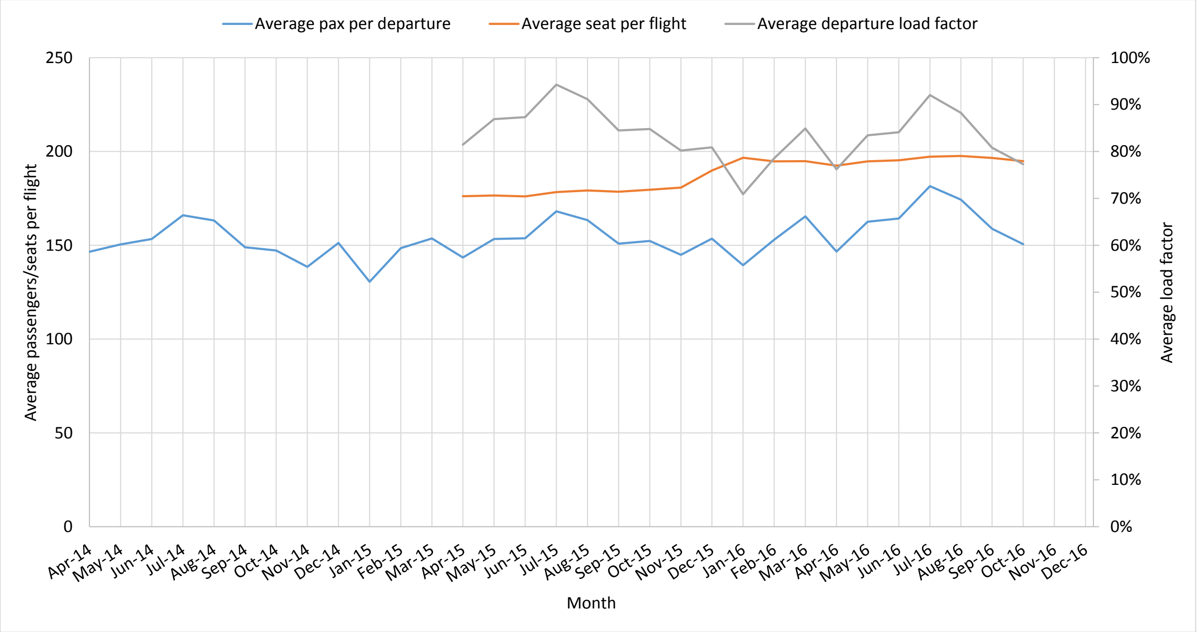


Figure 14: Evolution of passengers per departure and departure load factor from summer 2014 to summer 2016



Over the period being studied, the charts show that:

- From the beginning of April 2014 to July 2016, the average passengers per arrival increased from approximately 140 to approximately 178 and over the same period the average number of passengers per departure increased from 152 to approximately 180. During September and October the average number of passengers per flight reduced with departure levels reverting to their April 2014 levels
- Over the period from the beginning of April 2015 to the end of October 2016, the average seats per flight has increased from approximately 175 to 196, peaking in August 2016 at 199
- Load factor is cyclical, higher in summer than winter. Peak load factors of approximately 95% occurred in June/July 2015 for both arrivals and departures. Load factors ten reduced corresponding to the winter season and the increase in average gauge of aircraft. Arrival load factors increased to a peak of 90% in August 2016 with departure load factors reaching a peak of 92% in July 2016.

2.3.2 Origins for arrivals

This section investigates the stage length for arrivals, defined as long, medium and short haul. Short haul is defined as flights typically three hours or less; medium haul is defined as three to six hours flight time and long haul over six hours flight time.

Overall arrivals

Figure 15: Evolution of arrival volume from long, medium and short haul origins

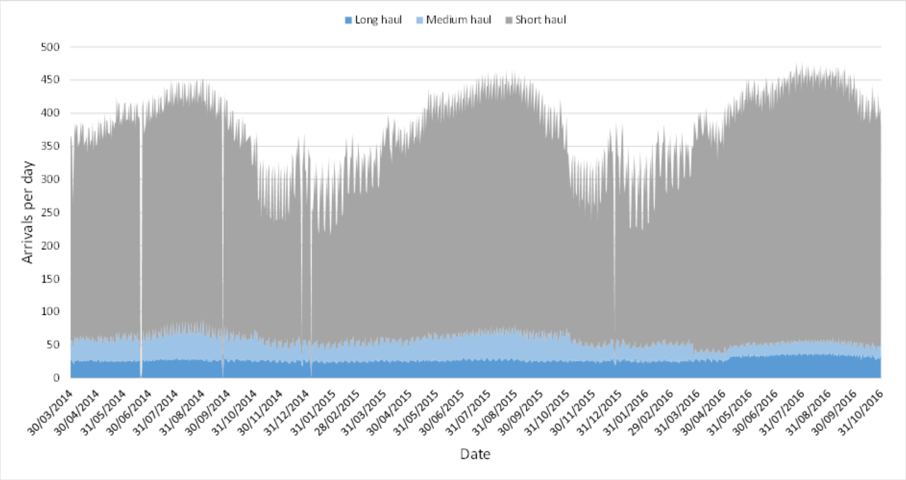
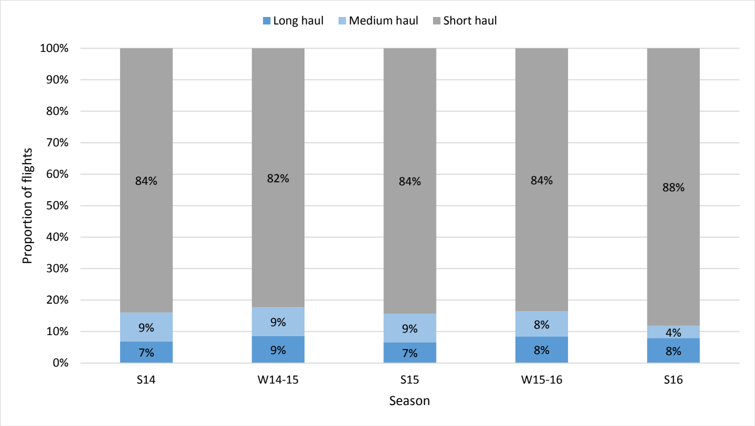


Figure 15 shows the volume of arrivals from long, medium and short haul origins on a daily basis from April 2014 through to October 2016. Figure 16 consolidates this picture to a seasonal resolution, showing the proportion of arrivals in each category.

Figure 16: Proportion of arrival traffic from long, medium and short haul origins by season

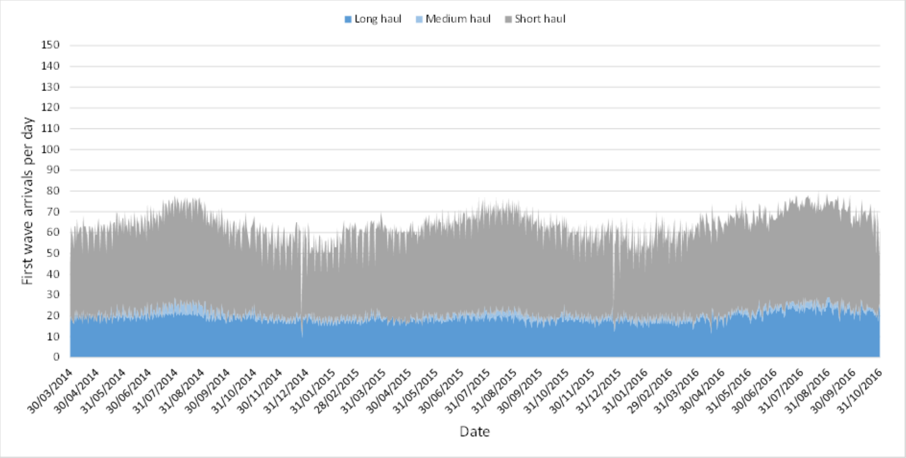


Across the period being investigated, the proportion of long haul arrivals has remained consistent at 7 to 9% of the total. Up to the start of summer 2016, the proportion of medium haul arrivals also did not vary appreciably at 8 to 9% of the total. However, at the start of the summer 2016 season there was a step-down in medium haul arrivals from 8 to 4% and a corresponding step-up of short haul arrivals from the previously consistent value of 84% to 88%.

First wave arrivals

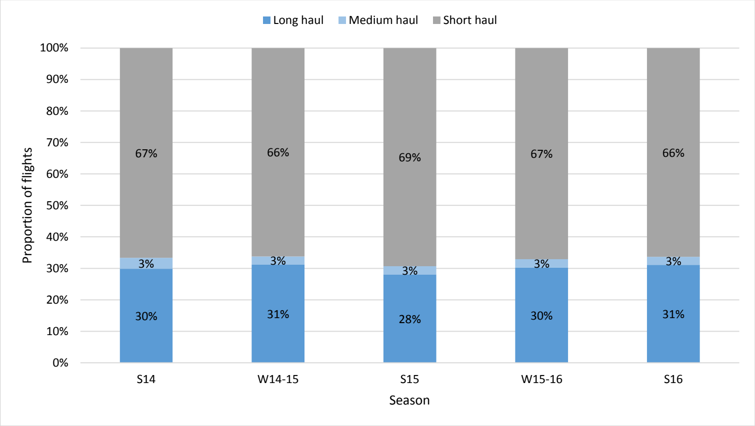
Similarly Figure 17 shows the daily of long, medium and short haul arrivals operating in the first wave and Figure 18 consolidates this into proportions of first wave flights arriving from each origin category.

Figure 17: Evolution of first wave arrival volume from long, medium and short haul origins



For the first wave, the proportion of long haul arrivals is much greater – at approximately 30% of the total – than the overall figure of 8% of the total. In the first wave there is not a step down in the proportion of arrivals from medium haul origins as there is the overall traffic profile.

Figure 18: Proportion of first wave arrival traffic from long, medium and short haul origins by season



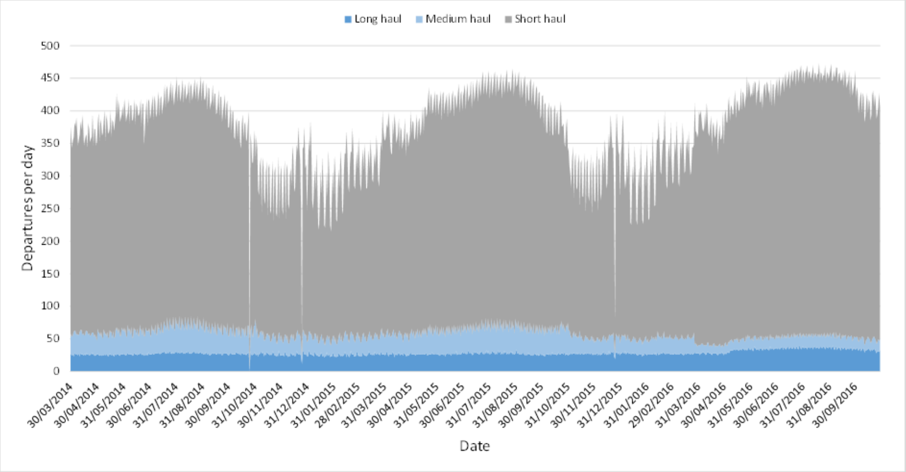
2.3.3 Destinations for departures

This section investigates the stage length for departures following the same approach as described above for arrivals.

Overall departures

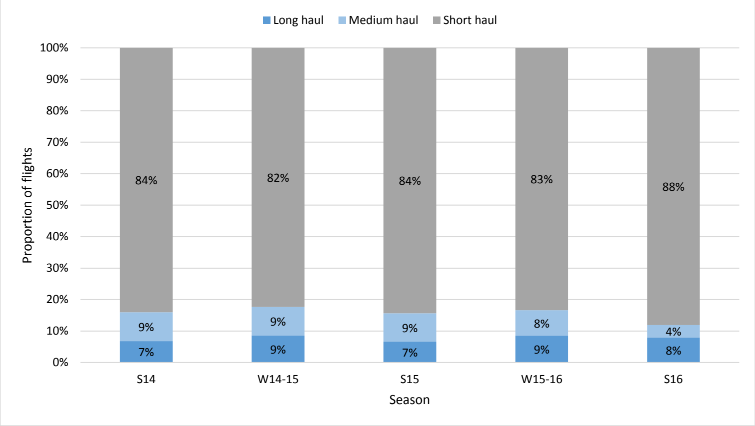
Figure 19 shows the volume of departures to long, medium and short haul origins on a daily basis from April 2014 through to October 2016. Figure 20 consolidates this picture to a seasonal resolution, showing the proportion of departures in each category.

Figure 19: Evolution of departure volume to long, medium and short haul destinations



Unsurprisingly the figures show very similar characteristics to those describing arrivals with the main feature being a step-down in the number and proportion of departures, from 8 to 4%, to medium haul destinations at the beginning of summer 2016 with a corresponding step-up, from 84 to 88%, of short haul departures. Other than this change, the proportions of departures are consistent with approximately 7 to 9% being long haul, 8% being medium haul and 82 to 84% being short haul.

Figure 20: Proportion of departure traffic to long, medium and short haul destination by season



First wave departures

Figure 21 shows the daily of long, medium and short haul departures operating in the first wave and Figure 22 consolidates this into proportions of first wave flights departing to each origin category.

Figure 21: Evolution of first wave departure volume to long, medium and short haul destinations

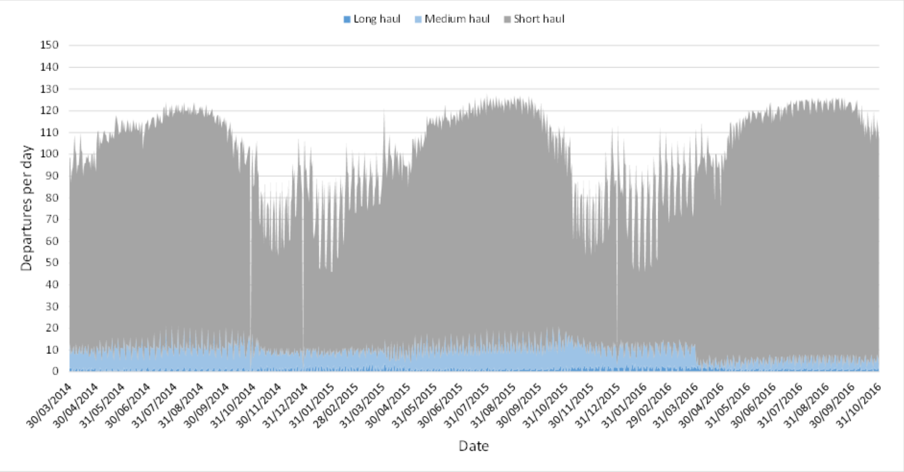
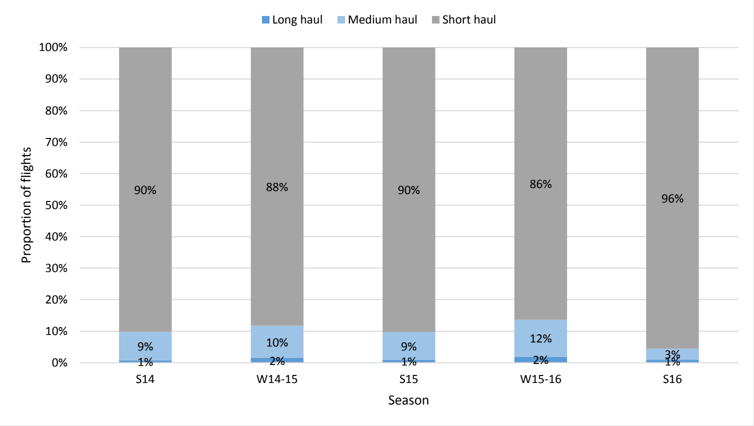


Figure 22: Proportion of first wave departure traffic to long, medium and short haul destination by season



The figures show that there are virtually no long haul departures in the first wave. The proportion of medium haul departures decreased to approximately 3% at the start of the summer 2016 season, leaving 96% of first wave traffic departing to short haul destinations.

2.4 Punctuality

The section investigates the evolution of Gatwick's punctuality performance from the start of summer 2014 through to the end of the 2016 summer season. Arrival punctuality is addressed in section 2.4.1 and departure punctuality is addressed in section 2.4.2.

2.4.1 Arrivals

Overall arrival punctuality

Figure 23 shows the evolution of the daily average arrival punctuality, which shows the familiar cyclical pattern being higher in winter than in summer. This is counter intuitive for punctuality, although not for traffic volume, where it is expected that summer performance would be better than winter performance that is subject to more weather effects.

Figure 23: Evolution of daily average arrival punctuality from summer 2014 to summer 2016

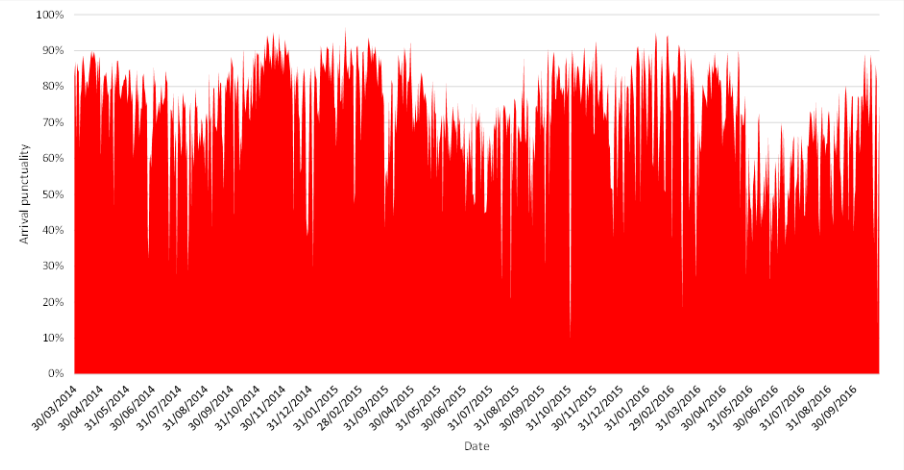
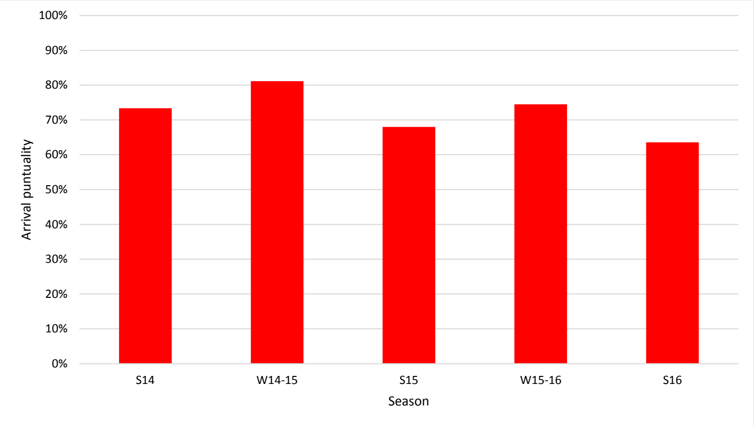


Figure 24 that shows the average seasonal arrival punctuality, confirms the cyclical summer-winter pattern but also illustrated a general downward trend, with summer punctuality decreasing from 73% in summer 2014 to 64% in summer 2016 and winter punctuality decreasing from 81% in winter 2014-15 to 74% in winter 2015-16.

Figure 24: Average seasonal arrival punctuality



First wave arrival punctuality

Figure 25 shows the evolution of first wave arrival punctuality from summer 2014 to summer 2016. This does not have follow a cyclical pattern and does not appear to have any underlying trend.

Figure 25: Evolution of daily average first wave arrival punctuality from summer 2014 to summer 2016

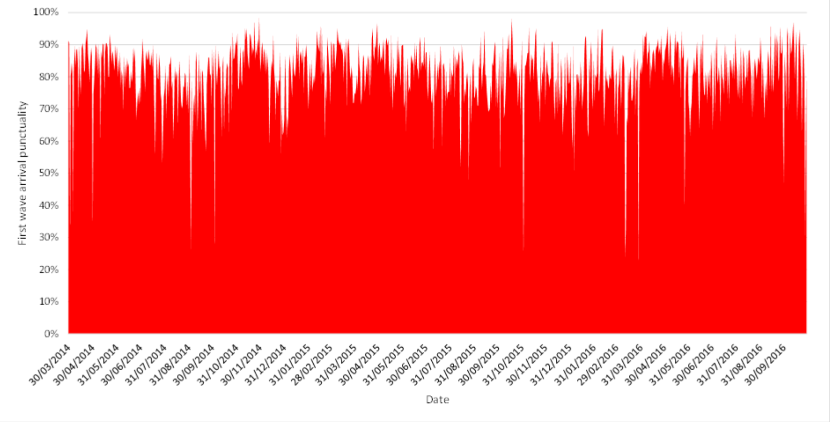
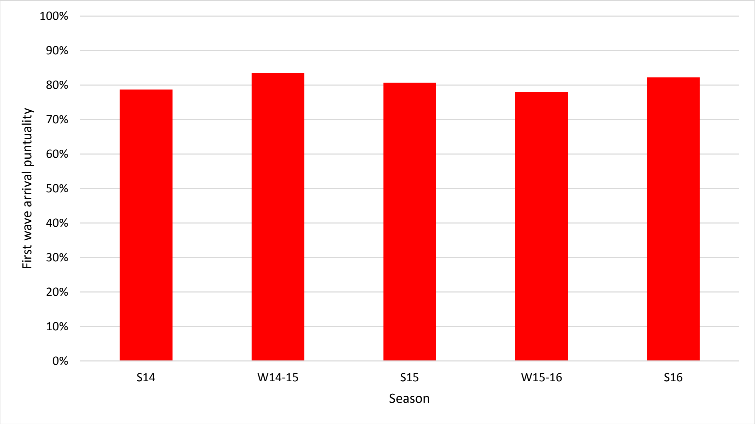


Figure 26 shows seasonal average first wave arrival punctuality has in fact improved slightly from summer 2014, at 79%, to summer 2016 at 82%.

Figure 26: Average seasonal first wave arrival punctuality



Comparison of summer 2014 and summer 2016

The heatmaps overleaf compare arrival punctuality in summer 2014(Figure 27), with arrival punctuality in summer 2016 (Figure 28). The heatmaps illustrate the marked reduction in arrival punctuality from summer 2014 to 2016.

In summer 2014, there are individual days and times within the day that punctuality performance is poor. In summer 2016, however, the areas of poor performance shown in the heatmaps have expanded considerably and cover multiple days and multiple hours across the day, particularly in the busy months. June and July showed especially poor arrival punctuality which, except in the early morning, was consistently below 50%. Across the season in the early morning and late at night punctuality performance was also very poor, below 50%, although in the early morning this only affects a small number of flights.

Figure 27: Heatmap showing arrival punctuality across summer 2014

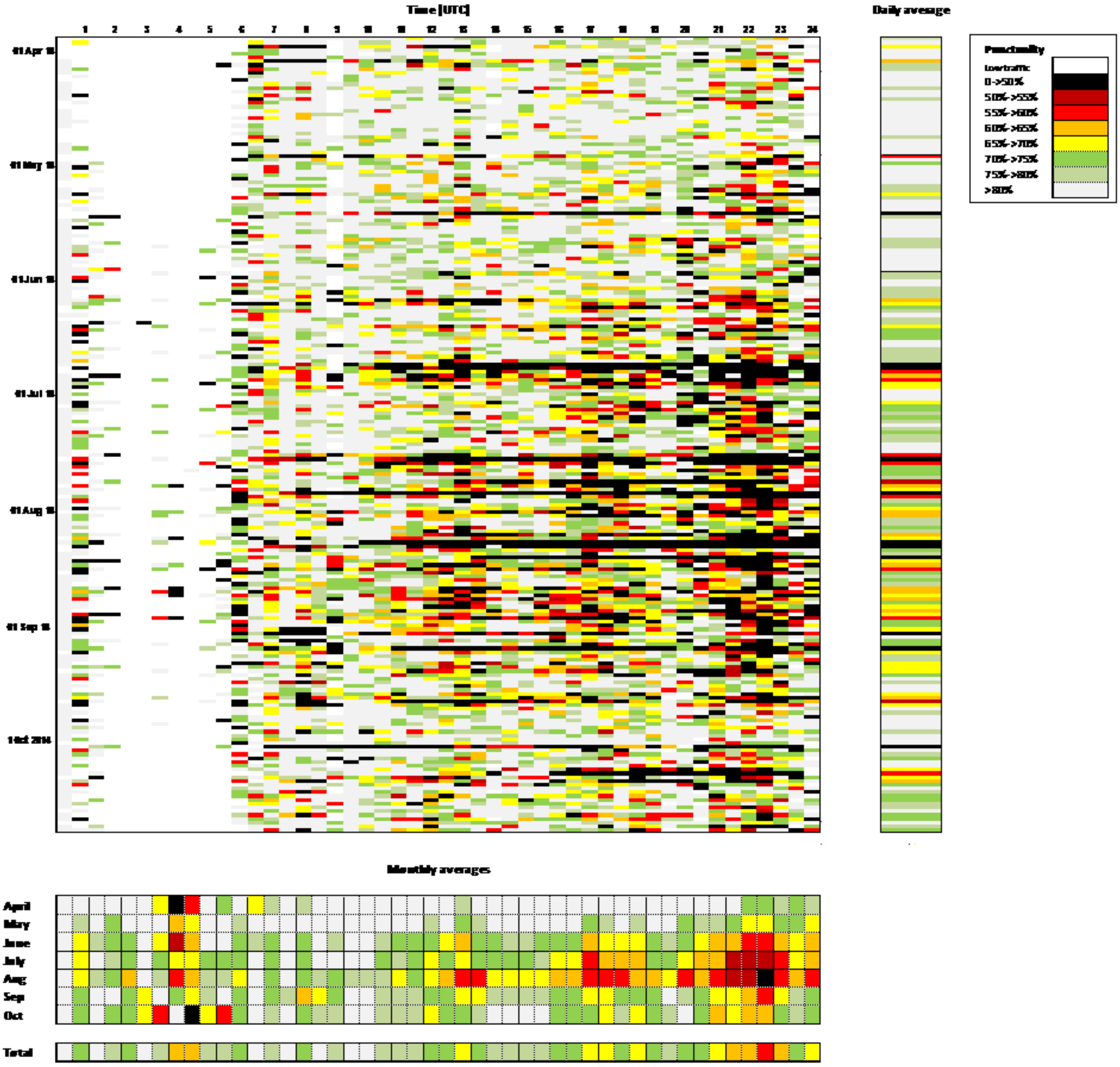
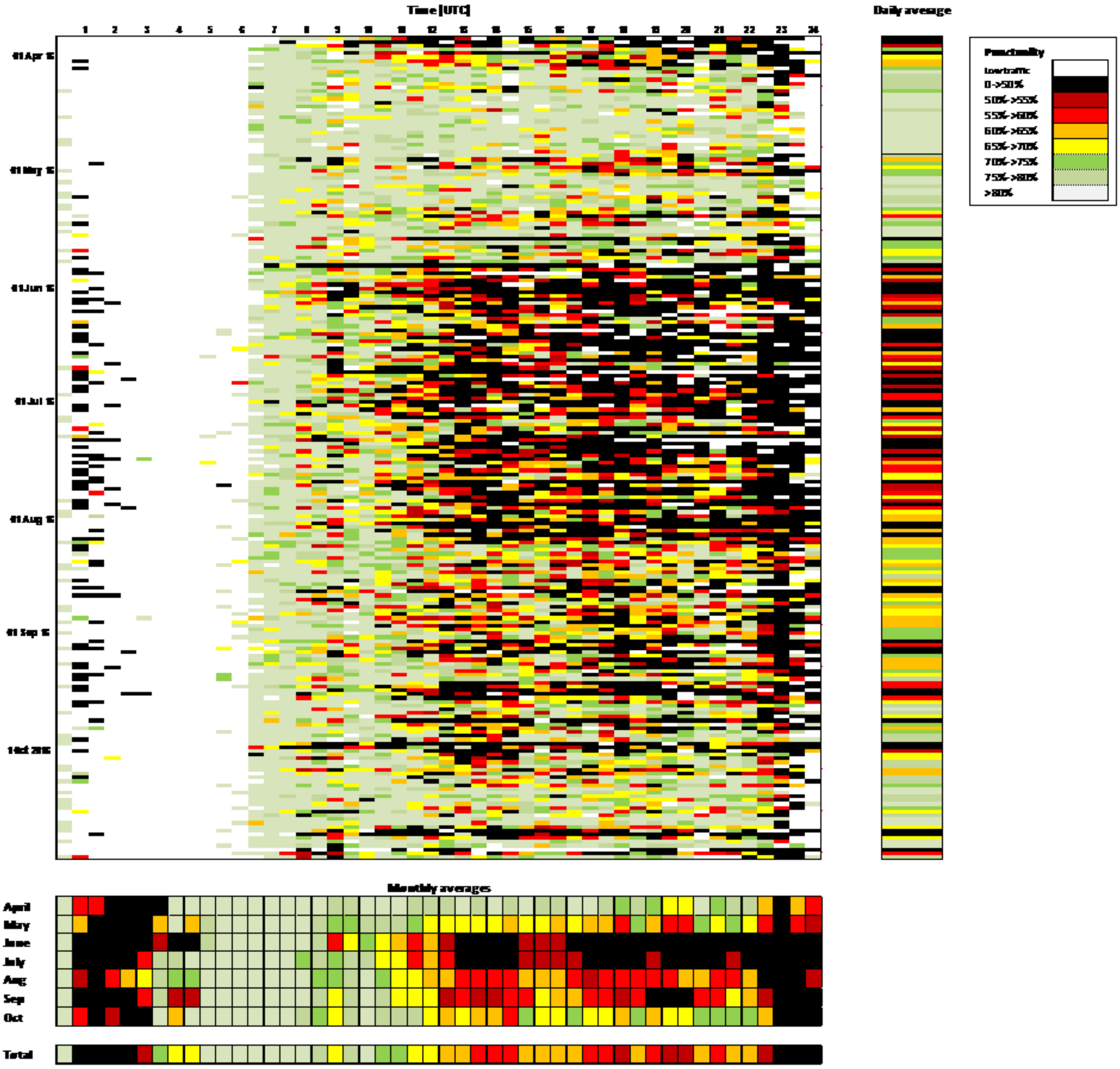


Figure 28: Heatmap showing arrival punctuality across summer 2016



2.4.2 Departures

Overall departure punctuality

Figure 29 shows the evolution of daily average departure punctuality from summer 2014 through to summer 2016 inclusive. As with arrival punctuality, the figure shows the cyclical summer to winter pattern with higher punctuality being achieved in the winter. There is also a general downward trend underlying the cyclical pattern.

Figure 29: Evolution of daily average departure punctuality from summer 2014 to summer 2016

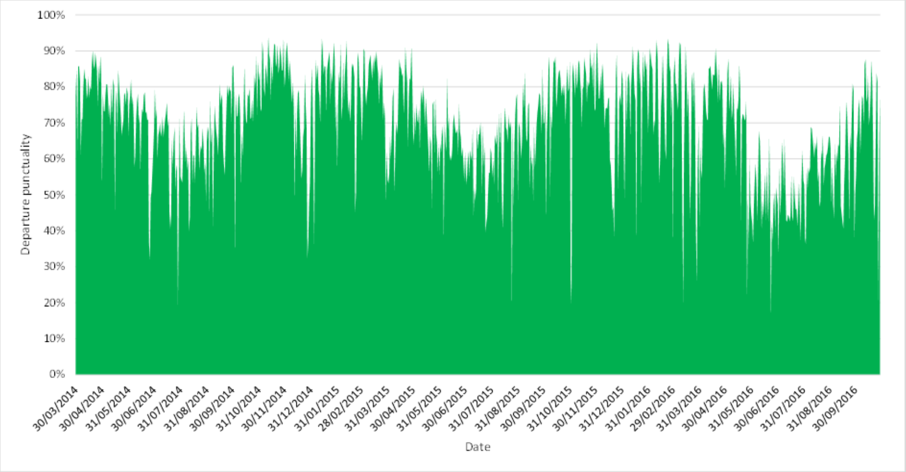
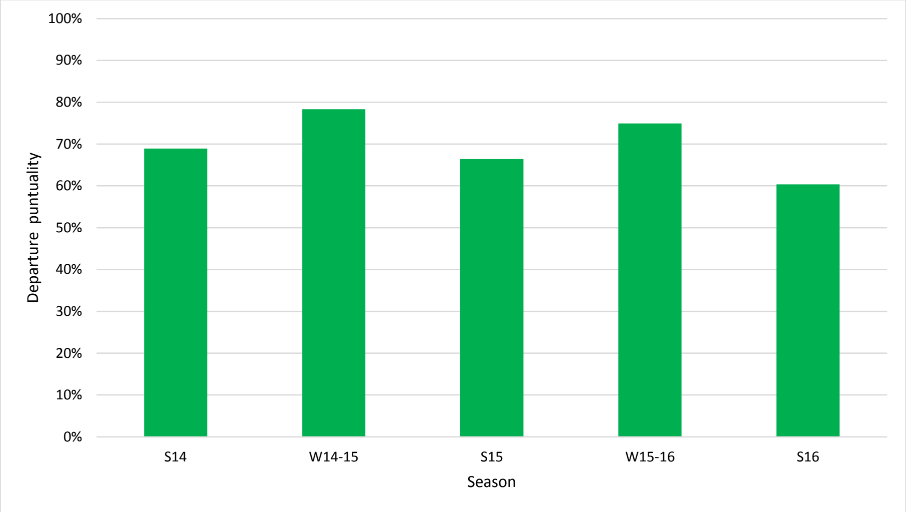


Figure 30 shows the average seasonal departure punctuality. The figure confirms the cyclical pattern and the underlying downward trend where average departure punctuality decreased from 69% in summer 2014 to 60% in summer 2016.

Figure 30: Average seasonal departure punctuality



First wave departure punctuality

Figure 31 shows the evolution of daily average first wave departure punctuality from summer 2014 through to summer 2016. Punctuality performance exhibits the cyclical summer winter pattern, with higher punctuality in winter than summer. There appears to be an underlying downward trend. First wave departure punctuality is considerably higher than the overall average departure punctuality, shown in Figure 29.

Figure 31: Evolution of daily average first wave departure punctuality from summer 2014 to summer 2016

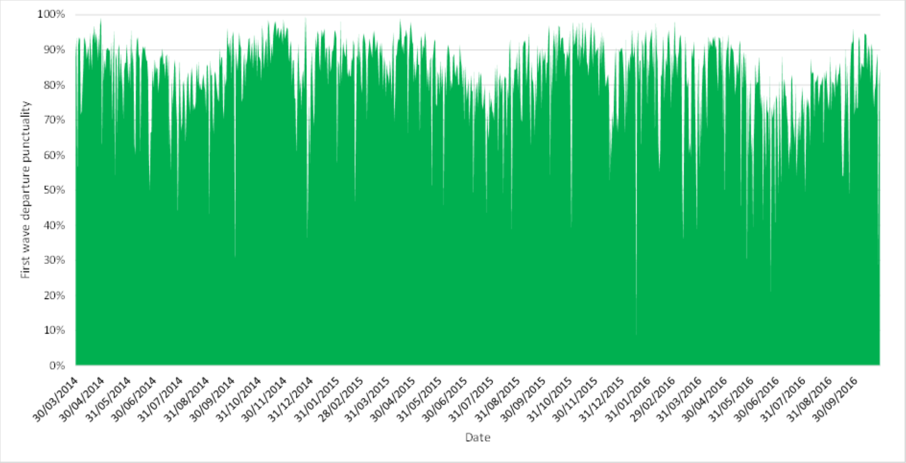
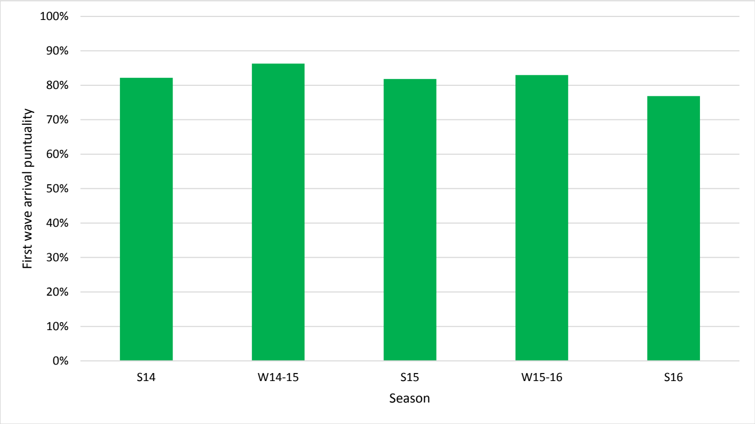


Figure 32 shows the seasonal average first wave departure punctuality. This confirms the downward trend from summer 2014, where the punctuality was approximately 82%, to summer 2016 where the punctuality was approximately 77%.

Figure 32: Average seasonal first wave departure punctuality



The heatmaps shown in Figure 33 and Figure 34 show departure punctuality performance in the summer seasons of 2014 and 2016 respectively. The heatmap for summer 2014 shows that punctuality is worst in the peak months of July and August. Punctuality starts are high levels – typically greater than 80% – in the early morning and generally, with the exception of April, gets worse through the day.

The heatmap for summer 2016 paints a more extreme picture. Punctuality is poor for the first few days of the season, then improves in April and May, although there is a tendency for poor performance in the evening after around 18:00 UTC (19:00 local time). In June, July August and September departure punctuality performance is uniformly poor from the early afternoon onwards until the end of the day. There is also often poor performance in the morning across this period, particularly in June and July. Performance improves in October, although there are several days with poor departure punctuality.

Comparison of summer 2014 and summer 2016

Figure 33: Heatmap showing departure punctuality across summer 2014

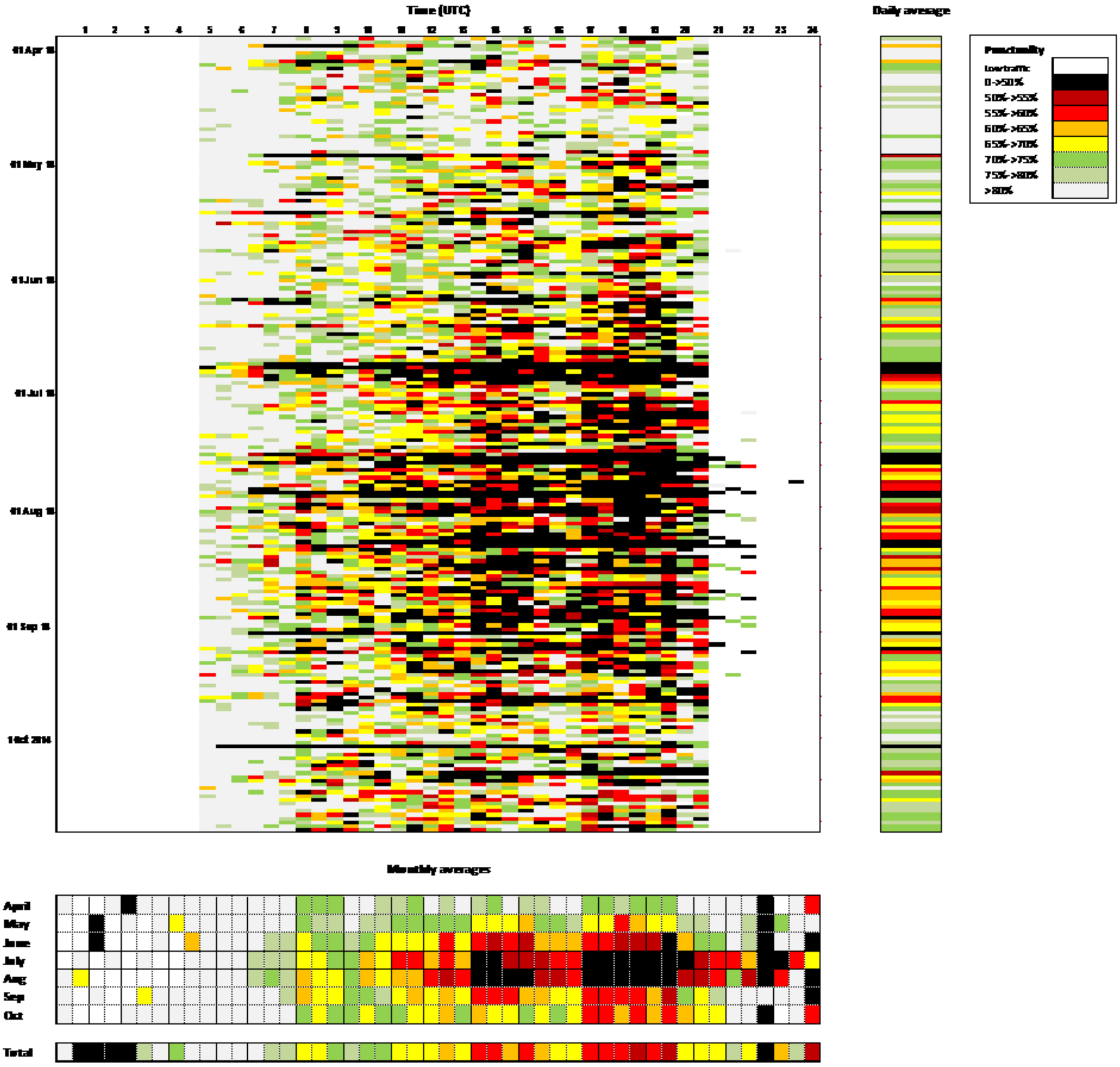
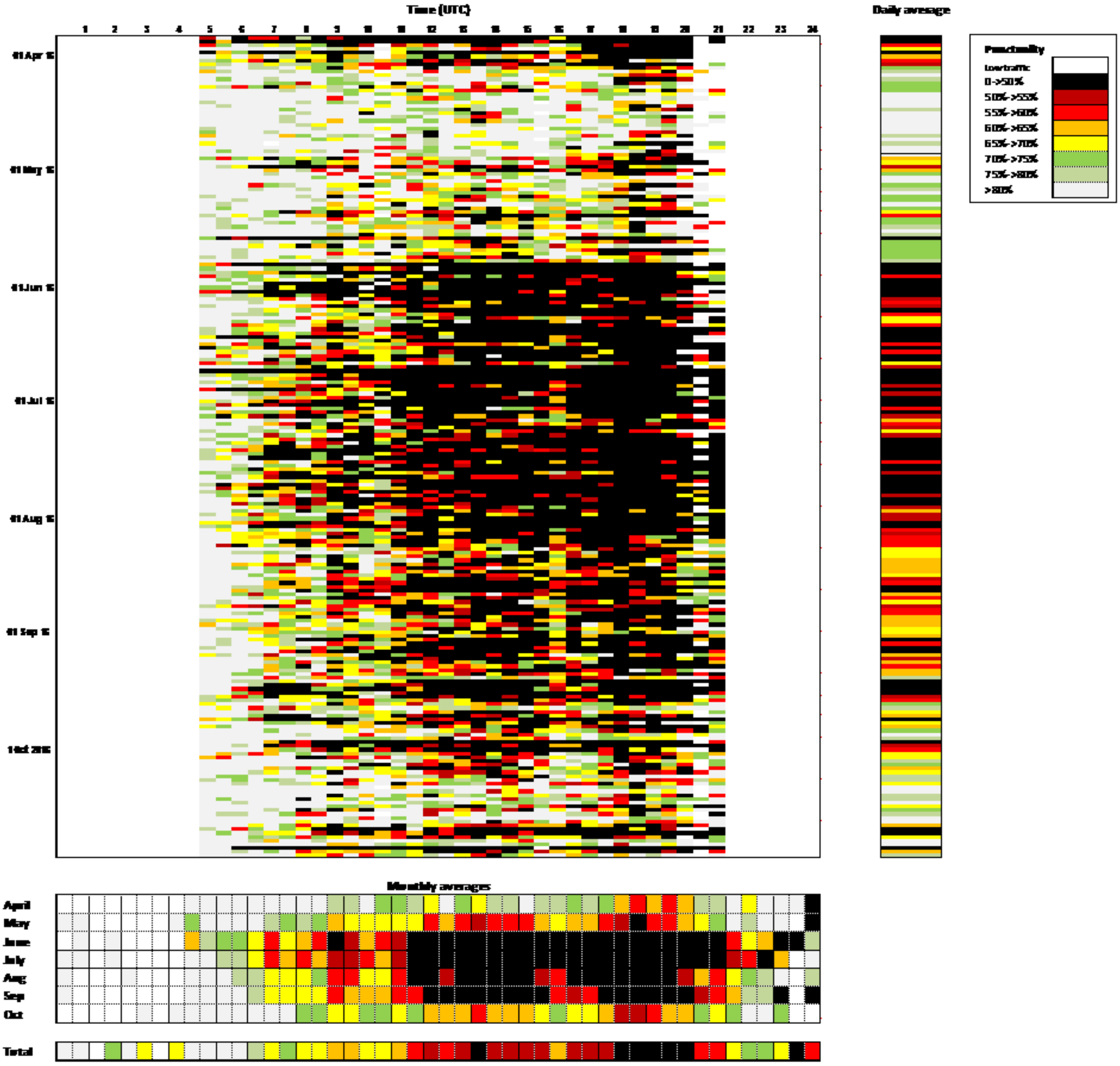


Figure 34: Heatmap showing departure punctuality across summer 2016



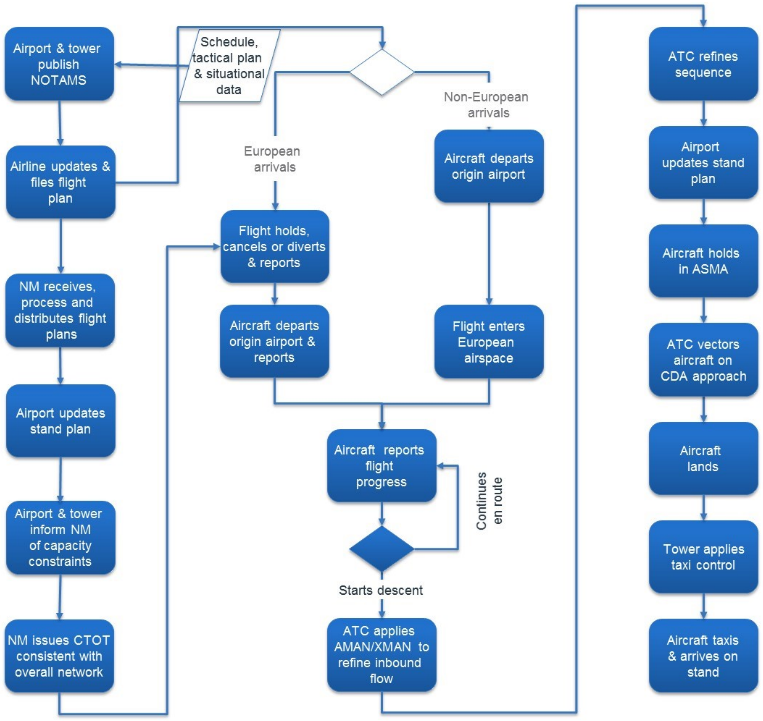
2.5 Traffic management processes

This section provides descriptions of the air traffic management processes applied at Gatwick, for arrivals in section 2.5.1 and departures in section 2.5.2. The descriptions are based on flow charts supplemented with full process maps identifying the roles of each of the actors and the underlying technology.

2.5.1 Arrival process

Gatwick's high level arrival process is illustrated in Figure 35 with a full process map being provided in Figure 36.

Figure 35: High level arrival process



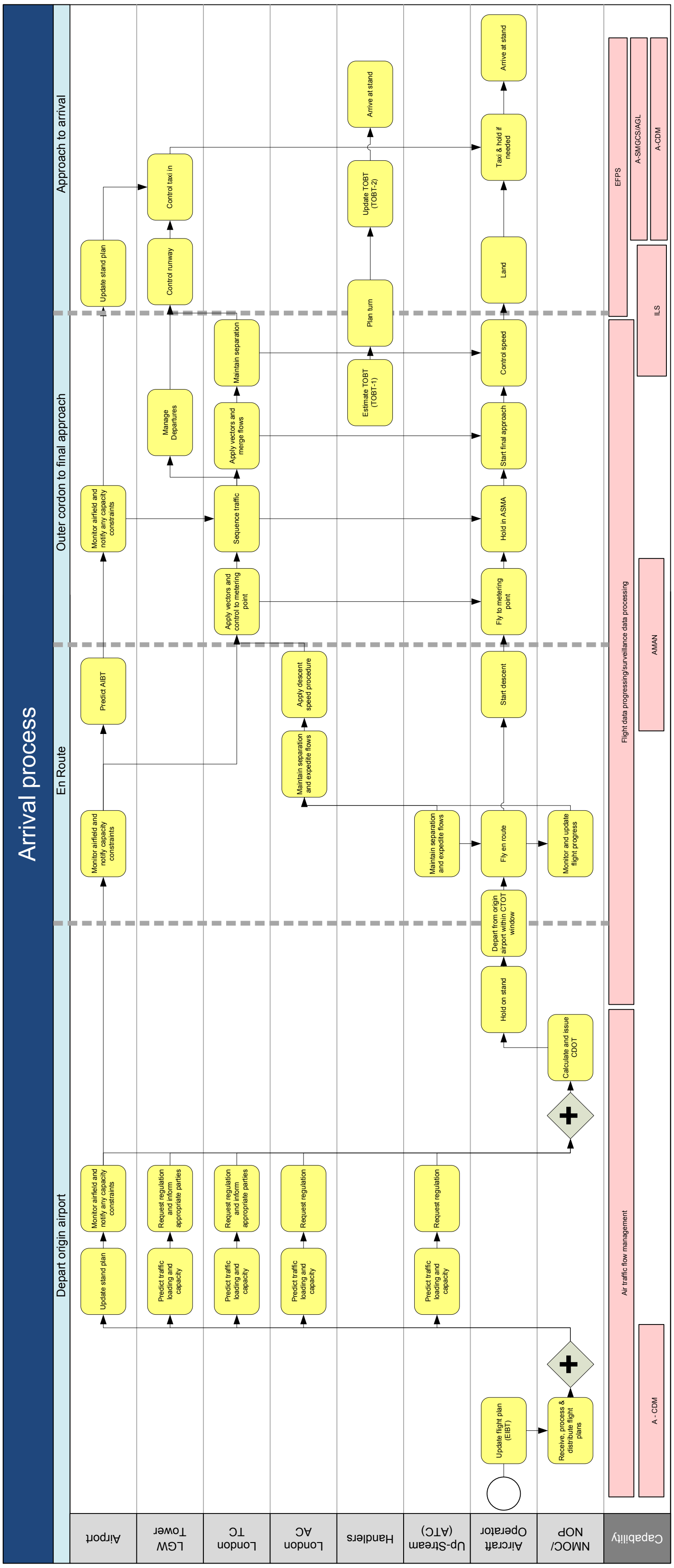
The basic arrival process on a per-flight basis is as follows:

- based on the schedule and other situational data (e.g. infrastructure status, weather reports and forecasts), the Airport and the Tower publishes the required operational data and notices to airmen (NOTAMs) the airline updated and files its flight plan
- the Network Manager receives, processes and distributes flight plans
- the Airport updates the stand plan
- the Airport and the Tower report any capacity constraints to the Network manager based on traffic load predictions
- the Network Manager optimises the flow across the entire network and issues regulations in the form of calculated take-off time (CTOT) as appropriate

Long haul traffic

- for long haul traffic outside of the area controlled by the Network Manager, the aircraft departs the origin airport consistent with its flight plan
- the long haul arrival enters European airspace and the process jumps to step 8

Figure 36: Arrival process map



European traffic

- aircraft arriving from European airports hold at their origin airport and subsequently departs consistent with its CTOT, or diverts or cancels if the CTOT is too severe
- the aircraft files periodic flight reports and the estimates within the Network Manager Operations Centre (NMOC) and the A-CDM system are updated
- from the 350 nautical mile action horizon, ATC applies speed control as directed by the arrivals managers (XMAN/AMAN) to refine the inbound flow
- London Terminal Control refines the arrival sequence as needed and the A-CDM system is updated
- the Airport updates the stand plan
- the aircraft holds in the arrival sequencing and metering area (ASMA) as needed
- the aircraft flies a continuous descent approach (CDA) and is vectored by ATC to optimise the sequence and ensure separations
- the aircraft lands
- the aircraft taxis in under the direction of ATC and arrives on stand.

This basic process is mapped in more detail in the figure above.

2.5.2 Departure process

Gatwick's high level departure process, starting with the arrival of the inbound aircraft, is illustrated in Figure 37 with a full process map being provided in Figure 38.

Figure 37: High level departure process

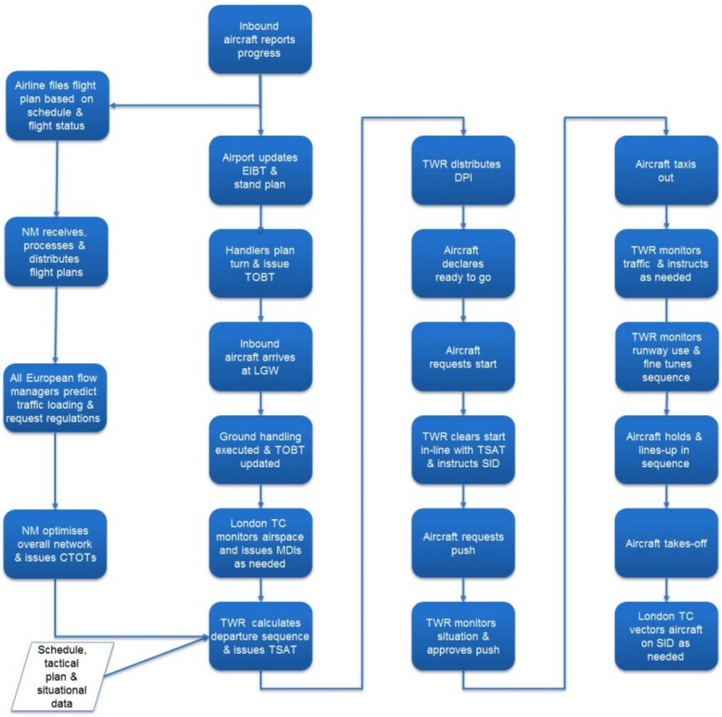
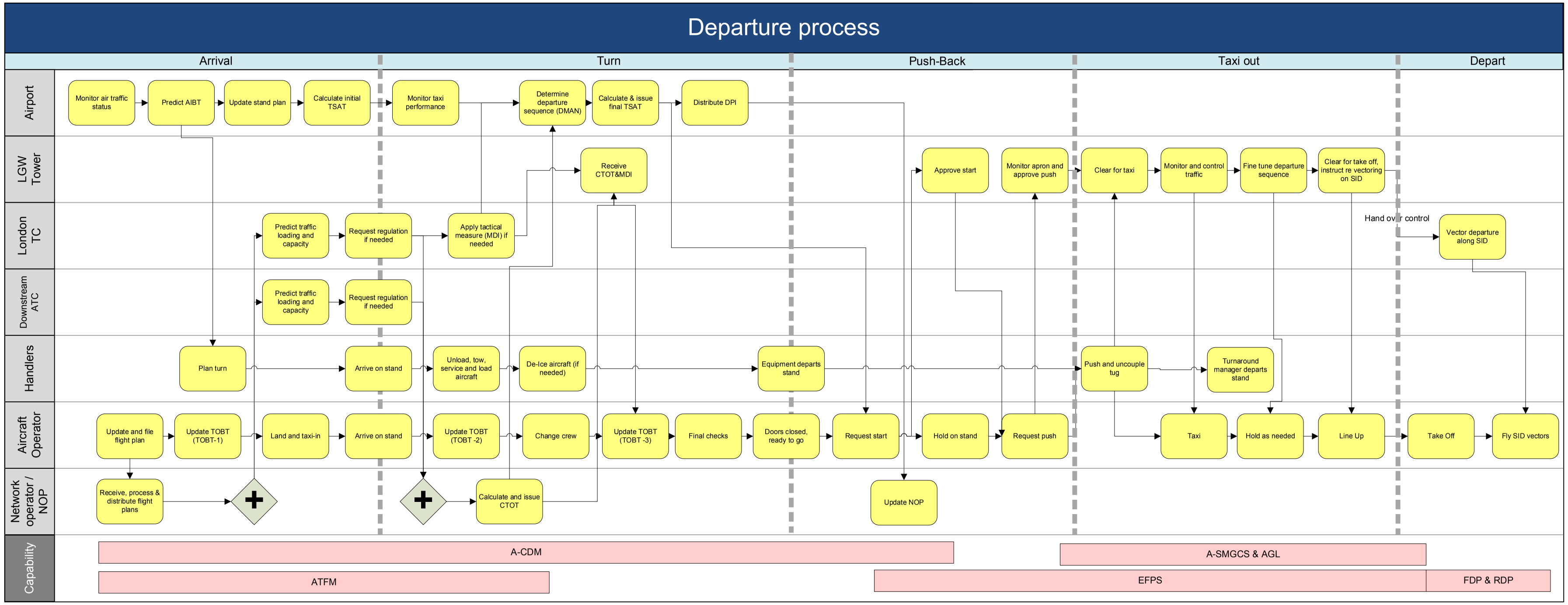


Figure 38: Departure process map



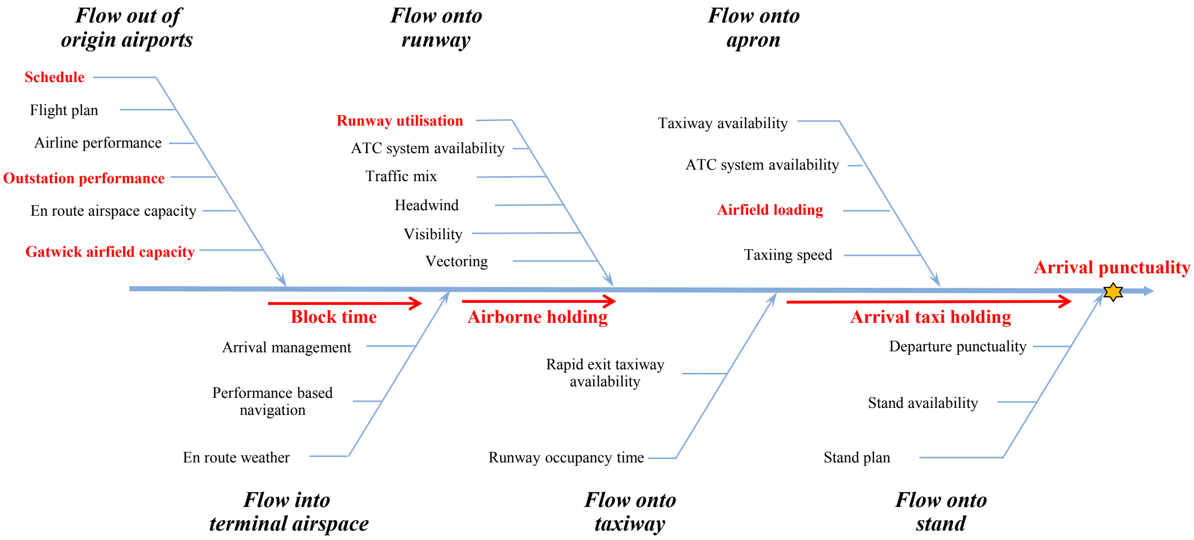
As with arrivals, the departure process starts with the schedule. The departure flow is moderated by in A-CDM by the target start approved time (TSAT) process, where a target start time is calculated for each aircraft to smooth and optimise the runway flow and manage holding times. The basic departure process on a per-flight basis is as follows:

- the airline files the flight plan for the departing flight
- the Network Manager receives, processes and distributes flight plans
- all downstream European flow managers predict traffic loading for their areas of responsibility and request flow regulations as needed
- the Network Manager optimises the overall network and issues a calculated take-off time (CTOT) as needed
- the inbound flight, if there is one, linked to the departure reports its progress
- the Airport updates the estimated in-blocks time (EIBT) and the stand plan; A-CDM is updated
- the handlers plan the turn and issue the target-off blocks time (TOBT)
- the inbound aircraft arrives at Gatwick
- ground handling is executed and the TOBT is updated as necessary
- London Terminal Control (TC) monitors the traffic situation and issues minimum departure intervals (MDIs) for Gatwick outbound traffic (as well as to the other airports in the London airport system) as needed
- the Tower calculates the departure sequence and issues a TSAT. This might include early pushback and remote holding for departures that are subject to a CTOT
- the Tower distributes departure planning information (DPI) to the Network Manager
- the aircraft declares ready to go
- the tower aircraft requests start consistent with its TOBT and TSAT
- the Tower authorises the start and instructs on the SID to be flown
- the aircraft requests pushback
- the Tower monitors the traffic situation and approves pushback when appropriate
- the aircraft pushes back, uncouples the tug and taxis out, including remote holding where needed
- the Tower monitors the traffic situation and issues taxi instructions as needed
- the Tower monitors runway use and fine tunes the departure sequence
- the aircraft holds at the runway holding point and lines up in sequence
- the aircraft takes-off
- TC vectors the aircraft on the SID as needed.

2.6 Performance influences

The relevant external drivers or performance influences had been identified using root cause, fishbone diagrams to chart the flow of arrivals and departures, highlighting where the key performance indicators (KPIs) were measured on the flow through the diagram. These charts are provided in Figure 39 for arrivals and Figure 40 for departures.

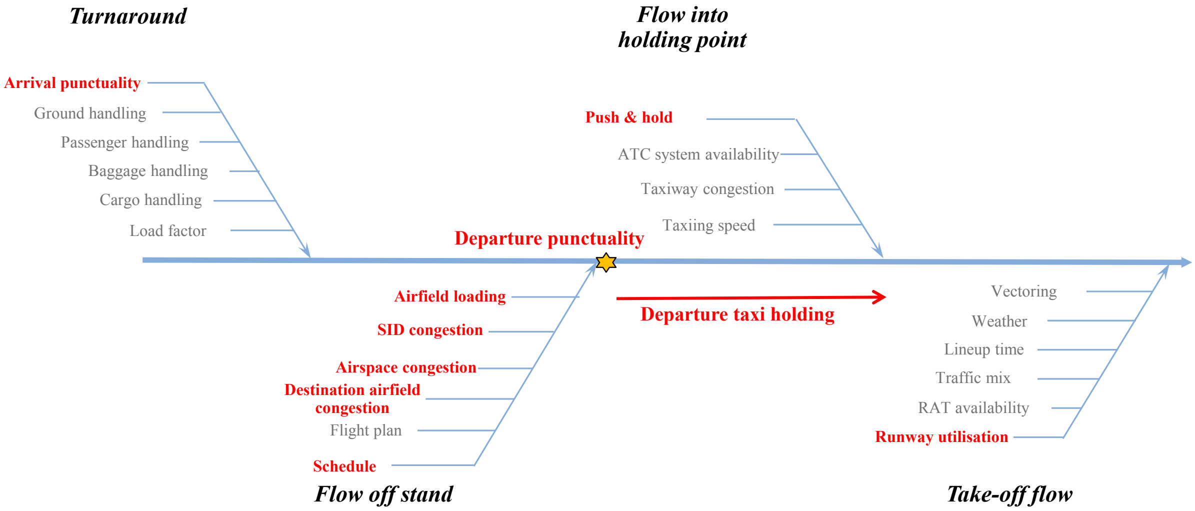
Figure 39: Root cause chart for arrivals



The main measurable influences that might be expected to influence arrival performance are:

- The schedule itself and specifically for arrivals:
  - whether the planned turn times at the outstation airport and the planned block time for inbound flights are realistic and achievable. This can be measured by comparing scheduled and achieved turn and block times
  - whether the level of airborne holding exceeds the limits applied during the capacity declaration part of the scheduling process.
- Gatwick airfield capacity which, if a constraint will result in:
  - inbound air traffic flow management (ATFM) delays attributed to Gatwick
  - airborne holding beyond the levels allowed during the capacity declaration process.
- runway utilisation, which will give a measure of how near to capacity the runway is and will impact on both airborne holding and departure taxi holding
- airfield loading, which might be expected to influence arrival taxi holding.

Figure 40: Root cause chart for departures



The main measurable influences that might be expected to influence departure performance are:

- Arrival punctuality
- The schedule itself and specifically for arrivals:
  - whether the planned turn times at Gatwick are realistic and achievable. This can be measured by comparing scheduled and achieved turn times
  - whether the level of departure taxi holding exceeds the limits applied during the capacity declaration part of the scheduling process.
- Congestion or capacity constraints in downstream airspace that will be manifested as air traffic flow management (ATFM) regulations resulting in holding delays at Gatwick
- Departure route (SID) congestion that will likely be realised as minimum departure intervals and result in start delay
- Airfield loading near to capacity constraints that might have as their source physical capacity constraints, air traffic controller workload and radio frequency availability. This might be expected to be manifested as start delay
- Push and hold, that is likely to result in additional departure taxi holding but improved departure punctuality for aircraft to which it is applied
- Runway utilisation, which will give a measure of how near to capacity the runway is and will impact on both airborne holding and departure taxi holding.

3 DEFINITIONS AND DATA

3.1 Introduction

The first major component of the study was to review and reach consensus on the definitions used in performance measurement and improvement as well as identify and agree the sources of data for performance measurement. This was achieved through workshops with the main stakeholders. This section describes the outcomes of those workshops and is organised as follows:

- Section 3.2 provides the definitions that form the basis of the study and should be used going forward to measure Gatwick's performance
- Section 3.3 lists the sources of data available and used for the study
- Section 3.4 highlights some recommendations for improvements to data sources and data sharing to facilitate performance measurement at Gatwick and ensure that all stakeholders are working with a common data baseline.

3.2 Definitions

This section contains the definitions that were reviewed and agreed during the project and form the basis of the analysis and this report. The definitions are classified under three headings: arrivals, departures and turns.

3.2.1 Arrivals

The following table provides the definitions most relevant to arrival traffic.

Table 1 Definitions relating to arrivals

Parameter	Definition
First arrival wave	All flights, regulated and non-regulated, actually arriving on-blocks at Gatwick between 04:00 local time and 09:00 local time, on the aircraft's first flight of the day
Arrival delay	The difference between the time that an aircraft was scheduled to arrive at its designated stand and the time that it actually arrived. Positive arrival delay implies late arrival and negative delay implies early arrival. Delay is measured as a statistical distribution, characterised by mean, mode, median, standard deviation and other statistical parameters
Arrival punctuality	The proportion of flights arriving on stand less than 15 minutes and 59 seconds after the scheduled time of arrival
On-time arrival performance (OTAP)	The proportion of flights arriving on the stand within ±15 minutes and 59 seconds of the scheduled time of arrival
Air traffic flow management (ATFM) arrival holding delay	A delay imposed on an arriving flight by the Network Manager because of a capacity constraint in upstream airspace or at Gatwick itself. ATFM delay is imposed by applying an ATFM regulation to the flight in the form of a calculated take-off-time (CTOT). The ATFM delay is defined as the CTOT minus the estimated take off time (ETOT) at the origin airport
Airborne sequencing and metering area (ASMA)	The arrival sequencing and metering area (ASMA) is defined by Eurocontrol as a virtual cylinder with a 40 nautical miles radius centred on the airport

Parameter	Definition
Airborne holding	Airborne holding and sequencing is applied by London Terminal Control (TC) to moderate the flow of arrival traffic into the runway and optimise runway utilisation by sequencing the traffic. Airborne holding can occur by holding aircraft in the stacks and/or by vectoring the aircraft to increase the length of the approach path. Airborne holding is defined as the difference between the actual time to fly from the edge of the arrival sequencing and metering area (ASMA) to the runway and the unimpeded time for the same journey
Scheduled inbound block time	The time difference between the scheduled in-block time (SIBT) at Gatwick and the scheduled off-block time (SOBT) at the origin airport
Actual inbound block time	The time difference between the actual in-blocks time (AIBT) at Gatwick and the actual off-blocks time (AOBT) at the origin airport
Inbound block time success rate	The proportion of actual inbound block times that are executed within their scheduled inbound block times
Flying time	The difference between the actual landing time (ALDT) at Gatwick and the actual take-off time (ATOT) at the origin airport
Arrival taxi holding	Arrival taxi holding moderates the flow of aircraft from the runway to the apron and stand. It can be applied by requiring the aircraft to stop at a holding point and/or controlling the speed of the taxing aircraft. Arrival taxi holding is defined as the difference between the actual time to taxi from the touchdown point on a runway to the stand and the unimpeded time for the same journey
Unimpeded taxi-in time	As a proxy for the time taken for a journey in the absence of congestion, the unimpeded taxi-in time is defined as the 5th centile of the time distribution that it takes an aircraft to travel the arrival runway and its designated stand. Extended taxi times give an indication of airfield loading as well as arrival stand availability
Scheduled runway arrival rate	The number of arrivals scheduled to use the runway per unit time derived from the schedule taking into account standard taxi-in times. The overall scheduled runway rate is the sum of the scheduled runway arrival rate and the scheduled runway departure rate
Actual runway arrival rate	The number of arrivals actually using the runway per unit time. The overall actual runway rate is the sum of the actual runway arrival rate and the actual runway departure rate
Scheduled runway utilisation	The proportion of time that the runway would be occupied by the traffic sequence, arrivals and departures, implied by the schedule
Actual runway utilisation	The proportion of time that the runway is occupied by the traffic sequence, arrivals and departures, actually delivered

3.2.2 Departures

The following table provides the definitions most relevant to departure traffic.

Table 2 Definitions relating to departures

Parameter	Definition
First wave	Flights scheduled to depart from Gatwick before 09:00 local time, using an aircraft not previously having departed from or arrived at Gatwick on the same day
Punctuality	The proportion of flights leaving the stand less than 15 minutes and 59 seconds after the scheduled departure time
On-time departure performance (OTDP)	The proportion of flights departing the stand within ±15 minutes and 59 seconds of the scheduled departure time
Departure delay	The difference between the time that an aircraft was scheduled to leave its stand and the time that it actually left its stand

Parameter	Definition
ATFM departure holding delay	A delay imposed on a departing flight by the Network Manager because of a capacity constraint in downstream airspace or at the destination airport. ATFM delay is imposed by applying an ATFM regulation to the flight in the form of a calculated take-off-time (CTOT). The ATFM delay is defined as the CTOT minus the estimated take off time (ETOT) at Gatwick.
Start delay	The elapsed time between the pilot requesting permission to start from air traffic control (actual start request time (ASRT) and that permission being granted (actual start approved time (ASAT)
Departure taxi holding	The difference between the actual time to taxi from the departure stand to the runway and the unimpeded time for the same journey. Departure taxi holding will reflect push and hold operations as well as holding due to runway congestion and sequencing
Unimpeded taxi-out time	As a proxy for the time taken for a journey in the absence of departure holding delay and congestion, the unimpeded taxi-in time is defined as the 5th centile of the time distribution that it takes an aircraft to travel between its departure stand and line-up at the departure runway
Push-and-hold	The practice of pushing back an aircraft allocated with a CTOT from the parking stand to free up the stand. The aircraft is then held at a remote point, and/or its taxi speed is managed so that it takes-off within its CTOT window
Scheduled runway departure rate	The number of departures scheduled to use the runway per unit time derived from the schedule taking into account standard taxi-out times. The overall scheduled runway rate is the sum of the scheduled runway departure rate and the scheduled runway arrival rate
Actual runway departure rate	The number of departures actually using the runway per unit time. The overall actual runway rate is the sum of the actual runway departure rate and the actual runway arrival rate
Minimum departure interval (MDI)	A minimum time spacing between aircraft using the same departure route (SID) imposed by London Terminal Control (TC) to manage congestion downstream on that departure route
Scheduled outbound block time	The time difference between the scheduled in-block time (SIBT) at the destination airport and the scheduled off-block time (SOBT) at Gatwick
Actual outbound block time	The time difference between the actual in-blocks time (AIBT) at the destination and the actual off-blocks time (AOBT) at Gatwick
Outbound block time success rate	The proportion of actual outbound block times that are executed within their scheduled outbound block times
Flying time	The difference between the actual landing time (ALDT) at the destination and the actual take-off time (ATOT) at Gatwick

3.2.3 Turns

The following table provides the definitions most relevant to turns.

Table 3 Definitions relating to turns

Parameter	Definition
Scheduled turn-time	The difference between the scheduled off- block time (SOBT) and the scheduled in-block time (SIBT) for a linked arrival-departure
Doors closed turn-time	The difference between the actual in-block-time (AIBT) or scheduled in-block time (SIBT), whichever is later, and the completion of ground servicing, indicated by the actual doors closed time. This measure isolates the impact of ground handling on turn time
Pre-departure delay turn-time	The difference between the actual in-block-time (AIBT) or scheduled in-block time (SIBT), whichever is later, and the actual start request time (ASRT).

Parameter	Definition
Off-block turn time	The difference between the actual in-block-time (AIBT) or scheduled in-block time (SIBT), whichever is later, and the actual off-block time (AOBT). This KPI will be used to understand the impact of pre-departure delay (CTOT, TSAT or MDI) on turn time
Turn success rate	The proportion of turns that are executed within their scheduled turn times

3.3 Sources of data

The sources of data used in the study were:

- Gatwick's Idaho system, effectively the airport operational database (AODB), linked to the airport collaborative decision making (A-CDM) system. These data cover arrivals and departures on a flight-by-flight basis. The data fields include, inter alia, the flight number, the aircraft type, the flight status (operated, cancelled or diverted), the scheduled time of arrival/departure, the actual time of arrival/departure, the actual time of touchdown/take-off, the calculated take off time (CTOT), the runway used, the terminal and stand used, the aircraft registration, the number of passengers carried and the number of seats on the aircraft. Idaho also contains additional data, such as the ground handler, first and last bag times, etc. Idaho has developed during the period analysed in the study and 2016 Idaho reports contain more comprehensive data than 2014 reports. One of the augmentations has been to provide links between Idaho arrival and Idaho departure records, making it possible to reconstruct turns. However, Idaho does not contain some data fields, particularly relating to departures that were needed for the analysis. The data fields include the estimated take off time (ETOT), departure route (SID) and departure taxi milestones. These were available from the Tower EFPS system
- The Tower electronic flight processing system (EFPS) which records, on a flight-by-flight basis, the passage of aircraft across the airfield for both arrivals and departures. The data fields available include: the flight number, the aircraft type, the aircraft registration, the actual time of arrival/departure, the actual time of landing/take-off, the terminal/stand used, the runway used and for departures only: the start-request and start-approved times, the push-back time, the taxi start time, the time that the aircraft reached the runway holding point and the time that the aircraft lined-up the runway. It is understood that tow data can be captured within EFPS but elapses over time and was not available for this project
- Neither Idaho nor EFPS contained data needed to calculate airborne holding. Therefore, airborne holding data for summer 2016, available on a flight-by-flight basis was provided to GAL by ANS as part of the reporting requirement both to Gatwick and to the Single European Sky (SES) Performance Scheme. This data is understood to be consistent with the Eurocontrol definitions or airborne holding
- Historical data available from the Eurocontrol Performance Review Unit (PRU) covering:
  - monthly averages of Gatwick airborne holding from 2012 through to 2014, consistent with the above airborne holding data
  - monthly averages of Gatwick departure taxi holding data covering the period from 2012 through to 2014
  - Gatwick attributed inbound ATFM holding data as monthly averages covering the period from 2008 to 2014.

Additional data that would have been useful for the study but was not available in the timescales include:

- Eurocontrol Network Management data that describes fully the ATFM regulations applied to Gatwick arrivals and departures. This would not only enable the magnitude of delays to be calculated but would allow them to be properly attributed to location and cause

- Airborne holding data covering seasons other than summer 2016 that would allow the evolution of airborne holding to be evaluated
- Tow data to describe the volume of towed aircraft to be understood and included in the estimates of airfield loading. It is understood that this data is captured but is time limited, so was not available for the study.

4 PLANNING AND SCHEDULING

4.1 Introduction

The second major component of the study was to review the planning and scheduling process applied at Gatwick to understand the effectiveness of the process, its impacts on performance and to understand whether actual performance is in compliance with the scheduling criteria. This section describes the analysis of the planning and scheduling process and is organised as follows:

- Section 4.2 describes the overall scheduling process, covering the definition by airlines of their wish list schedules, capacity declaration with focus on the runway, which is currently at the core of the capacity declaration, and slot allocation
- Section 4.3 describes the current level of runway capacity utilisation
- Section 4.4 compares the performance of arrivals, specifically airborne holding, with the scheduling criteria and derives the relationship between airborne holding and runway loading
- Similarly, section 4.5 compares the performance of departures, specifically departure taxi holding, with the scheduling parameters, investigates the impact of the push and hold policy on departure taxi holding and derives the relationship between departure taxi holding and runway loading
- Section 4.6 compares the achieved aircraft turn performance with that planned in the schedule
- Section 4.7 draws together the separate streams into a set of consolidated conclusions concerning Gatwick's planning and scheduling process.

4.2 The scheduling process

4.2.1 Overview

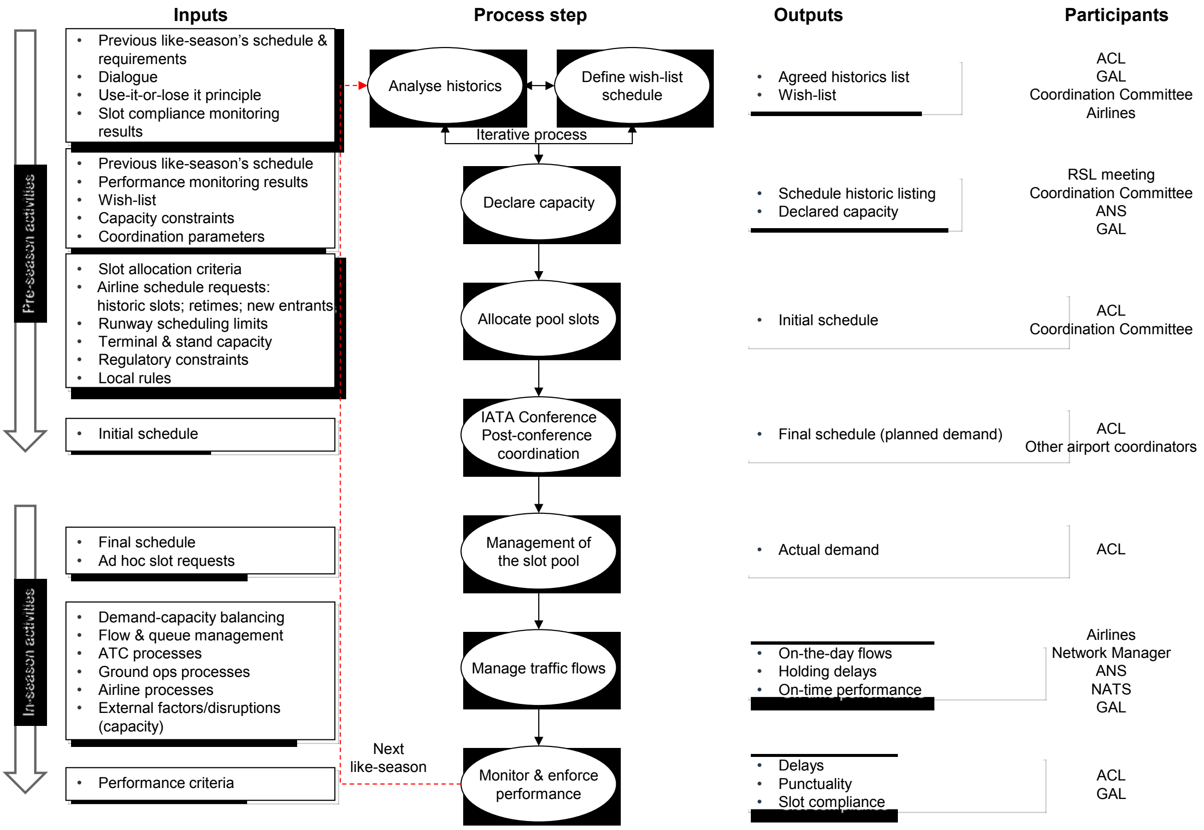
Gatwick is a fully coordinated, level three airport. Its scheduling process and associated governance arrangements are consistent and compliant with:

- the IATA Worldwide Scheduling Guidelines
- the EU Slot Regulation, 95/93, and its amendment Regulation 793/2004 on common rules for the allocation of slots at Community airports
- the UK statutory instrument 2006, no 2665, the airports slot allocation regulations 2006.

The processes are more detailed, more transparent and go beyond what is undertaken at most of the World's airports and in a comparative sense could be viewed as good practice.

The overall end-to-end scheduling process comprises several steps and involves a range of actors as illustrated in the following figure.

Figure 41: End-to-end scheduling process



The main steps in the end-to-end scheduling process can be summarised as:

- definition of the historics for the previous like-season and the definition of the wish-list for the season to be coordinated as a baseline for assessment of available capacity
- reporting the performance achieved on the previous like-season and determination of the runway scheduling limits as part of the capacity declaration
- initial allocation of seasonal slots based on the historics, wish-list slot requests and declared capacity
- coordination of Gatwick slots with slots at other coordinated airports at the twice-yearly IATA Scheduling Conference and any necessary post-Conference coordination, making adjustments to the schedule as necessary to produce the final schedule, which is the basis of the slot pool
- in-season management of the slot pool, including management of ad hoc slots when these are requested. Currently there are few ad hoc slots at Gatwick and volume restriction is applied to the allocation of these slots
- tactical traffic management to moderate demand to the available on-the-day capacity and to optimise the utilisation of scarce resources including runways and airspace
- monitoring and enforcing slot performance, compliant with the schedule.

4.2.2 Definition of the wish-list

The wish-list is based on airline requests to retime existing slots or add new, additional slots. These slot requests are derived from the airlines' scheduling processes. Slot times are underpinned by the block-times for travel between airport pairs and turn times at airports consistent with the airline's overall network.

Planned block times on existing routes are based on a pre-defined percentile of the block times operated during the previous like-season. The precise percentile used varies from airline-to-airline. For long haul flights the block time might be broken into its various components – flying time, taxi out time, taxi in time, standard turnaround times – whereas for short haul flights the components of the block time are usually consolidated into an end-to-end figure. Planned block times for new routes are based on judgement underpinned by flight planning. Planned block times for the same route can vary by time of day and day of week but do not generally vary across the season for slots at the same day and time. Where there is significant variation it can sometimes be more difficult get the correct estimates when scheduling block times.

The planned block time is effectively an average based on historical data. This has the disadvantage that there can be significant differences between the planned block time and the actual block time because of:

- weather impacts, particularly jet stream
- congestion at different parts of the route and different times
- turnaround performance
- outstation airport performance
- different performance of different aircraft types.

Because of increasing congestion in the overall air transport system, there is generally a year-on-year trend of increasing block times to maintain the same level of on-time performance. This has a negative impact on aircraft utilisation.

4.2.3 Capacity declaration process

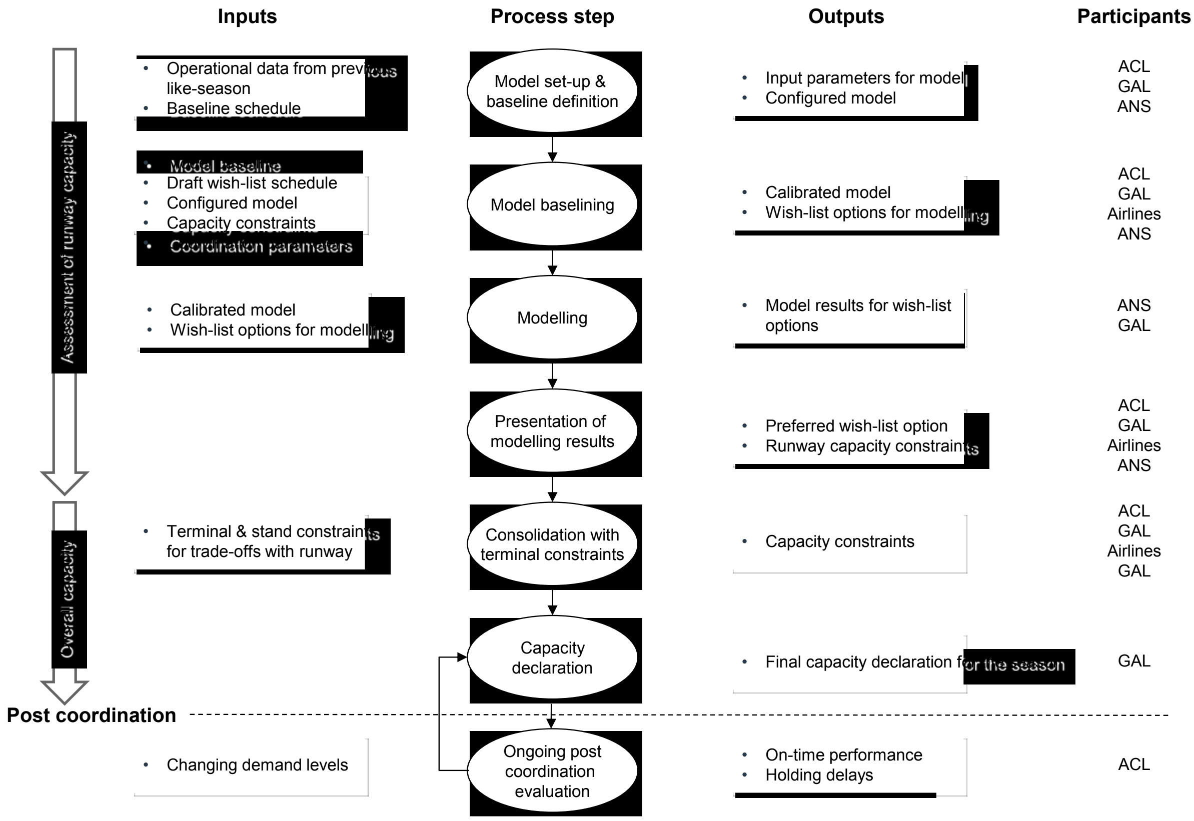
Process overview

As part of the coordination process for a fully coordinated airport, Gatwick is required to declare its available capacity on a season-by-season basis. This is a statutory responsibility delegated to the Airport by the State. There is not any formal requirement for any particular tool to be used in this capacity declaration process but that the scheduling limits are agreed between the airport managing body, the ATC provider and the airlines.

The overall generic capacity declaration process used at Gatwick is illustrated in Figure 42. The main participants in this process are:

- the Airport itself
- Air Navigation Solutions (ANS) both as the airport air traffic control (ATC) provider and to provide the analysis and modelling that underpins assessment of runway capacity
- Airport Coordination Limited (ACL), the slot coordinator
- the airlines.

Figure 42: Capacity declaration process



The basic steps in the process as illustrated in the figure are as follows:

- **model set-up and baseline definition:** GAL and ANS consolidate data from the previous like-season to use as inputs to the runway capacity model, which is based on the AirTop simulation tool. These parameters, such as runway occupancy time, taxi times, and actual aircraft separation distributions are collected routinely as part of Gatwick's continuous improvement programme. These parameters are used to configure the runway capacity model. ACL defines the baseline schedule to be used for subsequent capacity modelling. For summer seasons, this schedule is based on an example busy day, typically the third Friday in August. For winter seasons, three baselines are defined: a weekday, Saturday and Sunday to account for significant day of week variations in hourly demand profile
- **model baselining:** the model is calibrated by comparing its outputs, which are principally airborne and ground holding times, with a representative set of busy but not-disrupted days from the previous like-season. ACL consolidates the wish-list requests made by the individual airlines into a limited number of realistic scenarios, based on judgement of which requests can be accommodated. The model baseline and proposed wish-lists are presented to the airlines
- **modelling:** the runway capacity model is run for predominant westerly operations based on the wish-list scenarios, which are added to the baseline. The outputs of the model are compared to the baseline and to the scheduling parameters for airborne, ground and combined holding
- **presentation of modelling results:** the results of modelling the wish-list scenarios are presented to the airlines and a preferred wish-list option is proposed. This wish-list option is used to define the runway scheduling limits for arrivals, departures and combined arrivals-departures on a movements per hour basis. Additional sub-constraints are applied at a 15 minute and 5 minute level to smooth demand presented to the runway across the hour
- **consolidation with terminal and stand capacity constraints:** Terminal demand is modelled using historical demand, inflated consistent with increased runway capacity, to assess whether or when terminal capacity limits are reached. ACL undertakes modelling to determine the stand capacity limit. These terminal and stand capacity limits are combined with the runway capacity

modelling to identify whether these provide any additional constraints to the preferred wish-list, which is adjusted accordingly

- **capacity declaration:** taking into account the preferred wish-list option, stands and terminals, the Airport informs ACL of the season's capacity declaration, which is then promulgated by ACL and used in the coordination process.

Runway scheduling parameters

The runway capacity modelling process produces holding times as its principal outputs. These are:

- Airborne holding for arrivals
- Post-pushback, taxi-out holding for departures.

The modelling does not include air traffic flow management (ATFM) delays, any holding due to arrival or extended arrival management (AMAN/XMAN) nor start delay, where the aircraft is held on the stand at Gatwick.

The modelling focuses on the delays caused by queuing for use of the runway and, effectively, determines the balance between demand, capacity and holding time.

The criteria that are applied to assess the viability of the wish-lists are as follows:

- Average arrival, departure and combined holding calculated over hourly intervals should not exceed 10 minutes per flight for extended periods
- Average arrival, departure and combined holding calculated over hourly intervals should not exceed 15 minutes per flight
- Holding for individual flights, arrivals and departures, should not exceed 25 minutes.

Subsequently, there are additional, more detailed, scheduling parameters that are applied, including:

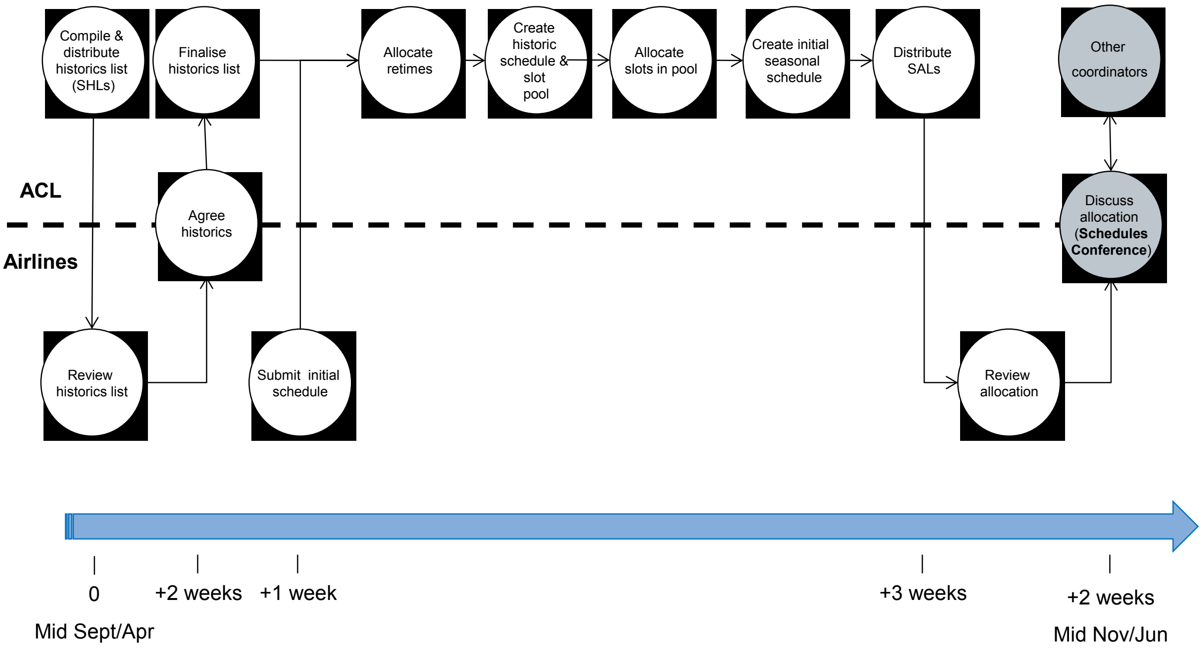
- The schedule is capped at 55 movements per hour
- There cannot be more than three consecutive hours scheduled at 55 movements
- Within each 15 minute period, no more than 14 movements can be scheduled, with maximum 7 arrivals and 9 departures: except:
  - When the number of arrivals in an hour is >+26, the 15 minute arrival limit for the straddling period may be increased to 8
  - When the arrival/departure limit in an hour is>=30, the 15 minute limit can be increased to 9 or 10 with no three consecutive 15 minute periods having 10 movements (ideally this is reduced to two periods and the traffic is distributed evenly across the hour).
- There should be no more than four arrivals or five departures in any five minute period.

4.2.4 Slot allocation process

Following capacity declaration, the seasonal allocation of the slot pool is undertaken. This can be viewed as a two-stage process: (1) prior to the IATA Schedules Conference as shown in Figure 43; and (2) after the IATA Schedules Conference as shown in Figure 44.

Slots are allocated as series, where a series is defined as at least five slots, at (approximately) the same time on the same day of the week regularly in the same scheduling period.

Figure 43: Pre-conference slot allocation process



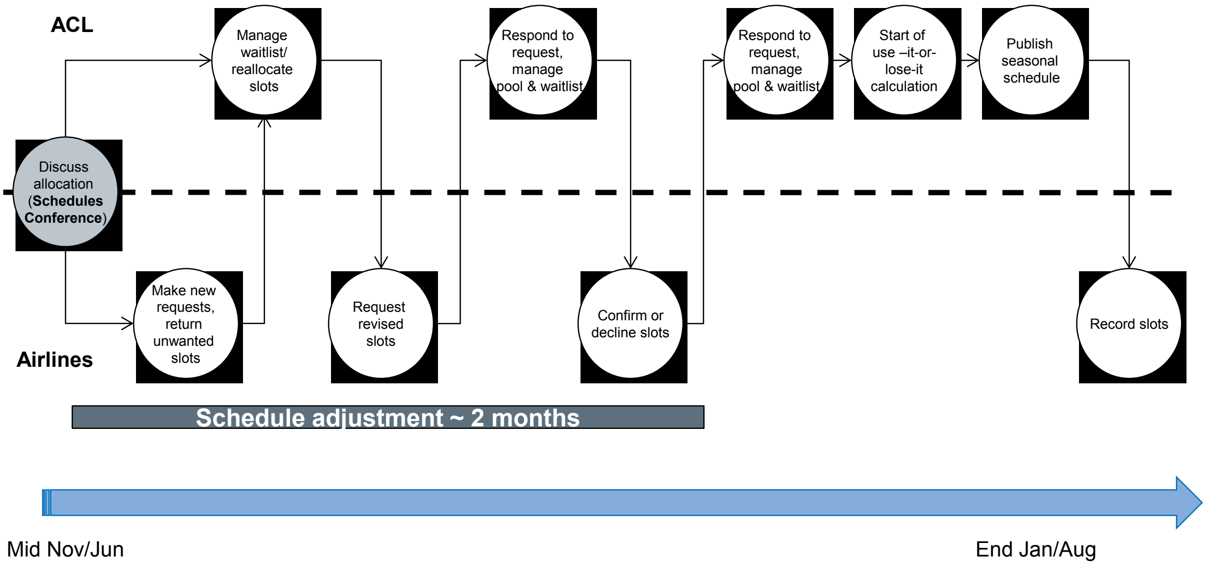
The basic process steps prior to the IATA Schedules Conference are as follows:

- by mid-September for the summer schedule and mid-April for the winter schedule, ACL compiles what it considers to be the historic schedule (the SHL) based on the preceding season for each airline and sends it to them individually for review. Any disagreements between ACL and the airline are then resolved through a discussion process. The historic schedule is based on the results of the slot monitoring and the use-it-or-lose-it principle
- the airlines submit schedule requests to ACL by early October for the next summer season and by early May for the next winter season
- ACL classifies the slot requests as historics, changed/retimed historics, new entrants and new incumbents. Retimed historics are accommodated as far as possible within the scheduling limits
- the remaining slots, including those historic slots no longer required, unused slots, those lost through use-it-or-lose-it and additional capacity identified during the capacity declaration process, are allocated to the slot pool
- new slots requests are allocated from the pool with up to 50% of the capacity allocated to new entrants both new to the airport and qualified incumbent new entrants i.e. those holding fewer than four slots per day, with the remaining 50% being allocated to new requests by incumbent carriers. If the 50% available to new entrants is not fully subscribed, the remaining slots are also allocated to new flights by incumbent operators. No slots are added that break the scheduling limits
- ACL then creates an initial seasonal schedule and distributes this to the airlines (as SALs which show the slots requested and the slots offered) by late October for the summer season and late May for the winter season
- the airlines then review and process their allocation in preparation for the IATA Schedules Conference
- the principal objective of the IATA Schedules Conference is to agree the slot allocations for the coming season between airlines and coordinators around the world. The process for this is for airlines to discuss with the coordinators of each of the airports they plan to serve in the coming season the feasibility of their proposed schedules. Airlines may also engage in slot exchanges with one another in order to improve the slots which they have been allocated by the coordinators.

The main part of the post-Conference activity is one of iterative dialogue between the airlines and ACL for a period of two months, as illustrated in the following figure:

- the airlines make new requests and return unwanted slots
- ACL endeavours to meet requests and maintains a waitlist of outstanding requests
- ACL maintains the updates and maintains the schedule and slot pool.

Figure 44: Post-conference slot allocation process



By the end of January for the summer season or the end of August for the winter season, ACL publishes the season's schedule, which is around 98% of that which will be operated. This schedule is the basis of the use-it-or-lose-it calculations which start at this point (slots returned prior to this time are not included in the calculations). The airlines record their allocations.

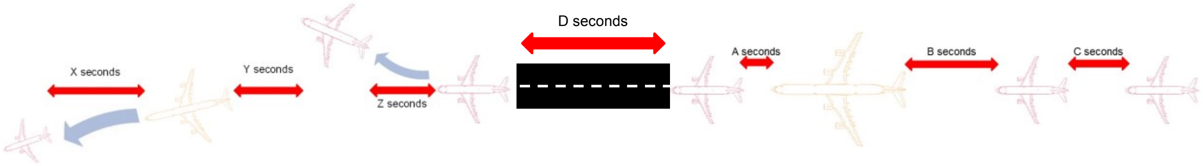
However, slot requests and the maintenance of the waitlist, schedule and slot pool continue throughout the season.

4.3 Runway capacity utilisation

4.3.1 Analysis approach

To assess the degree to which Gatwick's runway is utilised, we have applied a technique based on the minimum time spacing applied to separate aircraft in the runway sequence, as illustrated in Figure 45. This method uses Idaho *didfly* data to calculate the length in minutes of the traffic stream, scheduled or operated, over half hour time intervals. The level of utilisation is then simply the length of the traffic stream in minutes in each period divided by 30. This technique has the advantage over a simple assessment of the number of aircraft operating because, as well as considering pure volume, it accounts for both differences in wake vortex separations for different aircraft in the arrivals stream and different departure route separations in the departure stream as well as arrival-departure and departure-arrival separations, as illustrated in the figure.

Figure 45: Approach to modelling runway utilisation



For the simple example traffic stream illustrated in the figure, the total runway usage would be:

- X+Y+Z seconds accounting for the departure routes and wake vortex separations applied to the departure stream; plus

- D seconds accounting for the departure-to-arrival (or similarly the arrival-to-departure) spacing; plus
- A+B+C seconds accounting for the wake vortex separations in the arrival stream.

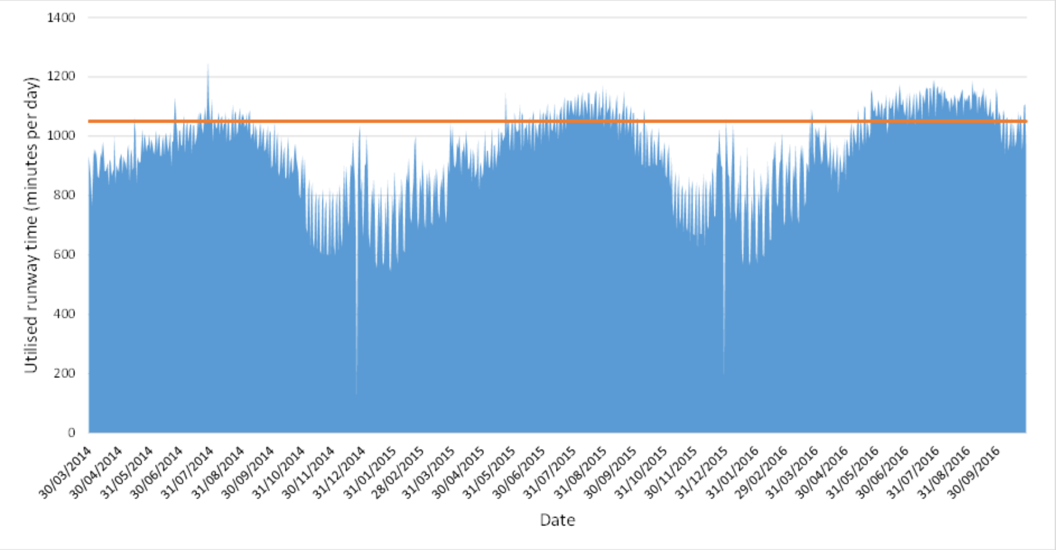
A number of assumptions have been applied:

- Normal UK wake vortex separations apply to the aircraft in the arrival stream, e.g. as promulgated in Aeronautical Information Circular P 001/2015. To convert wake vortex spatial separations into separations a landing speed of 145 knots has been assumed
- A departure separation of one minute is applied to successive aircraft departing using diverse standard instrument departure routes (SIDs) and a departure separation of two minutes is applied to successive aircraft departing using the same SID or SIDs bundled into common noise preferential routes
- For arrival-departure spacing, the most efficient arrival-departure-arrival (ADA) spacing of one departure every 130 seconds has been applied
- To calculate the capacity utilisation implied by the schedule, the scheduled sequence is modelled by determining the time that each flight would use the runway based on its scheduled in-blocks time (SIBT) or scheduled off blocks time (SOBT) adjusted by an average taxi time to/from the runway from the stand. This average, taken over all of the flights operated in the relevant season, has been calculated from operational data. An average is applied to emulate the scheduling process where it is not possible to account for the direction of operation or specific runway-stand combinations
- The capacity utilisation implied by the actual operation is calculated from the actual runway usage sequence recorded in the Idaho data
- Night jet operations are excluded from the overall capacity assessment, for the purposes of which the airport operating day is assumed to be 17.5 hours, from 06:00 hours local time until 22:30 hours local time.

4.3.2 Scheduled utilisation

Using the modelling approach described above, Figure 46 shows the daily daytime runway capacity utilisation modelled from the seasonal schedules from summer 2014 through to summer 2016 inclusive. The utilisation is measured in minutes of runway time needed per day to serve the schedule. The red, horizontal line indicates the capacity of 1050 minutes or 17.5 hours.

Figure 46: Scheduled daily runway utilisation from summer 2014 to summer 2015



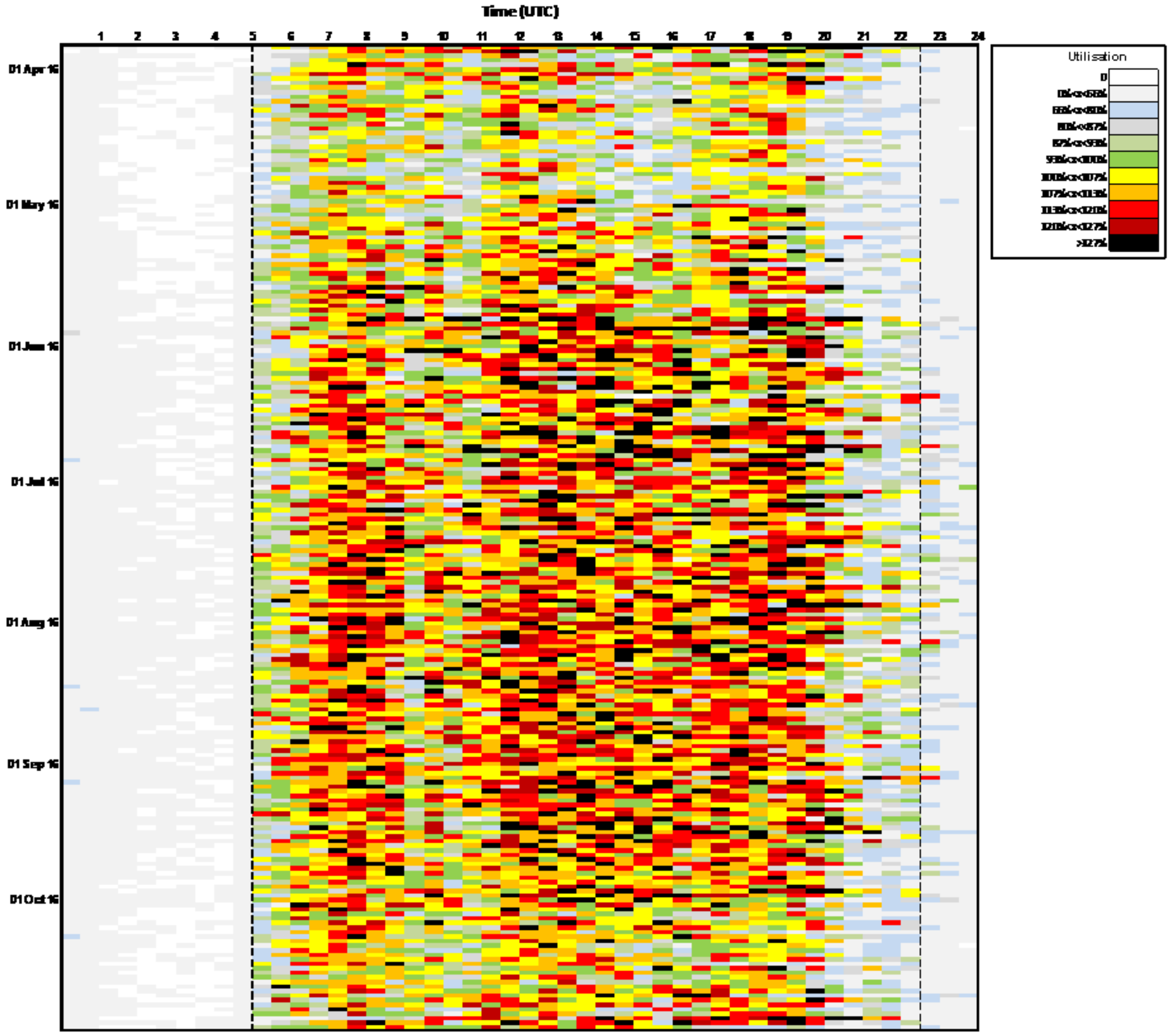
The figure shows the cyclical nature of Gatwick’s traffic, higher in summer than in winter but also indicates the complex nature of the schedule:

- with peaks over the Christmas-New Year period in winter
- peaks at the end of March followed by a reduction in April with a gradual transition and some overlap of winter and summer traffic demand.

The figure also illustrates that the demand derived from the schedule exceeds the available capacity in the peak summer period and that this demand has increased from 2014 through 2015 to 2016. The heatmap in Figure 47 below adds more detail to the picture of the 2016 summer season highlighting very high levels of scheduled utilisation across the day and across the season, again indicating many occurrences where the simple, scheduled utilisation exceeds the available capacity.

It should be remembered, however, that this demand is derived from the scheduled and does not take into account efficiencies that can be achieved tactically through optimal sequencing of the traffic stream (see Figure 48 below).

Figure 47: Scheduled runway utilisation heatmap summer 2016



4.3.3 Actual utilisation

In compassion to scheduled utilisation, Figure 48 shows the actual daily runway utilisation covering the period from summer 2014 to summer 2016 inclusive. The basic summer-winter cyclical pattern is still apparent. However, in this case, tactical optimisation of the sequence has reduced the level of utilisation to below the capacity level.

Figure 48: Actual daily runway utilisation from summer 2014 to 2016

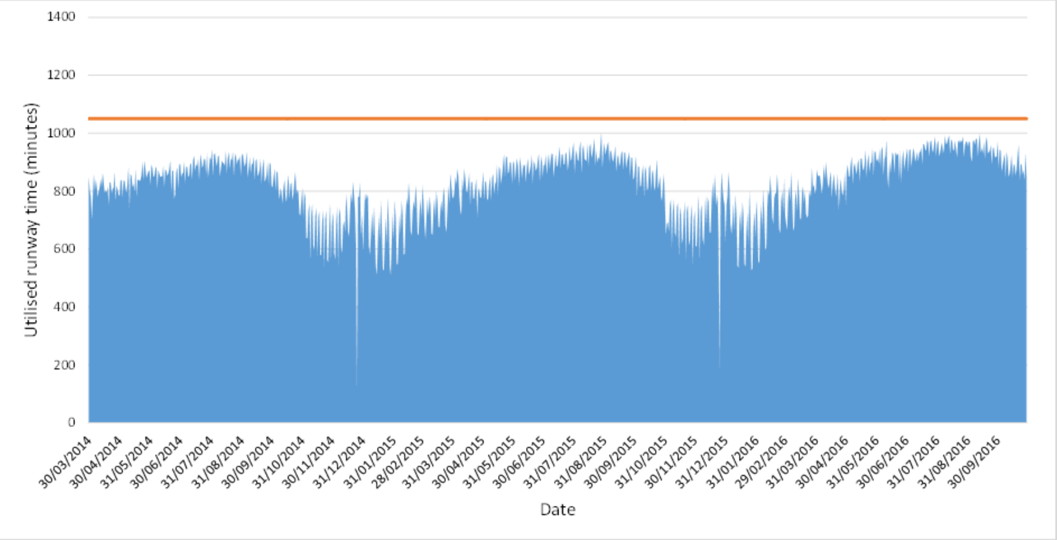
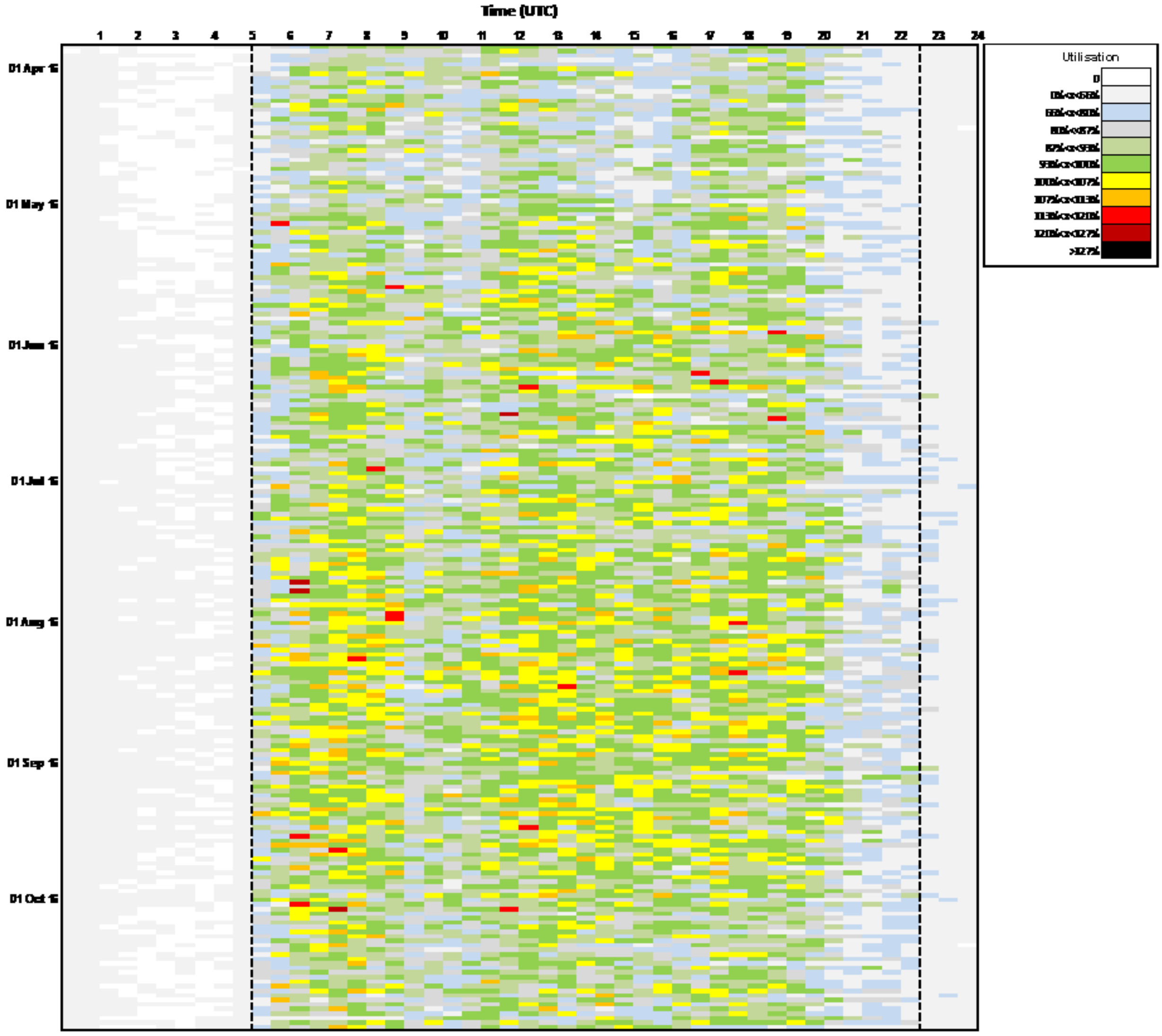


Figure 49: Actual runway utilisation heatmap summer 2016



The heatmap showing actual runway utilisation, above in Figure 49 shows that tactical optimisation of the traffic sequence enables this fit the available runway capacity. However, the levels of utilisation are often very high, at 100%. The modelled utilisation exceeds 100% in some places, likely due to the actual traffic sequencing being more efficient than that assumed in the model as well as hard boundaries in the 30 minute intervals applied in the model.

Comparison of the heatmaps for scheduled and actual utilisation illustrate graphically the increased efficiency with which the runway can be operated when the traffic sequence is optimised to minimise separations between successive movements. For example, taking the simple schedule, an estimate of the capacity utilisation for July and August 2016 is approximately 106% whereas for the optimised actual sequence this is reduced to 90%, implying an increased efficiency of 16%. Over the entire period from summer 2014 through to summer 2016, this sequencing delivered an increase in runway efficiency of approximately 12%.

4.4 Arrivals

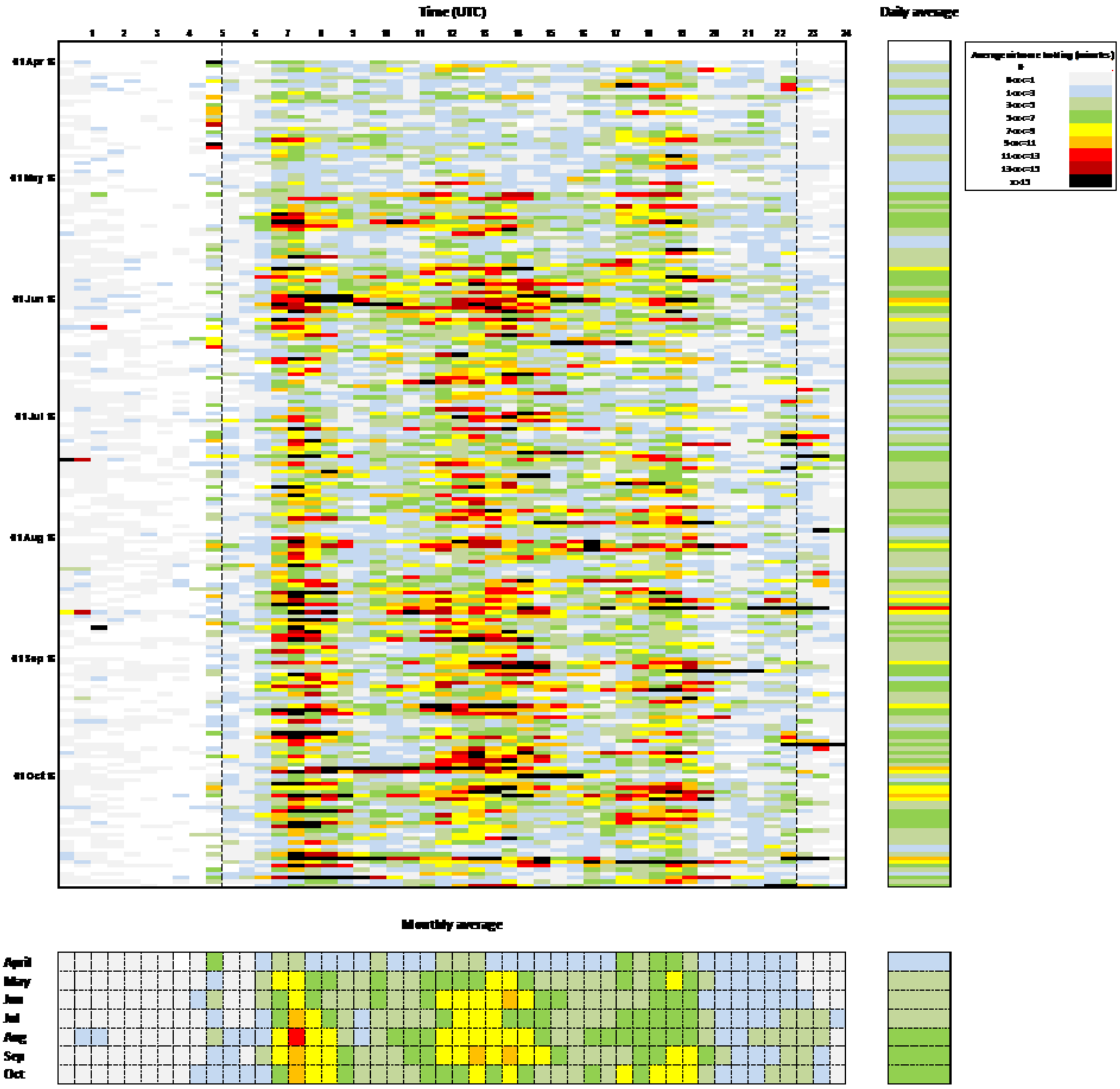
4.4.1 Introduction

Data describing airborne holding on a flight-by-flight basis for the 2016 summer season has been provided by ANS. Detailed data for other, previous seasons was not available for the study. The data describes the time spent holding by each inbound flight and is assumed to be consistent with the standard Eurocontrol holding definitions, describing the additional time spent in the approach sequencing and metering area (ASMA) compared to an unimpeded time.

4.4.2 Airborne holding performance

Figure 50 is a heatmap that shows the airborne holding applied across the 2016 summer season, both in half hourly intervals across each day individually and consolidated into months as well as the daily average.

Figure 50: Airborne holding heatmap summer 2016



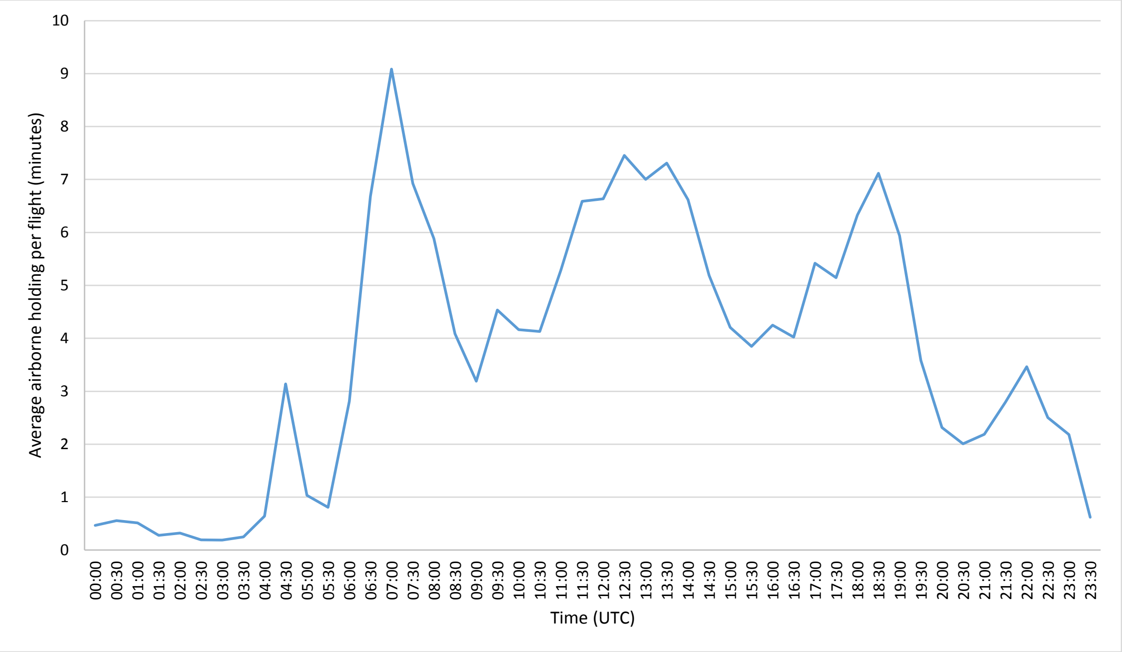
The heatmap shows that airborne holding:

- Is higher in August, September and October than May, June and July and is lowest in April
- Has peaks in the morning between 06:00 and 07:00 UTC (07:00 and 08:00 local time), the middle of the day between 11:00 and 14:00 UTC (12:00 and 15:00 local time) and early evening between 17:00 and 19:00 UTC (18:00 and 20:00 local time)
- Occurs immediately before 05:00 UTC (06:00 local time) where it is likely that early arriving traffic is queuing to wait for the end of the night period.

The main heatmap shows that there are periods, mostly short but some lasting several hours, where airborne holding exceed ten minutes per flight (red, dark red and black pixels) with some periods where holding exceeds 15 minute per flight (black pixels). There is only one day where the daily average exceeds ten minutes per flight although it approaches this on several days (orange pixels in the daily average column). In the half hour starting 07:00 UTC average airborne holding in August exceeds ten minute per flight (red pixel in the August monthly average).

Figure 51 shows the evolution of average summer 2016 airborne holding across the day. This conforms the main observations derived from the heatmap with peaks at 04:30, 07:00 and 18:00. These is also another smaller peak at around 22:30.

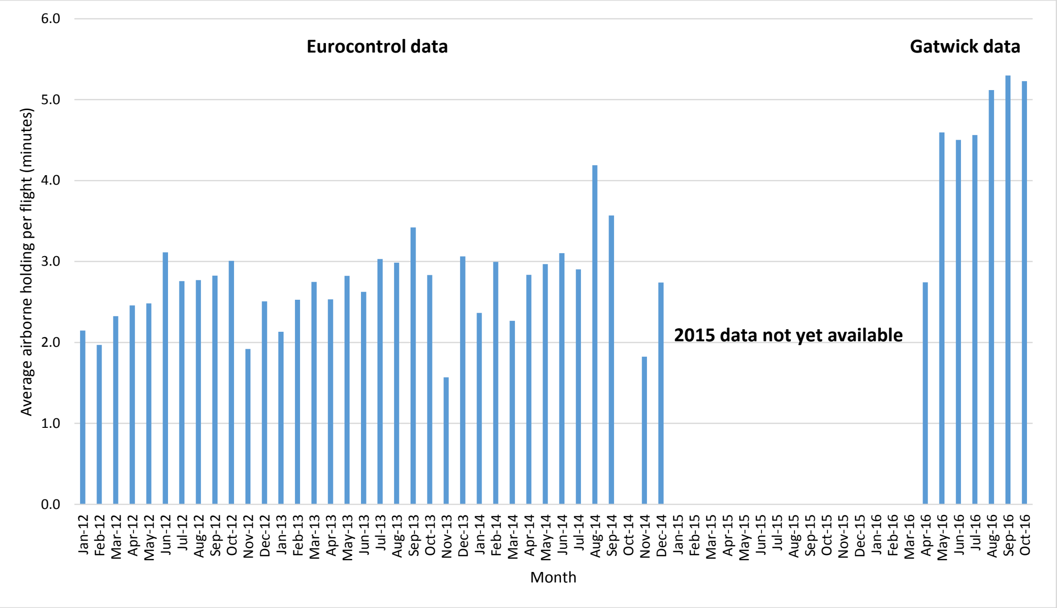
Figure 51: Average airborne holding summer 2016



4.4.3 Evolution over time

As part of its monitoring of European air traffic management performance Eurocontrol collects airborne holding data from reporting airports, of which Gatwick is one. Currently data is only available to the end of 2014 but this allows a comparison of Gatwick's summer 2016 airborne holding on a monthly basis with airborne holding in 2012, 2013 and 2014. This comparison is made in the following figure.

Figure 52: Gatwick monthly average airborne holding from 2012 to 2016

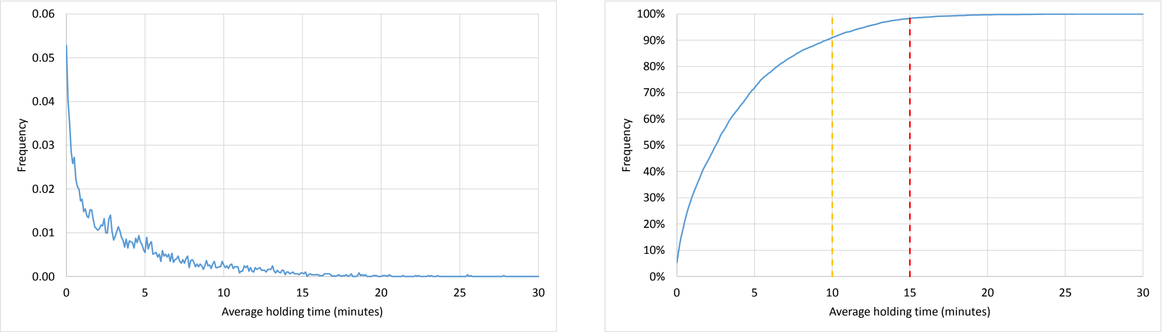


The figure suggests strongly that airborne holding at Gatwick has increased and is now between one and two minutes per flight greater than it was in 2013 and 2014.

4.4.4 Compliance with scheduling parameters

For comparison with the scheduling parameters for airborne holding, Figure 53 shows the actual hourly average airborne holding distributions for the 2016 summer season. These distributions are derived from the entire season whereas the capacity declaration is made on the basis of a busy day. The distributions are therefore likely to give an optimistic view of compliance with the scheduling parameters.

Figure 53: Hourly airborne holding distribution summer 2016



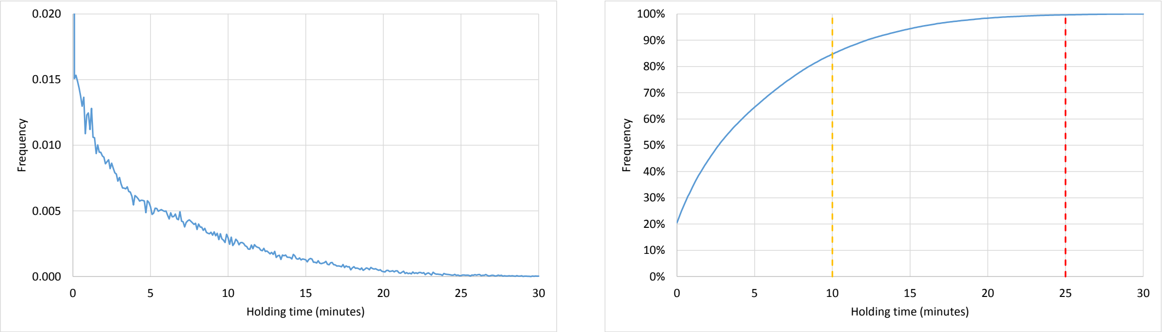
The scheduling criteria are that average holding does not exceeds 10 minutes per flight over extended periods and should never exceed 15 minutes per flight on average

On an hourly basis the actual summer 2016 performance across the entire season results in:

- Average airborne holding of less than 10 minutes for approximately 90% of the time
- Average airborne holding of less than 15 minutes for approximately 98% of the time.

The scheduling criteria also require that holding on a per flight basis never exceeds 25 minutes. Figure 54 shows the achieved airborne holding distributions for summer 2016 on a per flight basis.

Figure 54: Per flight airborne holding distribution summer 2016



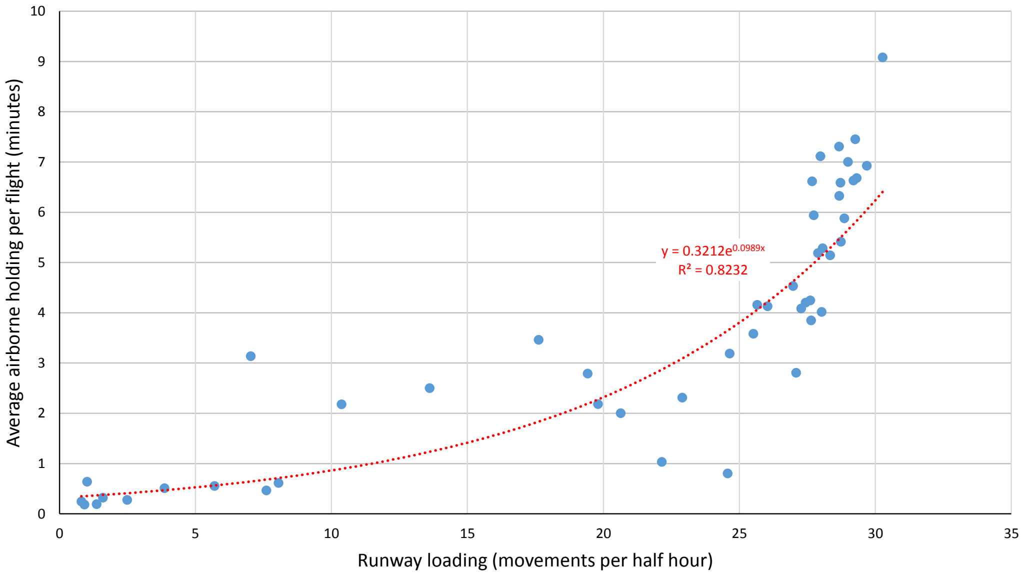
The figure shows that airborne holding is less than 25 minutes for approximately 99% of flights. Although not part of the scheduling criteria, the figure also shows that:

- Airborne holding is less than 10 minutes for approximately 84% of flights
- Airborne holding is less than 15 minutes for approximately 94% of flights.

4.4.5 Relationship between airborne holding and demand

Figure 55 shows the relationship between airborne holding and runway loading. The correlation has been derived from the airborne holding and runway loading (the sum of arrivals and departures segmented into 30 minute periods across the day and averaged across the season.

Figure 55: Correlation between airborne holding and runway loading



The high correlation coefficient and the form of the curve indicates a strong queuing type relationship between runway loading and airborne holding. The exponential nature of the delay curve suggests that small increases in runway loading would be expected to increase in large increases in delay at peak periods. The near-vertical, asymptotic nature of the observed data at high loadings suggests an absolute limit of approximately 30 runway movements per half hour.

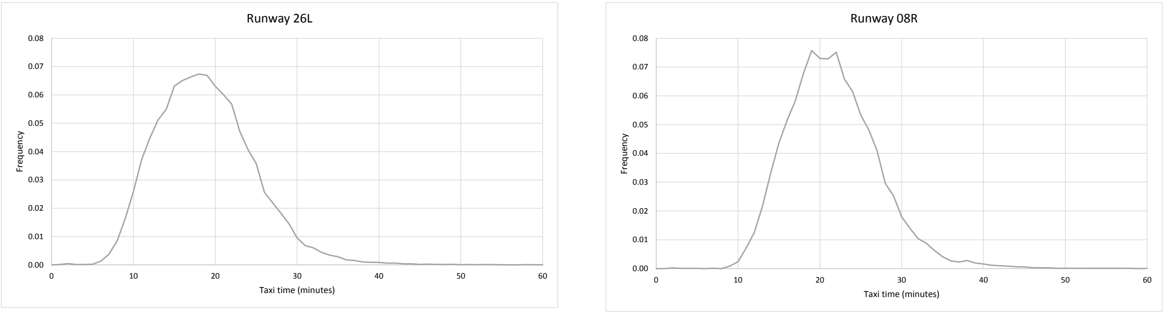
4.5 Departures

4.5.1 Analysis approach

Departure sequencing is analogous to airborne holding in that air traffic controllers, assisted by airport collaborative decision-making (A-CDM), sequence aircraft after push-back on their taxi from stand to runway to optimise the throughput of the runway, taking into consideration both departure route constraints as well as runway loading. This sequencing increases the time taken to taxi from the stand to the runway line-up point, although there can be other factors that contribute to this increase in taxi time.

Figure 56 shows the overall departure taxi time distributions for summer 2016 derived from EFPS data. These distributions comprise the taxi times from all stands to the line-up point for each end of the principal runway.

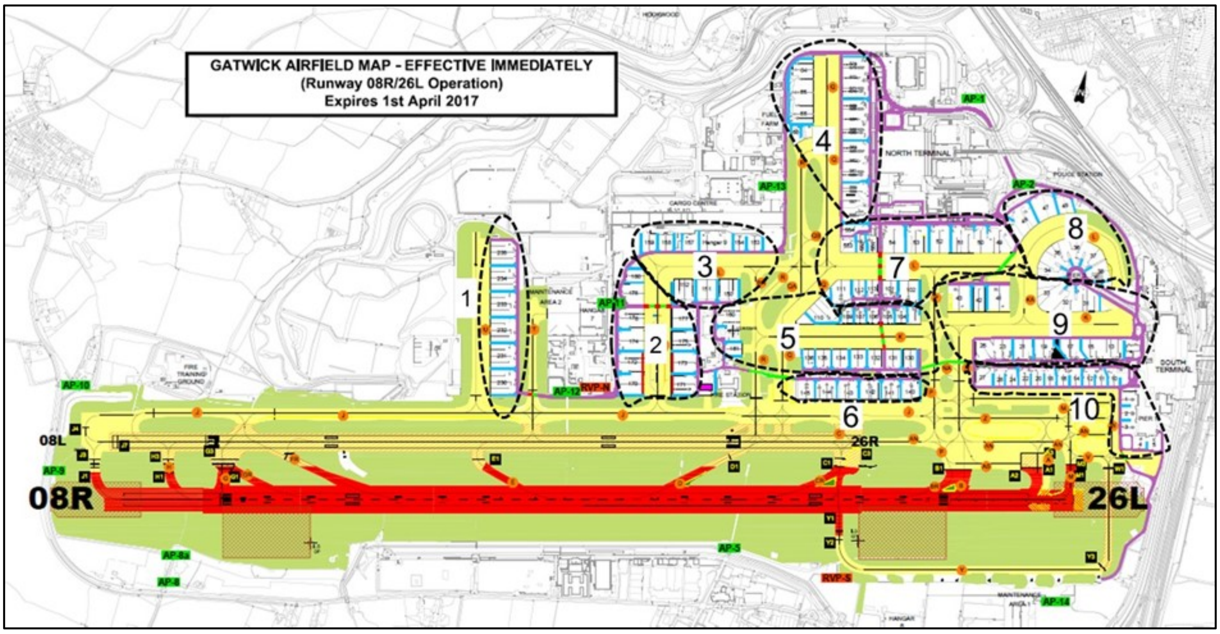
Figure 56: Consolidated departure taxi time distributions summer 2016



The figure shows that the summer 2016 mean departure taxi time to runway 26L is 19.1 minutes whereas the mean departure taxi time to runway 08R is 21.7 minutes compared to the 20 minutes average value assumed in the scheduling process.

In order to gauge departure taxi time delay it is necessary to compare the achieved departure taxi time with an unimpeded taxi time. This comparison needs to be on a like-for-like basis taking into account the different distances from stand to runway end. We have defined the unimpeded taxi time as the 5th percentile of the actual departure taxi time distribution. Ideally an unimpeded taxi time would be defined for each stand-runway combination but small sample sizes cause problems with statistical significance for some stands. To overcome this, we have consolidated stands into groupings that are likely to have similar taxi times. These stand groupings are illustrated in Figure 57 below.

Figure 57: Definition of stand groups



Thus unimpeded taxi time is defined as the 5%ile of the taxi time distribution between each stand group and each runway end, e.g. stand group 10 to runway 08R, stand group 10 to runway 26L, and so on. The two figures below illustrate the departure taxi time distributions from each stand group to each runway. Note that even with consolidation into groups, the sample sizes for stand groups 1, 2, 3, and 6 are small resulting in statistically noisy distributions that have not been shown on some of the charts.

Figure 58: Departure taxi time distributions from stand groups to 26L summer 2016

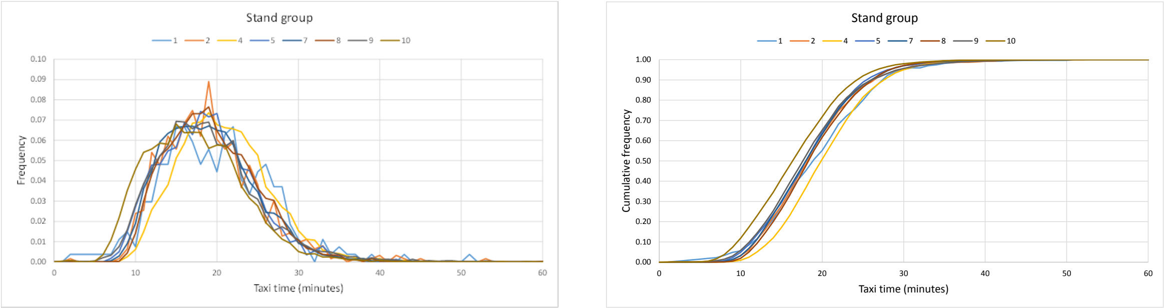
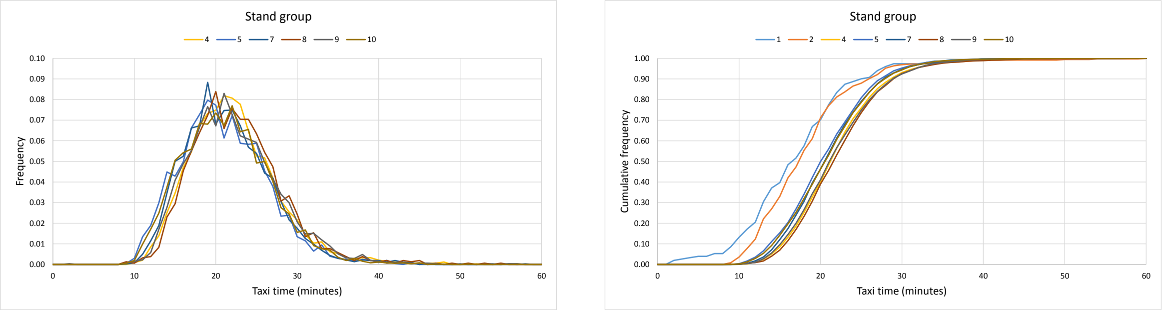


Figure 59: Departure taxi time distributions from stand groups to 08R summer 2016



The following tables show the unimpeded taxi times for summer 2016 based on the 5th centile of each distribution.

Table 4 Summer 2016 unimpeded taxi times from stand group to runway in minutes

	Stand group									
Runway	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
26L	10.2	11.1	15.4	12.4	10.5	9.1	10.9	11.5	10.5	8.8
08R	8.8	10.6	17.4	14.2	12.6	10.9	13.7	14.8	14.1	12.9

Unimpeded taxi times for the other seasons from summer 2014 to winter 2015-16 inclusive show similar patterns but slightly different values for unimpeded taxi times.

We have used EFPS data to determine departure taxi holding time on a flight-by-flight basis where the departure taxi holding time is then defined as the difference between the actual departure taxi time for a flight and the unimpeded taxi time for the stand group-runway combination used by that flight. Negative values, where the actual taxi time is shorter than the 5th centile are set to zero. We have then examined the statistical properties of the departure taxi holding distributions on a season-by-season basis.

The following sections describe the results of this analysis:

- Section 4.5.2 highlights the evolution of average daily departure taxi holding from summer 2014 to summer 2016 inclusive
- Section 4.5.3 focuses in detail on the departure taxi holding experienced during summer 2016
- Section 4.5.4 investigates compliance with the scheduling parameters
- Section 4.5.5 examines the impact of air traffic flow management (ATFM) regulations on departure taxi holding
- Section 4.5.6 derives the relationship between departure taxi holding and runway loading.

4.5.2 Departure taxi holding performance from summer 2014 to summer 2016

Figure 60 shows the evolution of the daily average departure taxi hold per flight in minutes from the start of the 2014 summer season through to the end of the 2016 summer season. The chart shows:

- An underlying upward trend
- A general cyclical background pattern generally with higher holding in summer than in winter, although there appear to be winter peaks in December
- Large spiky variations on a day-to-day basis superimposed on the underlying trends implying dependence on the specific daily environment as well as the macro-changes from season to season.

Figure 60: Evolution of departure taxi holding from summer 2014 to summer 2016

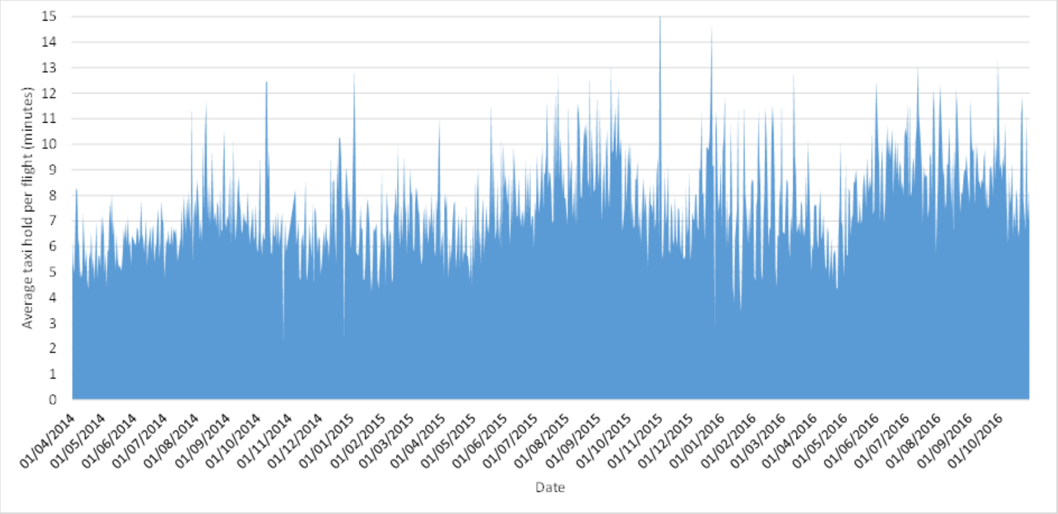


Figure 61 consolidates performance into seasonal averages, showing the departure taxi hold in minutes averaged over each season. The figure confirms the general underlying upward trend for departure taxi holding, which has reached approximately 8.5 minutes per flight for the 2016 summer season.

Figure 61: Departure taxi holding seasonal averages

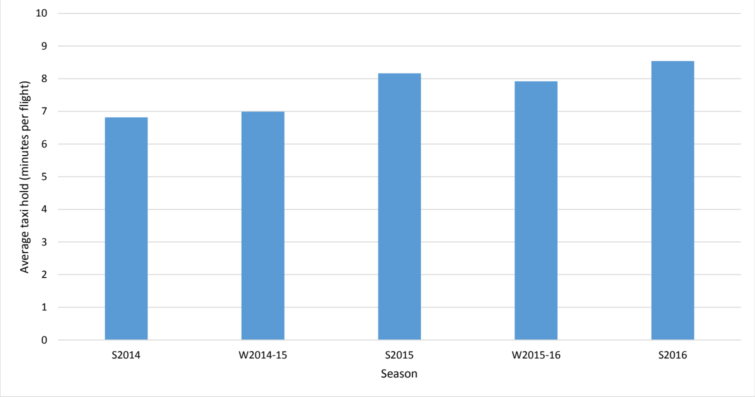


Figure 62 shows the evolution of average departure taxi holding since January 2012 using Eurocontrol data[1] covering the period from 2012 to 2014 inclusive, where this is available and data from this study from summer 2014 onwards. The patterns in the results of the two different analyses are similar although for the periods of overlap the Eurocontrol analysis results in a slightly lower value of departure taxi holding calculated in this study. This is likely due to differences in:

- The method used to calculate unimpeded taxi time
- Definition of taxi time: Eurocontrol uses push-back time to actual take-off time (which includes runway occupancy and the time taken to line-up on the runway thereby including delays not associated with queuing for the runway) whereas this study uses push-back to line-up time
- The use of different data sources – Eurocontrol uses data from the Network Manager whereas this study uses EFPS data from the Gatwick Tower.

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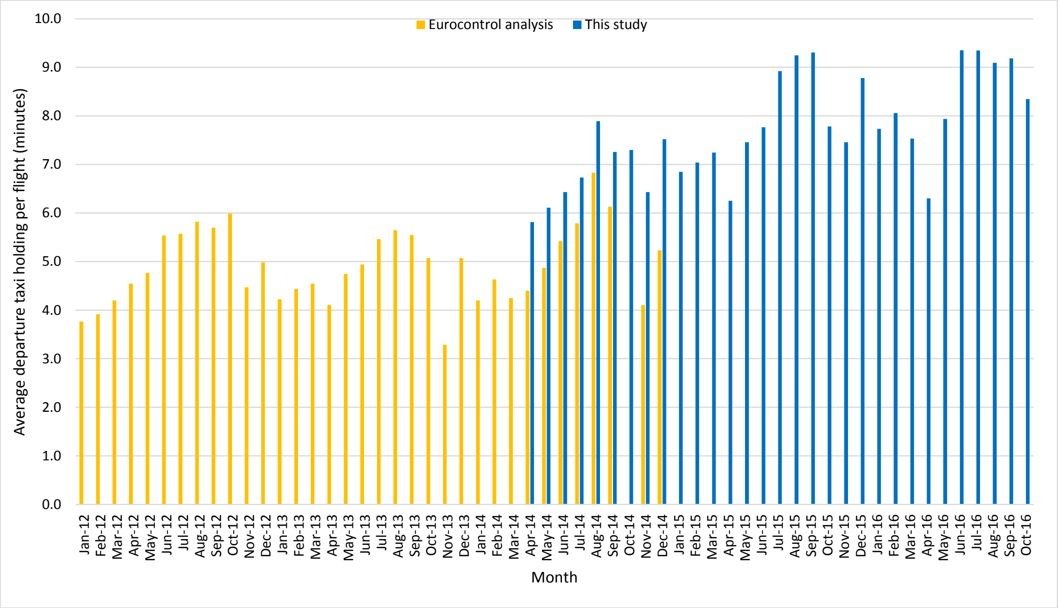
[1] http://www.eurocontrol.int/prudata/dashboard/downloads.html, taxi out additional time

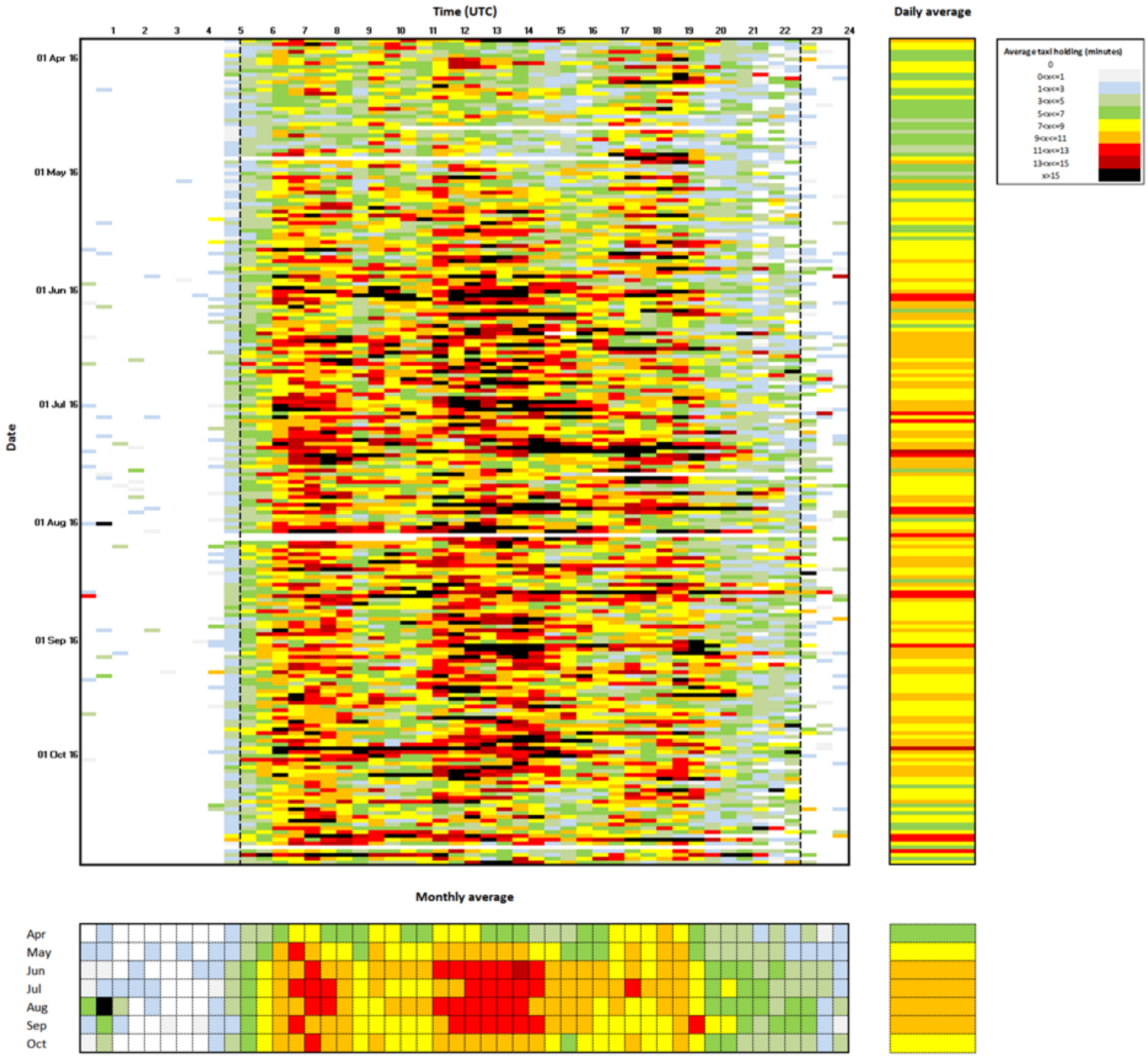
Figure 62: Monthly evolution of departure taxi holding since January 2012



4.5.3 Departure taxi holding performance in summer 2016

Figure 63 provides the departure taxi holding heatmap for the 2016 summer season.

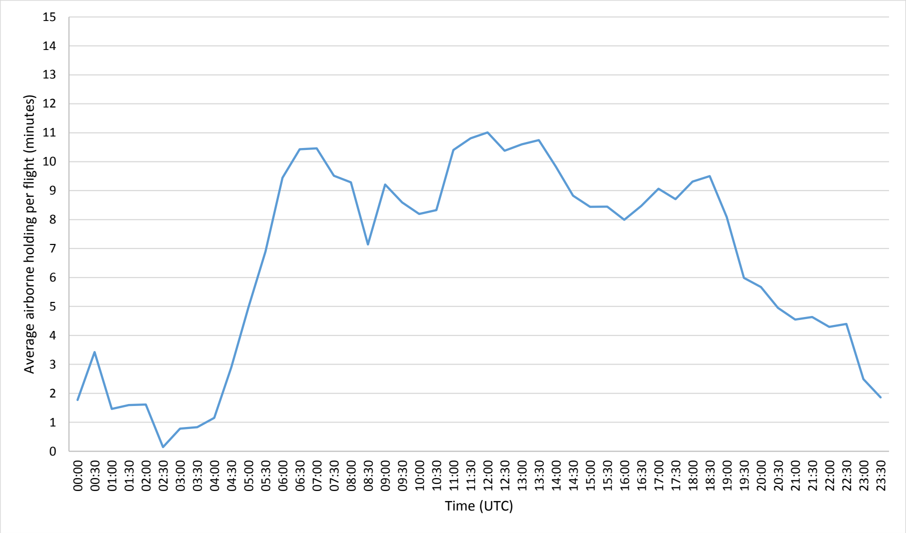
Figure 63: Departure taxi holding heatmap summer 2016



The heatmap shows a pattern of high holding during the first wave departure period between 06:00 and 08:00 hours UTC (07:00 and 09:00 hours local time) as well as in early-to-mid afternoon. The chart also shows lower holding in April with peak holding in June through to September. The main part of the chart shows that, averaged over half-hour periods, there are many occurrences of holding of greater than 10 minutes per flight with periods of holding, some extended, greater than 15 minutes per flight.

Figure 64, shows the summer 2016 average departure taxi holding profile across the day and confirms these observations. This figure shows morning and afternoon peaks, approaching 11 minutes per flight, as well as a smaller evening peak at 9½ minutes per flight. The background holding level across the remainder of the day is generally between eight and nine minutes per flight.

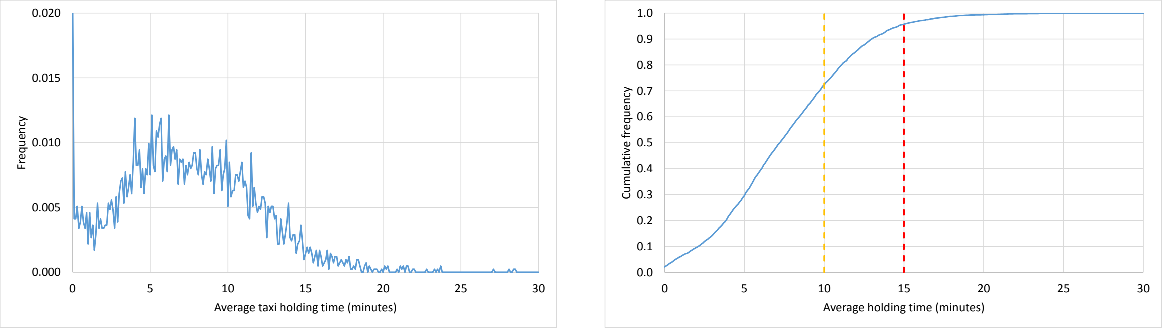
Figure 64: Average departure taxi holding summer 2016



4.5.4 Compliance with scheduling parameters

For comparison with the scheduling parameters for airborne holding, Figure 65 shows the actual hourly average departure taxi holding distributions for the 2016 summer season. As with arrivals, these distributions are derived from the entire season whereas the capacity declaration is made on the basis of a busy day. The distributions are also therefore likely to give an optimistic view of compliance with the scheduling parameters.

Figure 65: Hourly departure taxi time holding distributions summer 2016



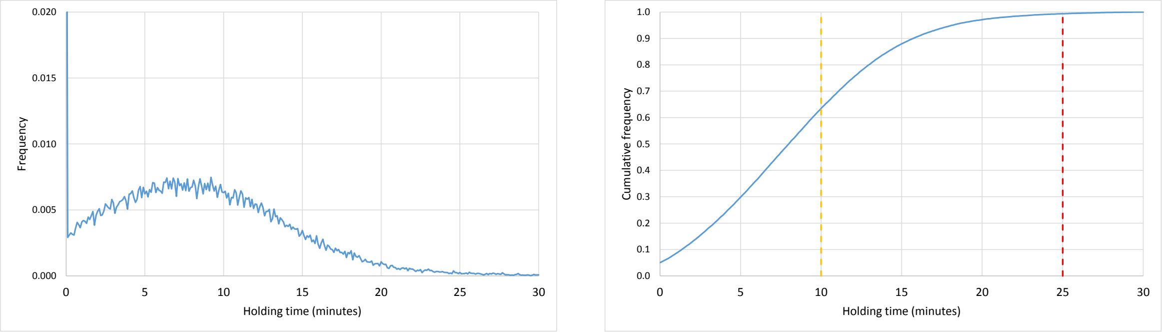
The scheduling criteria are that average holding does not exceed 10 minutes per flight over extended periods and should never exceed 15 minutes per flight on average

On an hourly basis the actual summer 2016 performance across the entire season results in:

- Average departure taxi holding of less than 10 minutes for approximately 72% of the time
- Average departure taxi holding of less than 15 minutes for approximately 96% of the time.

The scheduling criteria also require that holding on a per flight basis never exceeds 25 minutes. Figure 54 shows the achieved airborne holding distributions for summer 2016 on a per flight basis.

Figure 66: By flight departure taxi time holding distributions summer 2016

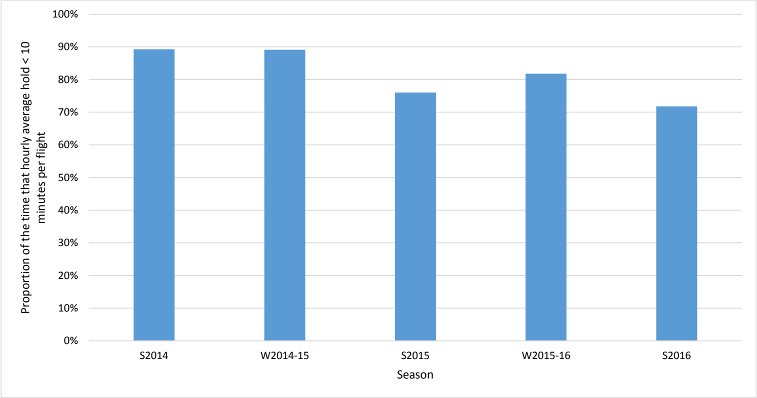


The figure shows that departure taxi holding is less than 25 minutes for approximately 99% of flights. Although not part of the scheduling criteria, the figure also shows that:

- Departure taxi holding is less than 10 minutes for approximately 63% of flights
- Departure taxi holding is less than 15 minutes for approximately 88% of flights.

Figure 67 shows how the proportion of the time that average departure taxi holding time is less than 10 minutes has evolved from summer 2014 through to summer 2016. There has been a general decline from nearly 90% in summer 2014 to just over 70% in summer 2016.

Figure 67: Proportion of the time that average departure taxi holding is less than 10 minutes



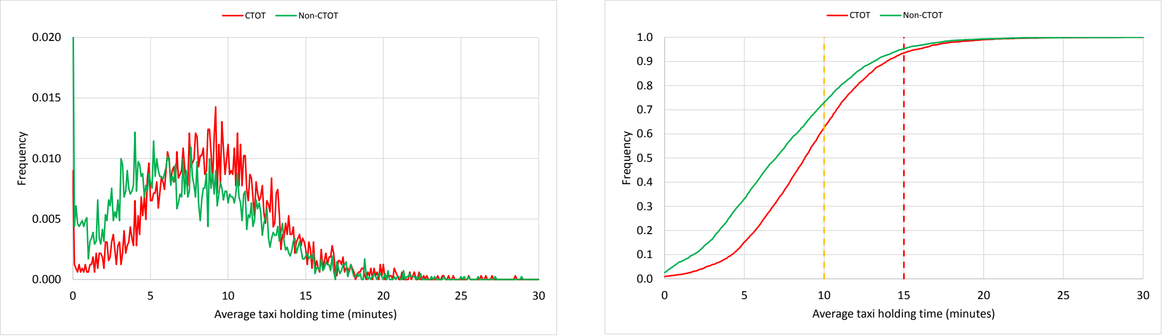
4.5.5 The impact of ATFM regulation on departure taxi holding

To understand the impact of Gatwick’s push and hold policy for ATFM regulated departures, Figure 68 compares the hourly departure taxi holding distributions for ATFM regulated departures (those with a calculated take-off time (CTOT)) with non-regulated (non-CTOT) departures.

The figure clearly shows the impact of ATFM regulation on departure taxi holding:

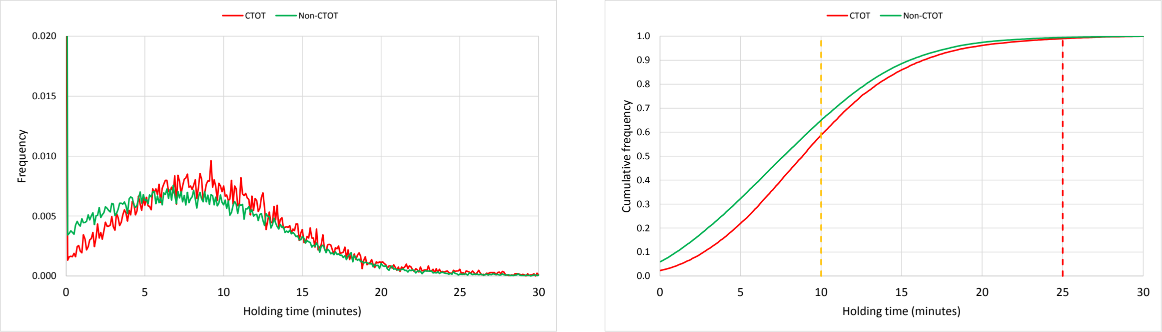
- For 62% of the time CTOT flights are held for less than 10 minutes as compared to 72% of the time for non-CTOT flights
- For 93% of the time CTOT flights are held for less than 15 minutes compared to 95% of the time for non-CTOT flights.

Figure 68: Hourly departure taxi holding distributions for non-CTOT and CTOT flights summer 2016



Similarly, Figure 69 compares the flight-by-flight departure taxi holding distributions for regulated (CTOT) and non-regulated (non-CTOT) departures.

Figure 69: By flight departure taxi holding distributions for non-CTOT and CTOT flights summer 2016



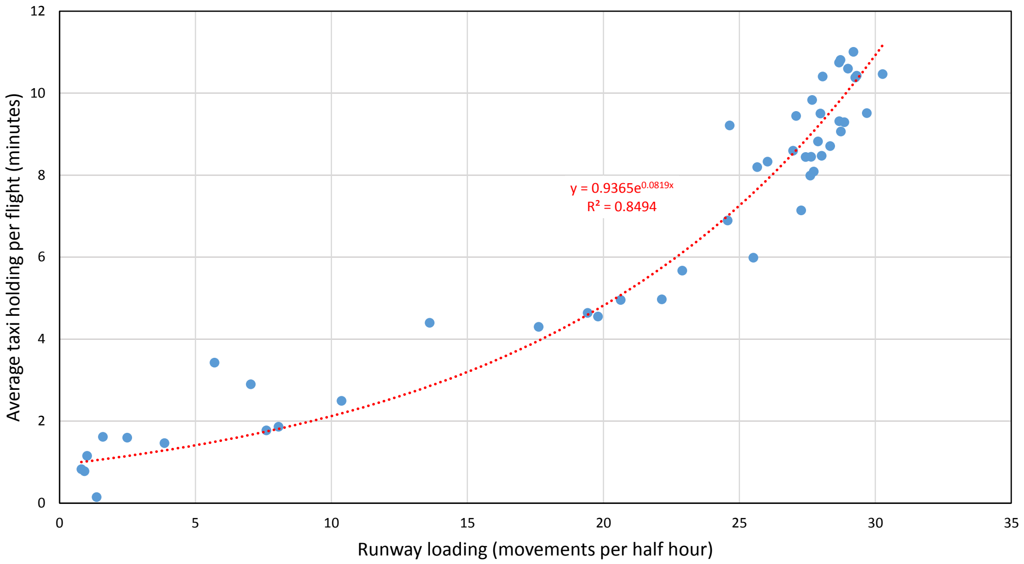
The chart shows that:

- Mean holding per flight is approximately 9.4 minutes for CTOT flights and 8.2 minutes for non-CTOT flights
- 58% of CTOT flights are held for less than 10 minutes compared to 64% of non-CTOT flights
- 86% of CTOT flights are held for less than 15 minutes compared to 88% of non-CTOT flights
- 99% of both CTOT and non-CTOT flights are held for less than 25 minutes.

4.5.6 Relationship between departure taxi holding and demand

Figure 70 shows the relationship between departure taxi holding and runway loading. The correlation has been derived from the departure taxi holding and runway loading (the sum of arrivals and departures segmented into 30 minute periods across the day and averaged across the 2016 summer season. Similar relationships exist for the other seasons.

Figure 70: Correlation between departure taxi holding and runway loading



As with airborne holding for arrivals, the high correlation coefficient and the form of the curve indicates a strong queuing type relationship between runway loading and departure taxi holding. The exponential nature of the delay curve suggests that small increases in runway loading would be expected to increase in large increases in delay at peak periods. As with airborne holding, the data suggests an absolute runway capacity limit of approximately 30 movements per half hour.

4.6 Turns

In addition to arrivals and departures, the third internal-to-Gatwick component of the schedule is the aircraft turn that links the arrival to the subsequent departure. This section describes the analysis to derive Gatwick's overall actual turn performance and compares this actual performance to the schedule.

4.6.1 Analysis approach

Although some individual airlines collect data that measure the performance of their turns at Gatwick, such data is not available on an airport-wide scale. However, the latest (summer 2016) version of the Airport's operational database, Idaho, links arrivals and departures allowing the reconstruction each aircraft's scheduled and actual work programme and, hence, the comparison of actual and scheduled turns. The analysis described below has, therefore, been limited to the 2016 summer season.

The approach taken to the analysis is as follows:

- Separate Idaho arrival and departure data records were combined to link the arrivals and departures for individual aircraft and create a data record describing the turn
- The **scheduled turn time** for each data record was calculated as the difference between the scheduled off-blocks time (SOBT) of the departure and the scheduled in-blocks time (SIBT) of the aircraft's previous arrival
- The **actual turn time** was calculated as the difference between the actual start request time (ASRT) of the departure and SIBT or actual in-blocks time (AIBT), whichever is later, of the previous arrival. ASRT is used as a proxy for time that the aircraft is ready to go thereby eliminating the impact of externally applied start delay from the turn time. Similarly departures with ATFM regulations were excluded from the analysis to avoid biasing turn time with ATFM effects. The later of the SIBT or AIBT is used to estimate the start of the actual turn to avoid artificially extending the turn for early arrivals

- The **extended turn time**, defined as the difference between the actual turn time and the scheduled turn time was calculated for each turn. The extended turn time is positive for turns that take longer than implied by the schedule, negative for turns that are shorter than implied by the schedule and zero if actual and scheduled turn times are the same
- The turn-by-turn data was analysed statistically over the 2016 summer season sample with the **turn success rate** defined as the proportion of turns that were completed within the scheduled turn time. This is a comparison of the length of the actual and planned turns: it gives no indication about the subsequent departure punctuality.

Records with inconsistencies, for example negative turn times and missing data fields, were excluded from the sample. The following sections describe the results of the statistical analysis.

4.6.2 Turn distributions

Figure 71 shows the distribution of scheduled and actual turn times at Gatwick over the 2016 summer season, covering the entire spectrum of turns from the shortest at 25 minutes to the longest at around 900 minutes.

Figure 71: Overall Gatwick turn time distributions summer 2016

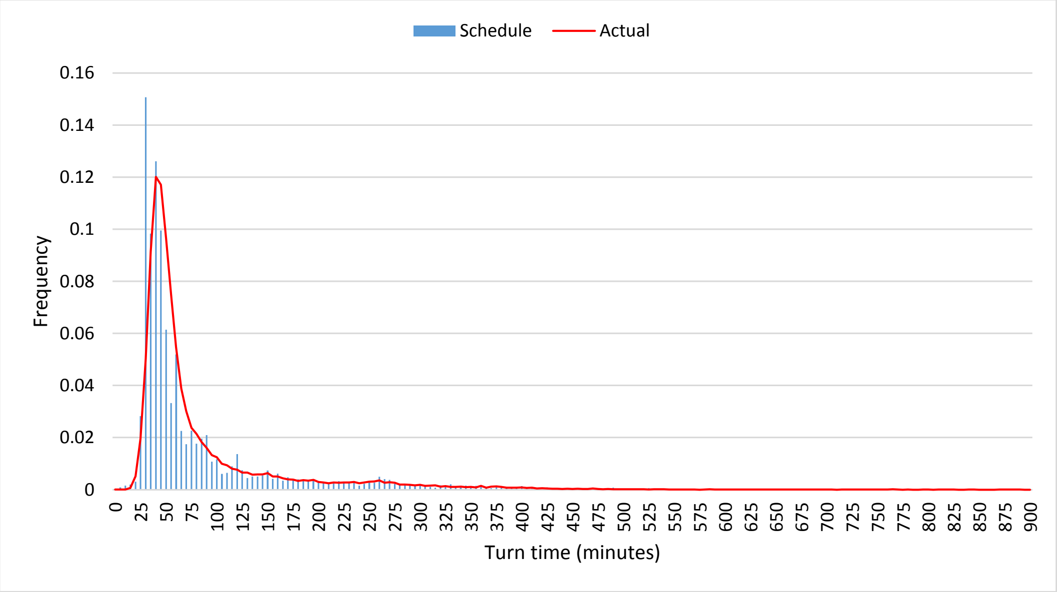
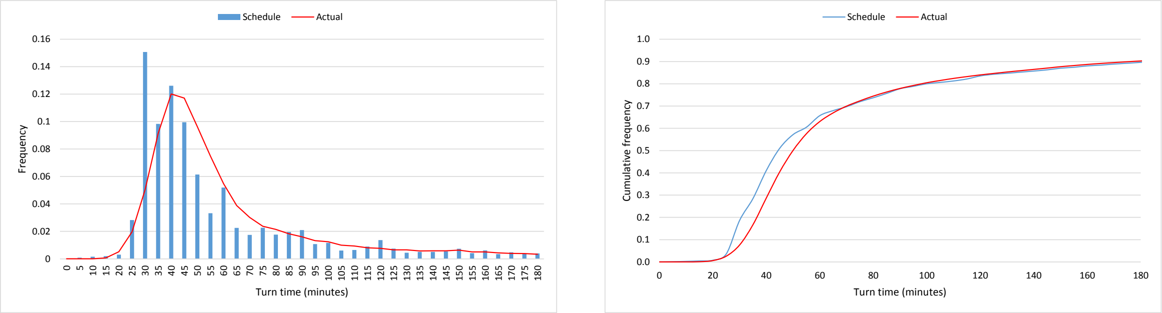


Figure 72 shows the same distribution as Figure 71 but focussed in on shorter turns, scheduled for three hours or less.

Figure 72: Scheduled and actual turn time distributions summer 2016



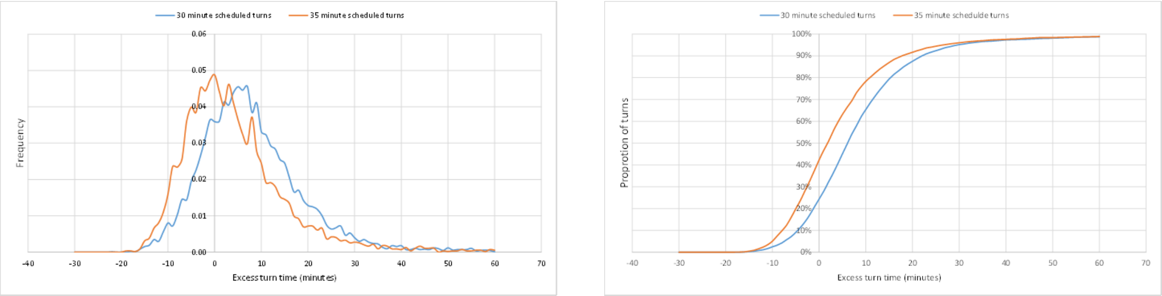
Both of the figures show that the most common scheduled turn time at Gatwick, the mode of the distribution, is 30 minutes with approximately 65% of all turns being scheduled at one hour or less and 80% of turns being scheduled at less than 100 minutes.

The distributions show that up to scheduled turns of approximately one hour, actual turns lag behind the schedule. The most common actual turn time, the mode of the distribution, is 40 minutes. There is little difference between actual and scheduled turn distributions for scheduled turns greater than one hour.

4.6.3 Turn success rates

Figure 73 shows example excess turn time distributions for turns scheduled for 30 and 35 minutes. An excess turn time of zero or less indicates that the actual turn has been executed to schedule or better whereas a positive value indicates that the turn has taken longer than planned.

Figure 73: Excess turn time distributions for 30 and 35 minute scheduled turns summer 2016



The figure shows:

- A success rate of approximately 24% for turns scheduled at 30 minutes
- A success rate of approximately 40% for turns scheduled at 35 minutes.

Figure 74 consolidates the success rates for the range of turns planned at Gatwick, showing success rate as a function of scheduled turn time. As with the specific example above, the chart shows that the success rate for 30 minute scheduled turns is 24%.

For short turns, as the scheduled turn time increases the turn success rate increases from approximately 5% for the very few very short turns of 20 minutes to a maximum of approximately 73% for turns scheduled at 65 minutes. Thereafter there is a gradual decrease in turn success rate as scheduled turn time increases from 65 to 150 minutes, when the success rate oscillates around 50%.

Figure 74: Turn success rates as a function of scheduled turn time summer 2016

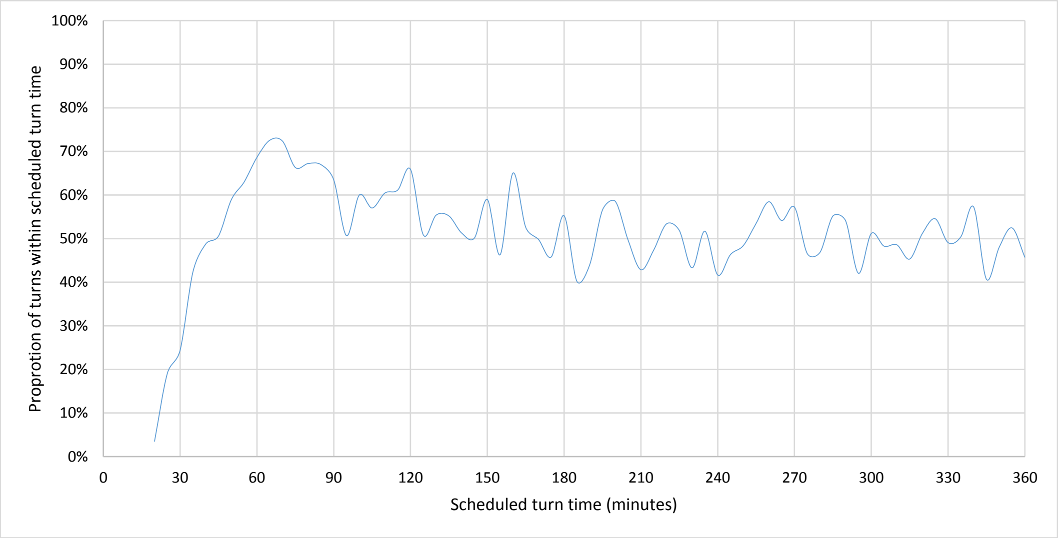
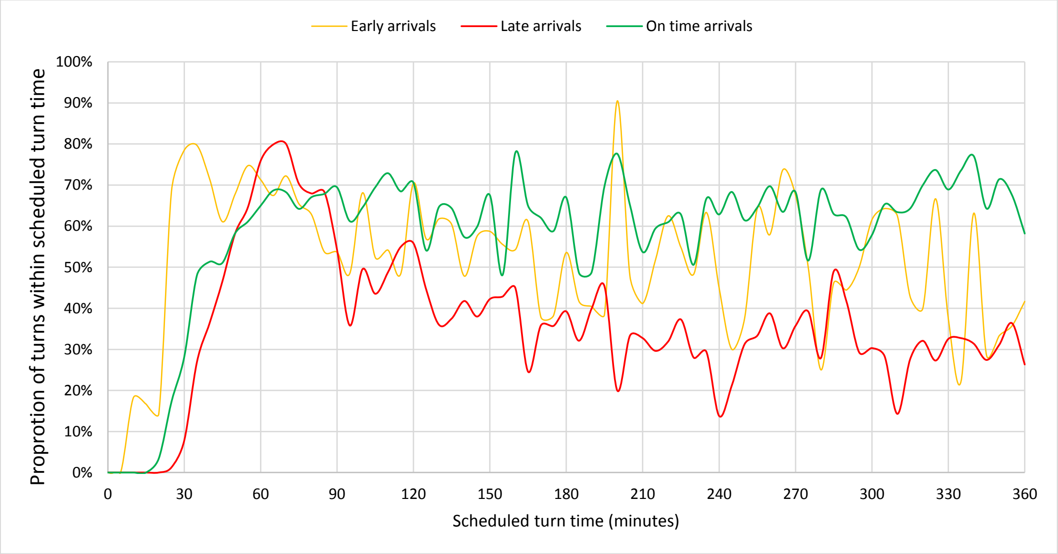


Figure 75 illustrates the impact of arrival punctuality on turn success rates. The three data sets show turn success rates as a function of scheduled turn time for:

- Early arrivals (yellow line) that are on-blocks more than 15 minutes before the scheduled arrival time
- Late arrivals (red line) that are on-blocks more than 15 minutes after the scheduled arrival time
- On-time arrivals (green line) that are on-blocks within a ±15 minute window of the scheduled arrival time.

Figure 75: The effect of arrival punctuality on turn success rates

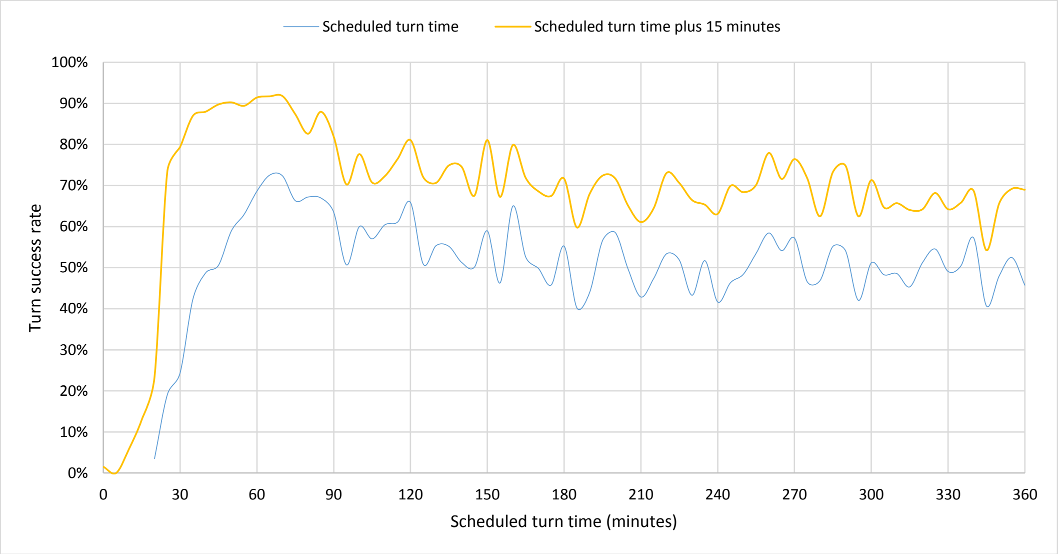


The chart shows that for short turns, scheduled at approximately one hour or less, turn performance is best for early arrivals. This increased success rate is likely due to there being extra actual time to manage the turn, compared to the planned time. For these short turns, performance for on-time arrivals is better than performance for late arrivals.

For longer scheduled turns, except for around 60 minutes where late arrivals show the best turn performance, on-time and early arrivals exhibit better turn success rates, oscillating around 50 to 60% than later arrivals where the success rate decreases from approximately 70% for 60 minute turns to around 30% for long turns of up to six hours.

Figure 76 shows the impact of measuring the actual turn time against a benchmark of the scheduled turn time plus the 15 minute punctuality buffer, based on an assumption that existing level of ground handling resource are in place. This means, for example, that a 30 minute scheduled turn would be deemed success as long as it was executed within 45 minutes. The chart shows that success rates increase markedly by up to 40%, especially for short turns where they reach 90%. The increase in success rate, from typically 50% to 70%, for longer turns is lower than for short turns.

Figure 76: The impact of adding a 15 minute turn buffer on turn success rates



The results shown in the chart suggest that adding buffer to planned turn times can increase turn success rates markedly. However, so-as-not-to prejudice departure punctuality, without adjusting block times this buffer would need to come from the arriving flight. As a very simple illustration of the potential for this type of buffering, in summer 2016 arrival punctuality was approximately 64% over the day (see Figure 23) and approximately 88% in the first wave. Coupled with a buffered turn success rate of 90% shown in Figure 76, this would result in a departure punctuality of approximately 58% across the day and approximately 80% for second wave departures. This illustration disregards any other factors that influence departure punctuality.

4.7 Summary

4.7.1 The scheduling process

Gatwick's scheduling process is sophisticated compared to that used at many airports. It is consistent with all IATA and statutory requirements. Runway capacity declaration is at the core of the airport capacity management process and is executed using a state-of-the-art simulation tool, AirTop. However, this process has a number of inherent risks:

- The wish-list schedule, which forms the basis of the scheduling process, is derived from airline planning based on historical performance. This wish list is not forward looking and does not take into account forecasts of traffic growth, likely future delays and other disruptions, e.g. due to planned air traffic control system upgrades
- Airborne and departure taxi holding delays due to the runway are the only performance indicators that are considered explicitly in declaring runway capacity, which forms the core part of the capacity declaration. These two components of the overall holding delay may not be wholly representative of the delays being incurred due to constraints in Gatwick's existing infrastructure. For example there is no assessment of taxiway or apron congestion. In addition, other runway, taxiway and airspace holding delays that are likely to have an impact are air traffic flow management (ATFM) regulations applied to inbound flights and attributed to Gatwick; start delays, where the departing aircraft is held on the stand to moderate the flow of traffic; minimum departure intervals (MDIs) applied to departing traffic due to downstream departure route or airspace congestion, not only arising from Gatwick traffic but from traffic using the other London airports
- Baselining of the model used to define runway capacity is based on a small number of busy but undisrupted sample days: this might introduce optimism bias into the assessment. In addition, Gatwick has large in-season variations in its schedule. These are taken into account in planning

process for the winter season but not for the summer, where the early-season schedule is considerably different to the late-season schedule

- The criteria used for declaring capacity is based on modelled holding delays alone, with additional flights being assessed as acceptable strictly if the modelled delays do not exceed a set of thresholds. There is no consideration of the direct and indirect costs and benefits of additional flights or the retiming of existing flights
- The delay criteria that form the basis of capacity declaration are simple averages that give no indication of the wide variation in delay performance that might result. Predictability is likely to be as important a factor in performance, if not more important, to both airlines and passengers. The AirTop tool used for modelling runway capacity is sophisticated and could be used to produce additional parameters useful to understanding the implications of the proposed schedule
- There is a perception of lack of engagement in the capacity declaration process from airline stakeholders:
  - There is a lack of transparency in the definition of the wish-list options to be considered as inputs
  - For pragmatic reasons only a limited number of wish-list options are modelled whereas a larger number of broader scenarios could be considered
  - There is a lack of transparency in the decision-making process that leads to the capacity declaration.
- Slot allocation also does not necessarily take into account all of the factors that are used to derive the capacity declaration, such as aircraft size, direction, origin/destination, etc. and can therefore lead to operational situations where the achievable performance is different to that on which the capacity declaration is based.

4.7.2 Runway utilisation and associated holding

Simple modelling indicates that, at least in peak summer periods, the airport is operating very near to the capacity of its single runway. Capacity utilisation is much lower during winter seasons. Comparison of the levels of utilisation predicted directly from the schedule with that actually delivered indicate the vital importance of optimised sequencing of the traffic stream applied tactically by air traffic control. The consequence of this sequencing, that on average from summer 2014 to summer 2016 increased runway efficiency by approximately 16%, is the airborne and departure taxi holding needed to provide adequate buffers to optimise the traffic flow. This holding is factored into the capacity declaration process.

The levels of holding experienced in summer 2016 indicate that during that period the runway was operating very near to capacity. The scheduling limits for both airborne and departure taxi holding are not having extended periods when average holding is greater than 10 minutes per flight; not exceeding an average holding of 15 minutes per flight and not exceeding a hold of 25 minutes for any flight. For arrivals, summer 2016 performance was very near to and may have breached these criteria on several occasions. Departure holding was more severe that airborne holding, indicating an understandable preference for arrivals. In summer 2016 there were average departure taxi holding was above 10 minutes per flight for 28% of the time. Average holding per flight also exceeded 15 minutes per flight for 4% of the time. Historical data indicates a degradation in departure taxi holding over time. Furthermore, in summer 2016 the mean departure taxi time on westerly operations was 19.1 minutes whereas the mean departure taxi time to easterly operations was 21.7 minutes, compared to the 20 minutes average assumed in the scheduling process.

The policy of push-and-hold for departures that are subject to downstream ATFM regulation raises the level of departure taxi holding as these departures are held on overage for a minute longer than flights that are not subject to ATFM regulation.

There are strong exponential, queuing-type relationship (delay curve) between both airborne holding and departure taxi holding, and runway loading. Gatwick’s position on the delay curves for summer

2016 emphasises that the runway is operating at capacity and further increases in demand would very likely result in large increases in holding delay. Quantitatively, the data suggests that the capacity limit is around 30 runway movements for a single half hour although this would unlikely be sustainable.

4.7.3 Turn performance

The analysis, albeit based on one season, suggests that Gatwick's operating environment with a prevalence of short turns is very challenging. Turn success rates for 30 minute turns, the most common scheduled at Gatwick, are less than 25%. As the scheduled turn time increases so does, unsurprisingly, the turn success rate, which reaches a maximum of around 70% for turns scheduled at approximately one hour. Thereafter, the turn success rate decreases slightly and oscillates around 50% independent of scheduled turn time.

On-time or early arrival performance increases turn success rates. For short turns early arrival increases success rate markedly but has less of an impact for longer scheduled turns. In all cases, late arrivals show the worst turn performance. However, other than for first wave arrivals, arrival punctuality performance offers little scope for buffering turns. Eating into the 15 minute punctuality buffer also increases turn success rates considerably. For turns scheduled at 30 minutes, using the 15 minute punctuality buffer (effectively extending the turn time to 45 minutes) increases the success rate to greater than 90% although, as this uses the buffer, it is not clear that this would result in improved punctuality.

We recommend that further areas of focus should include investigating and mitigating the causes of poor turn performance and understanding if adding buffer time to turn times would prove beneficial from a punctuality perspective.

5 OPERATIONS

5.1 Introduction

The third major component of the study is to analyse the evolution of operational performance over the past few years. At the outset of the study, the focus of this analysis was on the first wave to: (i) understand the drivers of first wave performance; (ii) assess how first wave performance influenced performance over the reset of the day; and (iii) determine the degree to which the drivers of first wave performance are controllable. However, given commonalities in data requirements and analysis techniques, the scope of this activity has been expanded to address performance over the entire day without, however, losing the focus on first wave.

The section is organised as follows:

- Section 5.2 reviews first wave performance, addressing long and short haul arrivals separately as well as departures. This section also investigates the correlation between first wave performance and performance across the rest of the day
- Section 5.3 analyses the impact that air traffic flow management (ATFM) regulations, imposed as calculated take-off time (CTOT) has on departure performance, both on first wave and subsequently. This section also reviews the risk of departures being allocated a CTOT by time of day and departure route, as well as assessing how this risk has evolved over time
- Similarly, Section 5.4 reviews the impact that start delay (the difference between the departure requesting to start and that request being granted by air traffic control) on departure performance, again assessing the risk by time of day and departure route. Potential root causes of start delay are also investigated, including departure route loading and airfield loading
- Section 5.5 reviews taxi in performance for arrivals
- Section 5.6 draws together the separate streams into a set of consolidated conclusions concerning the drivers of Gatwick’s operational performance.

5.2 The first wave

This section addresses first wave performance and is organised as follows:

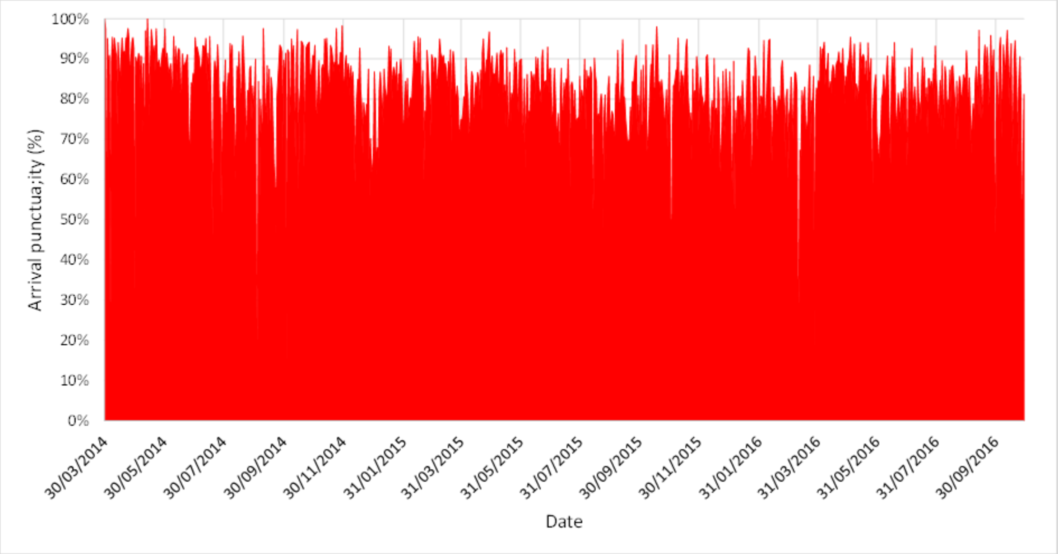
- Section 5.2.1 investigates first wave arrival performance, separating long and short haul arrivals to identify any differences in performance
- Section 5.2.2 performs similar analysis for first wave departure performance
- Section 5.2.3 explores the correlations between first wave performance and subsequent performance later in the day.

5.2.1 First wave arrival performance

All arrivals

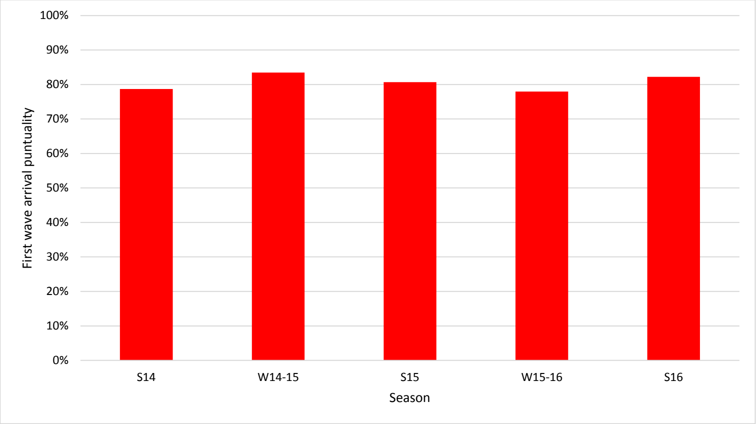
Figure 77 shows the evolution of first wave daily arrival punctuality from the start of summer 2014 through to the end of summer 2016. The performance of all arrivals, both long and short haul, is included in the figure.

Figure 77: Daily average first wave arrival punctuality



The chart does not show any obvious trend and there is no obvious summer-winter cyclical pattern that is observed in overall daily punctuality, see for example Figure 23. There are large day-to-day variations in punctuality performance. As shown in Figure 78, at seasonal level except for the 2015-16 winter season, the average overall arrival punctuality is around 80% and has increased slightly from summer 2014 to summer 2016.

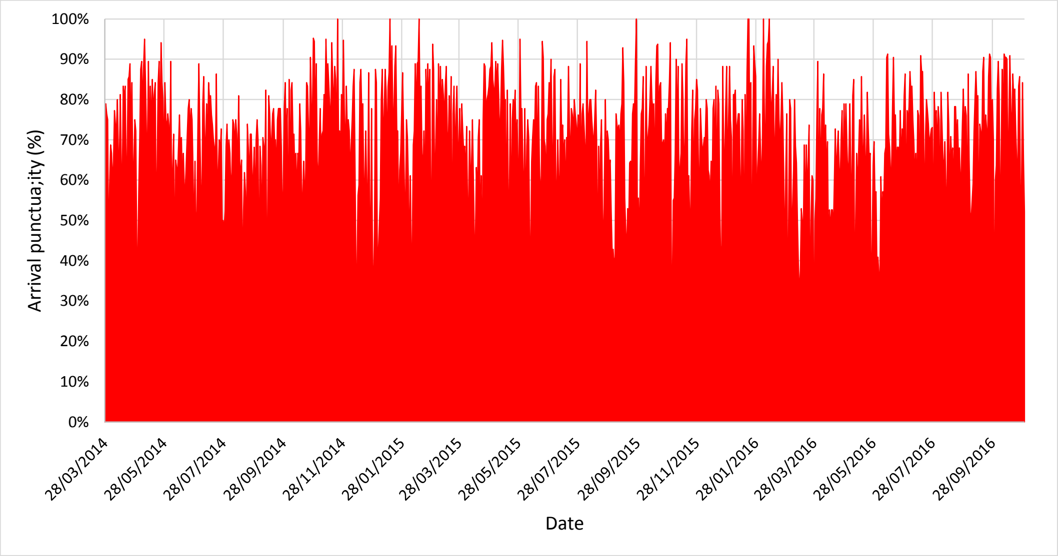
Figure 78: Seasonal average first wave arrival punctuality



Long haul arrivals

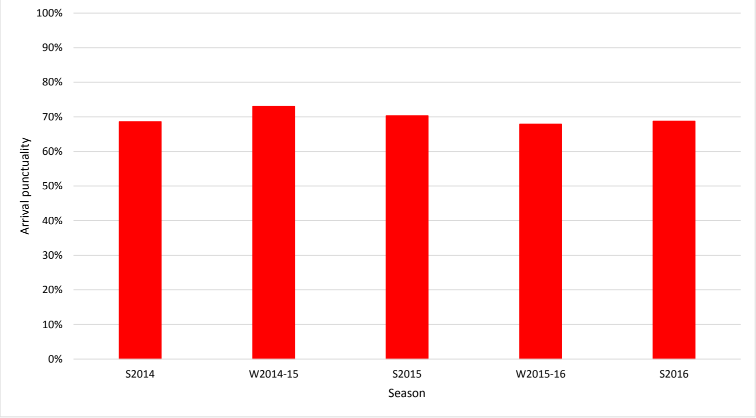
Figure 77 shows the evolution of daily first wave long haul punctuality performance from 2014 to 2016. The figure shows that long haul arrival punctuality is worse than overall punctuality (compare with Figure 77) and that there can be large day-to-day fluctuations.

Figure 79: Daily average first wave long haul arrival punctuality



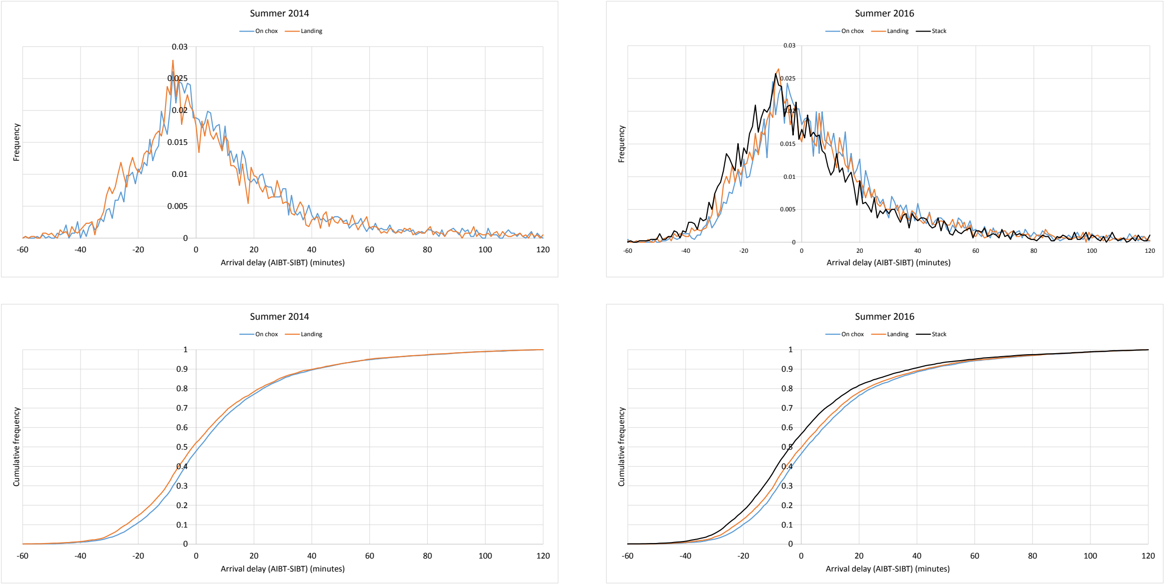
The seasonal average first wave long haul punctuality performance illustrated in Figure 80 is generally around 70% compared to an overall average of approximately 80%. There is no systematic seasonal trend in first wave long haul arrival punctuality.

Figure 80: Seasonal average first wave long haul arrival punctuality



In order to investigate performance in more detail, Figure 81 shows the arrival delay distributions for first wave long haul arrivals for summer 2014 and summer 2016. Delay is measured as the difference between the actual time at a flight milestone and the scheduled time at that milestone. Three distributions are shown for summer 2016: on-blocks, landing and stack. Delay is measured against the scheduled time at each milestone. For the upstream milestones – landing and stack – the scheduled time has been backtracked from the scheduled in-blocks time (SIBT) using the average taxi in and approach times respectively. As airborne holding data is only available for 2016, it has not been possible to determine delay performance at the stack for summer 2014.

Figure 81: First wave long haul arrival distributions summer 2014 and summer 2016



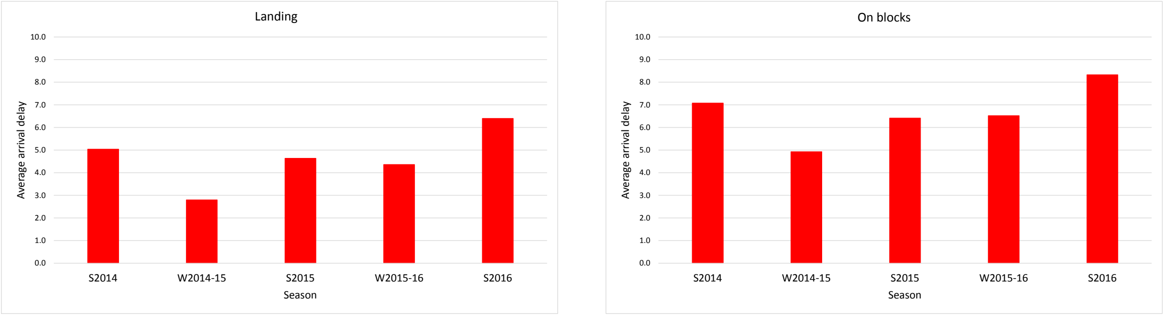
The distributions show that for first wave long haul arrivals:

- In summer 2014 the average on blocks delay was approximately seven minutes while the landing delay was approximately five minutes (implying a two minute taxi delay – see section 5.5). Approximately 55% of flights arrived on blocks within a ±15.59 minute window around the scheduled time; 17% arrived more than 15 minutes early and 28% arrived more than 15.59 minutes late. At the landing milestone, approximately 52% of flights landed within a ±15.59 minute window around the backtracked scheduled time; 21% of flights were greater than 15.59 minutes early and 26% were greater than 15.59 minutes late
- In summer 2016 the average on blocks delay was just over eight minutes while the landing delay was approximately six minutes (again implying a two minute taxi delay). Approximately 55% of flights arrived on blocks within a ±15 minute window around the scheduled time; 16% arrived more than 15 minutes early and 29% arrived more than 15 minutes late. At the landing milestone, approximately 52% of flights landed within a ±15 minute window around the backtracked scheduled time; 21% of flights were greater than 15 minutes early and 26% were greater than 15 minutes late. At the backtracked stack milestone the average delay per flight was approximately three minutes; 51% of flights were within a ±15 minute on-time window; 26% of flights were more than 15 minutes early and 23% of flights were more than 15 minutes late.

Figure 82 and Figure 83 show the seasonal first wave long haul arrival on time performance and delay respectively.

Figure 82: First wave long haul arrival on time performance

Figure 83: Average first wave long haul arrival delay

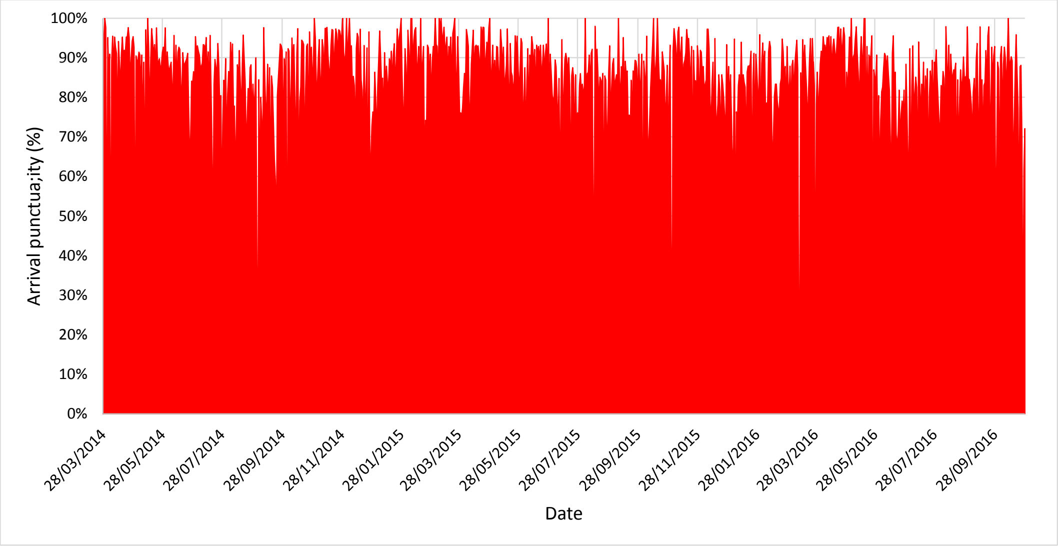


The figures show that although there is little change in the proportion of flights on time, early or late (Figure 82) that the average arrival delay per flight after falling from summer 2014 has increased from winter 2014-15 through to summer 2016 for both landing and on blocks milestones. In both cases the increase has been approximately three minutes per flight.

Short haul arrivals

Figure 84 shows the evolution of daily first wave short haul punctuality performance from the start of summer 2014 to the end of summer 2016. The figure shows that short haul arrival punctuality is better than overall punctuality (compare with Figure 77) and is generally between 80% and 90% but that there can be large day-to-day fluctuations. There is also a faint summer-winter cyclical pattern.

Figure 84: Daily average first wave short haul arrival punctuality



The seasonal average first wave short haul punctuality performance illustrated in Figure 85 is just over 80% similar to the overall average of approximately 80% and higher than the long haul average at approximately 70%.

Figure 85: Seasonal average first wave short haul arrival punctuality

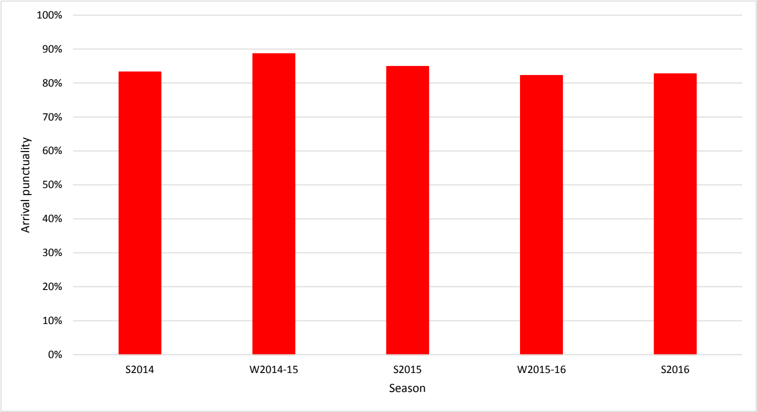
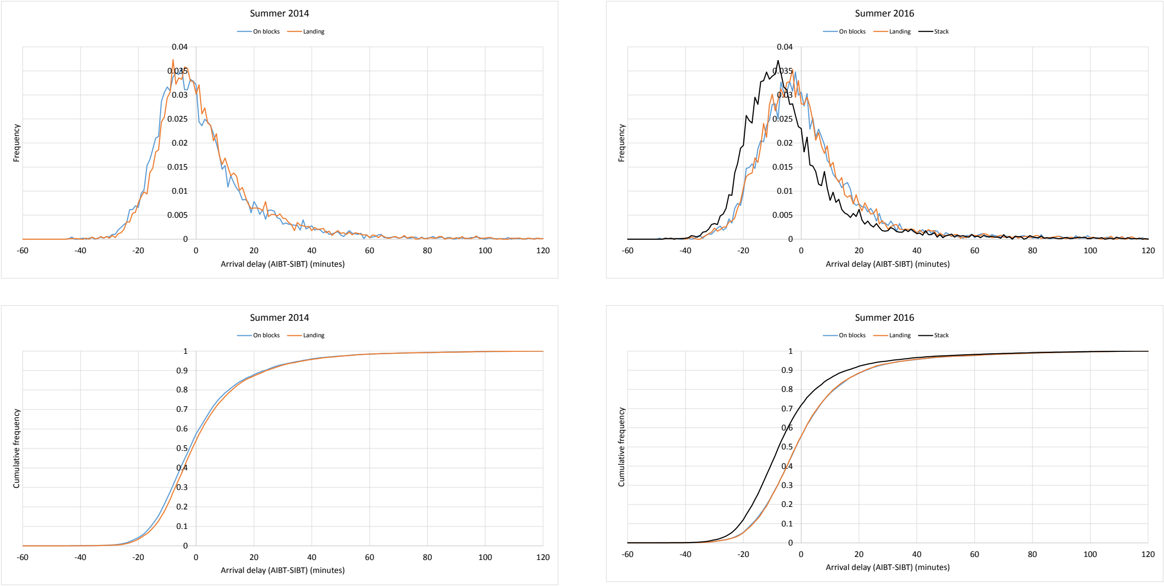


Figure 86 shows the arrival delay distributions for first wave short haul arrivals for summer 2014 and summer 2016. Delay is measured as the difference between the actual time at a flight milestone and the scheduled time at that milestone. Three distributions are shown for summer 2016: on-blocks, landing and stack. Delay is measured against the scheduled time at each milestone. For the upstream milestones – landing and stack – the scheduled time has been backtracked from the scheduled in-blocks time (SIBT) using the average taxi in and approach times respectively. As airborne holding data is only available for 2016, it has not been possible to determine delay performance at the stack for summer 2014.

Figure 86: Short haul arrival distributions summer 2014 and summer 2016



The distributions show similar performance for on blocks and landing milestones. However, comparison with the long haul stack distribution for summer 2016 (see Figure 81) implies more marked earlier arrival at the stack milestone for short haul arrivals than for long haul arrivals. The distributions show that for first wave short haul arrivals:

- In summer 2014 the average on blocks delay was approximately two minutes while the landing delay was approximately three minutes (this is the opposite observation to the first wave long haul arrivals where the landing delay is smaller than the on blocks delay). Approximately 73% of flights arrived on blocks within a ±15 minute window around the scheduled time; 11% arrived more than 15 minutes early and 16% arrived more than 15 minutes late. At the landing milestone, approximately 74% of flights landed within a ±15 minute window around the backtracked scheduled time; 9% of flights were greater than 15 minutes early and 17% were greater than 15 minutes late

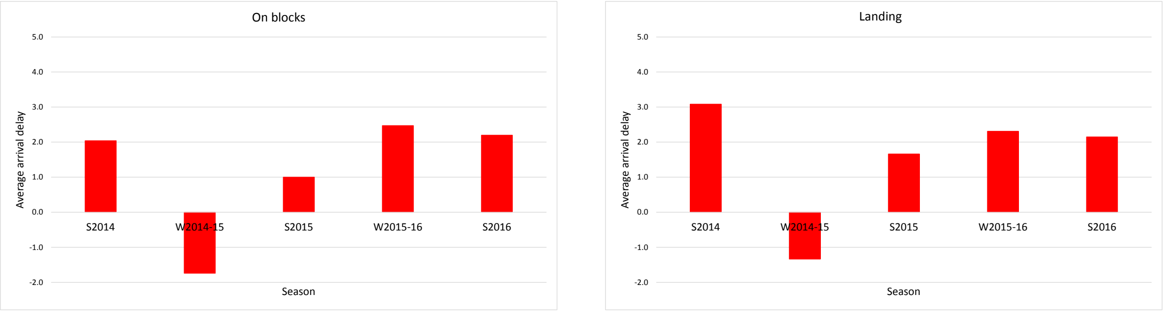
- In summer 2016 the average on blocks delay was two minutes and the landing delay was also approximately two minutes. Approximately 71% of flights arrived on blocks within a ±15 minute window around the scheduled time; 13% arrived more than 15 minutes early and 16% arrived more than 15 minutes late. At the landing milestone, approximately 72% of flights landed within a ±15 minute window around the backtracked scheduled time; 13% of flights were greater than 15 minutes early and 16% were greater than 15 minutes late. At the backtracked stack milestone the average delay per flight was approximately 3½ minutes; 64% of flights were within a ±15 minute on-time window; 25% of flights were more than 15 minutes early and 11% of flights were more than 15 minutes late.

Figure 87 and Figure 88 show the seasonal first wave arrival on time performance and delay respectively. Figure 87 shows that with the exception of winter 2014-15 first wave short haul on time arrival performance is consistent from summer 2014 to summer 2016. In winter 2014-15 the proportion of early arrivals on blocks was around 4% higher than in the other seasons. The negative average delay for this season, illustrated in Figure 88 confirms the tendency for early arrivals in that season.

Figure 87: First wave short haul arrival on time performance

Figure 88 shows that there is no particular trend in arrival delay for first wave short haul flights. In summer 2016 the short haul arrival delay was approximately two minutes per flight compared to just over eight minutes per flight for long haul arrivals.

Figure 88: Average first wave short haul arrival delay



5.2.2 First wave departure performance

Figure 89 shows the evolution of first wave daily departure punctuality from the start of summer 2014 through to the end of summer 2016. Unlike first wave arrival performance, departure punctuality shows the summer-winter cyclical pattern, with generally higher punctuality in winter than in summer. Superimposed on this underlying pattern, there is considerable day-to-day variation in performance.

Figure 89: Daily average first wave departure punctuality

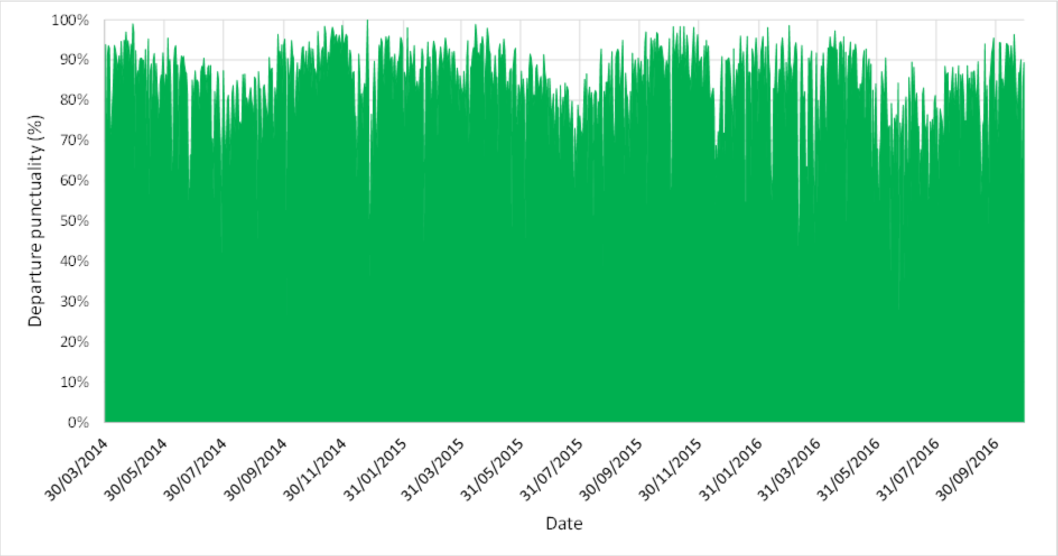


Figure 90 shows the seasonal averages of first wave departure punctuality. As observed in the daily averages shown in the figure above, punctuality in the two winter seasons, at around 82% to 85%, was higher than in the three summer seasons, which has fallen from approximately 82% in summer 2014 to approximately 77% in summer 2016.

Figure 90: Seasonal average first wave departure punctuality

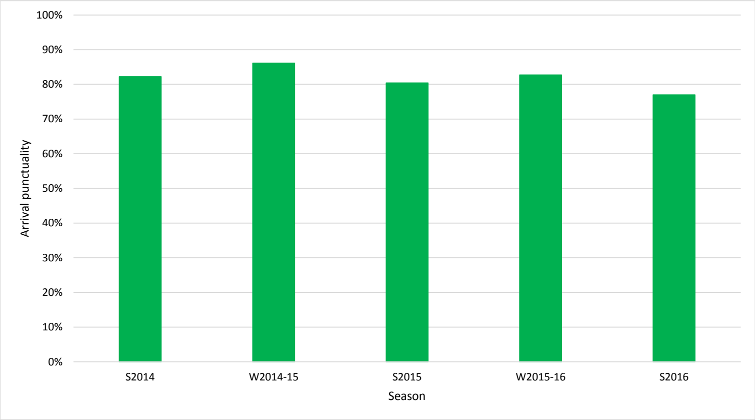
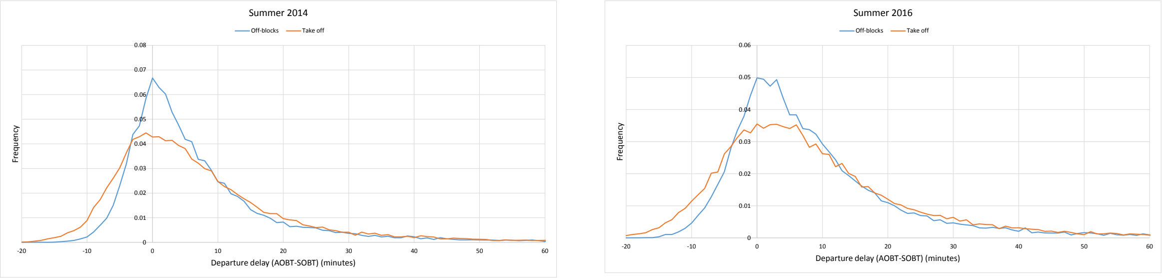
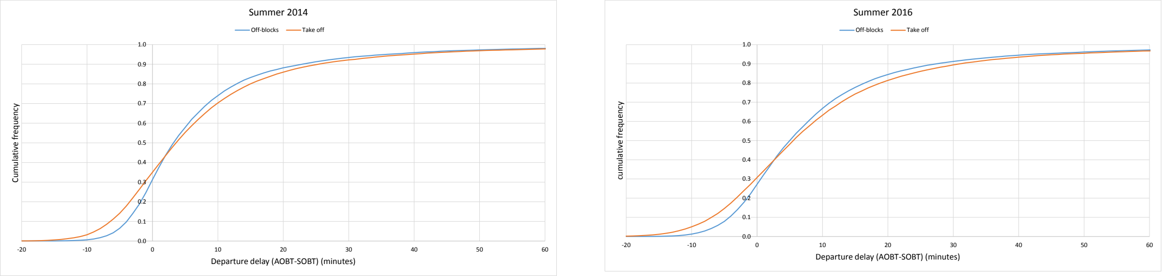


Figure 91 shows the first wave departure delay distributions for summer 2014 and summer 2016. Delay is measured as the difference between the actual time at a flight milestone and the scheduled time at that milestone. Two distributions: off-blocks and take-off. Delay is measured against the scheduled time for each of these milestones. For the take-off milestone, the scheduled time has been projected forward from the scheduled off-blocks time (SOBT) using the average taxi out time.

Figure 91: First wave departure distributions summer 2014 and summer 2016





The distributions are broader and less peaked for the take-off milestone than the off-blocks milestone. This implies greater variability in take-off performance than in off-blocks performance likely caused by the variability in taxi out time. Quantitatively, the distributions show that for first wave departures:

- In summer 2014 the average off-blocks delay was just under eight minutes with the take-off delay being just over eight minutes. Approximately 83% of flights departed off-blocks within a ±15 minute window around the scheduled time; virtually no flights departed more than 15 minutes early and 17% departed more than 15 minutes late. At the take-off milestone, approximately 80% of flights took off within a ±15 minute window around the projected scheduled time; just under 1% of flights left greater than 15 minutes early and 20% were greater than 15 minutes late
- In summer 2016 the average off-blocks delay was just over ten minutes and the take-off delay was slightly greater at 10½ minutes. Approximately 78% of flights departed off-blocks within a ±15 minute window around the scheduled time; virtually no flights departed more than 15 minutes early and 22% departed more than 15 minutes late. At the take-off milestone, approximately 73% of flights took off within a ±15 minute window around the projected scheduled time; 1% of flights were greater than 15 minutes early and 26% were greater than 15 minutes late.

Figure 92 and Figure 93 show the seasonal first wave departure on time performance and delay respectively. Figure 92 shows that from summer 2014 through to and including summer 2015 there is little variation in either off-blocks or take-off performance. In winter 2015-16 on-time performance at off-blocks is similar to previous years but has reduced at take-off, where it is 10% lower than for off-blocks. Half of this reduction is due to early take-offs with the other half due to late take-offs, implying an increase in taxi-out variability at first wave. In summer 2016, on-time performance at off-blocks has decreased by approximately 5% compared to previous years. Take-off performance in summer 2016 is similar to the reduced level experienced in winter 2015-16 but in this case the reduction is almost solely due to late take-offs, implying an increase in taxi-out time, rather than more variability.

Figure 92: First wave departure on time performance

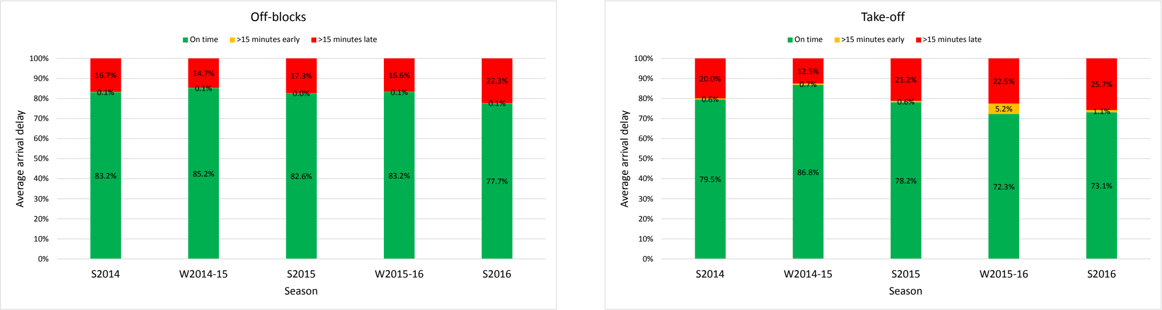
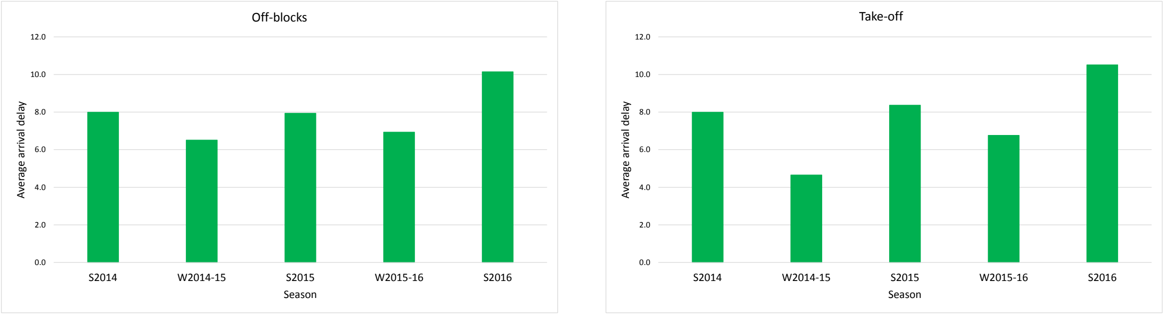


Figure 93 showing average first wave departure delay illustrates the increased delay levels experienced in summer 2016 compared to previous summer seasons.

Figure 93: Average first wave departure delay

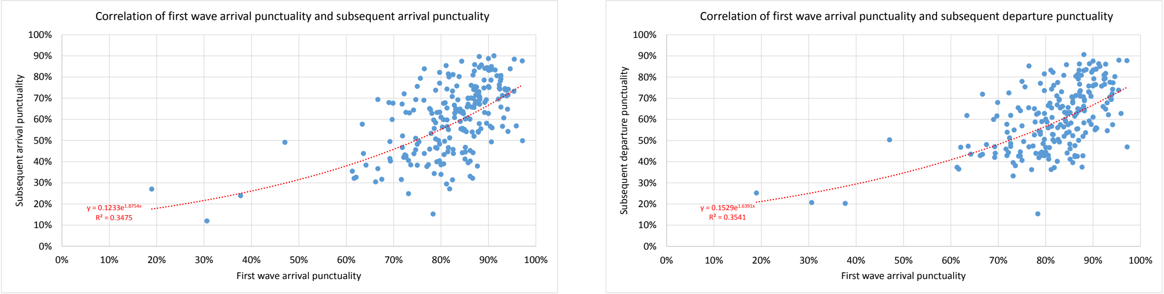


For both off-blocks and take-off the average departure delays in summer 2016 were just over ten minutes; an increase of approximately two minutes over the previous summer seasons.

5.2.3 First wave influence on the rest of the day

It is expected that, in a busy airport, first wave performance will set the scene and have a strong influence over performance for the rest of the day. To test this hypothesis, the correlations have been investigated between first wave arrival and departure punctuality and subsequent arrival and departure punctuality in all combinations. The results for first wave arrivals are shown in Figure 94 and first wave departures in Figure 95 respectively. The figures show the best curve fits, which are exponential in each case, as well as the regression statistics indicating the significance of the correlations.

Figure 94: Influence of first wave arrival punctuality



Regression Statistics	
Multiple R	0.589502667
R Square	0.347513394
Adjusted R Square	0.344478573
Standard Error	0.262615273
Observations	217

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	7.897295101	7.897295	114.5087
Residual	215	14.82785802	0.068967	
Total	216	22.72515312		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-2.092958366	0.144718781	-14.4622	1.46E-33
First wave punctuality	1.875403476	0.175257056	10.70087	1.07E-21

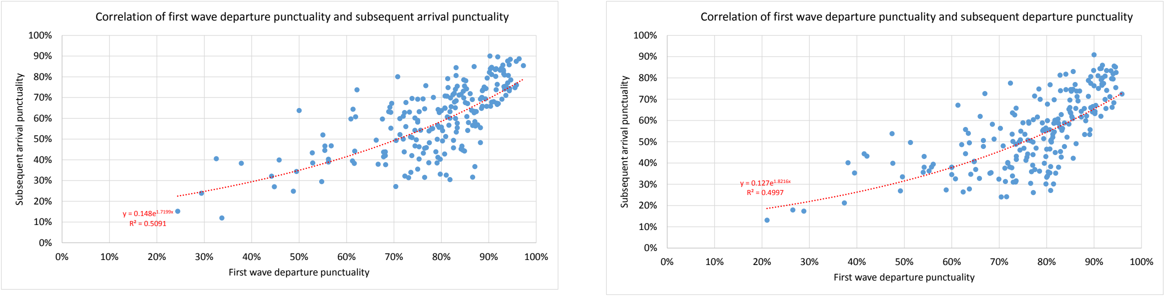
Regression Statistics	
Multiple R	0.595051
R Square	0.354085
Adjusted R Square	0.351081
Standard Error	0.226243
Observations	217

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	6.03283541	6.032835	117.8613
Residual	215	11.00496648	0.051186	
Total	216	17.03780189		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-1.87797	0.124675193	-15.0629	1.75E-35
First wave punctuality	1.639141	0.150983909	10.85639	3.56E-22

Figure 95: Influence of first wave departure punctuality



Regression Statistics	
Multiple R	0.743682
R Square	0.553063
Adjusted R Square	0.550984
Standard Error	0.217349
Observations	217

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	12.56844281	12.56844281	266.0522079
Residual	215	10.15671031	0.047240513	
Total	216	22.72515312		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-1.9273	0.085348066	-22.58161735	1.16442E-58
First wave punctuality	1.778853	0.109057769	16.31110689	1.83526E-39

Regression Statistics	
Multiple R	0.706918
R Square	0.499733
Adjusted R Square	0.497406
Standard Error	0.247719
Observations	217

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	13.17933486	13.17933486	214.7705188
Residual	215	13.19341691	0.06136473	
Total	216	26.37275177		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-2.06387	0.097273781	-21.21711583	1.23367E-54
First wave punctuality	1.821571	0.124296448	14.65505097	3.53235E-34

In all cases there is a strong statistical significance between first wave and subsequent performance as evidenced by the very small P-values in each case. The exponential relationship illustrated in the above charts gives both the highest levels of significance and the highest values of R^2.

Usually with regression analysis it is only possible to draw conclusions about relationships between variables rather than causality. However, in this case it is reasonable to assume that the first wave performance is a contributing factor causing the subsequent performance. However, the value of R^2 of about 0.35 for first wave departures and 0.50 for first wave departures indicates that individually first wave arrivals account for 35% of the variation in subsequent operations and first wave departures are a slightly stronger driver accounting for 50% of the variation. Combination of first wave arrivals and departures in a multivariate regression increase the value of R^2 up to approximately 0.55 indicating that together first wave arrivals and departures can explain around 55% of the variation in subsequent performance.

In all cases, the intercept in the regression results is approximately -2. In the $\log_n$ relationship that is being tested this gives a residual punctuality of approximately 14% should first wave punctuality fall to zero. This residual is likely to be accounted for by subsequent arrivals and departures that have not previously touched Gatwick.

The second observation from the regression results is that in all cases perfect first wave performance would result in, on average, subsequent punctuality of approximately 80%, estimated by extrapolation of the fitted curves.

5.3 The impact of CTOTs on departure performance

5.3.1 Introduction

The Network Manager Operations Centre (NMOC), evolved from the Eurocontrol Central Flow Management Unit (CFMU), *inter alia*, applies flow controls to balance demand and capacity across European airspace and at European airports. When demand is forecast to exceed capacity, air traffic flow management (ATFM) regulations are applied to aircraft departing European airports in the form of a calculated take-off time (CTOT), which is generally later than the estimated take-off time (ETOT) contained with the flight plan. This is in effect a form of holding delay where the departing aircraft is held on the ground prior to its departure to optimise flow across the entire European network. When applied, the ATFM regulation is associated with the most constraining pinch-point along the aircraft's flight path, thus only one CTOT is applied to each flight, although the CTOT might change as the traffic situation evolves.

This section investigates the risk, in terms of likelihood of occurrence and delay impact, of flow regulation applied to departures from Gatwick:

- Section 5.3.2 investigates the impact of the application of CTOTs on departure delay
- Section 5.3.3 assesses how the risk of CTOT application varies across the day, focused on summer 2016
- Section 5.3.4 analyses the likelihood of CTOT application by departure route
- Section 5.3.5 explores the evolution of CTOT risk from summer 2014 through to summer 2016
- Finally, section 5.3.6 draws together the analysis to draw conclusions on how CTOT risk has affected Gatwick’s departure performance.

5.3.2 Impact on departure delay

To understand the impact that having a CTOT applied has on departure delay Figure 96 compares the summer 2016 first wave departure delay distributions for flights that are subject to CTOTs with the delay distribution for flights that did not have a CTOT applied. Similarly, Figure 97 compares CTOT and non-CTOT departure delay distributions for operations outside of the first wave.

Figure 96: Influence of CTOTs on first wave departure delay

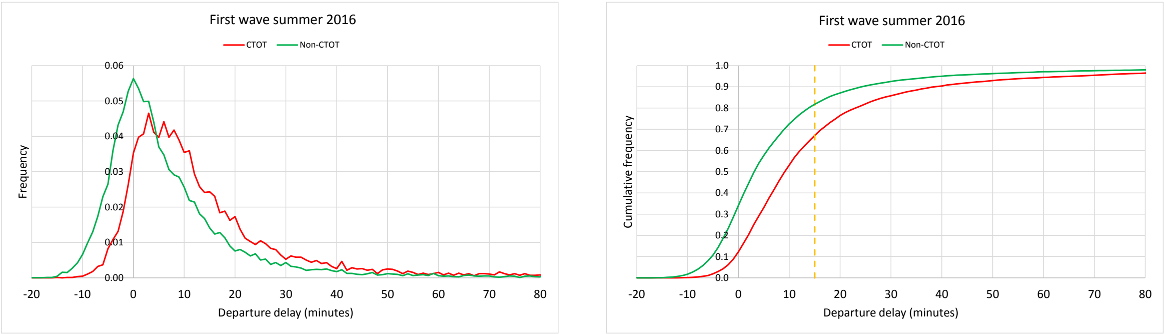
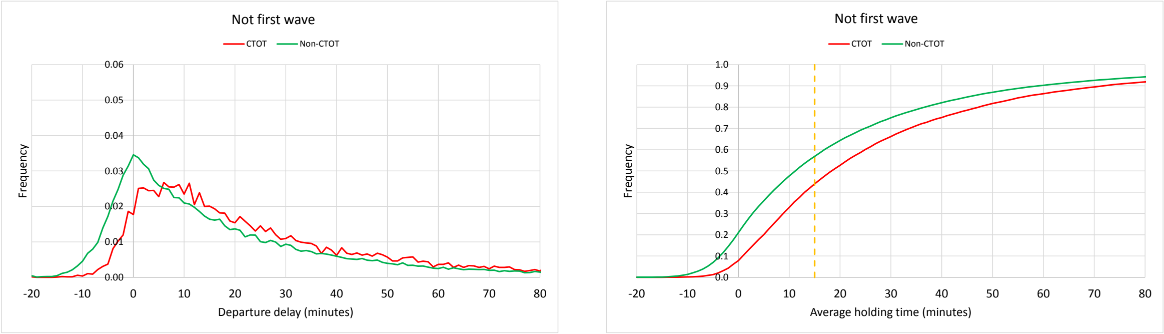


Figure 97: Influence of CTOTs on non-first wave departure delay



The distributions show clearly the impact of the CTOT. The distributions for the CTOT flights are shifted later (to the right). The following table shows the impact of ATFM regulation by comparing the key statistical parameters for flights that are and are not subject to CTOTs.

Table 5 Comparison of on-time departure performance for CTOT and non-CTOT flights

	First wave		Not first wave	
	CTOT	Non-CTOT	CTOT	Non-CTOT
Mean departure delay (minutes per flight)	17.6	9.6	30.8	23.8
Most likely departure delay (minutes)	3	0	6	0
Punctuality (%)	67.1	81.8	43.9	56.9

The table shows that:

- For first wave departures, the impact of the application of CTOTs is to increase departure delay by eight minutes per flight, from 9.6 minutes per flight to 17.6 minutes per flight. Departure punctuality is reduced by approximately 15% from 81.8% to 67.1%. The mode of the distribution shows that the most likely pushback time for first wave CTOT flights is three minutes after scheduled time whereas the most likely pushback time for first wave non-CTOT flights is the scheduled time
- For departures other than the first wave, the impact of the application of CTOTs is to increase departure delay per flight by seven minutes from 23.8 minutes per flight to 30.8 minutes per flight. Departure punctuality is reduced by 13% from 56.9% to 43.9%. The mode of the distribution shows that the most likely pushback time for non-first wave CTOT flights is six minutes after scheduled time whereas the most likely pushback time for non-first wave non-CTOT flights is the scheduled time.

The policy of push-and-hold for flights that are subject to ATFM regulation might also be masking some of the negative impact of CTOTs. This policy will likely reduce the negative impact of ATFM regulation on departure punctuality that is measure at pushback: flights that push-and-hold will show higher departure punctuality than those that are held on stand.

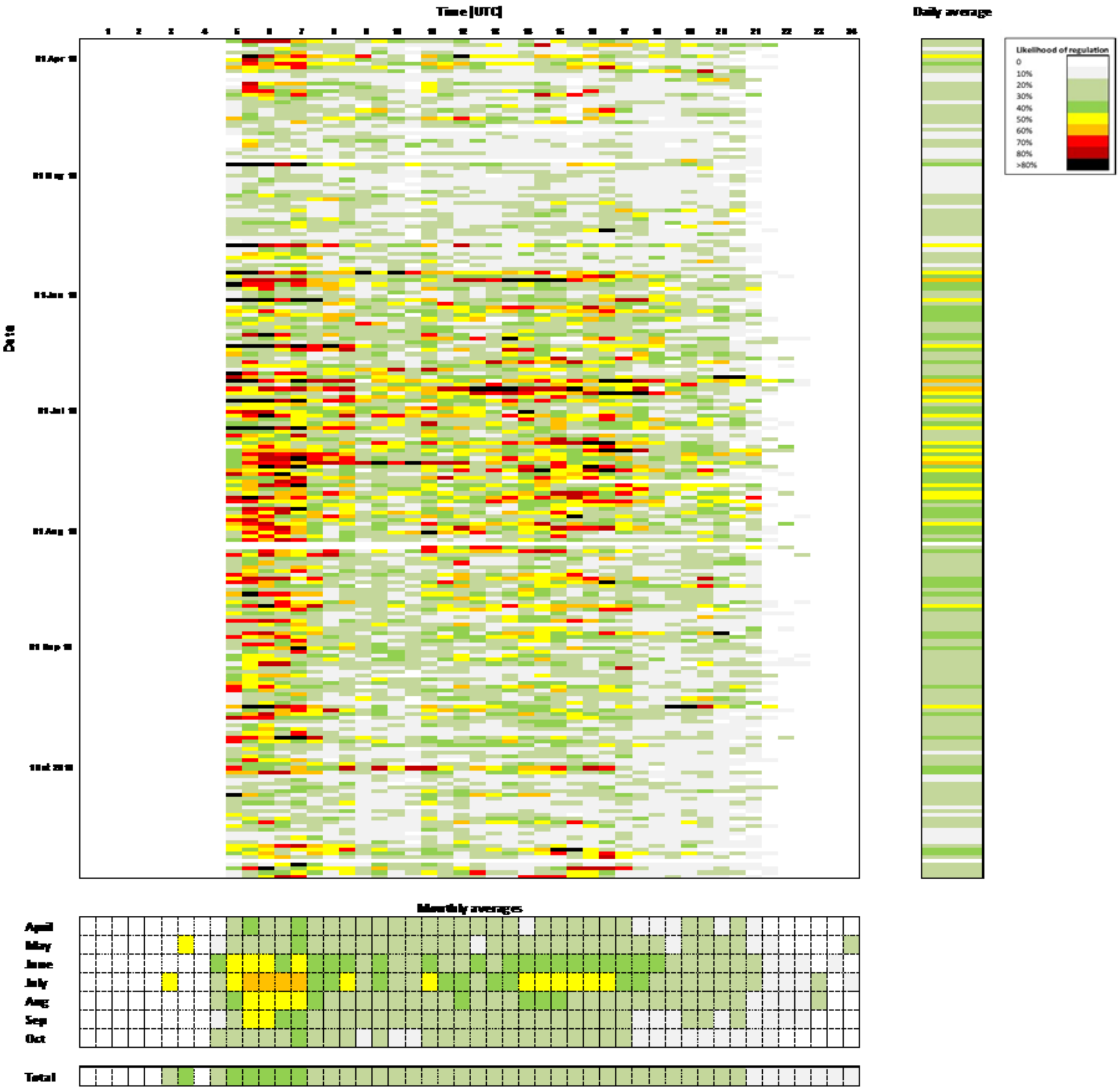
5.3.3 Risk of CTOT by time of day

To understand how the risk of CTOTs varies by time of day, day and month across the summer season, Figure 98 is a heatmap showing the proportion of all departures that were subject to CTOTs across the 2016 summer season.

The main part of the chart shows the high risk of CTOTs for first wave departures, especially in June, July and August. On a high proportion of days during these months, CTOTs were regularly applied to 70 to 80% of departures often extending over several hours. Particularly in July, the proportion of flights subject to CTOTs extended over large parts of the day. This is emphasised by the daily average, (right hand side of the chart) that shows at the end of June and the beginning of July 50% to 70% of daily departures were subject to ATFM regulation.

The monthly averages shown at the bottom part of the chart show that consistently across each of June, July and August and leading in to September, between 50% and 60% (70% in July) of first wave departures were subject to ATFM regulation. The monthly averages also show that in the afternoon period in July more than 50% of departures were subject to ATFM regulation.

Figure 98: Heatmap showing the proportion of departures subject to ATFM regulation in summer 2016



To complement the chart above that is an indicator of the likelihood of an ATFM regulation being applied to Gatwick departures, Figure 99 is a heatmap that shows the average ATFM holding delay per flight for Gatwick departures. As is this norm in this type of analysis, the average in taken over all flights so the delay per delayed flight is likely much greater.

The heatmap shows that where ATFM regulations are imposed, the delay is generally 10 to 20 minutes per flight (grey and light blue pixels). The chart also shows, however, there are periods, sometimes extended, where the delay per flight is on the range 25 to 35 minutes per flight (green and yellow pixels) and several periods where the delay exceeds 40 minutes per flight (red, dark red and black pixels).

On a monthly basis, in June, July, August and September first wave average ATFM holding per flight is generally greater than 10 minutes per flight and reaches 20 minutes per flight in July and August. In June and July, these levels of holding persisted across large parts of the day.

Figure 99: Heatmap showing the average ATFM delay per departure summer 2016

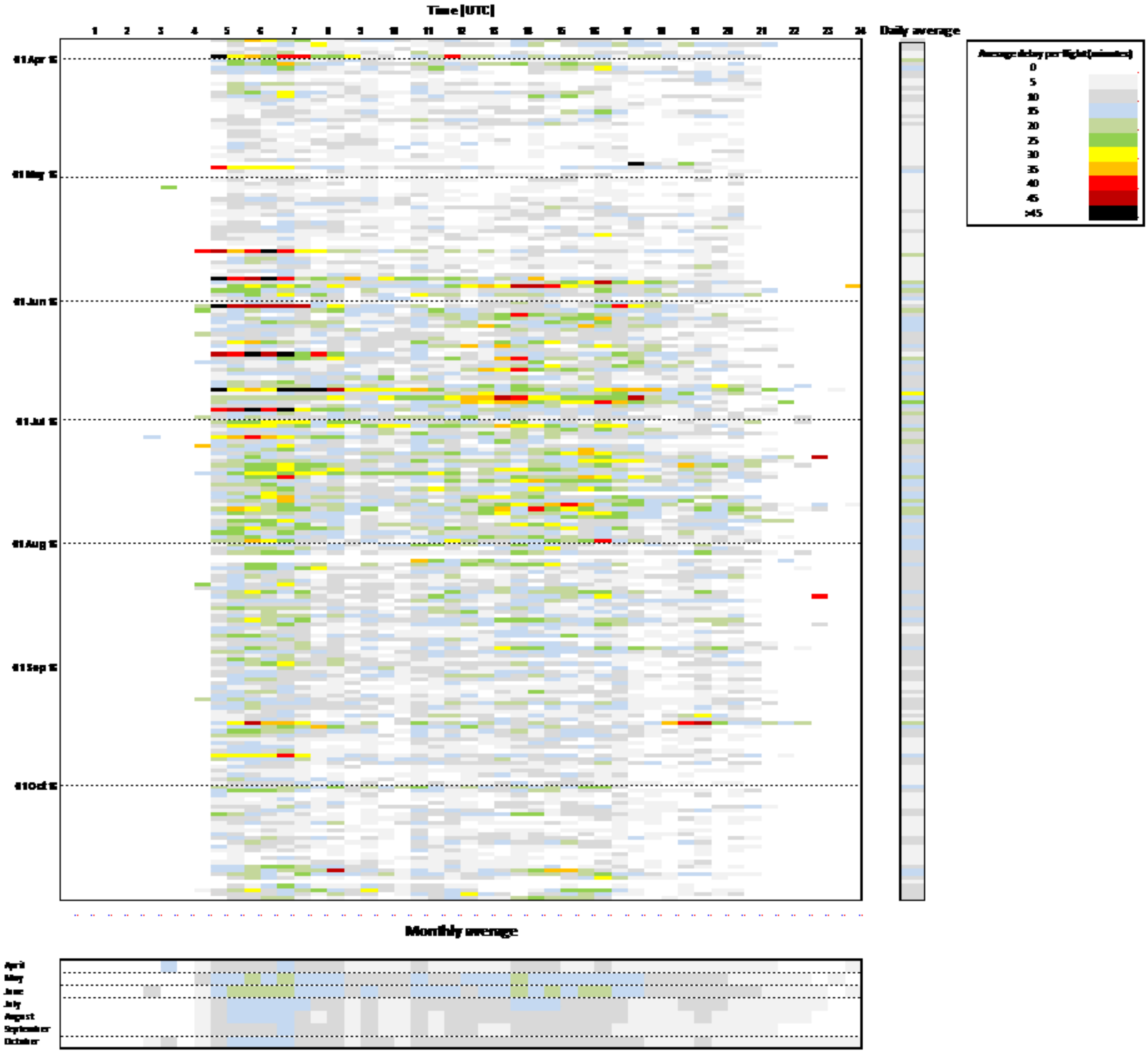


Figure 100 consolidates the data from the heatmap shown in Figure 98 to show the proportion of flights subject to ATFM regulation in half hour intervals average over the entire summer 2016 season. The chart shows that for the first wave between 05:00 and 06:30 UTC (06:00 and 07:30 local time) that 40% of all flights over the season were subject to a CTOT. There are short peaks across the morning and early afternoon periods with an extended peak in the mid-afternoon where CTOTs were applied to just under 30% of flights over the season.

Figure 100: Proportion of flights subject to ATFM regulation across the day in summer 2016

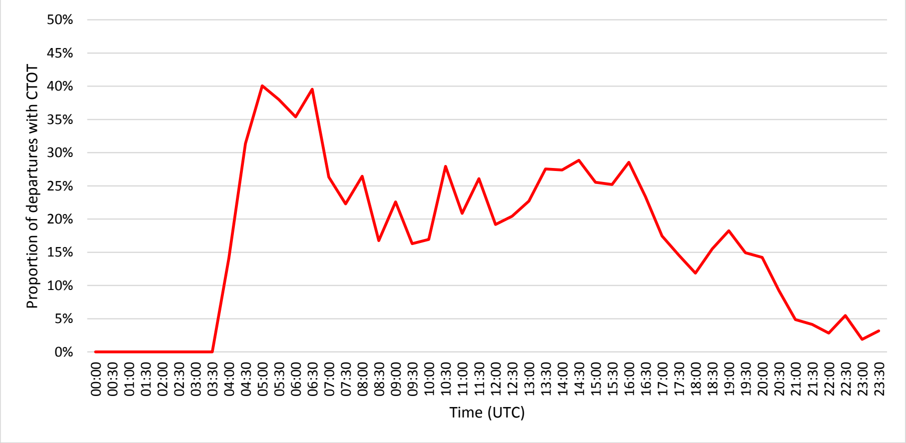
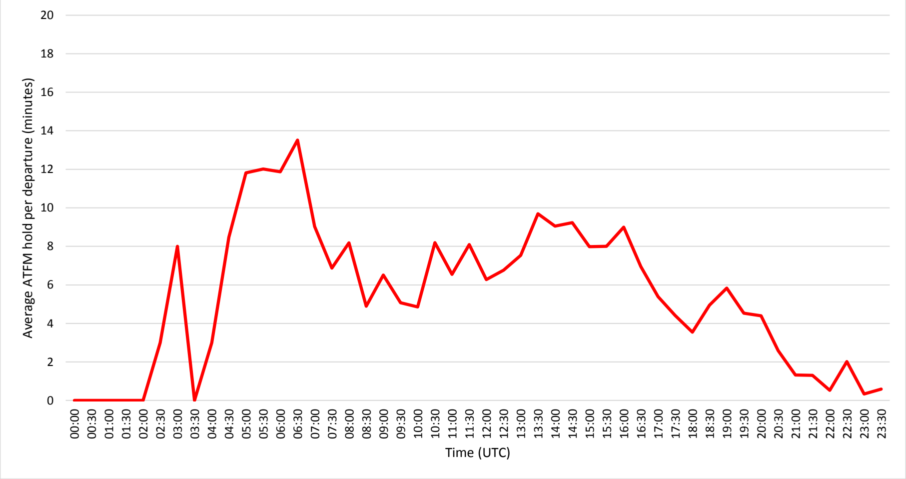


Figure 101 shows how the ATFM hold per flight evolved over the day average across the season. Corresponding to the first wave and afternoon peaks in the proportion of flights being held, there are peaks in holding time of approximately 12 minutes per flights and 10 minutes per flight respectively.

Figure 101: Average ATFM hold per departure across the day during summer 2016

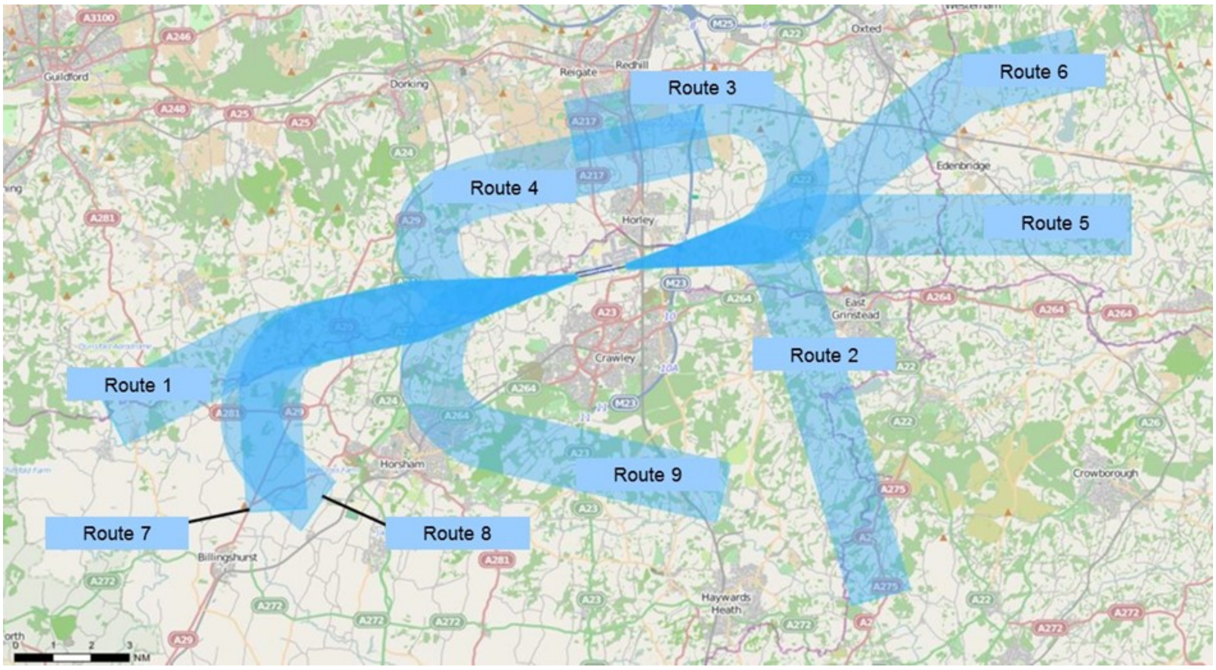


An average holding time of 12 minutes per flight when 40% of flights are held, translates into a hold per delayed flight of approximately 30 minutes. Similarly, the hold per delayed in the afternoon period can be estimated to be approximately 40 minutes.

5.3.4 Variation of CTOT application by departure route

As ATFM regulations are associated with a specific pinch point in airspace they are likely to vary be departure route as well as temporally. To investigate this potential variation, the CTOT risk associated with each of Gatwick's main departure routes, shown in Figure 102, has been investigated.

Figure 102: Gatwick departure routes



These routes are an aggregation of standard instrument departure routes (SIDs). Routes 2, 3, 5, and 6 apply to easterly operations and routes 1, 4, 7, 8 and 9 apply to westerly operations. The proportion of traffic using each route, split by first wave and overall traffic, during summer 2016 is shown in Figure 103.

Figure 103: Traffic volume by route

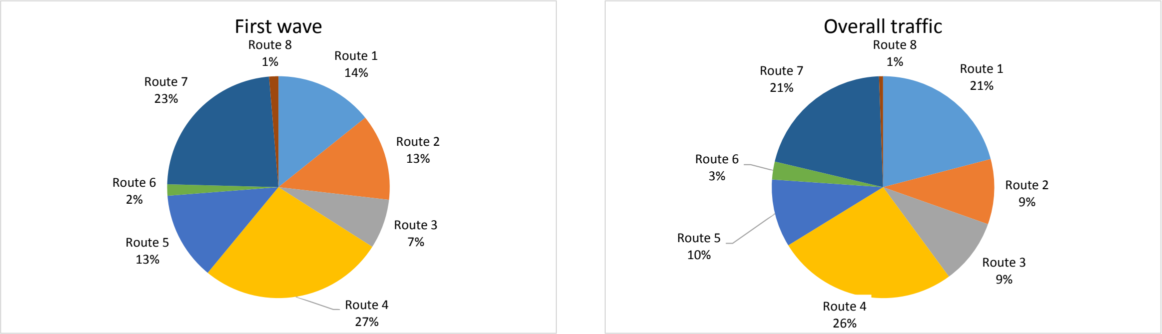
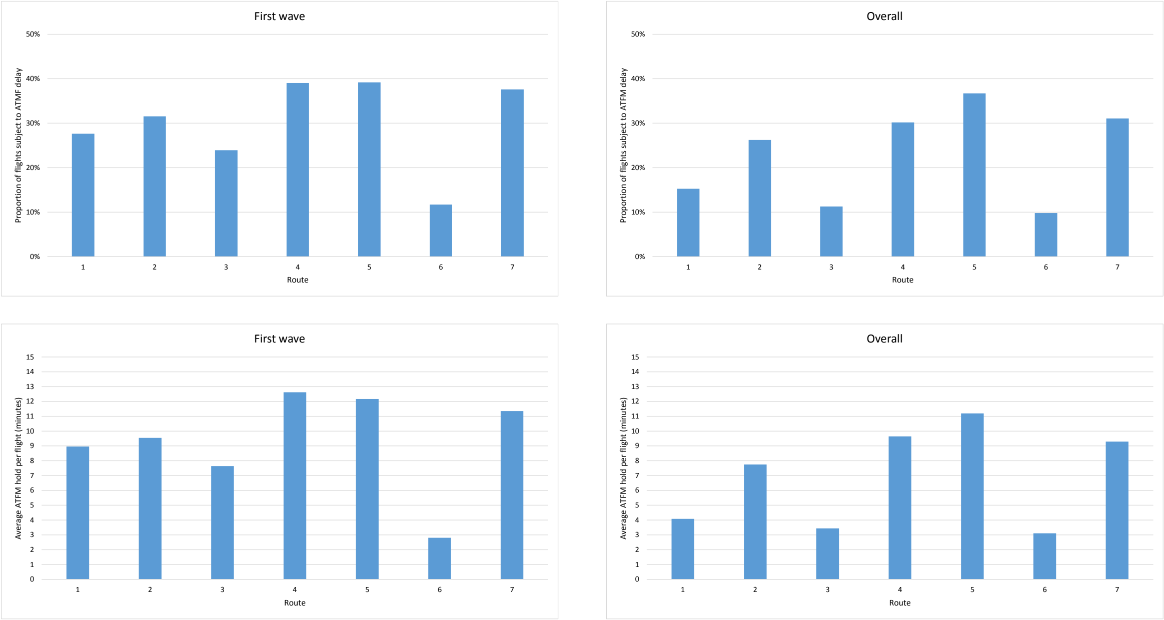


Figure 104 shows the ATFM holding risk by route for first wave and overall derived from summer 2016 data. The top row of charts show the proportion of flights using each route that were subject to ATFM regulation and the bottom row shows the average ATFM holding delay for flights using the routes. Rotes 8 and 9 have been excluded because of the low volume of traffic associated with them.

Figure 104: ATFM holding risk by route for summer 2016



The charts show that:

- For first wave departures, routes 4 and 7 (westerly) and route 5 (easterly) have the highest proportion of flights subject to ATFM regulation. These are also the three routes with the highest level of holding and routes 4 and 7 are the two highest volume routes
- Overall, route 5 has the highest proportion of flights subject to ATFM regulation, followed by routes 4 and 7. Routes 4 and 7 each carry approximately twice as much traffic as route 5.

For this study, data describing the location of ATFM regulations has not been available. However, the Eurocontrol Network Manager collects this data and it is available to the main air transport stakeholders, including Gatwick, its airlines and ANS. Further analysis to understand the locations of ATFM regulations would be useful in order to understand if re-routing could be used to ameliorate ATFM risk for Gatwick departures.

5.3.5 Evolution of CTOT application from 2014

Figure 105 and Figure 106 show the evolution of ATFM risk by season for first wave and overall traffic respectively. Both charts show a step change in risk, both likelihood of occurrence and level of holding in summer 2015. There was a further increase from 2015 to 2016. It is interesting to note that in the intermediate season, winter 2015-16 the risk associated with first wave departures was noticeably lower than for the adjacent summer seasons. However, over the entire day this difference is less marked with the winter holding being similar to the adjacent summer seasons.

Figure 105: Application of first wave ATFM holding delay by season

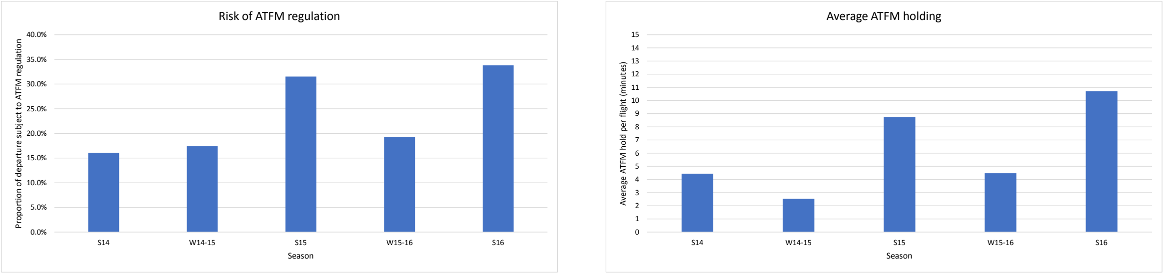
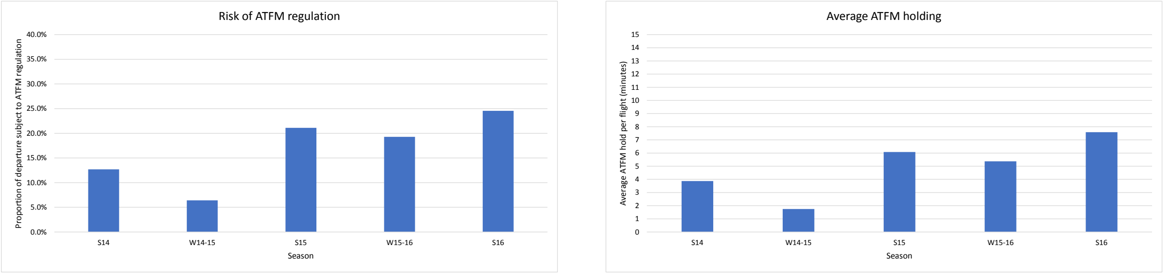


Figure 106: Overall application and magnitude of ATFM holding delay by season



Not only has the application of first wave ATFM regulation increased over time, it has also increased relative to the daily averages. The risk of first wave ATFM regulation is now proportionately higher (nearly 35% of flights held with an average hold of nearly 11 minutes per flight) compared to the overall performance (25% of flights with average hold of 7.5 minute per flight) than it was in summer 2014 (15% of flights at average hold of approximately 4.5 minute per flight for the first wave compared to the overall figure of 13% of flights held at an average hold of nearly four minutes per flight).

5.4 The impact of start delay on departure performance

5.4.1 Introduction

Start delay is defined as the elapsed time between the pilot requesting permission to start from air traffic control (ATC), termed the actual start request time (ASRT), and that permission being granted, termed the actual start approved time (ASAT). Start delay can have multiple causes, including:

- The application of minimum departure intervals (MDIs) to manage the flow of traffic downstream along the departure route. MDIs are usually imposed by London Terminal Control. In addition to Gatwick departures, traffic from the other London airports contributes to the route congestion that leads to MDIs being applied
- Traffic loading on the airfield
- Air traffic controller workload
- The application of ATFM departure regulations.

This section assesses the impact of start delay on departure performance. Flights where ATFM regulations have been imposed have been excluded from this analysis to avoid the potential because the impact of CTOTs has been assessed in the previous section. The section is structured as follows:

- Section 5.4.2 investigates the impact of start delay on departure delay and punctuality
- Section 5.4.3 explores how the risk of start delay varies across the day, focusing on summer 2016
- Section 5.4.4 assesses whether there is an correlation between start delay and departure route to understand the potential impact of MDIs
- Section 5.4.5 investigates potential correlations between start delay and airfield loading

- Section 5.4.6 describes how the risk of start delay has evolved from summer 2014 to summer 2016
- Finally, section 5.4.7 draws conclusions concerning the impact of start delay.

5.4.2 Impact on departure delay

To understand the impact start delay has on departure delay Figure 107 compares the summer 2016 first wave departure delay distributions for flights that are subject to start delay with the delay distribution for flights that did not have a start delay. Similarly, Figure 108 compares delay distributions for flights with start delay and flights without start delay for operations outside of the first wave. To avoid blurring with the impact of CTOTs, all of the flights that were subject to ATFM regulation have been excluded from this analysis.

Figure 107: Influence of start delay on first wave departure delay

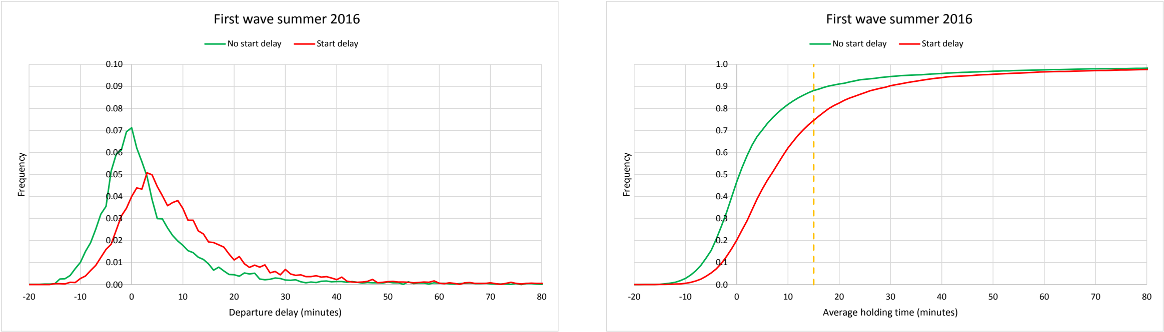
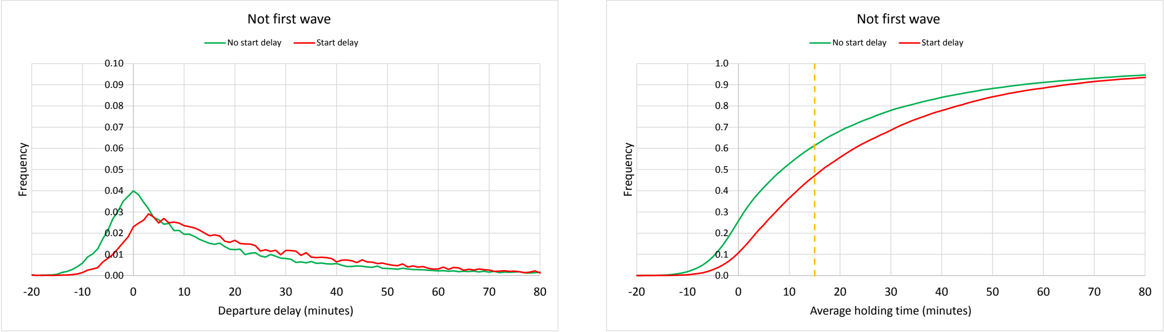


Figure 108: Influence of start delay on non-first wave departure delay



As with the analysis of CTOT impact, the distributions clearly show the impact of start delay. The distributions with start delay are shifted to the right (longer delay) and are broadened and flattened (more uncertainty in delay). The following table summarises the impact of start delay on departure on-time performance.

Table 6 Comparison of on-time departure performance for flights with and without start delay

	First wave		Not first wave	
	Start delay	No start delay	Start delay	No start delay
Mean departure delay (minutes per flight)	13.2	6.5	28.4	21.7
Most likely departure delay (minutes)	3	0	3	0
Punctuality (%)	74.5	88.1	47.1	61.4

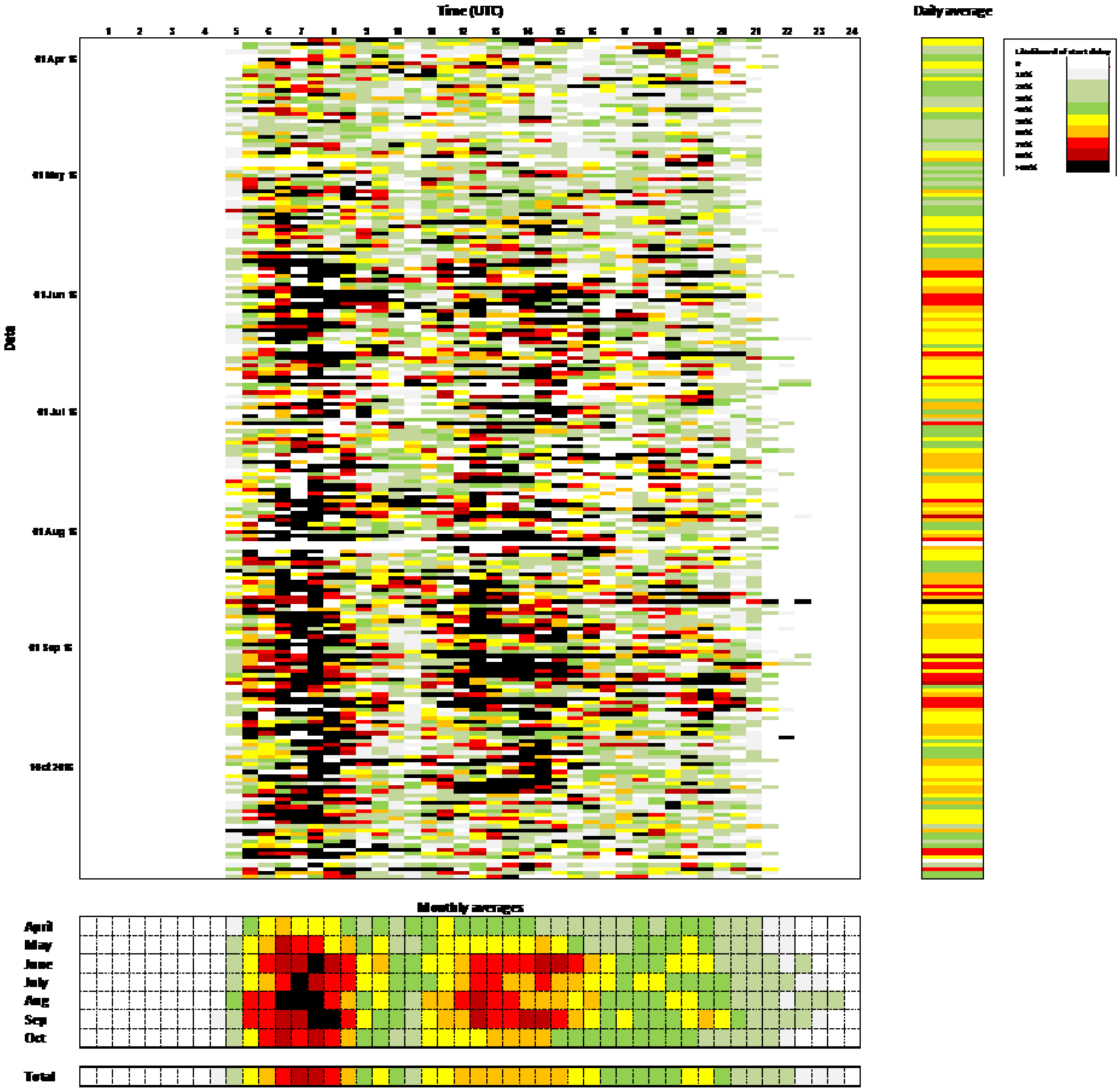
The table shows that:

- For first wave departures, the impact of the application of start delay is to increase departure delay by 6.7 minutes per flight, from 6.5 minutes per flight to 13.2 minutes per flight. Departure punctuality is reduced by approximately 14% from 88.8% to 74.5%. The mode of the distribution shows that the most likely pushback time for first wave start delay flights is three minutes after scheduled time whereas the most likely pushback time for first wave flights with no start delay is on schedule
- For departures other than the first wave, the impact of the application of start delay is also to increase departure delay per flight by 6.8 minutes from 21.6 minutes per flight to 28.4 minutes per flight. Departure punctuality is reduced by just over 14% from 61.4% to 47.1%. The mode of the distribution shows that the most likely pushback time for non-first wave flights with start delay is three minutes after scheduled time whereas the most likely pushback time for non-first wave flights without start delay is the scheduled time.

5.4.3 Risk of start delay by time of day

To understand how the application of start delay varies across the day, the heatmap in Figure 109 shows the proportion of flights that are not subject to ATFM regulation but are subject to start delay. The main part of the chart shows the entire summer 2016 season at half hourly resolution with time of day on the horizontal axis and day on the vertical access. The right-hand chart shows the daily average and the sub-chart at the bottom of the figure shows: (i) the half-hourly variation averaged over each month and (ii) averaged over the entire season.

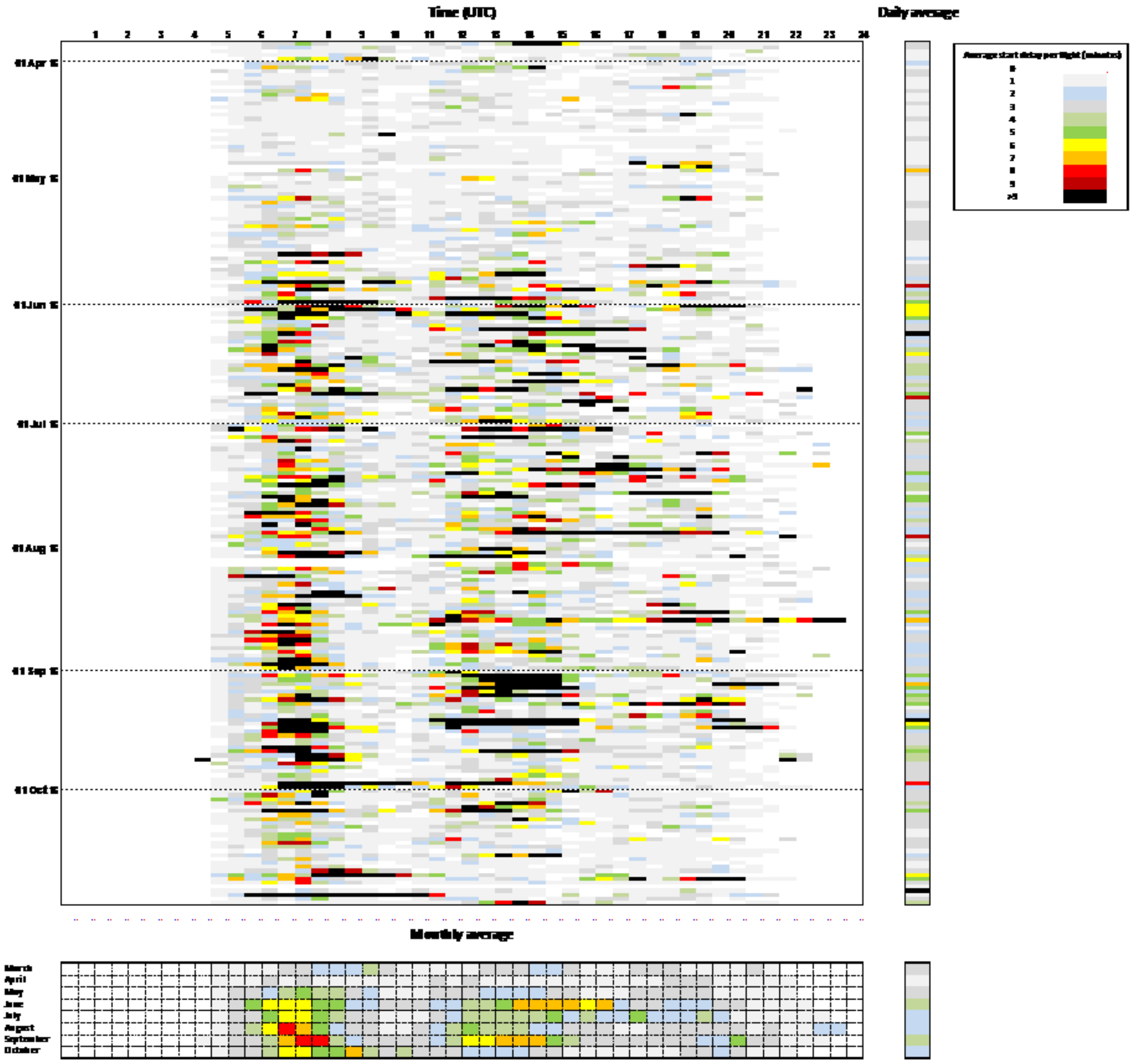
Figure 109: Heatmap showing the proportion of non-CTOT departures subject to start delay in summer 2016



The heatmap shows that in the first wave the majority of flights are subject to start delay. In the peak of the season, more than 80% of first wave departures are subject to start delay. There is also another peak in the occurrence of start delay in the early afternoon, again worst in the peak summer months from June through to September. For the majority of days after the end of May, 50% of more of departures are subject to start delay; this often rises to 60% or 70% and occasionally 80%.

To understand the impact of start delay, the heatmap in Figure 110 shows the average start delay per flight across the season at half hour resolution. Note the scale on this chart is different to the equivalent chart showing ATFM holding (Figure 99), with ATFM holding being much greater than start delay.

Figure 110: **Heatmap showing the average start delay per non-CTOT departure summer 2016**



The heatmap shows that for the majority of the time, start delay per flight is of the order of one to two minutes. However, there are frequent hotspots, principally related to the first wave and early afternoon where start delay reaches an average of eight or nine minutes per flight.

Figure 111 consolidates the data from the heatmap shown in Figure 109 to show the proportion of non-ATFM regulated flights subject to start delay in half hour intervals averaged over the entire summer 2016 season. The chart shows that for the first wave between 05:00 and 07:30 UTC (07:00 and 08:30 local time) up to 60% of all flights over the season were subject start delay. In the early afternoon, there is another broader peak where approximately 40% of flights are subject to start delay.

Figure 111: Proportion of non-CTOT flights subject to start delay across the day during summer 2016

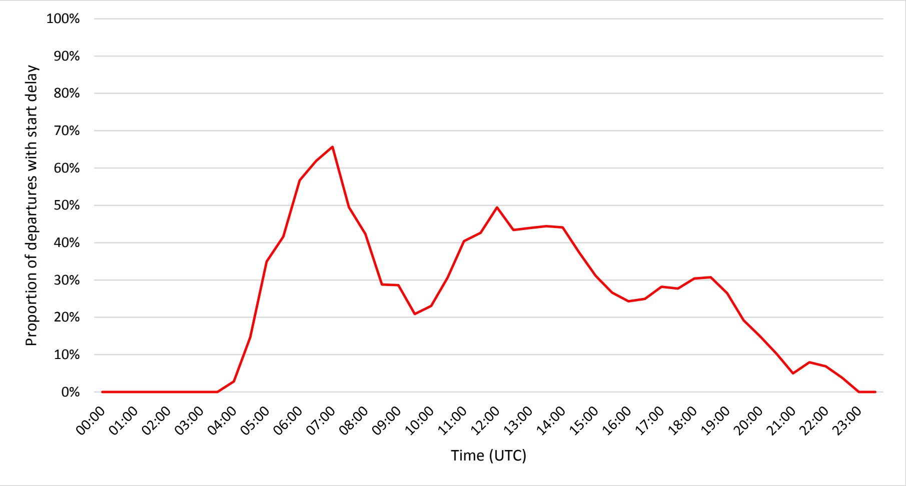
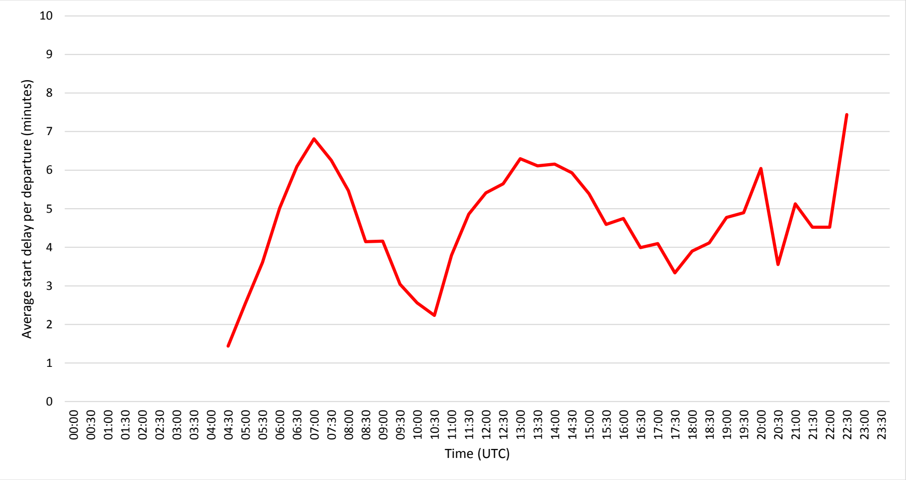


Figure 112 shows the start delay per flight in half hour intervals across the day averaged over summer 2016. In the morning and afternoon peaks the start delay per flight is between six and seven minutes. There is also a rise in average start delay in evening, up to six minutes at 20:00 UTC. The erratic behaviour after this time is probably due to a small number of fights being subject to large start delay.

Figure 112: Average start delay per flight across the day during summer 2016



5.4.4 Variation of start delay risk by departure route

One potential cause of start delay is the moderation of traffic using particular departure routes to balance capacity and demand, where departures from other London airports can also be contributing to the demand. To investigate this, the variation of start delay by route has been assessed. The route definitions applied to the investigation of ATFM regulation (Figure 102) have also been used in this analysis.

Figure 113 shows the risk of start delay associated with each departure route, as the proportion of flights using the route that were subject to start delay (upper charts) and the average start delay per flight using the route (lower charts). In all cases, the variation from route to route is much less pronounced than the variation of ATFM risk by route (cf Figure 104). What is apparent from the figure, however, is the much higher likelihood of start delay being incurred for first wave departures than overall across the day.

Figure 113: Risk associated with start delay for summer 2016

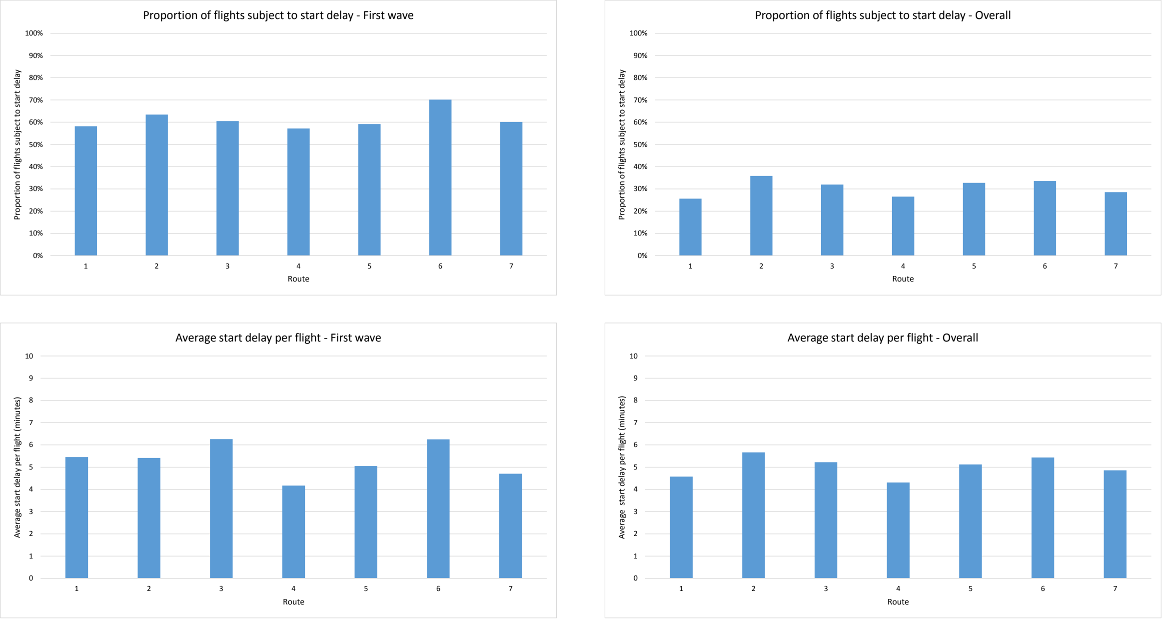


Figure 114 shows some example correlations between loading on the departure route and the start delay associated with the departure route. Table 7 shows the statistical parameters associated with a simple straight line regression between route loading and start delay.

Figure 114: Example correlations between route loading and start delay for summer 2016

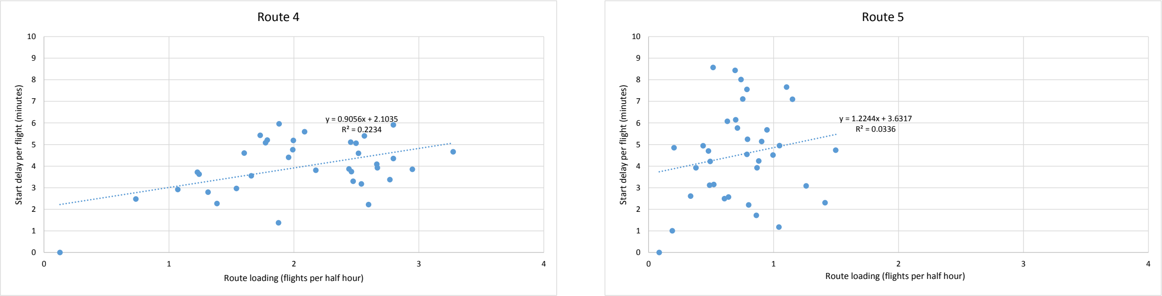


Table 7 Statistical parameters showing the lack of relationship between route loading and start delay

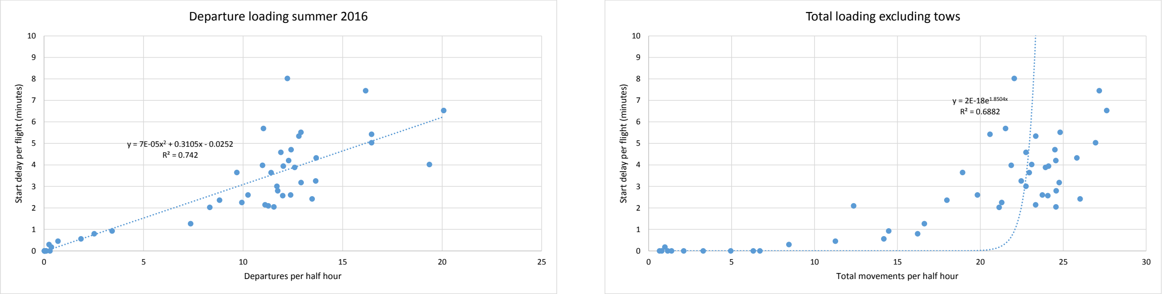
Route	R^2	Significance (F)
1	0.03	0.336
2	0.04	0.222
3	0.02	0.451
4	0.22	0.003
5	0.03	0.285
6	0.01	0.489
7	0.01	0.589

The table shows that with the exception of route 4, there is no statistically significant relationship between route loading and start delay. For route 4, although there is a statistically significant relationship, to 99.7% confidence, between loading and start delay, the R^2 value indicates that this relationship only explains 22% of the variation.

5.4.5 Impact of airfield loading on start delay

Figure 115 shows the correlation between start delay and airfield loading: the left hand chart shows departure loading only and the right hand chart shows departure and arrival loading. It has not been possible to include towed aircraft in the loading figures because of the lack of towing data.

Figure 115: Correlations between start delay and airfield loading for summer 2016



Regression Statistics	
Multiple R	0.861422
R Square	0.742048
Adjusted R Square	0.73644
Standard Error	1.115079
Observations	48

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	164.5365477	164.5365477	132.3278126
Residual	46	57.19645057	1.243401099	
Total	47	221.7329983		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.02688	0.286803329	-0.09373619	0.925725823
Departure loading	0.311654	0.027092337	11.50338266	3.93807E-15

Regression Statistics	
Multiple R	0.829579
R Square	0.688201
Adjusted R Square	0.681423
Standard Error	10.98469
Observations	48

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	12251.0737	12251.0737	101.5310155
Residual	46	5550.514663	120.6633622	
Total	47	17801.58836		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-40.8646	3.599961991	-11.3514074	6.21128E-15
Total loading	1.850389	0.183638476	10.07625999	3.19482E-13

Statistical tests show that the relationship with both departure loading and total loading are both significant; however, the relationship with departure loading alone is stronger.

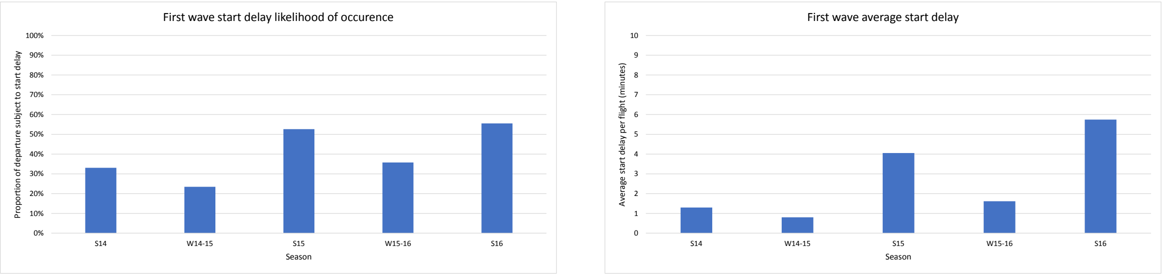
It is clear that there is a relationship between start delay and airfield loading. However, from this analysis it is not possible to determine whether the drivers for the relationship are physical capacity, controller workload, radio frequency congestion or a combination of factors. Also because tow data is not available, it is not possible to determine the effect of towing on start delay.

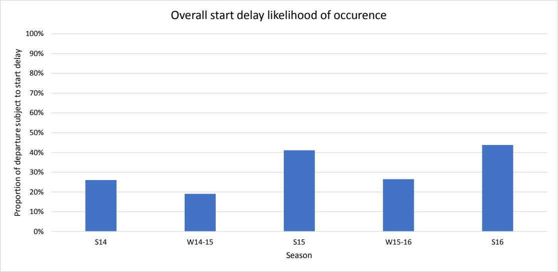
Further work is needed to assess this relationship.

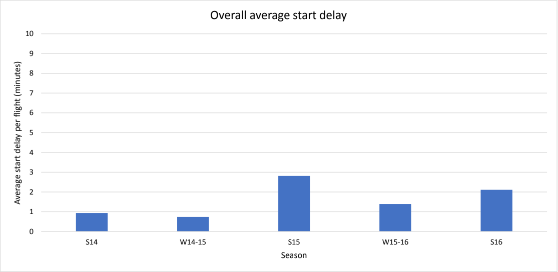
5.4.6 Evolution of start delay risk from 2014

Figure 116 shows the evolution of start delay risk by season from summer 2014 to summer 2016, separately for first wave and overall across the day.

Figure 116: Risk and magnitude of first wave start delay by season





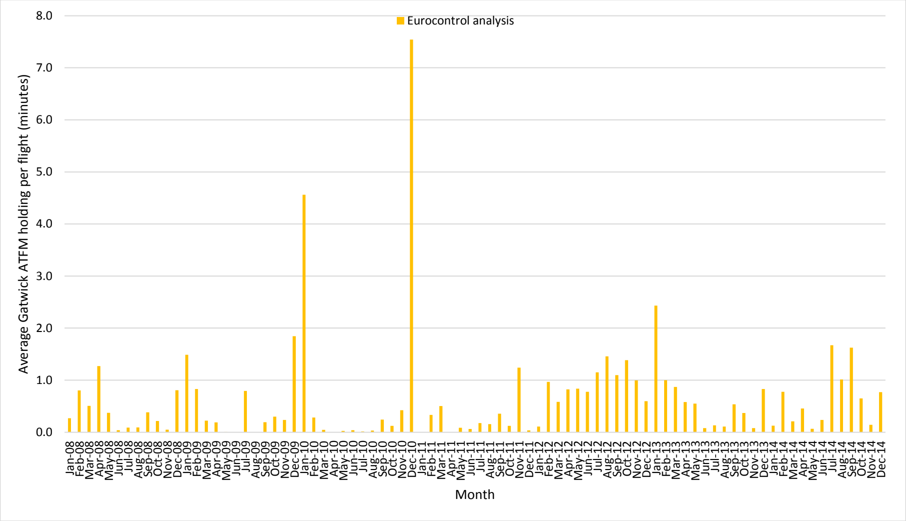


The chart confirms that first wave departures are more prone to start delay and suffer higher levels of delay than the daily average and that start delay risk is higher in summer than in winter. For both first wave and across the day, the likelihood of occurrence of start delay took a step upwards in summer 2015 and then increased slightly to summer 2016. For the first wave, the average start delay per flight also increased to summer 2015 and then increased again to summer 2016. However, the daily average start delay per flight across the entire day increased to summer 2015 and then decreased to summer 2016. This suggests that measures have been put in place to manage start delay between summer 2015 and summer 2016.

5.5 The impact of ATFM delay on arrival performance

Similarly to that described for departures, Gatwick arrivals from European origin airports can have ATFM regulations imposed due to flow restrictions at Gatwick or in intermediate airspace. Unfortunately no ATFM data has been available for this study. However, the following chart reproduces Eurocontrol data showing Gatwick attributed ATFM hold per flight on a monthly basis from 2008 through to the end of 2014.

Figure 117: Gatwick attributed ATFM arrival holding from 2008 to 2014



Prior to 2012 the figure shows that inbound Gatwick attributed ATFM delay was highest in the winter and more detailed data shows this was attributed to weather. The two largest peaks are in fact snow events, notably in December 2010. However, post-2011, ATFM holding starts to increase in the summer months and is increasingly attributed to airport capacity and staffing as well as “other”.

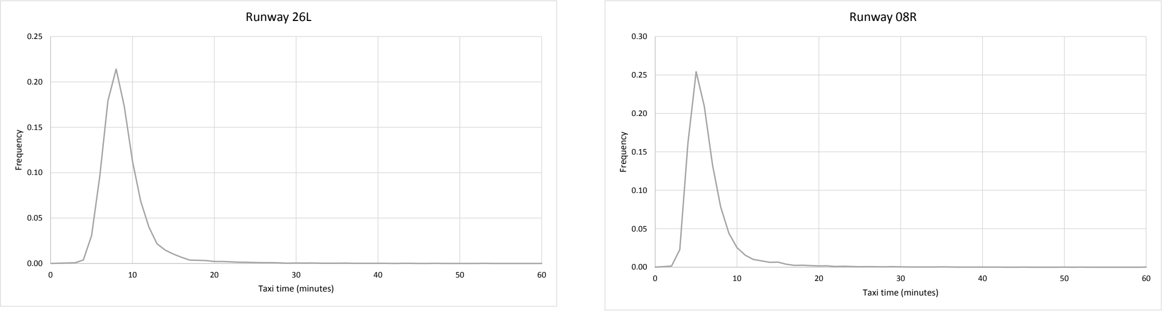
The chart suggests that ATFM holding is increasing and it is recommended that Gatwick access up-to-date ATFM data from the Eurocontrol Network Manager to assess the level of increase through to summer 2016 and beyond.

5.6 Taxi in performance

5.6.1 Analysis approach

Figure 118 shows the overall arrival taxi time distributions for summer 2016 derived from EFPS data. These distributions comprise the taxi times from to all stands from the touch-down point for westerly operations on runway 26L and easterly operations on 09R.

Figure 118: Consolidated arrival taxi time distributions summer 2016



Comparison with Figure 56 shows that taxi in times for arrivals are significantly shorter and less variable than taxi out times for departures. For summer 2016, the mean arrival taxi time from runway 26L is 8.5 minutes whereas the mean departure taxi is 19.1 minutes. The mean arrival taxi time from runway 08R is 6.0 minutes while the mean departure taxi time to the same runway is 21.7 minutes.

As with departure taxi times, in order to gauge arrival taxi delay it is necessary to define an unimpeded taxi time. This has been done in the same way as for departure taxi times using runway-stand group combinations, with the same stand groups as for departure, defined in Figure 57 below.

Thus unimpeded taxi time is defined as the 5%ile of the taxi time distribution between each runway end and each stand group and each runway end, e.g. stand group 10 from runway 08R, stand group 10 from runway 26L, and so on. The two figures below illustrate the departure taxi time distributions from each stand group to each runway. Note that even with consolidation into groups, the sample sizes for stand groups 3 and 6 are small resulting in statistically noisy distributions that have not been shown on some of the charts.

Figure 119: Arrival taxi time distributions to stand groups from 26L summer 2016

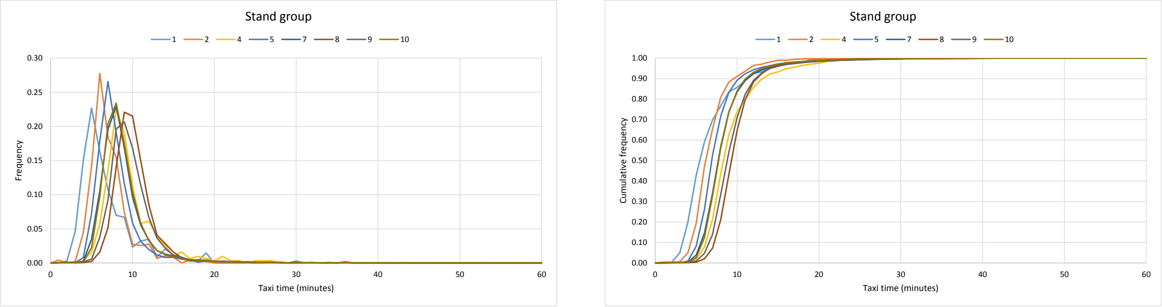
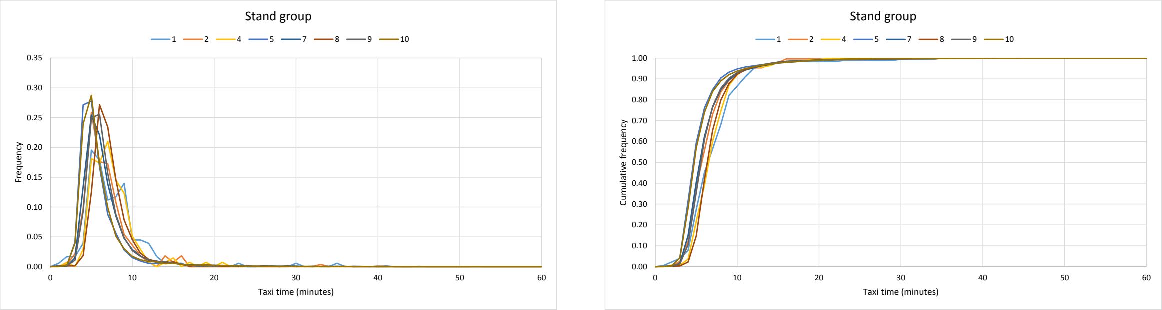


Figure 120: Arrival taxi time distributions to stand groups from 08R summer 2016



The following tables show the unimpeded taxi in times for summer 2016 based on the 5th centile of each distribution.

Table 8 Summer 2016 unimpeded arrival taxi times from runway to stand group in minutes

	Stand group									
Runway	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
27L	3.8	3.6	4.0	4.1	3.1	3.2	3.4	4.4	3.6	3.1
08R	3.0	4.0	5.2	5.8	4.8	4.4	5.2	6.7	6.1	5.4

Unimpeded taxi times for the other seasons from summer 2014 to winter 2015-16 inclusive show similar patterns but slightly different values for unimpeded taxi times.

We have used EFPS data to determine arrival taxi holding time on a flight-by-flight basis where the arrival taxi holding time is defined as the difference between the actual arrival taxi time for a flight and the unimpeded taxi time for the stand group-runway combination used by that flight. Negative values, where the actual taxi time is shorter than the 5th centile are set to zero. We have then examined the statistical properties of the arrival taxi holding distributions on a season-by-season basis.

The following sections describe the results of this analysis:

- Section 5.5.2 highlights the evolution of average daily arrival taxi holding from summer 2014 to summer 2016 inclusive
- Section 5.5.3 focuses in detail on the departure taxi holding experienced during summer 2016
- Section 5.5.4 derives the relationship between departure taxi holding and runway loading.

5.6.2 Arrival taxi holding performance

Figure 121 shows the evolution of the daily average arrival taxi hold per flight in minutes from the start of the 2014 summer season through to the end of the 2016 summer season. The chart shows:

- A perceptible but small underlying upward trend
- Large spiky variations on a day-to-day basis superimposed on the underlying trends implying dependence on the specific daily environment. There are some particularly large peaks in summer 2015, the cause of which is not known.

Figure 121: Evolution of arrival taxi holding from summer 2014 to summer 2016

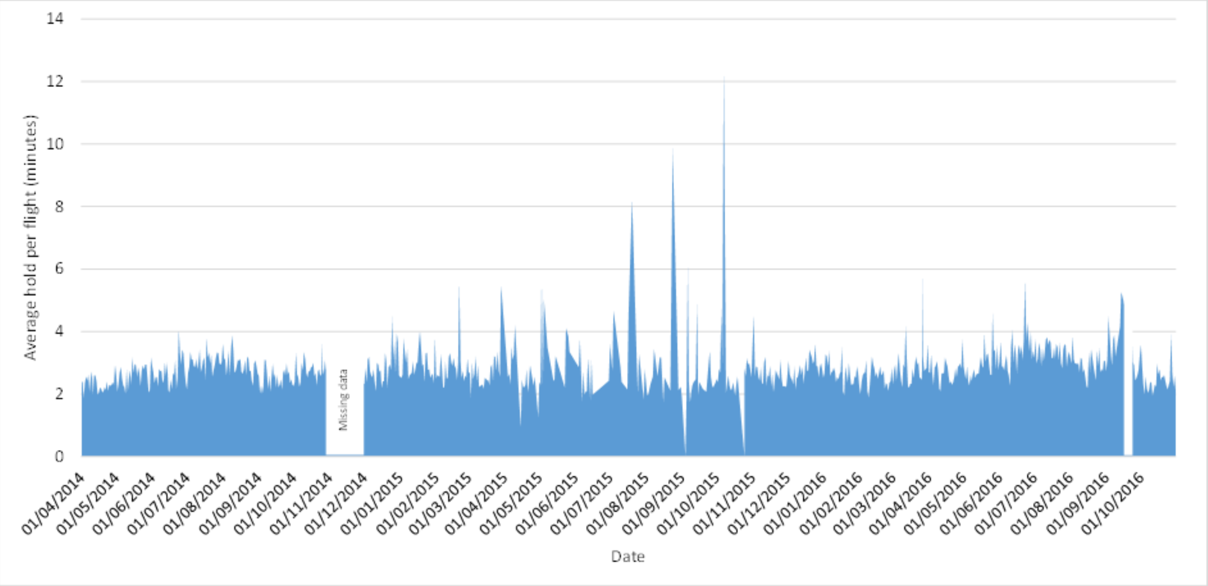
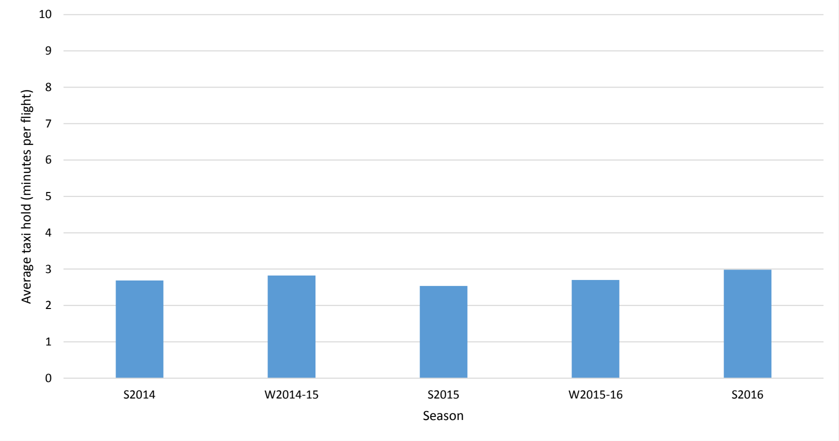


Figure 122 consolidates performance into seasonal averages, showing the arrival taxi hold in minutes averaged over each season. The figure indicates that there has not been a general trend from summer 2014 although arrival taxi holding in summer 2016 was slightly higher than in previous years, at approximately three minutes per flight compared to 2.5 to 2.8 minutes per flight for other seasons.

Figure 122: Arrival taxi holding seasonal averages



5.6.3 Summer 2016 performance

Figure 123 shows the arrival taxi holding heatmap for summer 2016.

Comparison of the heatmap with Figure 63 (note the difference in scales) shows that arrival taxi holding is uniformly much lower than departure taxi holding. Arrival taxi holding is highest in the night period, especially towards the end, and in the early morning but without any obvious systematic pattern. The highest levels of holding occur in June and July.

Figure 123: Arrival taxi holding heatmap summer 2016

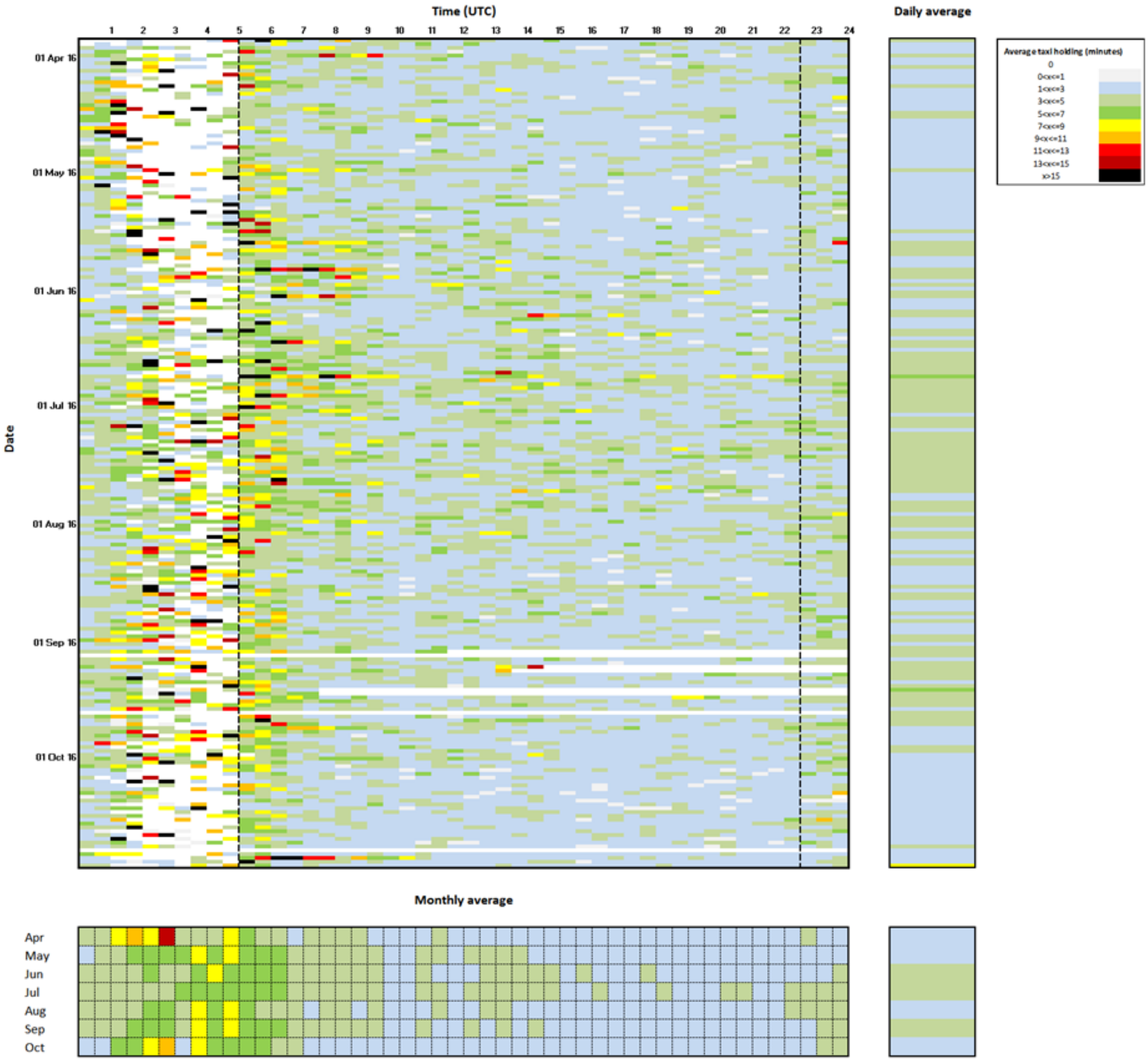


Figure 124 shows the seasonal average hourly arrival taxi holding in half hour intervals across the day. The figure shows that holding is highest during the early morning period from 03:00 to 05:00 hours UTC (04:00 to 05:00 hours local time). After about 07:00 hours UTC, the holding profile is flat across the day at between two and three minutes per flight.

Figure 124: Average arrival taxi holding summer 2016

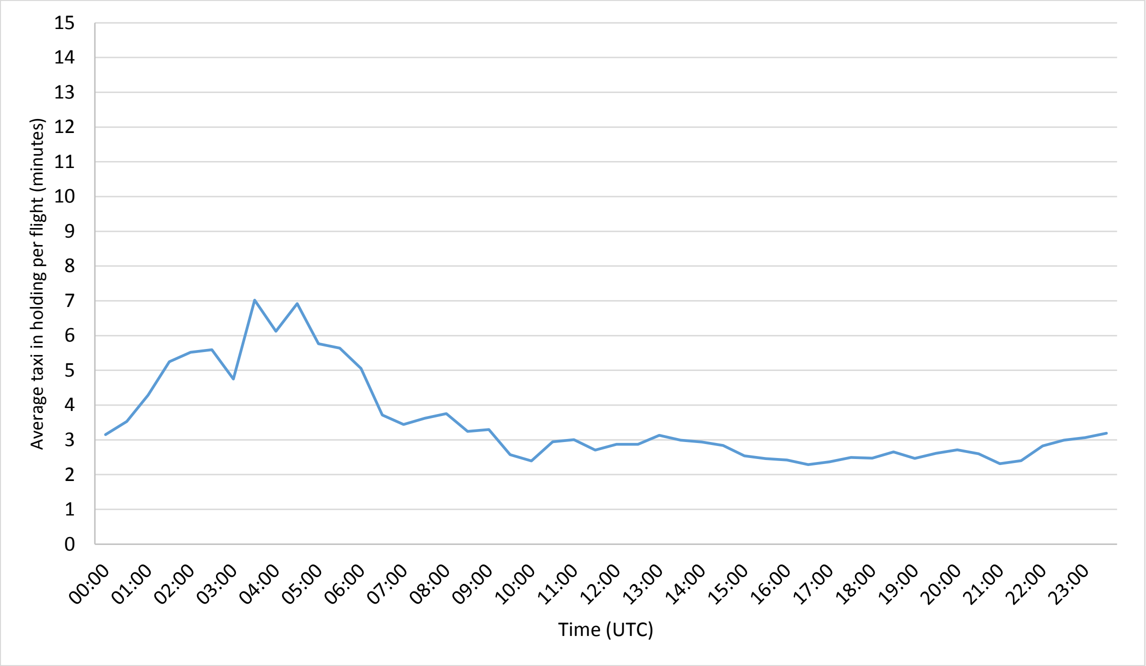
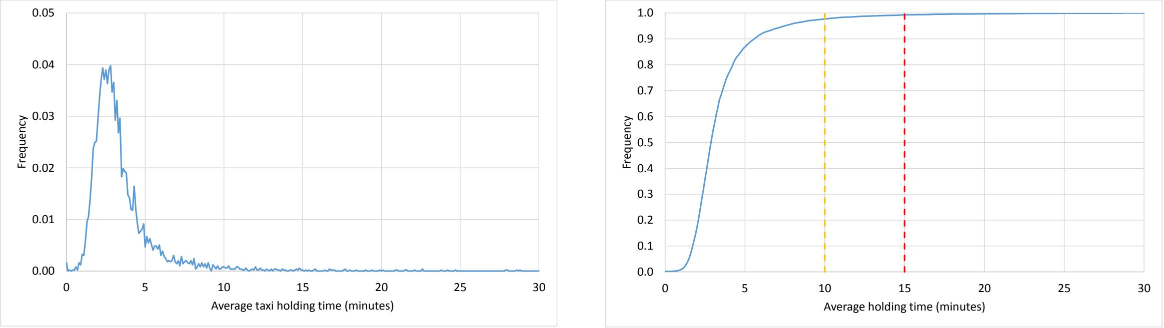


Figure 125 shows the hourly average arrival taxi holding distributions for summer 2016.

Figure 125: Hourly arrival taxi time holding distributions summer 2016

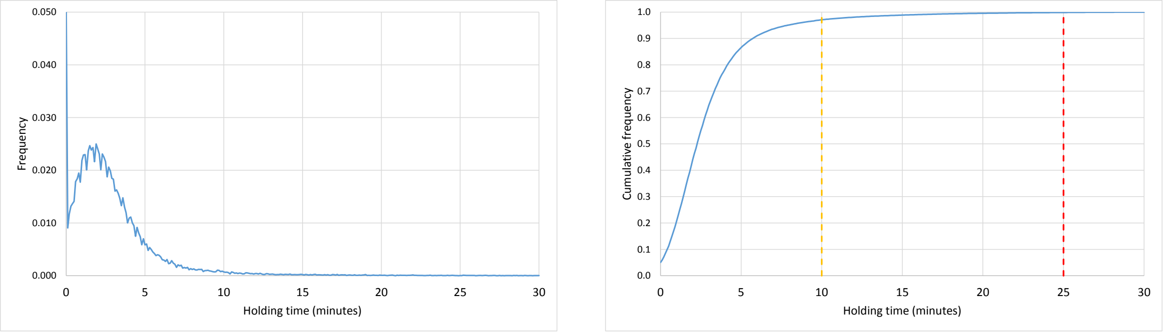


The figure shows that on an hourly basis:

- Average hourly taxi holding is 3.5 minutes per flight
- Average arrival taxi holding is less than 10 minutes for approximately 97.6% of the time
- Average arrival taxi holding is less than 15 minutes for approximately 99.3% of the time.

Figure 126 shows the by flight arrival holding distributions for summer 2016.

Figure 126: By flight arrival taxi time holding distributions summer 2016

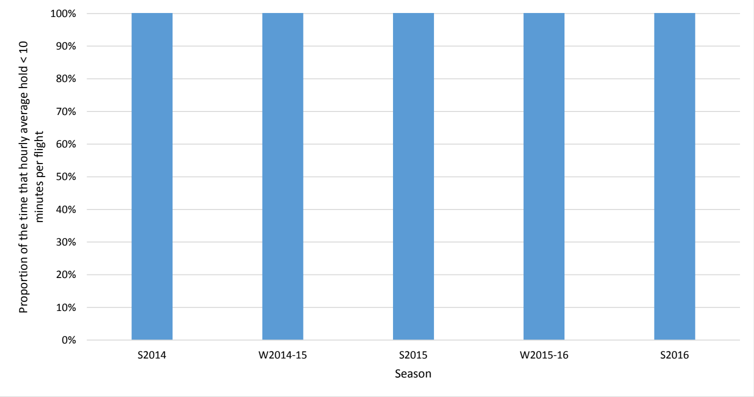


The figure shows that:

- Arrival taxi holding is less than 25 minutes for greater than 99% of flights.
- Arrival taxi holding is less than 10 minutes for approximately 97% of flights
- Arriva taxi holding is less than 15 minutes for approximately 98% of flights.

Figure 127 illustrates that the proportion of flights subject to arrival taxi holding of less ten minutes has been consistent at 97-98% each season from summer 2014 through to summer 2016.

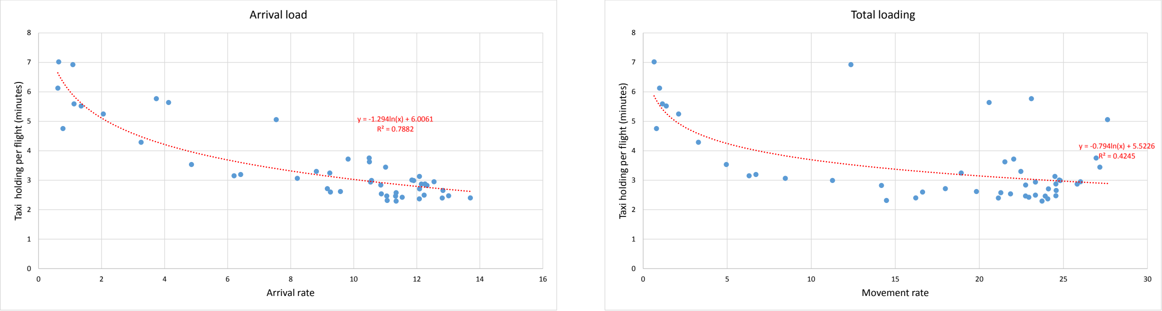
Figure 127: Proportion of the time that average arrival taxi holding is less than 10 minutes



5.6.4 Relationship between arrival taxi holding and demand

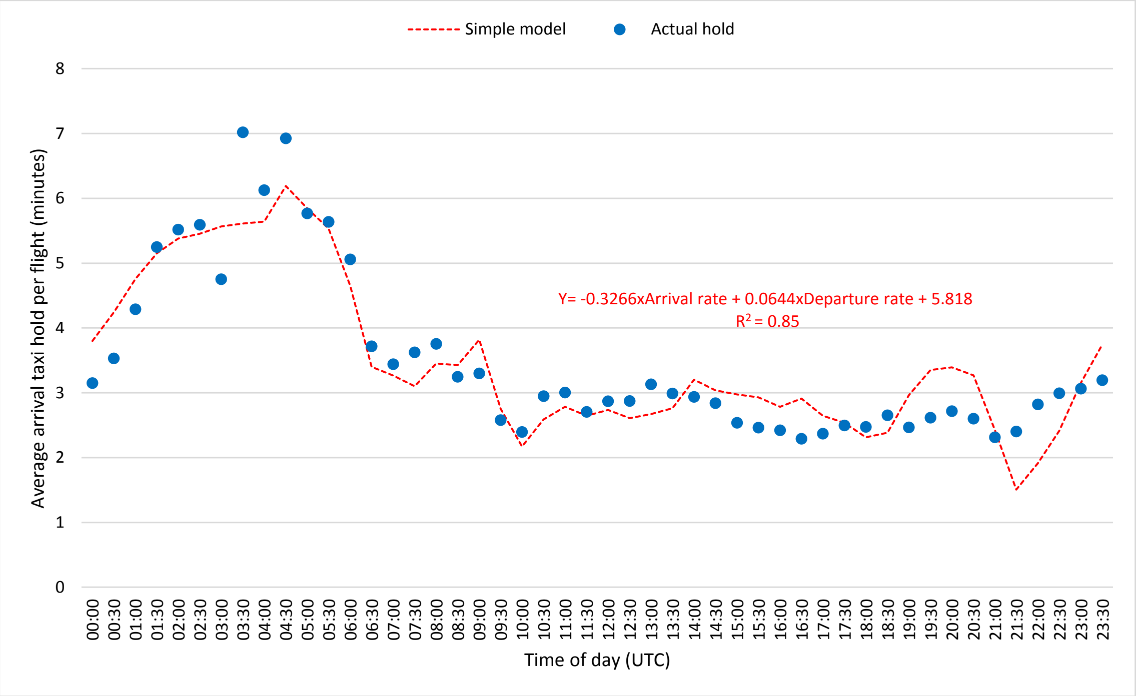
In order to investigate the potential correlation between traffic levels and airfield loading, Figure 128 shows simple relationships between arrival taxi holding, and arrival rate and total movement rate respectively. Both relationships are highly statistically significant but the correlation with arrival load being at a higher confidence level.

Figure 128: Correlation between arrival taxi holding and airfield loading



An even better, highly statistically significant description of arrival taxi holding is obtained using a simple linear combination of arrival and departure loading as illustrated in Figure 129 below.

Figure 129: Simple model of arrival taxi holding



In all cases, even with the simple model above where the independent variables account to 85% of the variation, the arrival taxi hold appears to decrease as the arrival rate increases and increase as the departure rate increases, which is counter-intuitive.

5.7 Summary

5.7.1 The first wave

There is no particular trend over time in first wave arrival punctuality, which in summer 2016 stood at just above 80%. Segmenting operations into long and short haul, shows that, unsurprisingly, short haul punctuality performance is better than long haul punctuality performance.

First wave long haul arrival punctuality is general worse than the overall average at 70%. There is no systematic trend in punctuality over time. Approximately 55% of long haul flights arrive on blocks within ±15 minutes of the scheduled time. The proportion of long haul flights arriving more than 15 minutes late is just under 30% with the remainder arriving more than 15 minutes early. Prior to airborne holding in summer 2016 (the only year for which airborne holding data is available) 26% of flights were earlier than anticipated from the schedule. In terms of absolute delay per flight, from winter 2014-15 onwards there is a general trend of increasing delay per arrival which currently averages at just over eight minutes per flight.

Similarly, there is no systematic trend in short haul first wave arrival punctuality, which was approximately 82% in summer 2016. Approximately 71% of short haul flights arrive on blocks within ±15 minutes of the scheduled time with the proportion of short haul flights arriving more than 15 minutes late being 16% with the remaining 13% arriving more than 15 minutes early. Very similar to long haul, approximately 25% of short haul arrivals were more than 15 minutes earlier than anticipated from the schedule prior to airborne holding. There has been no particular trend over time in average delay per short haul first wave arrival, which currently averages at approximately two minutes per flight.

There is a strong cyclical pattern in departure punctuality, which is higher in winter than summer. There is an underlying downward trend superimposed on this pattern. Departure punctuality in summer 2016 was approximately 77%, down from 82% in summer 2014. This degradation in performance has extended from off-blocks performance to actual take off where in summer 2016 approximately 73% of flights took off within 15 minutes of an extrapolated scheduled time compared to 80% in summer 2014. Average departure delay has increased by two minutes per flight from summer 2014 at eight minutes per flight, to 10 minutes per flight in summer 2016.

Regression analysis implies that there is a statistically significant relationship between first wave arrival performance and subsequent departure and arrival performance. Although strictly this does not completely confirm a direct causal relationship between first wave arrival and subsequent punctuality performance, it is a very good indicator that such a relationship is likely to exist. The statistical parameters suggest that there are also other factors contributing to subsequent performance alongside first wave arrivals that accounts for 35% of variation. Similar regression analysis strongly suggests a statistically significant relationship between first wave departure performance and subsequent downstream arrival and departure performance. Statistical parameters suggest that first wave departure performance contributes to 50% of the variation in subsequent. In both cases, the regression analysis suggests given current infrastructure, processes and external factors an upper limit of approximately 80% for average downstream punctuality performance if 100% first wave punctuality performance is achieved. Both sets of analysis also suggest a lower bound of 14% average downstream punctuality performance for zero first wave punctuality. The interpretation of this second figure is that it is associated with non-first wave flights that do have not previously touched Gatwick. Both of these figures are, of course, averages and due to the statistical nature of the analysis, the performance of actual operations would be subject to fluctuations around the averages.

5.7.2 ATFM delays

ATFM holding is imposed by the European Network Manager on flights departing Gatwick to ameliorate capacity constraints within downstream European airspace or at European destination airports. ATFM delays are imposed by applying a regulation to a departing flight in the form of a calculated take-off-time (CTOT) that is general later that the estimated take-off-time in the flight plan.

In summer 2016, statistical analysis suggests that application of CTOTs reduced the punctuality of Gatwick's first wave departures by 15% from around 82% to 67% and reduced the punctuality of non-first wave departures by 13% from 57% to 44%. Detailed analysis of summer 2016 data, shows that the likelihood of a flight having a CTOT applied was highest, at approximately 40%, for first wave departures. The average holding delay (over all flights) for first wave departures during summer 2016 was 12 minutes, which translates to a delay of approximately 30 minutes per delayed flight. CTOTs were also applied in the afternoon where the associated likelihood, in summer 2016, was just under 30%. Here the delay per flight was 10 minutes averaged over all flights, translating to 40 minutes per delayed flight.

The risk of CTOT application also varies by route. This risk is highest for the most densely used routes, comprising DVR, CLN, LAM, BIG, HARDY, BOGNA and ODVIK standard instrument departure routes (SIDs), particularly for first wave departures.

The application of ATFM regulation has increased significantly over the past few years. In summer 2016 the risk of both first wave and subsequent ATFM holding was more than double the summer 2014 levels

ATFM regulation has a significant and increasing impact on Gatwick departure performance. This risk of this happening is greatest in the first wave and on the busiest routes.

5.7.3 Inbound ATFM delay

Only limited data to December 2014 is available describing inbound Gatwick attributable ATFM delay, which stood at approximately one minute per flight in summer 2014, increased from very low levels prior to 2012. Further investigation is needed to assess the current levels and impact of Gatwick's inbound ATFM delay.

5.7.4 Start delay

Start delay is the elapsed time between the pilot asking permission to start and air traffic control granting that permission. It is usually associated with a demand-capacity imbalance either managed by ATFM regulation or other more tactical or local means. As ATFM regulations influence start delay, flights with ATFM regulations have been excluded from the analysis of the impact of start delay.

Similar to ATFM regulations, statistical analysis suggests that start delay reduced the punctuality of Gatwick's non-ATFM regulated first wave departures to which it was applied compared to those to which it was not applied by 14% from around 89% to 75% and also reduced the punctuality of non-first wave departures by 14% from 61% to 47%.

Analysis of summer 2016 operations showed that start delay was most likely to be applied and have the highest magnitude for first wave departures. Across the season, average the risk of start delay being applied to first wave departures was approximately 65%, reaching typically seven minutes per flight, translating to approximately 11 minutes per delayed flight. The risk is higher in the peak months.

Unlike ATFM regulation, start delay does not appear to vary by departure route, other than the busiest route for westerly operations comprising the DVR, CLN, LAM and BIG SIDs. However, statistical analysis does show that start delay is strongly correlated with both departure loading and total airfield loading[2] although it is not possible to determine the root causes of this, for example whether it is associated with air traffic controller workload, physical capacity, radio-frequency availability or a combination of factors.

Like ATFM delay, the risk of start delay has increased markedly from summer 2014 to summer 2016 with the greatest increases being associated with first wave departures.

5.7.5 Arrival taxi performance

Arrival taxi times are generally shorter and much less variable than departure taxi times. Over time arrival taxi time has increased slightly by nearly half a minute per flight from 7.3 minutes per flight in summer 2014 to 7.7 minutes per flight in summer 2016.

The arrival taxi holding profile is flat over most of the day, averaging approximately 3.5 minutes per flight, but shows a broad peak in the early morning, where the average arrival taxi delay rises to approximately six minutes per flight. There is a counter-intuitive relationship between arrival taxi holding and airfield loading: arrival taxi holding decreases as airfield loading increases. However, it is possible to build a good model of arrival taxi holding based on departure and arrival loading.

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[2] This excludes aircraft towing because towing data was not available for the period of the study

6 CONCLUSIONS AND RECOMMENDATIONS

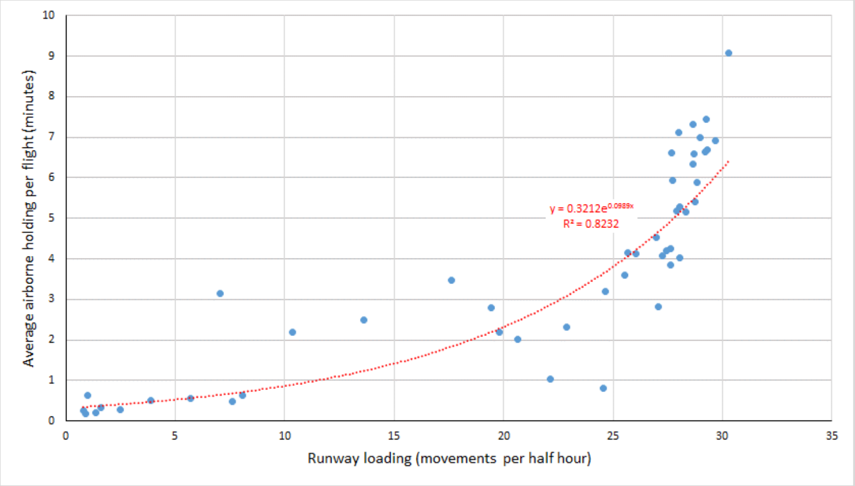
6.1 Conclusions

Significant causes of delays are driven by runway capacity constraints, airborne holding, turn and first-wave performance, application of outbound ATFM/CTOTs and start delays

Our analysis indicates that the theoretical level of utilisation resulting from the pure summer schedule would exceed available runway capacity. However, optimisation of the arrival and departure flows by air traffic control increases the efficiency of runway use, by up to 16%, to enable the demand to be met. However, at peak times runway utilisation is approaching 100%. Airborne and departure taxi holding are two of the consequences of flow optimisation by air traffic control.

The analysis, performed over the summer 2016 season in its entirety, indicates that season-wide airborne holding has reached the limits applied in capacity declaration. Departure holding performance is worse than arrivals and has degraded over time to the point that the capacity declaration limits are being breached consistently across the season. The policy of push-and-hold for departures that are subject to outbound ATFM regulation results in increased departure taxi holding although it frees up stands for arrivals and provides benefits in helping achieve departure punctuality.

The correlations between airfield loading and airborne holding delay indicate, in general, exponential queuing type relationships. The data graph below provides an early analytical signal of an area of planning and performance that should be further investigated. The graph shows that loading above 25-27 movements per half hour can result in increased delays. Movements maintained at these levels is likely to mean that OTP will be significantly more challenging to recover.



The graph illustrates the statistical correlation between the number of movements (per half hour) occurring on the runway and the average time (in minutes), an aircraft was held in airborne holding. The data covers the summer 2016 period. The line of best fit is drawn using a statistical package.

The data provides initial evidence that suggests it can be difficult to manage and limit delays above a certain range of runway movements. The data provides an initial analytical signal that should be further investigated.

The presence of statistical association between the *y* and *x* variables does not necessarily prove a scientific linkage or a cause-and-effect relationships between them.

As such, the analytical robustness of this insight needs to be improved through additional analytical exploration.

Short turns are very challenging

A significant proportion of Gatwick Airport's traffic is accounted for by airlines whose scheduling and planning is predicated on short turns: the most common arrival-departure turn time is 30 minutes. Operational data for summer 2016 shows that achieving such short turns is very challenging with a success rate of around only 25%. This success rate increases to approximately 70% as the scheduled turn time increases up to a turn time of approximately one hour after which it decreases to approximately 50%.

Further ground operations investigation was unable to be investigated further within the timescales of this study and we recommend this as an area for further analysis and examination.

First wave performance underpins performance for the remainder of the day

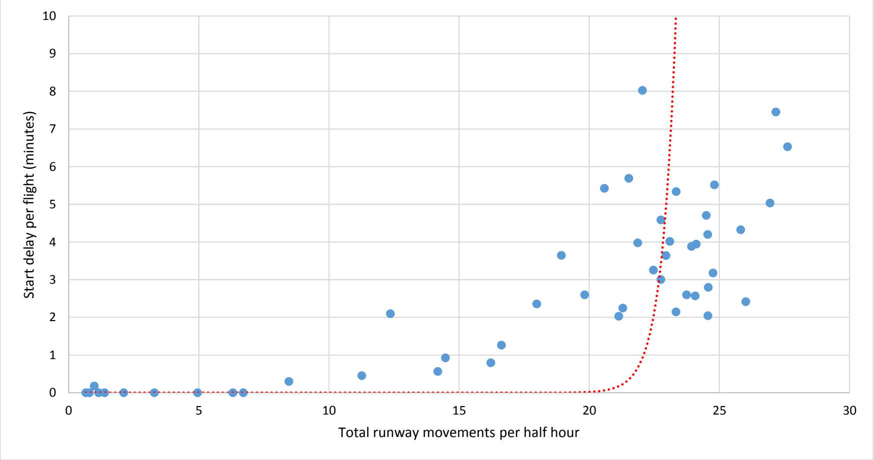
There is a statistical relationship between first wave departure punctuality and subsequent, downstream arrival and departure punctuality. Similarly, there is a relationship between first wave arrival punctuality and subsequent downstream arrival and departure punctuality. However, in both cases the statistical significance of the correlations indicate that there are other factors influencing downstream punctuality: absolutely perfect first wave punctuality would still only result in an average of 80% punctuality downstream.

Holding on stand is severely affecting punctuality, especially first wave

Two of the principal causes of the observed degradation in first wave departure punctuality are outbound air traffic flow management (ATFM) holding and start delay:

- **ATFM Holding** – is imposed by the European Network Manager on flights departing Gatwick Airport to ameliorate capacity constraints within European airspace or at European destination airports. First wave departures subject to ATFM regulation have punctuality performance reduced by 15% compared to unregulated flights/Non-CTOT flights (i.e. punctuality for non-CTOT first wave flights is 81.8% while punctuality is reduced to 67.1% where ATFM regulations are applied). The application of ATFM regulation can increasingly be seen as becoming the new 'normal' operating regime for Gatwick Airport. For instance, its application to first wave departures more than doubled from summer 2014 to summer 2016 where it stood at a level of 40% of flights being regulated at a level of 30 minutes holding per delayed flight.
- **Start Delay** - is the elapsed time between the pilot asking permission to start and air traffic control granting that permission. It is usually associated with a demand-capacity imbalance. Start delay at Gatwick Airport does not appear to be route dependent and is therefore unlikely to be related to the imposition of minimum departure intervals (MDIs) to moderate traffic on specific routes. Start delay does, however, appear to be associated with airfield loading, as shown in the figure below. It has

not been possible to understand whether the constraints are due to infrastructure, processes or air traffic controller workload based on the data made available within the duration of this study.



The graph illustrates the statistical correlation and best line fit between start delay and airfield loading for summer 2016..

The data provides initial evidence that suggests it can be difficult to manage and limit delays above a certain range of runway movements. However, the best-fit line illustrates that the analytical robustness of this insight needs to be improved through additional analytical exploration. We therefore recommend the initial analytical signal should be further investigated.

It has not been possible to assess fully the impact of Gatwick Airport attributable inbound ATFM delay due to a lack of access to data available in this area. However the trend for ATFM regulation appears to be increasing based on reproducing Eurocontrol analysis of Gatwick Airport attributed ATFM arrival holding from 2008-2014.

6.2 Recommendations

At busy times of the year Gatwick Airport is at high risk of disruption to first wave departures. There is a strong correlation between first wave and subsequent performance; therefore when there is disruption this is likely to propagate through the day.

In addition, in busy periods, Gatwick Airport is operating at very high levels of utilisation and very tightly scheduled operations with no headroom for recovery. In particular, the achievement of planned short turns by the airlines appears very challenging and may be exacerbating the situation. In addition, the effects of disruption to the first wave persist throughout the day. The recommendations arising from the study are aimed building resilient schedules through optimising planning and operations by both Gatwick Airport and its airlines.

5. **Improve the planning process**. The scheduling process should be reviewed by both the airlines and GAL to avoid OTP impacts and improve the resilience of the schedule within available capacity. This process should acknowledge the new operating norm of a heavily CTOT regulated environment. **GAL** should improve the capacity declaration process to:
    c. Include all Gatwick Airport associated holding delays in the process, including inbound ATFM, any holding applied through XMAN/AMAN and start delay that are currently not included.
    d. Ensure that any assumptions used in the process, e.g. the 20 minute average taxi out time, are validated and/or updated to reflect the current reality of operations at Gatwick.
    e. Improve the modelling baseline so that it avoids the potential optimism bias arising from only calibrating the model against the performance achieved on good, busy days.
    f. Explore the potential for expanding the KPIs used in the modelling to: (i) reflect risks as well as average holding delays; and (ii) apply some simple form of cost benefit analysis to understand the economic and financial implications of the wish-list scenarios being explored.
    g. Make the process more transparent and inclusive, including balancing of commercial and operational considerations for both the Airport and the airlines.

The **airlines** should explore whether it is feasible to use forward looking forecast data as well as historical performance in their block time and network planning activities to anticipate and mitigate issues that could potentially be foreseen and reflect this in the wish-list.

6. **Build headroom into the schedule**. Gatwick Airport is very tightly scheduled both in terms of its runway capacity declaration, the time allowed for aircraft turns and, potentially, block times between Gatwick Airport and outstation airports. Meeting scheduled times is very challenging and when things go wrong there is no resilience in the system for recovery.

The **airlines** should review the capability to adhere to schedules such as turn times, including associated ground handling resources, scheduled block times and outstation performance to identify where headroom can be usefully built in: (i) to increase the probability of being able to meet scheduled times; and (ii) to allow space for recovery.

Any extension of turn times needs to take into consideration the impact on stand occupancy and pier service requirements. The treatment of block times also needs careful consideration. For example, simple buffering (e.g. addition of a 15 minute turn buffer on turns) may reduce the number of flights arriving late but increase the number of flights arriving early with its own consequences on holding delay and congestion whereas reduction in the variability in block times would increase the proportion of flights operating on time. Given the current infrastructure constraints, in parallel **GAL** should:

h. Explore operational and long-term slot management options as part of an overall approach to resilience-based scheduling and planning. Local rules on slot usage and performance should be evaluated to assess available options including 1) the feasibility and trade-offs of not re-allocating slots at busy times that are handed back to reserve the additional capacity as headroom for resilience and 2) mechanisms for temporary retirement of slot use which balances rights to use later on.

i. Continue with its process improvement activities, such as integrated arrival and departure managers (AMAN-DMAN) with examination of how additional capacity generated could support resilience-based planning.

7. **Drill down to the detailed causes of CTOTs and start delay**, especially for first wave departures. It is clear that outbound ATFM regulation and start delay, especially in the first wave, are prejudicing punctuality performance both in the first wave and throughout the remainder of the day. However, further work, beyond just the data analysis, such as lean process investigation, is required to identify and improve the robustness of the defined root causes of ATFM regulation and start delay:

j. GAL, in conjunction with the airlines, should work with the Eurocontrol Network Manager to identify the location and cause of ATFM regulation as well as forecasts for future levels of regulation, especially those affecting the first departure wave. Based on the information obtained, work should be done to explore the potential for potential re-routing or other mitigation for affected flights to ameliorate the impact of ATFM regulation.

k. Further analysis should be undertaken by GAL and ANS to understand the root causes of start delay and explore mechanisms through which these can be addressed.

8. **Enhance monitoring metrics (e.g. Idaho)**. Idaho coupled with A-CDM provides the best platform for a common data source and dictionary, building on the work from this study. This platform should combine airport, airspace and airline data to improve subsequent performance monitoring, analysis and improvement. We recommend GAL and the airlines should explore with ANS and potentially NATS, the scope for importing additional operational data into Idaho. This data could include elements of EFPS to address airfield air traffic issues; data from London Terminal Control to enable airborne holding to be assessed; tow data to understand how aircraft towing affects airfield performance and airline data to, for example, allow validation of different measurements of pushback and to allow turn performance to be better monitored by incorporating addition turn milestones consistently, such as doors closed, which is already partially available.

Gaining insight from summer 2017 on-time performance needs a new collaborative approach which adopts formal problem-solving methodologies

Through the approach taken in this study, we have categorised a number of significant causes of delay. However, we acknowledge there is an additional level of analytical rigour and on-the ground engagement required, that wasn't possible to achieve within the timescales and constraints of this study, to reach indisputably robust and empirical definitions of delay root causes.

We acknowledge also that both GAL and ACC have welcomed the analysis undertaken within the parameters of the provided data and the time available. Within these constraints, the evidence base thus far constructed now provides GAL and the ACC with the foundation to adopt highly data-driven ways of collaborative working. This will help generate quantified, statistically tested and operationally relevant insights that can be built upon, or challenge the current understanding of the inter-linked root causes of punctuality held by key stakeholders.

Significant effort was made to review and reach consensus on the definitions used in performance measurement and improvement as well as identify and agree the sources of data. This step forward from the status quo has been viewed as a valuable benefit of the study by stakeholders.

It was the foremost challenge of the study to obtain an agreed common data set which has resulted in the absence of data from airlines and the wider system (e.g. Eurocontrol) as well as the restriction of its use and publication within the final report. This has been the rate limiting step in reaching stronger and statistically robust insights on root causes and advancing beyond the initial signals from the exploratory analysis undertaken. For example, we were specifically unable to obtain IATA delay code and description in the time allotted for the study from GAL. Although this was in the context of overall timely and cooperative responses to requests for data from GAL.

The study's stated requirement was the examination of key aspects of planning and operations at Gatwick Airport, as detailed in the originating ITT. However, poor on-time performance is often a symptom of wider-system complexity and is affected by decisions and issues made in multiples areas both within and outside of Gatwick.

We recognise further actionable insights are required to develop 'COO ready' initiatives which enhance and protect on-time performance in the future. We believe the study has demonstrated the limitations of a desk-top analytics approach.

Therefore, further work should adopt a joint iterative analytics approach with access and transparency of the full range of datasets to allow an analytical synthesis of the contributing factors across the 'system'. This approach will provide the best opportunity to convert the initial analytical signals that we have found from the data made available into further on-site exploratory analytical exercises that provide greater understanding of root causes that weren't necessarily widely understood before.

The key advantages of this approach includes the flexibility to frame problems with both a data-driven component and people/process-related aspects offering the flexibility for the conversation to be moved 'top-down' (e.g. system view) or 'bottom-up' (e.g. individual process components).

We therefore greatly value Gatwick Airport's suggestion on creating a collaborative and joint 'On-Time Performance Analysis Group' to develop further the common dataset building on airport, air traffic, airlines and European network manager datasets and a supporting analytics programme to develop shared root cause and improvement recommendations.

We have seen this approach be successfully adopted in other sectors with infrastructure provider and user models. In one example this has seen the implementation of an operating model that maintains an integrated control centre and joint planning and integrated performance teams.

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