



SESAR PJ24 VLD Exercise 3b – Summary of Results

SESAR Wave 1 Achievements Event

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NATS



Heathrow

Agenda

- Introductions & Agenda
- PJ24 Very Large Demonstration (VLD) Exercise 3b - Aims and Methodology
- Summary of results, including;
 - ATFM delay results comparison between Target Time of Arrival (TTA) derived regulations and CASA regulations
 - Resolution of predicted hotspots in airborne delay
 - Comparison of average ATFM delay by flight when using TTA-derived regulations and CASA regulations
 - Equity of TTA-derived regulation solution
 - Stability of DCB tool when using TTA-derived regulations
 - Overview of key metrics during VLD period
 - Summary of qualitative results
 - Next steps
- Conclusions



PJ24 VLD Exercise 3b - Aims and Methodology

- Between 27th March and 16th June 2019, Heathrow led Exercise 3b of the SESAR Project 24 VLD
- The aims of Exercise 3b were:
 - 1) To demonstrate our ability to predict, at D-1, forecast airborne holding delay accurately by using our Airport Demand Capacity Balancing (DCB) tool;
 - 2) To use the Airport DCB tool to manage hotspots in airborne holding delay by allocating Target Times of Arrival (TTAs) to candidate aircraft within a hotspot period;
 - 3) To demonstrate that our Airport DCB tool can then provide a solution that is as good or (ideally) better than the solution currently provided by CASA (which allocates delay to all aircraft within a flow regulation period);
 - 4) To demonstrate our ability to connect our Airport Operations Plan (AOP) with the Network Operations Plan (NOP) and exchange information dynamically with NM
- The VLD only affected flights originating from the ECAC zone.

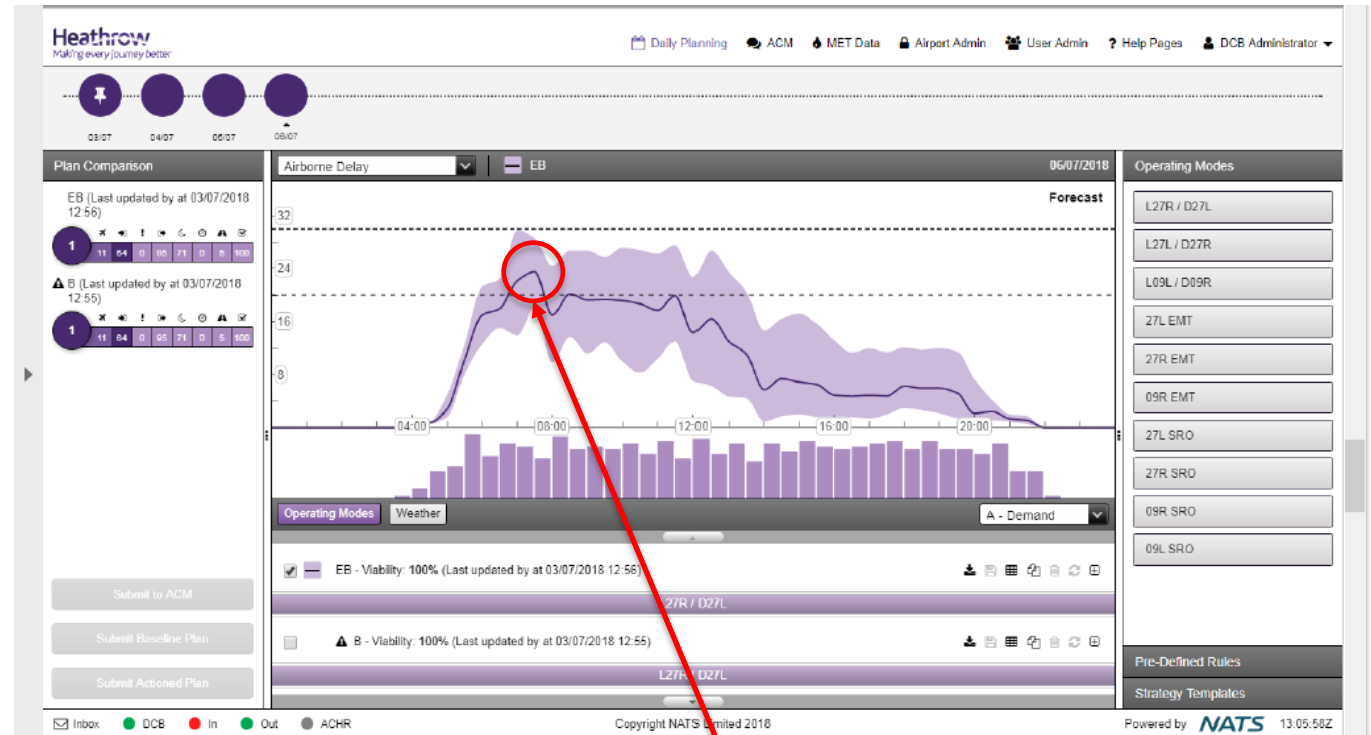


PJ24 VLD Exercise 3b - Definition of Key Terms

Our DCB tool allows us to spot airborne delay 'Hotspots' at D-1 (i.e. one day before the day of operation)

Hotspot - a time period where the predicted airborne delay (resulting from arrival demand) exceeds acceptable limits based on predicted runway capacity

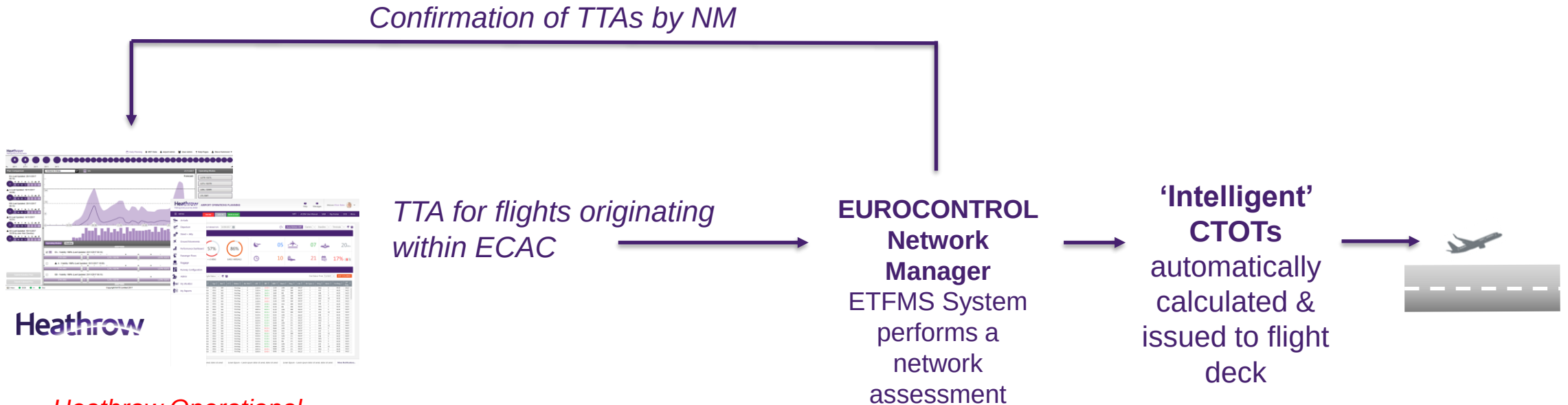
Target Time of Arrival (TTA) - the calculated time at which an aircraft is requested to arrive at a specific waypoint on its trajectory in order to balance predicted runway demand and capacity, thus reducing the need for associated 'blanket' Flow Regulations within Terminal Control airspace, and optimising airborne holding.



Hotspot in airborne holding delay

PJ24 Exercise 3b Aims and Methodology

End-to-End Process Flow



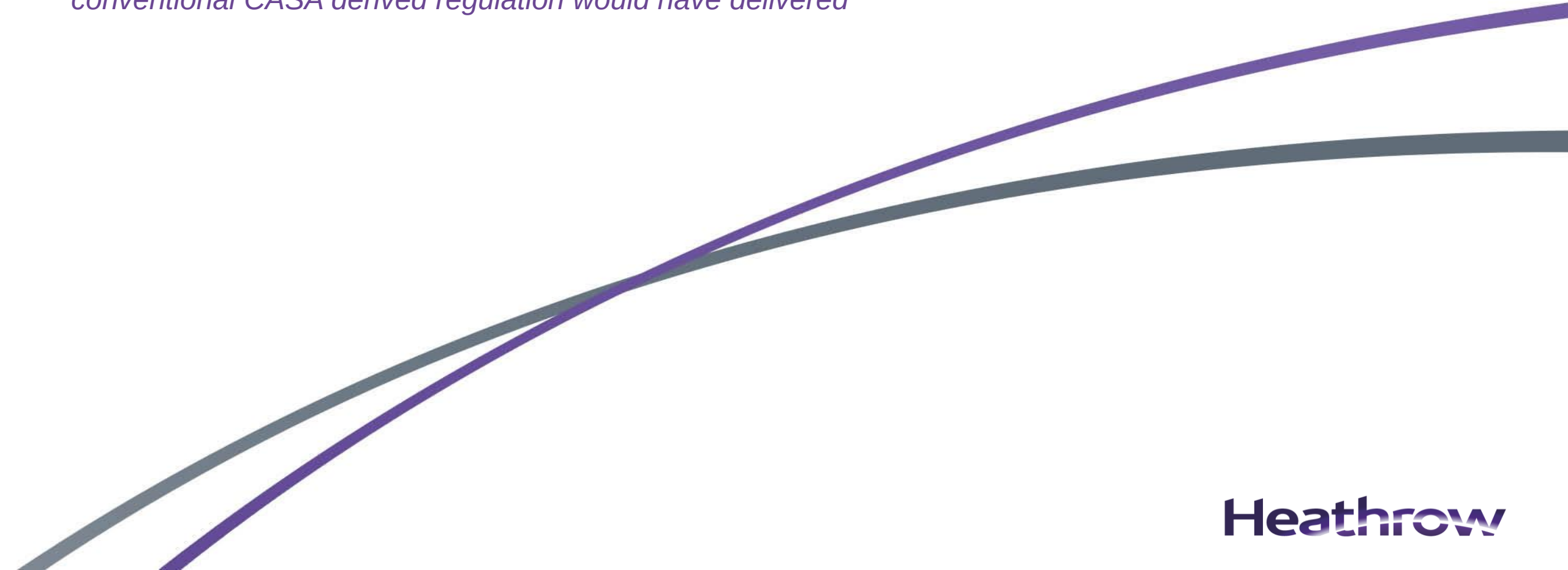
Heathrow Operational Efficiency Cell (HOEC) agree plan in DCB with Airspace Capacity Management (ACM) and Terminal Control (TC) prior to submitting it to AOP

Summary of PJ24 VLD Exercise 3b results

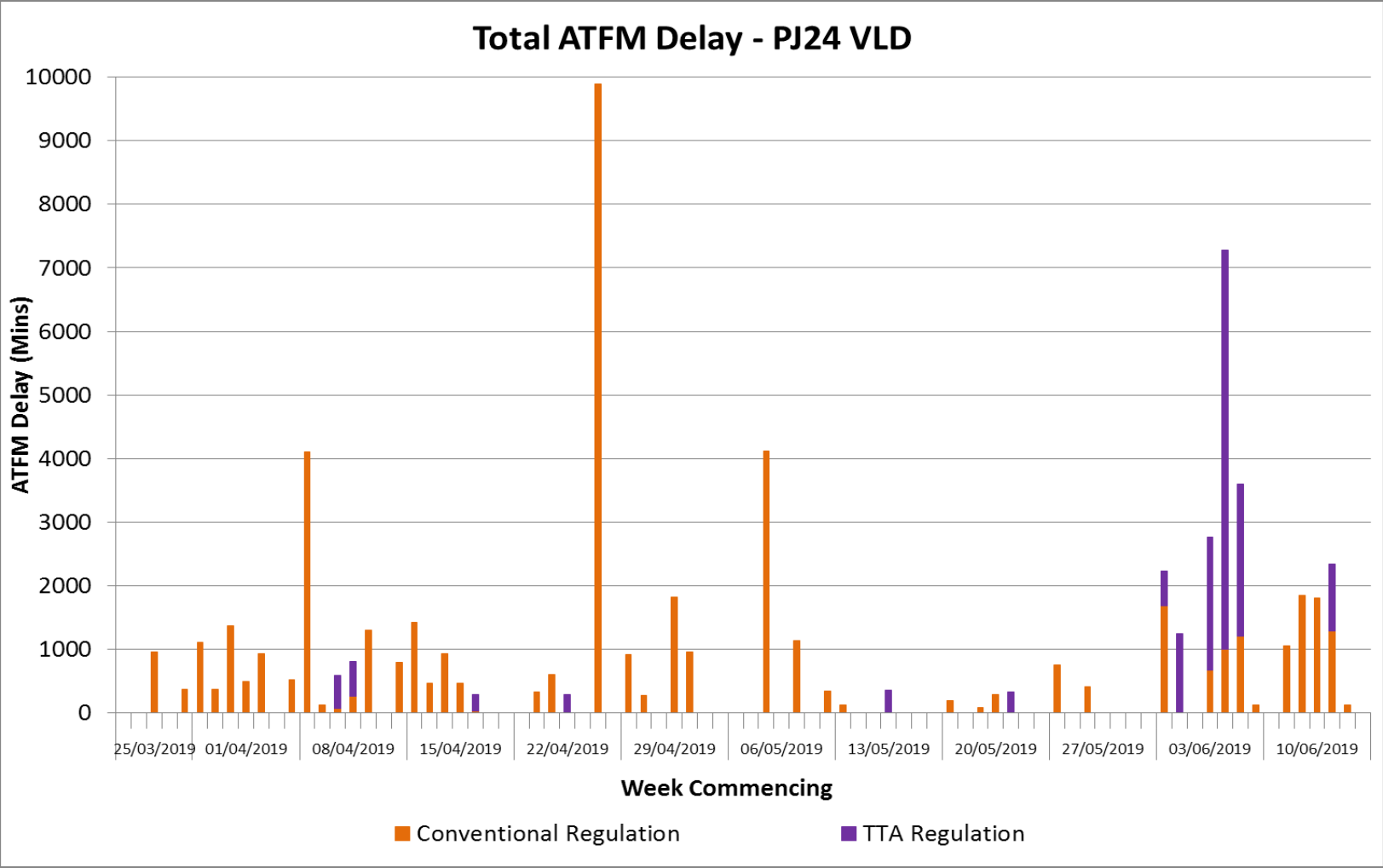
- a) Heathrow's TTA derived regulation delivered a **significant reduction in overall ATFM delay** when compared to that which conventional CASA derived regulation would have delivered
- b) Heathrow's A-DCB systems and processes were **able to predict and subsequently resolve all periods of excessive runway demand**, and resultant predicted airborne delay, during the VLD
- c) Heathrow's TTA derived regulation was **demonstrated to be no more penalising**, in terms of ATFM delay per flight, than conventional CASA derived regulations
- d) Heathrow's TTA derived regulation, based upon agreed A-DCB algorithms and prioritisation criteria, provided **equitable distribution of ATFM delay per flight** across all Airspace Users
- e) Heathrow's TTA derived regulation **provided a more stable resolution** to the delay hotspot, with the average number of update messages per flight being significantly lower for TTA flights when compared to conventional regulations
- f) **Heathrow, Europe's busiest airport, successfully used TTA derived regulations to safely resolve periods of excessive runway demand and associated airborne holding, during peak operational days, with record numbers of Air Traffic Movements.**

(a) ATFM delay comparison

Heathrow's TTA derived regulation delivered a significant reduction in overall ATFM delay when compared to that which conventional CASA derived regulation would have delivered



Total Regulation Delay



NEST vs TTA results



Across the 6 regulation days considered, the level of ATFM delay predicted by the NEST simulations was between 26% and 41% higher than the ATFM delay generated by applying a TTA regulation through DCB.

TTA regulation				Assumed regulation rate	NEST simulated delay, min	Percentage Change
Date	Start	End	Actual delay, min			
03/06/2019	06:00	09:12	555	41 – 42	505 to 1,296	-9% to 134%
04/06/2019	10:00	19:00	1,246	40 – 41	1,373 to 2,015	10% to 62%
06/06/2019	09:00	12:40	1,192	41	609	-49%
06/06/2019	17:30	18:59	899	34 – 42	190 to 497	-79% to -45%
07/06/2019	06:00	15:34	6,283	38	10,550	68%
08/06/2019	05:20	12:40	2,398	38	3,371	41%
14/06/2019	16:30	19:24	1,056	41 – 42	529 to 832	-50% to -21%
Total			13,629		17,127 to 19,170	26% to 41%

SIMEX vs TTA results

Across the 6 regulation days considered, the level of ATFM delay predicted by the SIMEX simulations (run by Eurocontrol) was 27% - 33% higher than the ATFM delay generated by applying a TTA regulation through DCB.

Date	Start	End	Actual Delay using TTA regulation	Assumed regulation rate	SIMEX FTFM simulated delay of conventional CASA regulation	Conventional CASA Regulation Percentage increase
03/06/2019	06:00	09:12	555	41-42	612 to 834	10% to 50%
04/06/2019	10:00	19:00	1246	40-41	499 to 663	-60% to -47%
06/06/2019	09:00	12:40	1192	41	1276	7% to 7%
06/06/2019	17:30	18:59	899	34-42	251 to 618	-72% to -31%
07/06/2019	06:00	15:34	6283	38	10227	63% to 63%
08/06/2019	05:20	12:40	2398	38	3006	25% to 25%
14/06/2019	16:30	19:24	1056	41-42	1388 to 1483	31% to 40%
			13629		17259 to 18107	27% to 33%

(b) Resolution of predicted hotspots in airborne delay

Heathrow's A-DCB systems and processes were able to predict and subsequently resolve all periods of excessive runway demand, and resultant predicted airborne delay, during the VLD

Peak Airborne Delay vs. Target Delay



The DCB system solved Airborne Delay hotspots for 100% of the time periods it was applied to.

Date	Count of 30 min bins in TTA period	% Resolved Bins	Peak average airborne delay in TTA period	Target Delay in TTA period	Count of TEAM movements in TTA period
10/04/2019	11	100%	11	17	13
11/04/2019	3	100%	4	17	2
19/04/2019	2	100%	6	17	0
25/04/2019 ¹	0	100%	0	17	0
16/05/2019	3	100%	7	17	1
24/05/2019	10	100%	10	17	7
03/06/2019	7	100%	10	17	2
04/06/2019	19	100%	13	17	5
06/06/2019	12	100%	9	17	3
07/06/2019 ²	21	100%	14	17 & 14	12
08/06/2019 ³	16	100%	14	17	34
14/06/2019	7	100%	10	17	0
Total	111	100%	14	17	79

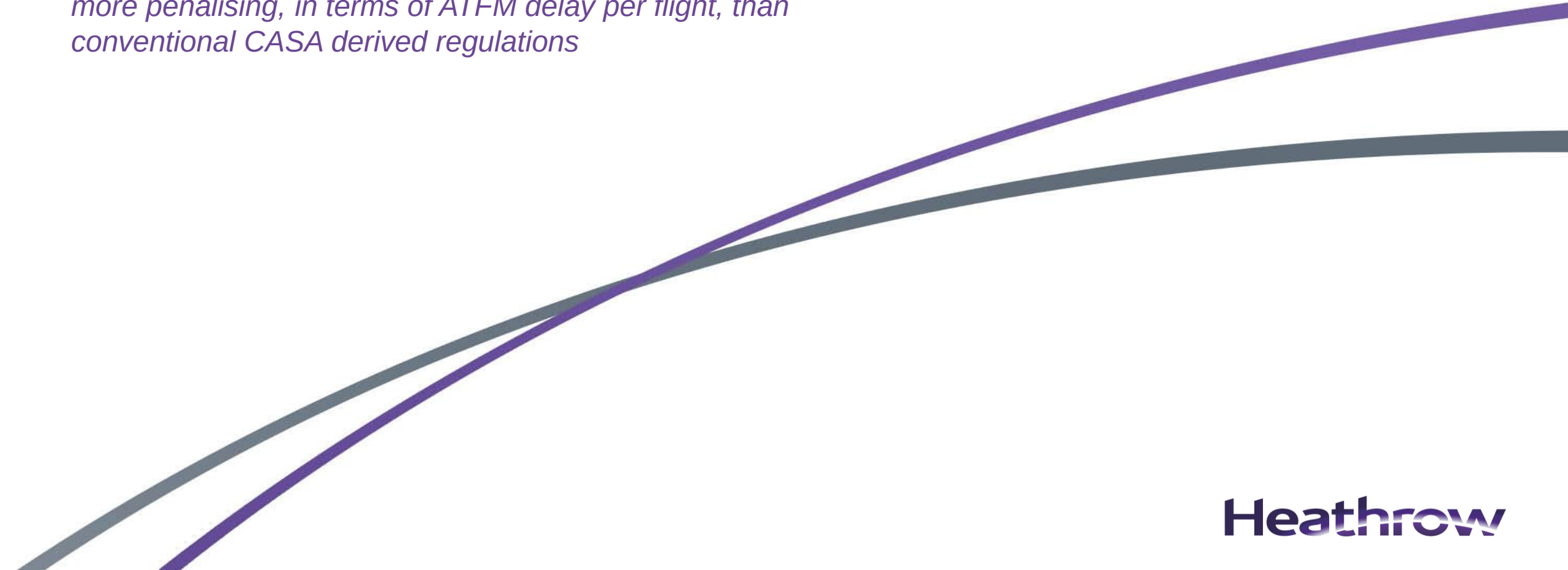
¹ 25/04/2019 – the TTA regulation was cancelled before it's start time.

² 07/06/2019 had a target delay of 17 minutes between 05:30:00 – 11:00:00 and this reduced to 14 minutes between 11:00:00 – 15:30:00.

³ 08/06/2019 included a full runway closure for 15 minutes for an RAF flyover. This was the cause of the high level of TEAM movements on that day.

(c) Comparison of average ATFM delay by flight

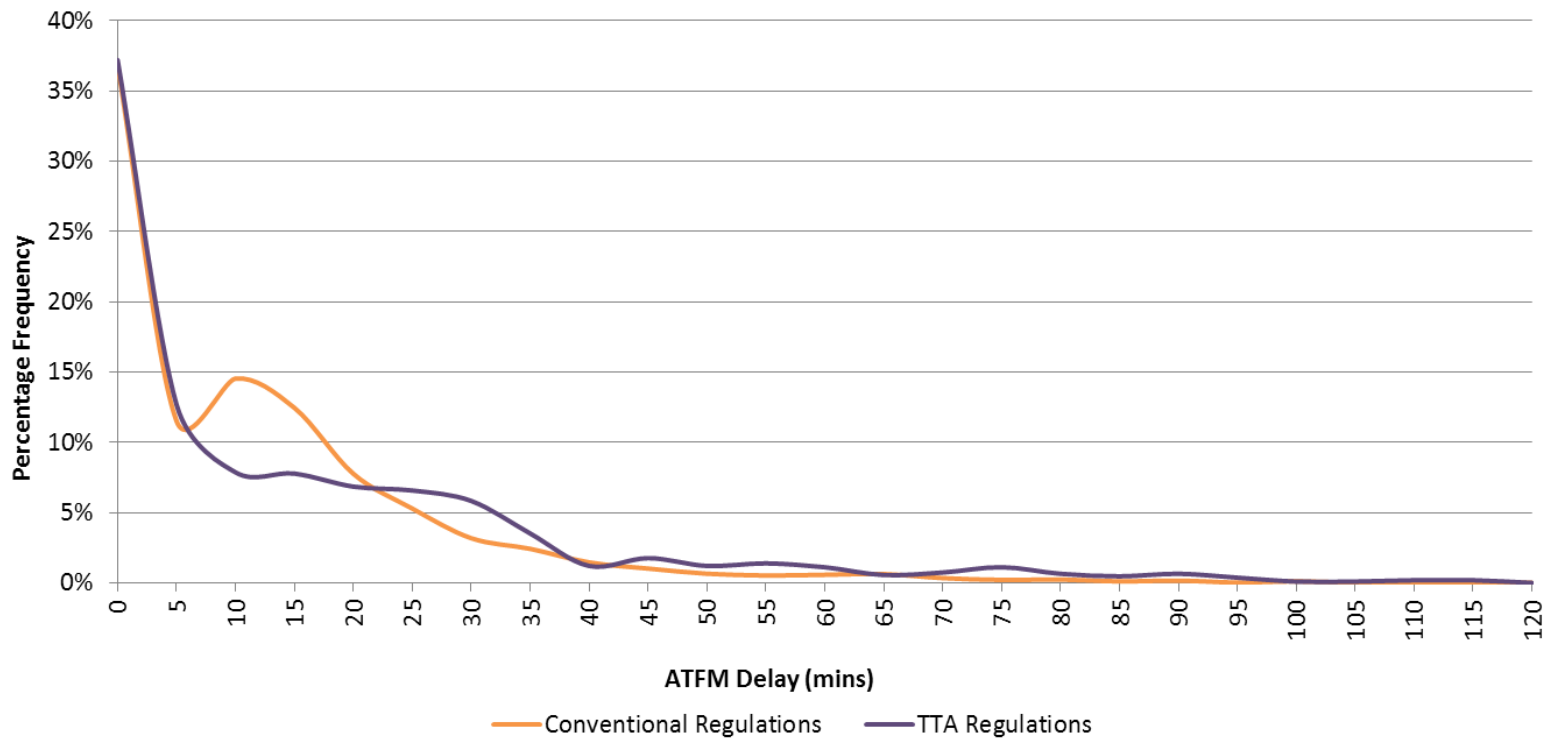
Heathrow's TTA derived regulation was demonstrated to be no more penalising, in terms of ATFM delay per flight, than conventional CASA derived regulations



Distribution of TTA vs. Conventional Delay



Comparison of ATFM Delay Distributions

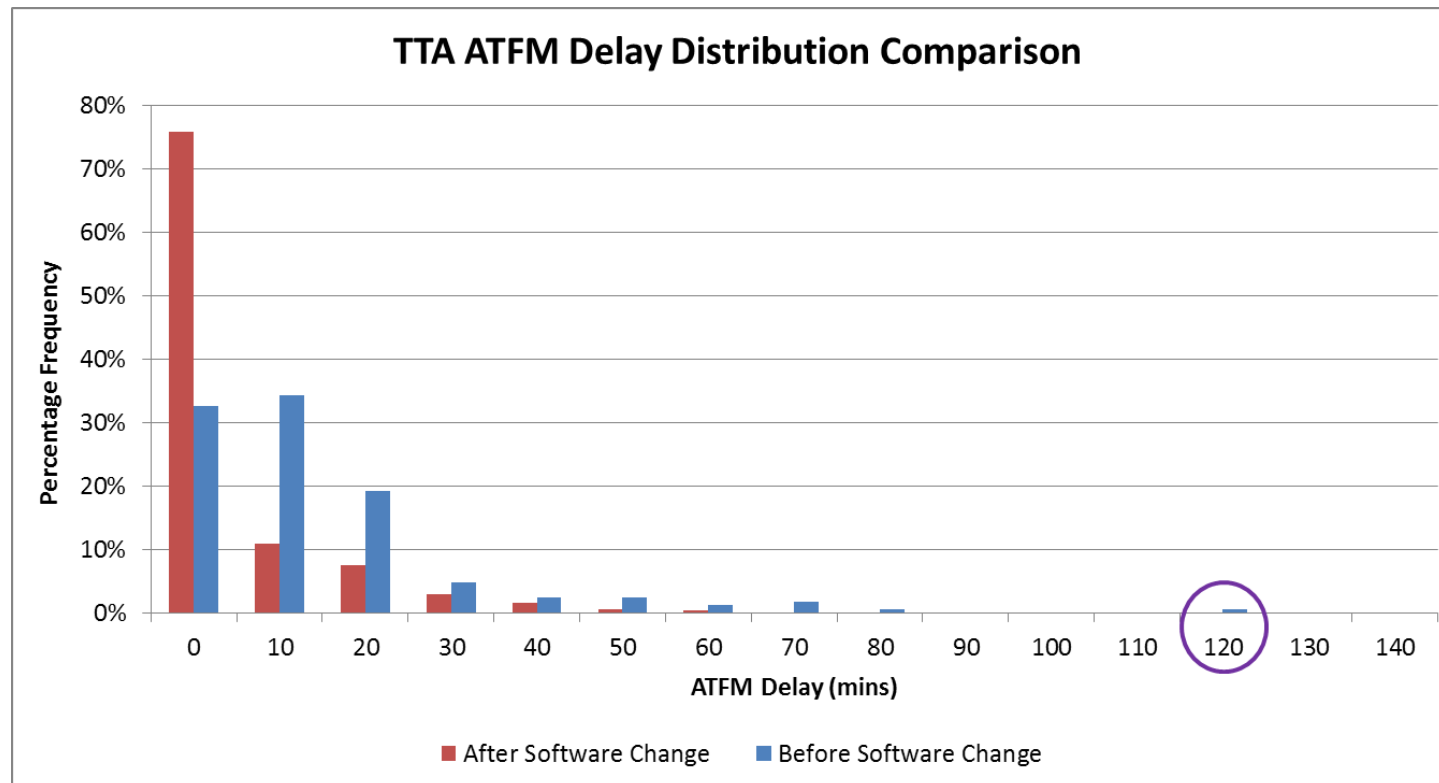


	TTA	Conventional
Median Delay per Flight (Mins)	6	6
St Dev of ATFM Delay (Mins)	21	14
Maximum Delay Issued (Mins)	115	100
95 Percentile Delay (Mins)	65	45
% of Flights with 0 delay	37%	37%

Distribution of Delay

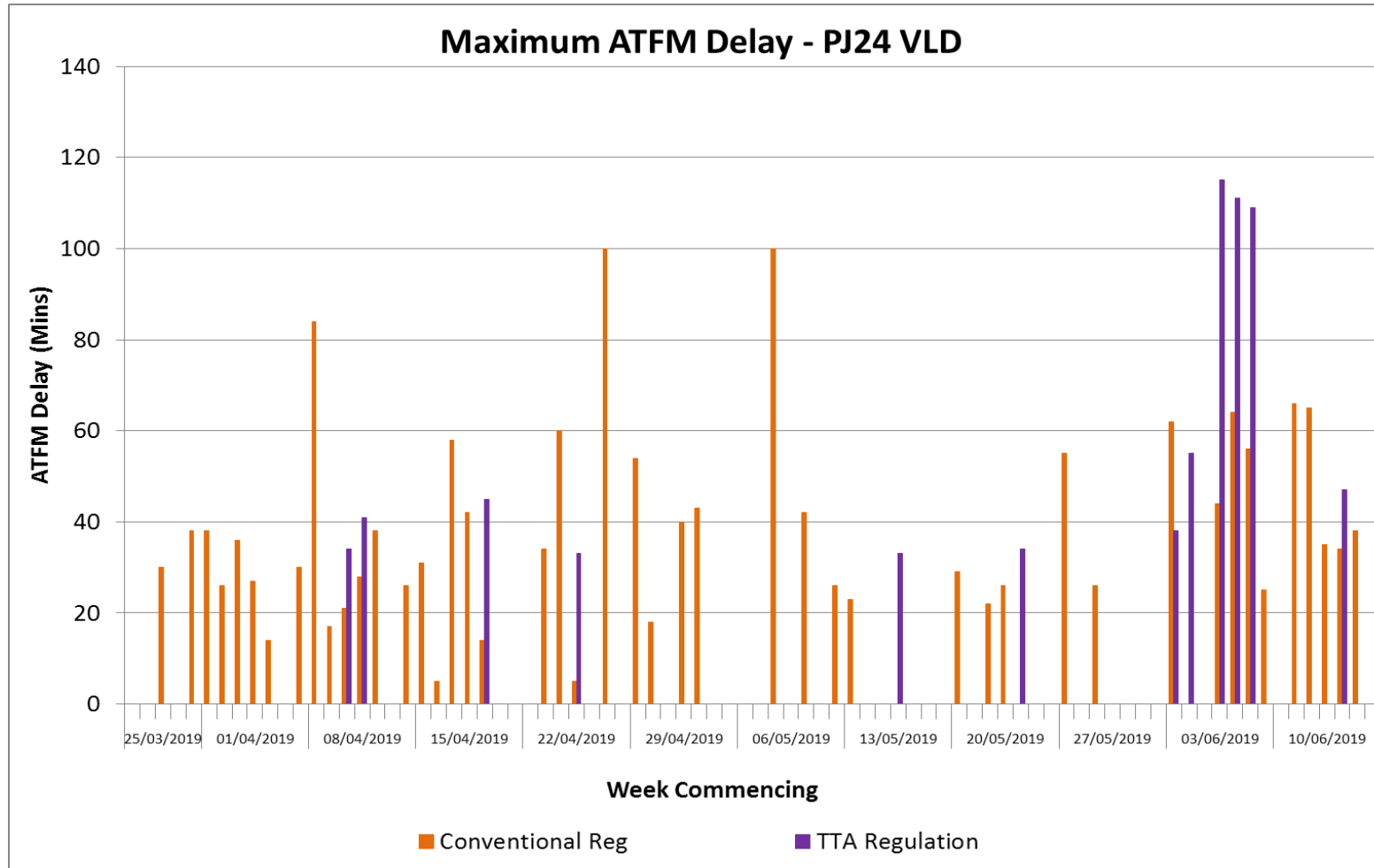
At the start of the VLD period, one of the key findings was that some flights received much larger ATFM delays than the other regulated flights. The chart below shows an example of this where one flight on 19/04/2019 (circled) was predicted to receive 120 minutes of delay, whereas the next highest delay for a single flight was 80 minutes.

A software change was implemented on 21/05/2019 to improve this and the red bars show the distribution of delay on 03/06/2019. After the software change, these outliers were removed.



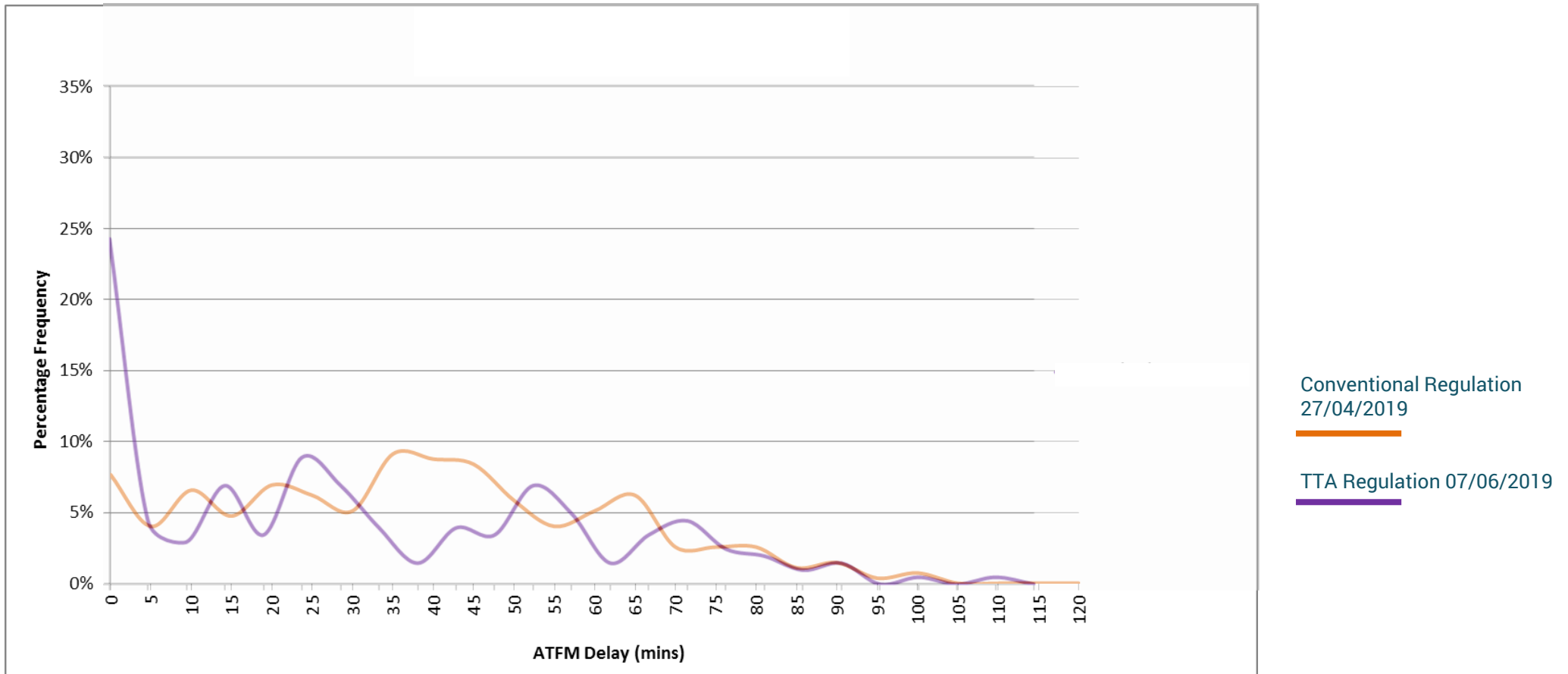
Maximum Regulation Delay

The maximum delay applied to a single flight was only slightly higher for TTAs compared to Conventional Regulations.



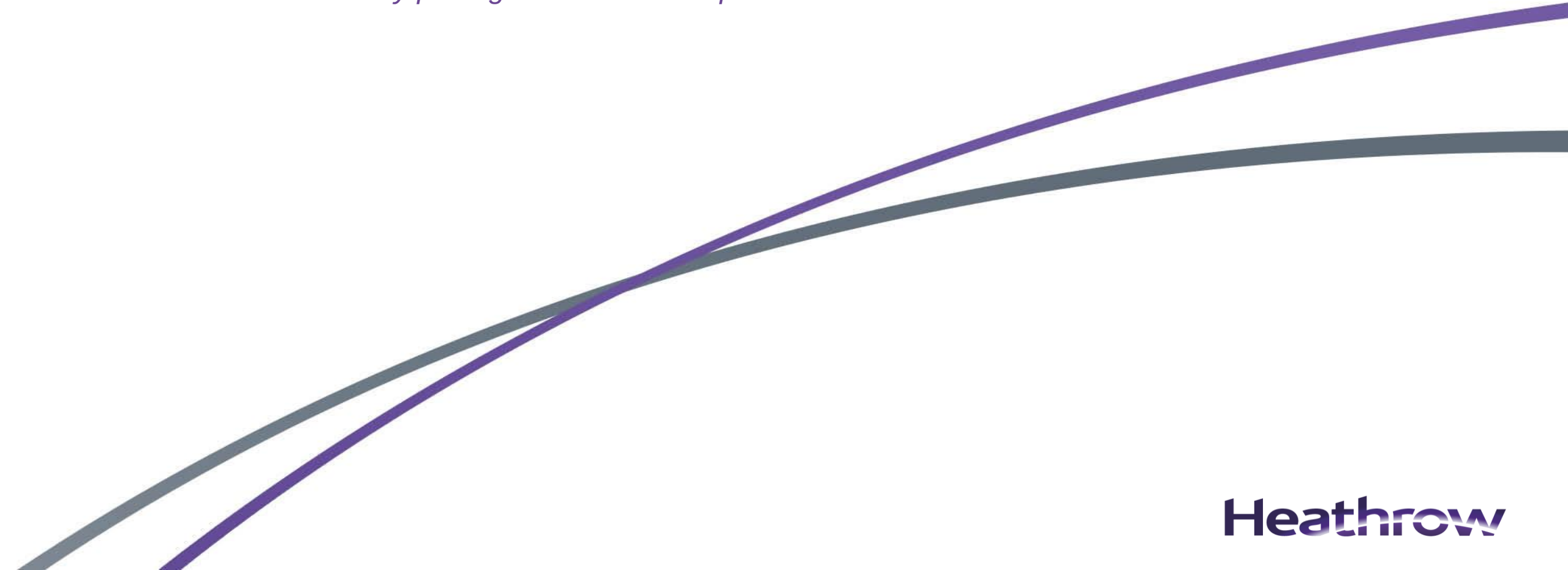
Comparison to a Conventional Regulation

The 07/06/2019 TTA regulation had a similar number of regulated flights to a conventional regulation on 27/04/2019. When comparing the ATFM delay distributions for these two examples, it is clear that although a few flights with TTAs had larger delays, there was also a higher proportion of flights with zero delay than the conventional example. As a result, the total delays are lower for the TTA example.



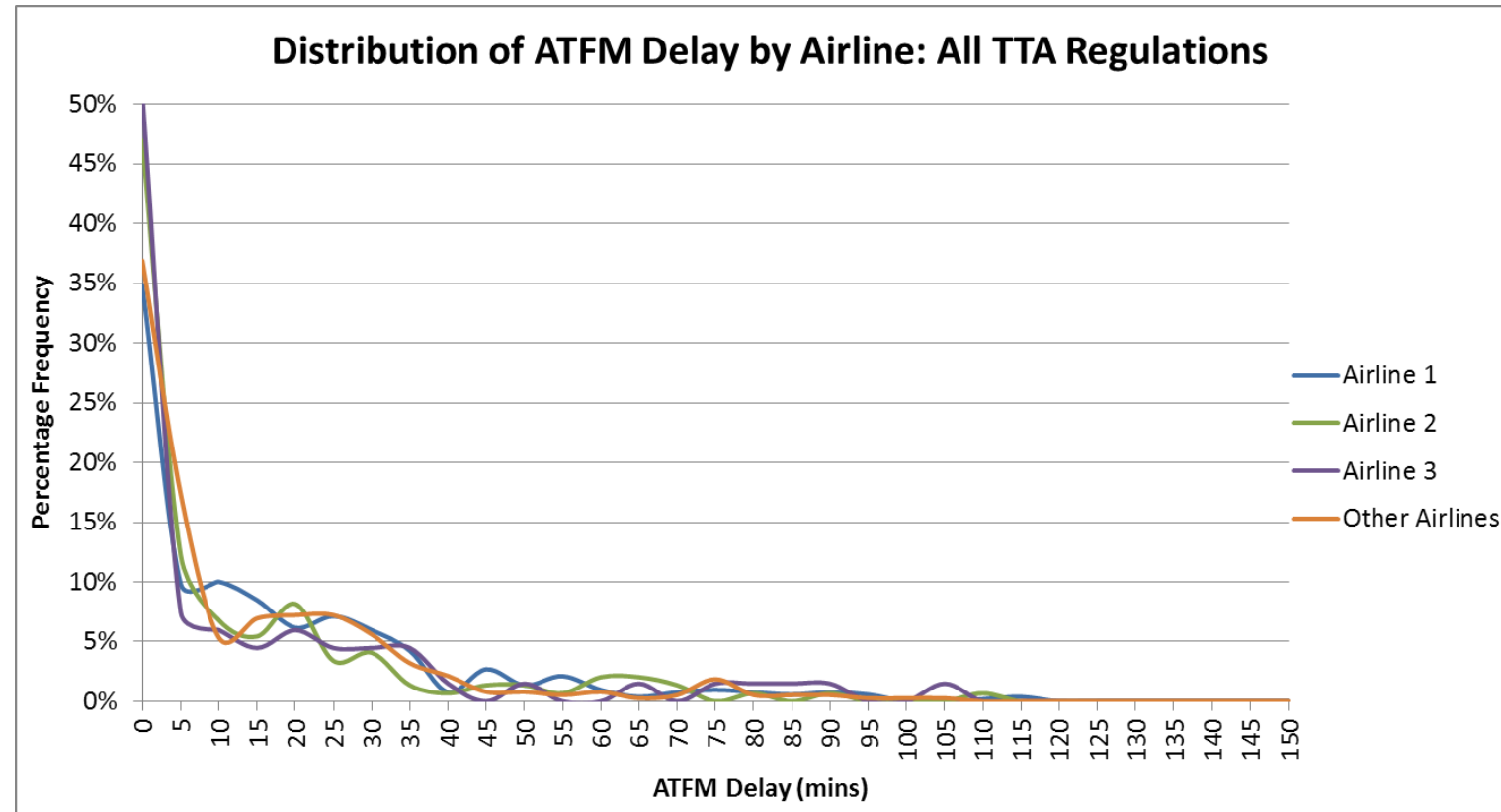
(d) Equity of TTA-derived regulation solution

Heathrow's TTA derived regulation, based upon agreed A-DCB algorithms and prioritisation criteria, provided equitable distribution of ATFM delay per flight across all Airspace Users



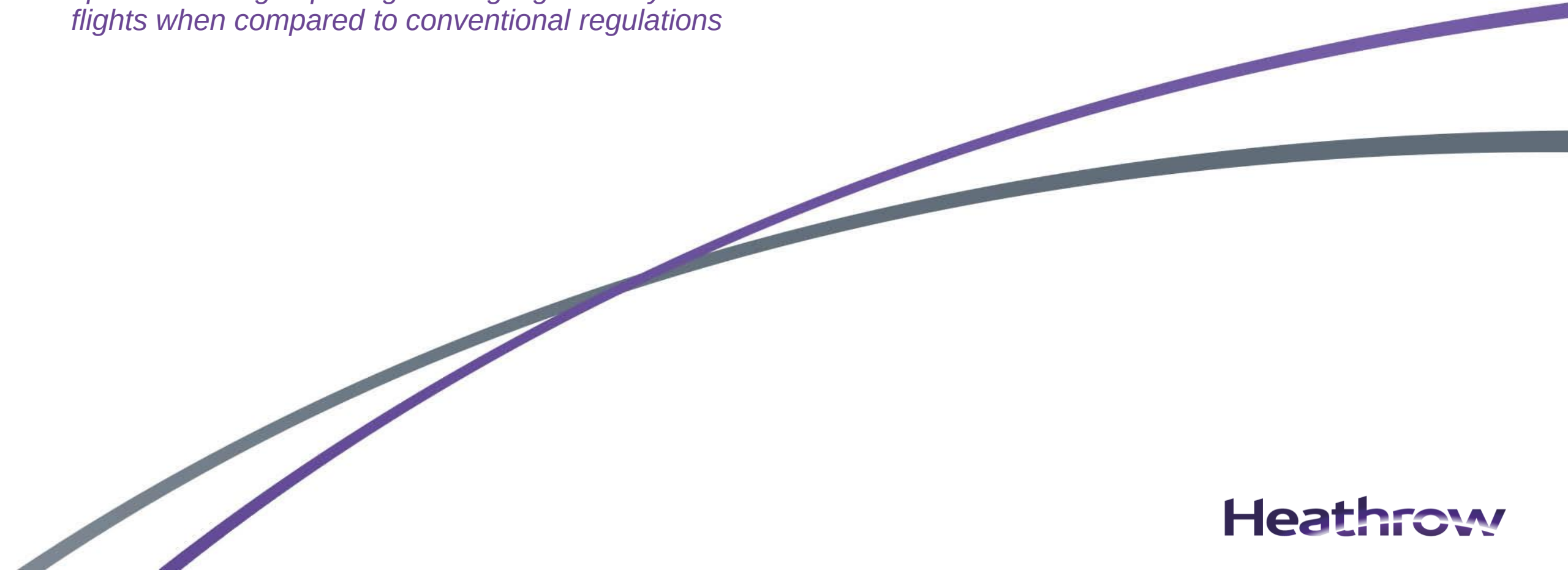
Equity of ATFM Delay

When comparing the distribution of TTA ATFM delays throughout the VLD for 3 key short haul carriers, the chart below demonstrates that each airline had a variety of delays of differing magnitudes. ATFM delay was shared equally between airlines with no single airline being penalised more than any other.



(e) Stability of DCB tool when using TTA-derived regulations

Heathrow's TTA derived regulation provided a more stable resolution to the delay hotspot, with the average number of update messages per flight being significantly lower for TTA flights when compared to conventional regulations



Stability Comparison



The table below provides a comparison of two similar regulations (one conventional regulation and one TTA regulation) with a similar magnitude of regulated flights. CTOT is shown for conventional regulation data and CTA is shown for TTA regulation.

Key findings:

- There were significantly more updates for the conventional regulation (average of 35 updates per flight vs. 3 per flight for the TTA regulation).
- The conventional regulation updated more frequently (average of 14 minutes between updates vs. 139 minutes for the TTA regulation).
- Although less frequent, the magnitude of TTA updates tended to be higher when they did occur (absolute average change of 5 minutes for the conventional regulation vs. 21 minutes for the TTA regulation).

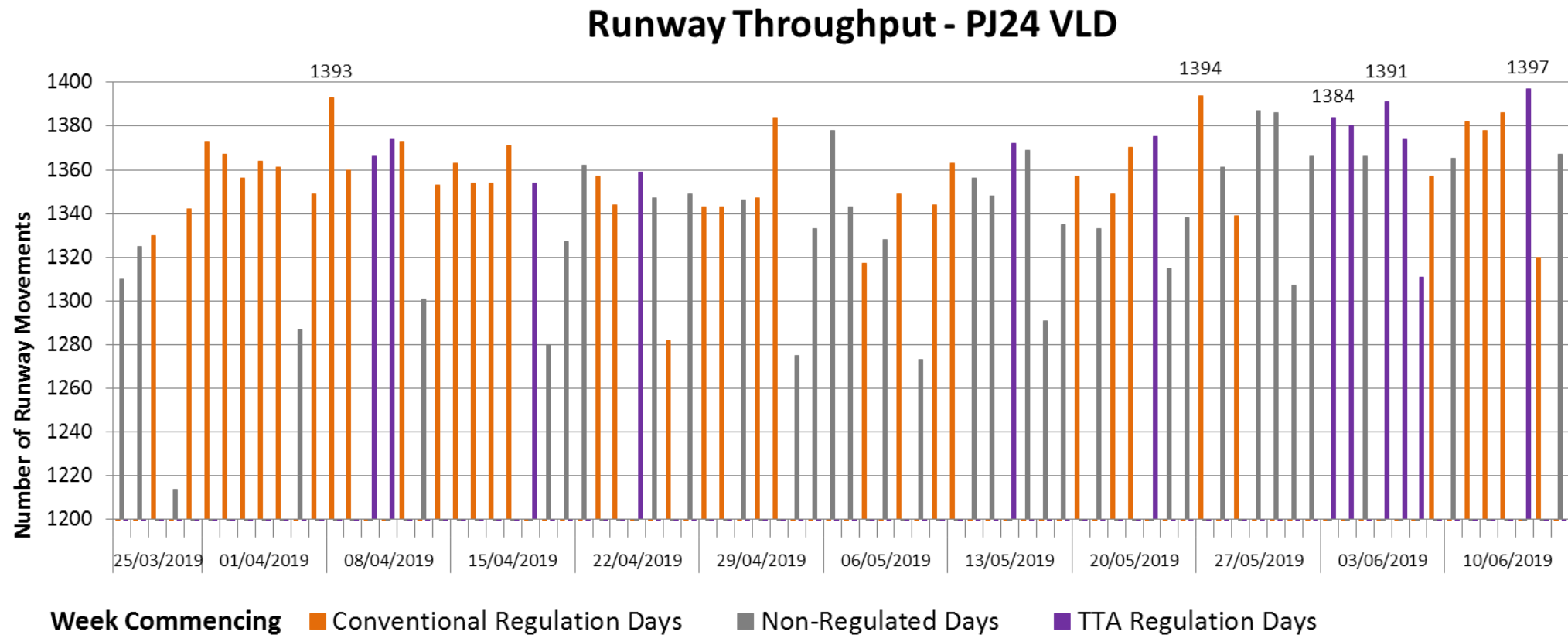
Metrics		CTOT (Conventional Regulation)	TTA (TTA Regulation)
		27/04/2019 EGLLA27	07/06/2019 CPGLLO7M
Number of Flights Regulated		384	354
Number of updates to regulation times received by flights	Total Number of Updates	13,577	1,016
	Average Number of Updates per flight	35	3
	Maximum Number of Updates to a Single Flight	76	13
When flight's regulation times were updated, how many minutes did they change by?	Average Duration Between Updates (mins)	14	139
	Maximum Change in a Single Update (mins)	186	99
	Average Absolute Change (mins)	5	21
	Median Update (mins)	1	20
	95% Update (mins)	8	71

(f) Overview of key metrics during VLD period

Heathrow, Europe's busiest airport, successfully used TTA derived regulations to resolve periods of excessive runway demand and associated airborne holding during peak operational days with record numbers of Air Traffic Movements

Runway Throughput

The VLD period saw days with unusually high demand and throughput for the time of year. This was partially due to the timing of Easter 2019. The chart below shows that when TTAs were issued during the VLD there was no negative impact to runway throughput, with the airport experiencing two record breaking days for ATMs in June.

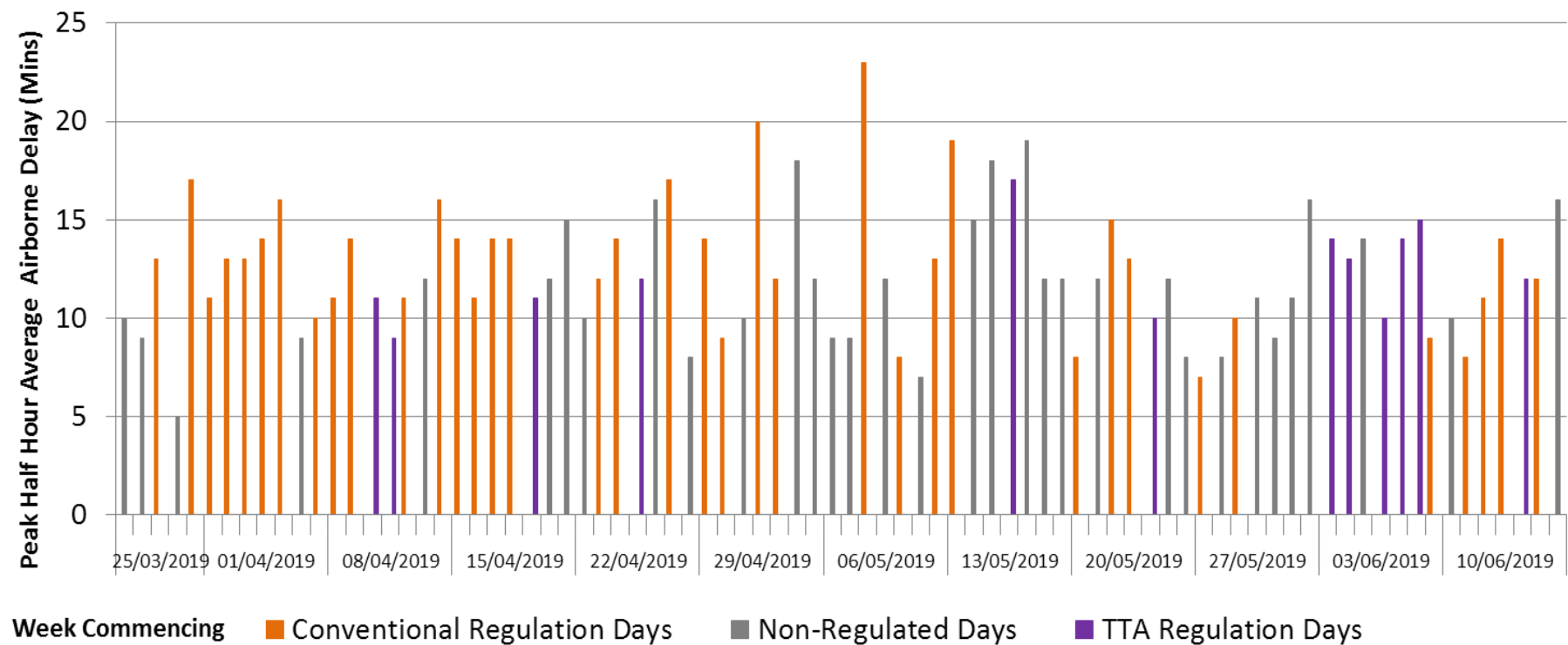


Airborne Holding Delay



Peak half hourly holding during days with TTA regulations was between 9 and 17 minutes, with an average of 12.3 minutes. It is expected that this value would be closer to the target delay threshold (often 17 minutes during the VLD) when the historic airborne delay values are enhanced.

Peak Half Hourly Average Airborne Delay - PJ24 VLD



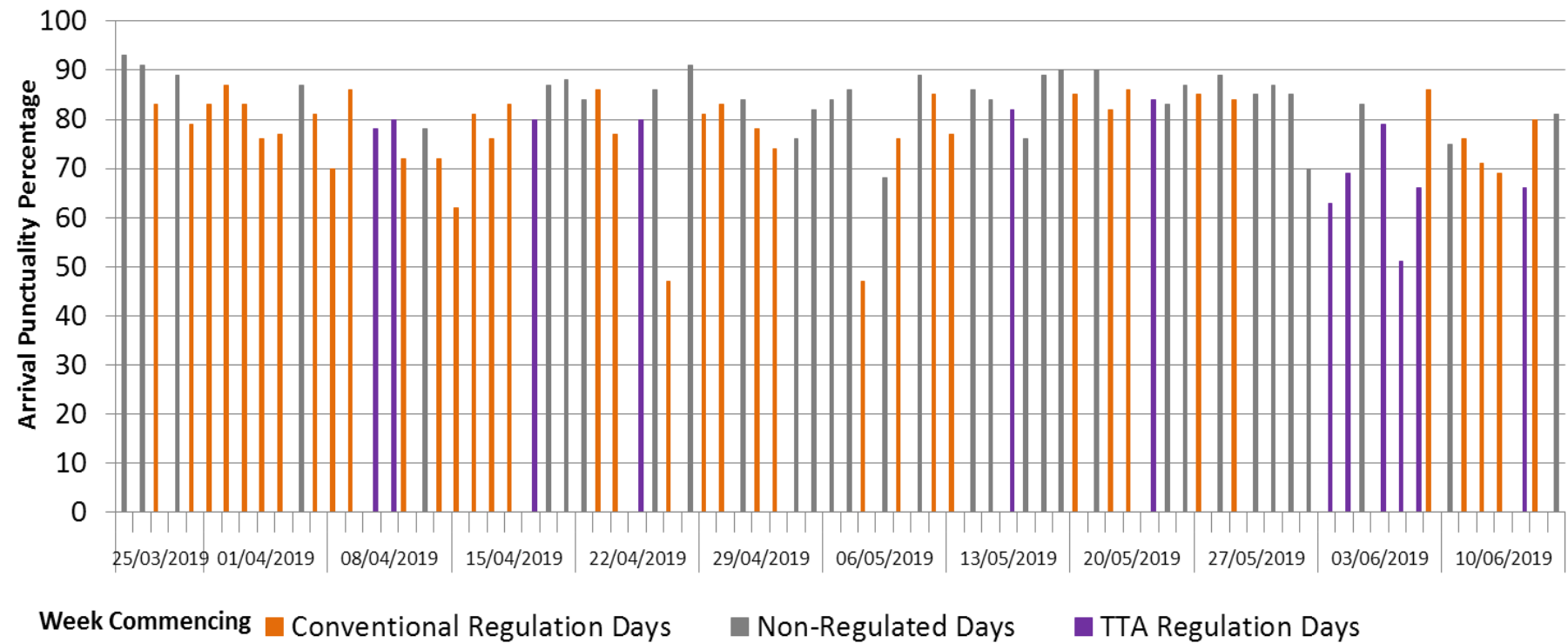
	Average Peak Half Hourly Airborne Delay (mins)
Conventional Regulation Days	13
TTA Regulation Days	12
Non-regulation Days	12

Arrival Punctuality



Arrival Punctuality remained at a similar level when the TTA regulations were applied compared to days where conventional regulations were applied.

Heathrow Arrival Punctuality - PJ24 VLD



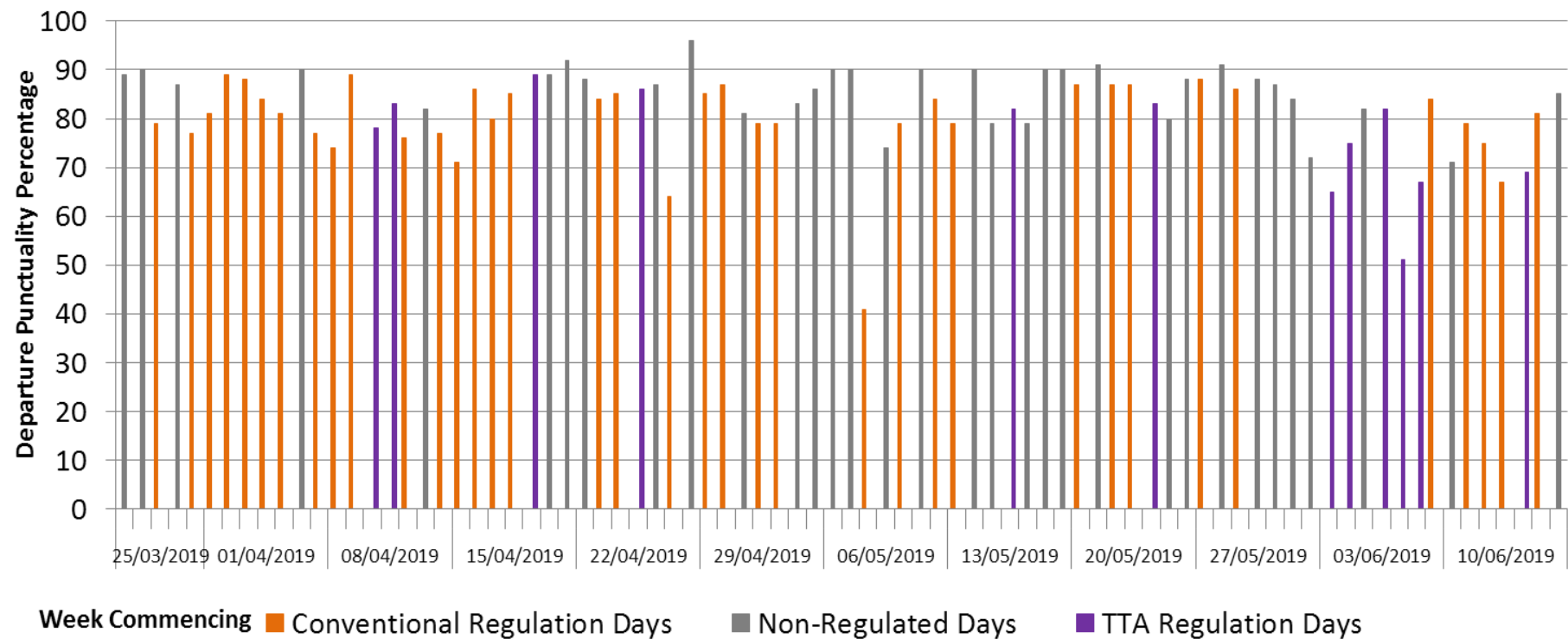
	Median Arrival Punctuality
Conventional Regulation Days	80%
TTA Regulation Days	79%
Non-regulation Days	86%

Departure Punctuality



Departure Punctuality remained at a similar level when the TTA regulations were applied compared to days where conventional regulations were applied.

Heathrow Departure Punctuality - PJ24 VLD



	Median Departure Punctuality
Conventional Regulation Days	81%
TTA Regulation Days	80%
Non-regulation Days	88%

Summary of qualitative results

- No safety concerns were raised during the VLD
- The TTA functionality in DCB was tested on a wide variety of scenarios with some of the highest numbers of movements Heathrow has experienced in its history
- Procedures generally worked, with minor tweaks implemented as the VLD progressed and confidence in the use of the tool increased
- Confidence in the tool was gained quickly, with the overarching regulation deemed as not required after only 2 instances of using the TTA-derived regulation
- It was easy to transition from a TTA-derived regulation to a conventional regulation when required
- Workload for HOEC and TC was deemed to be higher during the VLD. However this was attributed to a lack of familiarity with the tool and should improve with further trials
- Workload for airlines (flight planners and crews) was unchanged and remained the same as when a conventional CASA regulation is applied
- Issues around the message limit and manual intervention required in AOP to send TTA messages to NM led to confusion on occasion, especially on the more challenging days of operation
- Excluding flights in a TTA-derived regulation was more difficult than when a conventional regulation is applied, however, further enhancements to DCB should mean that this shouldn't be necessary often

Next steps

- **Flights from within ECAC area**

Following the success of the VLD it is envisioned that TTAs operations will become 'business as usual' at Heathrow from Q2 2020; subject to the necessary changes and enhancements needed within both DCB and NM systems. We are planning further trials, similar to the VLD, to test the next round of DCB enhancements in a full range of conditions in readiness for 'business as usual' go-live.

- **Non-ECAC area flights**

Some trials have been undertaken with Singapore Airlines, British Airways and Air New Zealand. We will be engaging more airlines on TTAs for non-ECAC flights in the coming months. Once the procedures are established, Heathrow would consider sharing airborne TTAs with NM using the available NM B2B services.

Conclusions

- Heathrow's TTA derived regulation delivered a **significant reduction in overall ATFM delay** when compared to that which conventional CASA derived regulation would have delivered
- Heathrow's A-DCB systems and processes were **able to predict and subsequently resolve all periods of excessive runway demand**, and resultant predicted airborne delay, during the VLD
- Heathrow's TTA derived regulation was **demonstrated to be no more penalising**, in terms of ATFM delay per flight, than conventional CASA derived regulations
- Heathrow's TTA derived regulation, based upon agreed A-DCB algorithms and prioritisation criteria, provided **equitable distribution of ATFM delay per flight** across all Airspace Users
- Heathrow's TTA derived regulation **provided a more stable resolution** to the delay hotspot, with the average number of update messages per flight being significantly lower for TTA flights when compared to conventional regulations
- **Heathrow, Europe's busiest airport, successfully used TTA derived regulations to safely resolve periods of excessive runway demand and associated airborne holding, during peak operational days, with record numbers of Air Traffic Movements.**

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Making every journey better