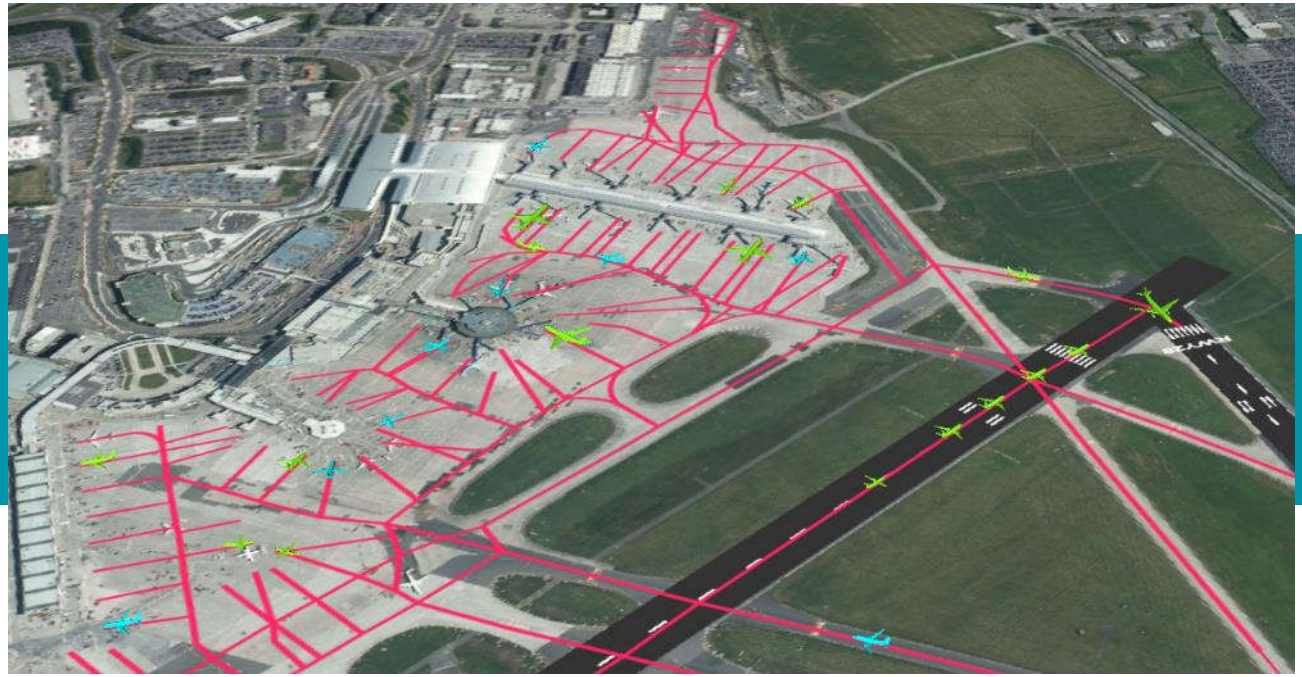
HELIOS
The aviation consultancy of Egis

Supplementary airfield projects assessment

Fast time simulations of selected PACE projects

12 January 2018



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Overview

The Commission for Aviation Regulation requested Helios simulate the operational impact of the following taxiway projects on airfield performance:

- Link 6 extension
- Link 3 extension
- Dual taxiway F (parallel Code E)
- Re-alignment of taxiway A (Code F)
- Widening of taxiways Z and B1 (parallel Code E)
- Combined impact of the projects above

The impact of new line-up points in the R10 direction was assessed separately.

Simulations

- FTS model of Dublin Airport developed for the Commission for Aviation Regulation within Helios' support to assessing S18 coordination parameters was used.
- All simulations were run using S18 forecast schedule with 36 departures in the peak hour.
- Random variation in block times of (-10;+10) minutes was added to scheduled block times.
- 10 iterations of each simulation were run and results were then averaged.
- All scenarios were simulated with RWY 28 in operations (with the exception of RWY 10 line-up points scenario).
- Results were compared against S18 baseline presented to Coordination Committee earlier in 2017.

Metrics

All scenarios were compared against the S18 forecast performance using these metrics:

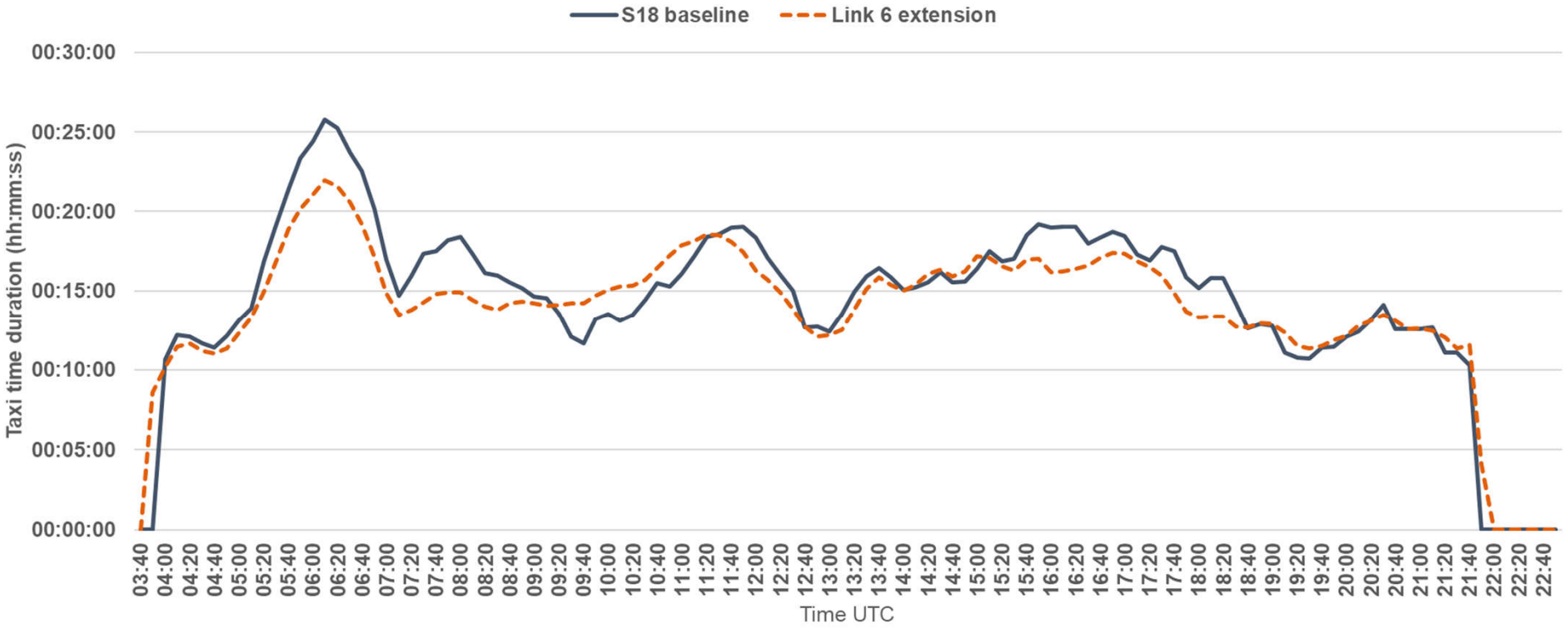
- Departure taxi out duration
  - Calculated as the time duration between off block and reaching the runway stopbar. This metric represents the actual time it takes the aircraft to get from stand to the runway.
- Runway holding delay
  - Calculated as the time duration between joining the back end of the runway queue and reaching the runway stopbar. This metric represents the delay caused by the runway demand being greater than the runway throughput. It is essentially the time spent waiting for the runway to become available.
- Departure taxi out duration minus runway delay
  - Calculated as the difference between the departure taxi out duration and the runway holding delay. This is essentially unimpeded taxi time plus any delay of the departing aircraft that is not runway related. This category includes delays caused by inefficiencies in taxiway layout, delays on ground caused by other traffic and pushback delays due to blockage by other aircraft.
- Arrival taxi in time
  - Calculated as the time duration the arriving aircraft has been taxiing between vacating the runway and reaching its final parking position.
- Arrival taxi delay
  - This metric represents any delay of arriving aircraft experienced on ground. This category includes delays caused by inefficiencies in taxiway layout or delays on ground caused by other traffic.
- Additionally, heat maps showing delay accumulated on taxiway segments and number of aircraft stoppings on taxiway segments were also produced.

Link 6 extension

Link 6 extension (R28)
Operational rules modelled

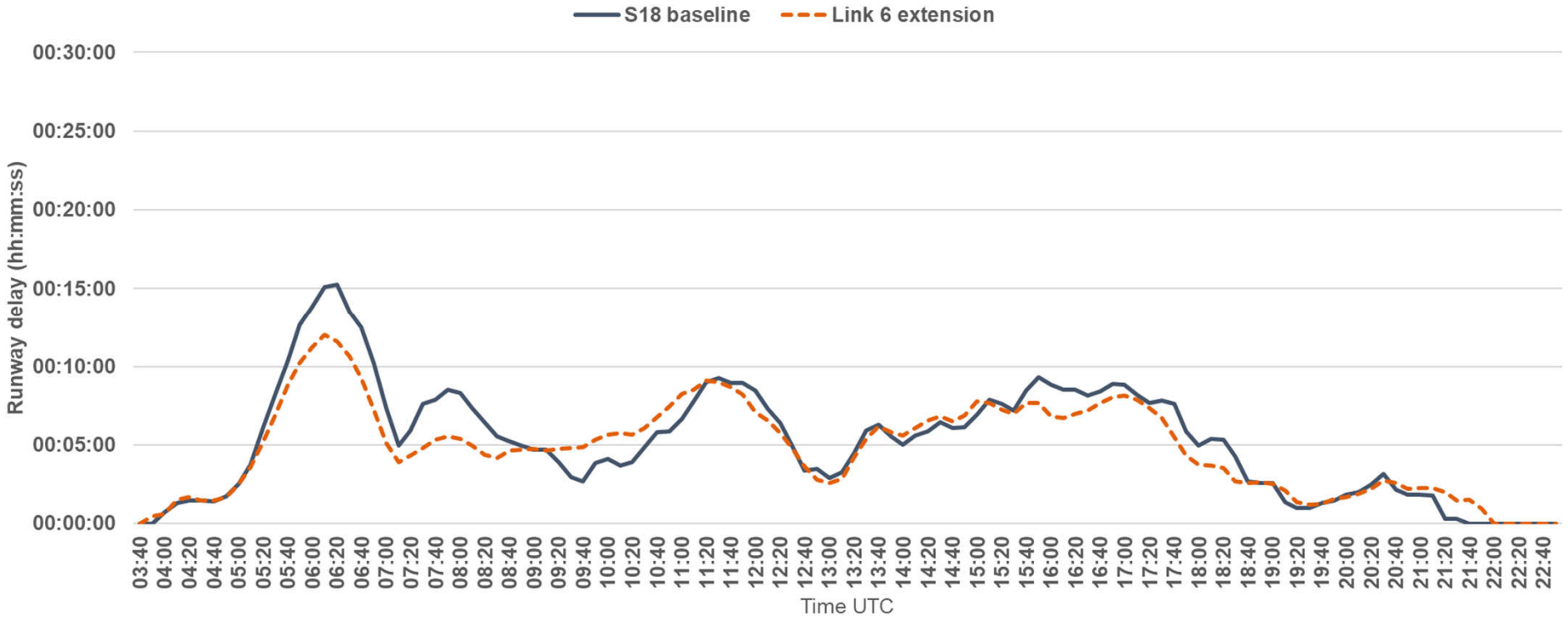
- Any aircraft of up to Code E size could use the Link 6 extension in both directions (in/out)
- Preferred departure taxi route for aircraft from Apron 5G and Pier 1 North is through Link 6 extension and RWY 16/34 to holding point for RWY 28
- Preferred arrival taxi route for aircraft to Apron 5G and Pier 1 North is through H2, RWY 16/34 and Link 6 extension
- Towed aircraft given an option to consider Link 6 extension in the towing routes

Link 6 extension (R28)
Departure taxi out time



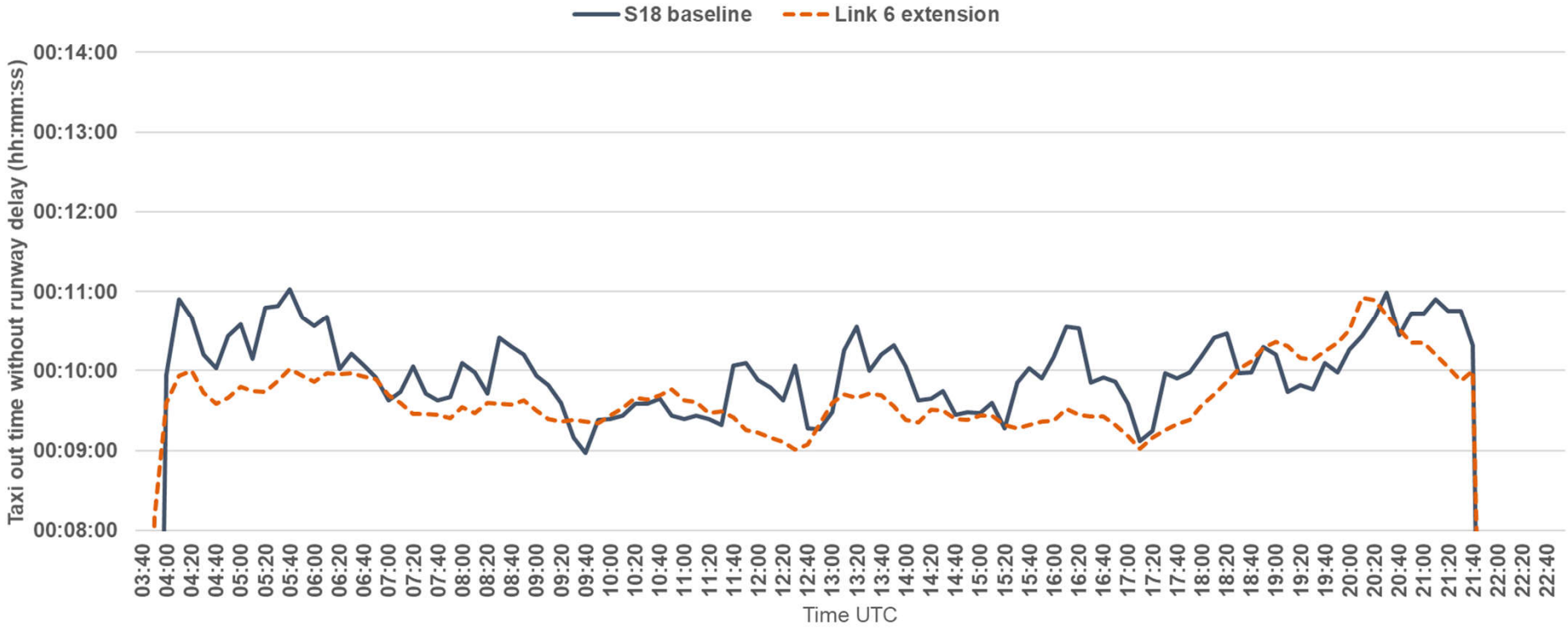
- Measured impact:
  - Peak change: -00:03:48
  - Average change: -00:00:46
- The key drivers for shorter taxi out times are less congestion on taxiway F, Link 5 and Link 4, and different departure sequence

Link 6 extension (R28)
Runway delay



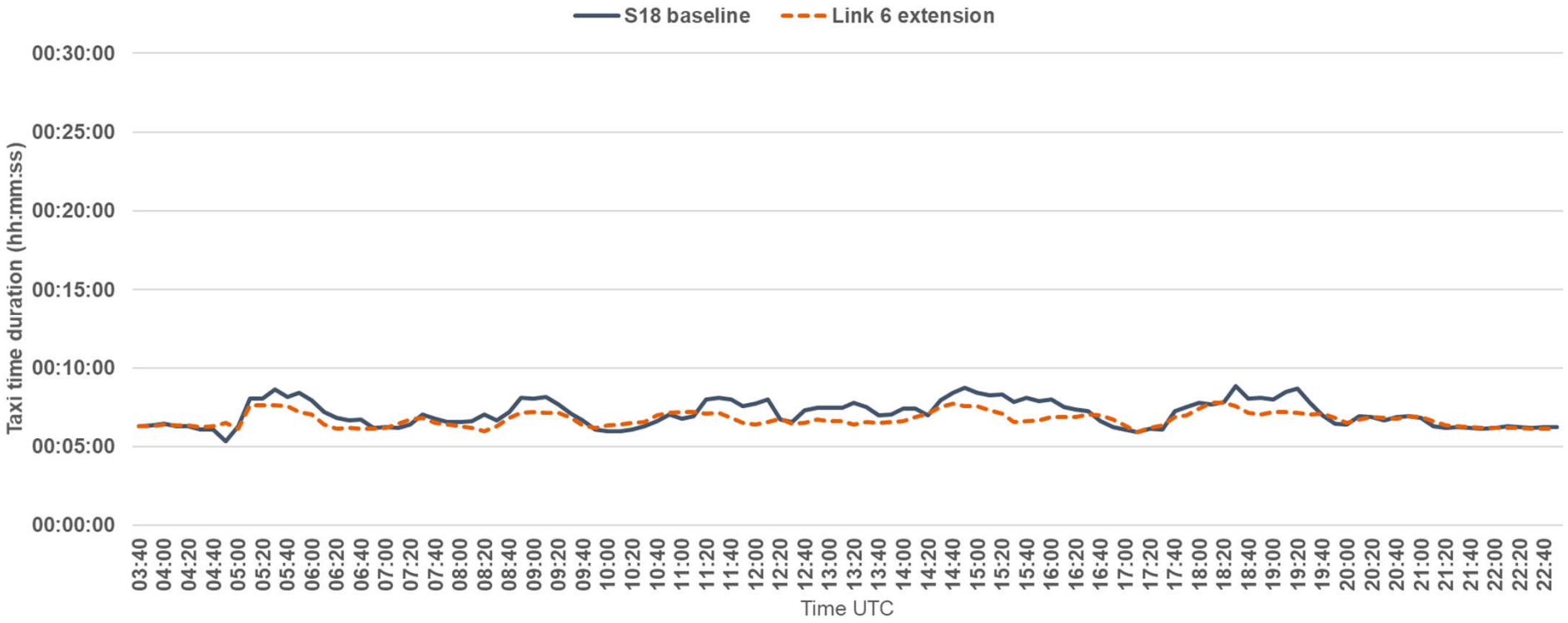
- Measured impact:
  - Peak change: -00:03:37
  - Average change: -00:00:27
- Decrease in the morning peak runway delay attributable to different departure sequence as part of the aircraft coming from the north of the airport use the new Link 6 extension while others take F-inner.

Link 6 extension (R28)
Departure taxi time without runway delay



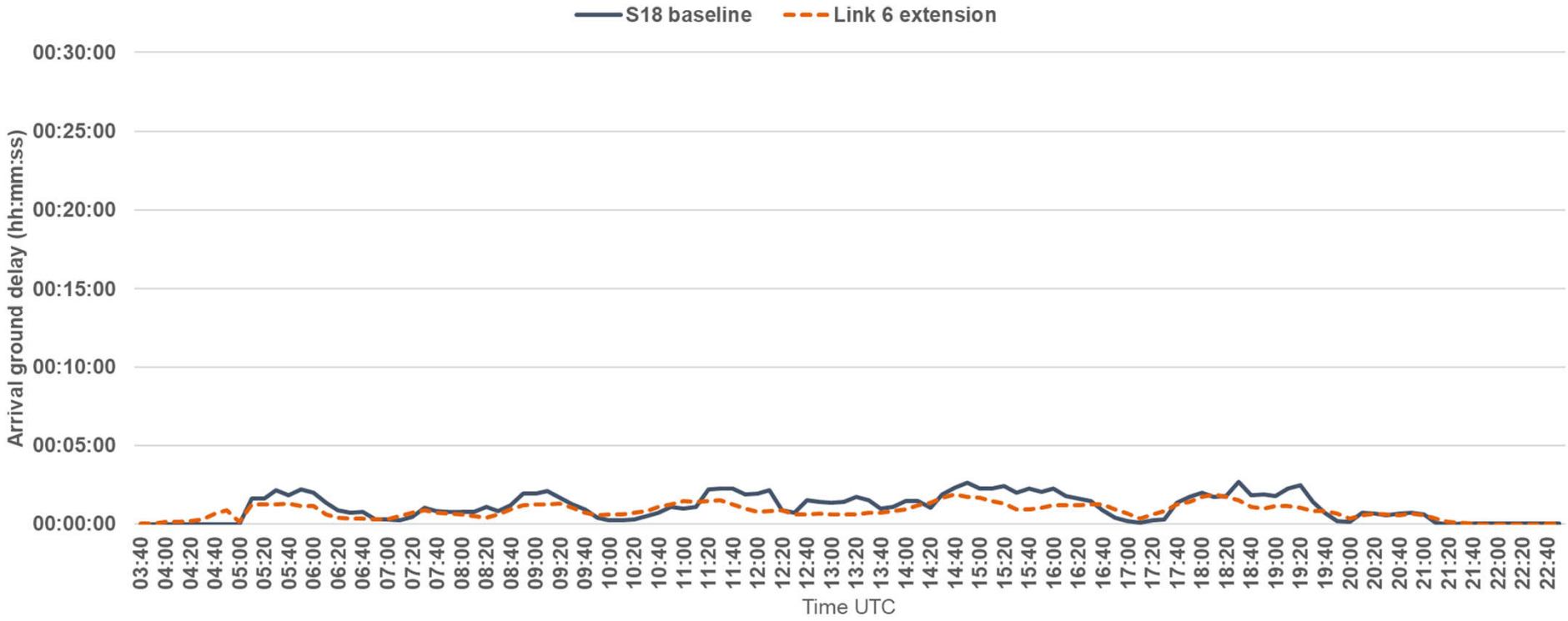
- Measured impact:
  - Peak change: -00:01:05
  - Average change: -00:00:19
- Periods of improvements aligned with periods of short-haul activity from Pier 1 North and Apron 5G.
- Aircraft from Apron 5G and Pier 1 North going through Link 6 extension and RWY 16/34

Link 6 extension (R28)
Arrival taxi in duration



- Measured impact:
  - Peak change: -00:01:34
  - Average change: -00:00:22
- Slight improvement throughout the whole day

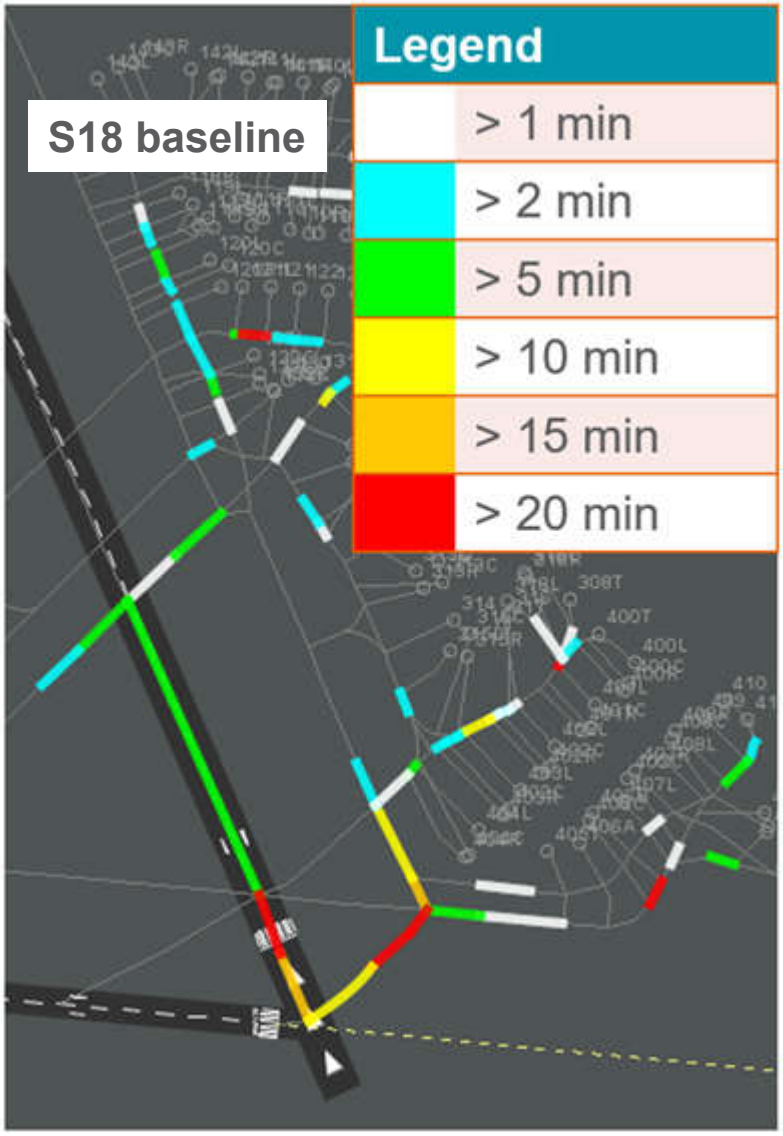
Link 6 extension (R28)
Arrival taxi delay

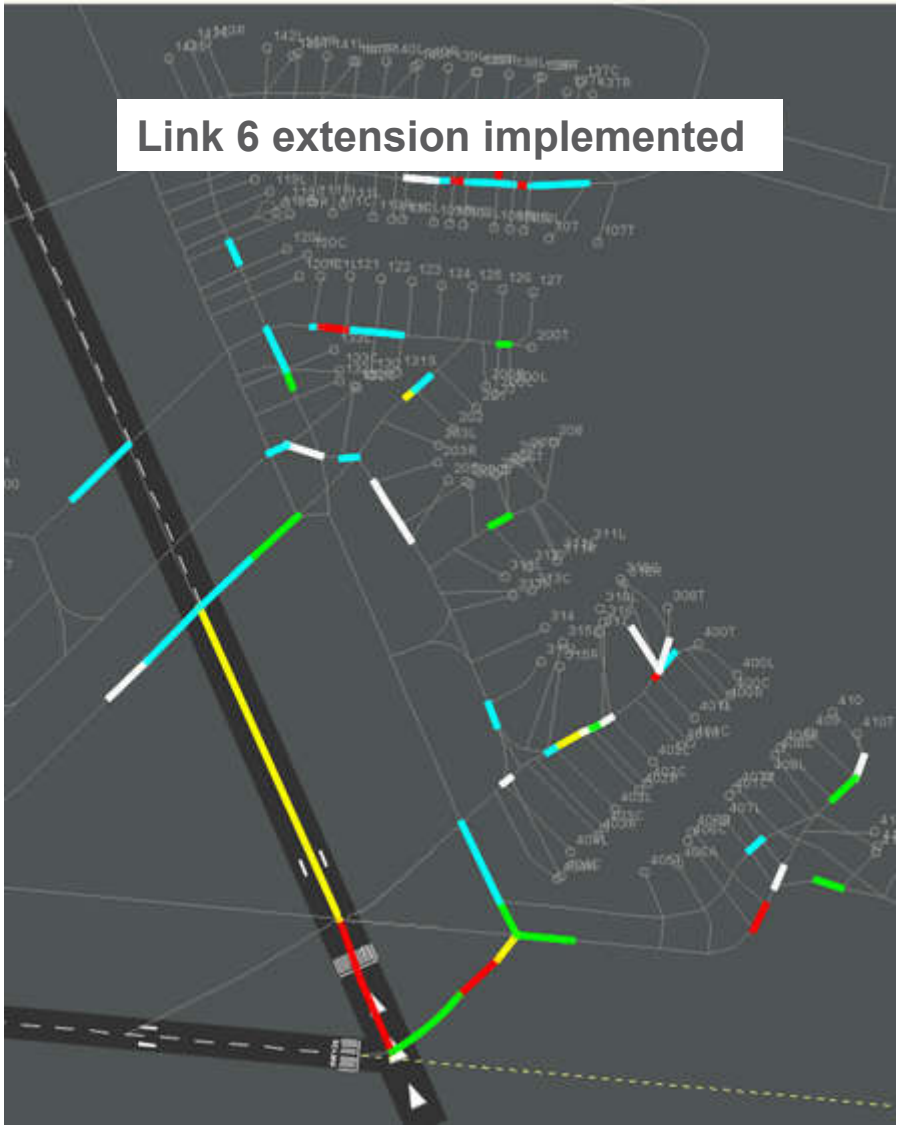


- Measured impact:
  - Peak change: -00:01:25
  - Average change: -00:00:16
- Delays reduced in periods when Pier 1 North and Apron 5G aircraft come in. Instead of going through complex area between Link 4 and Link 6 these arrivals use RWY 16/34 and Link 6 extension to get to their parking position.

Link 6 extension (R28)

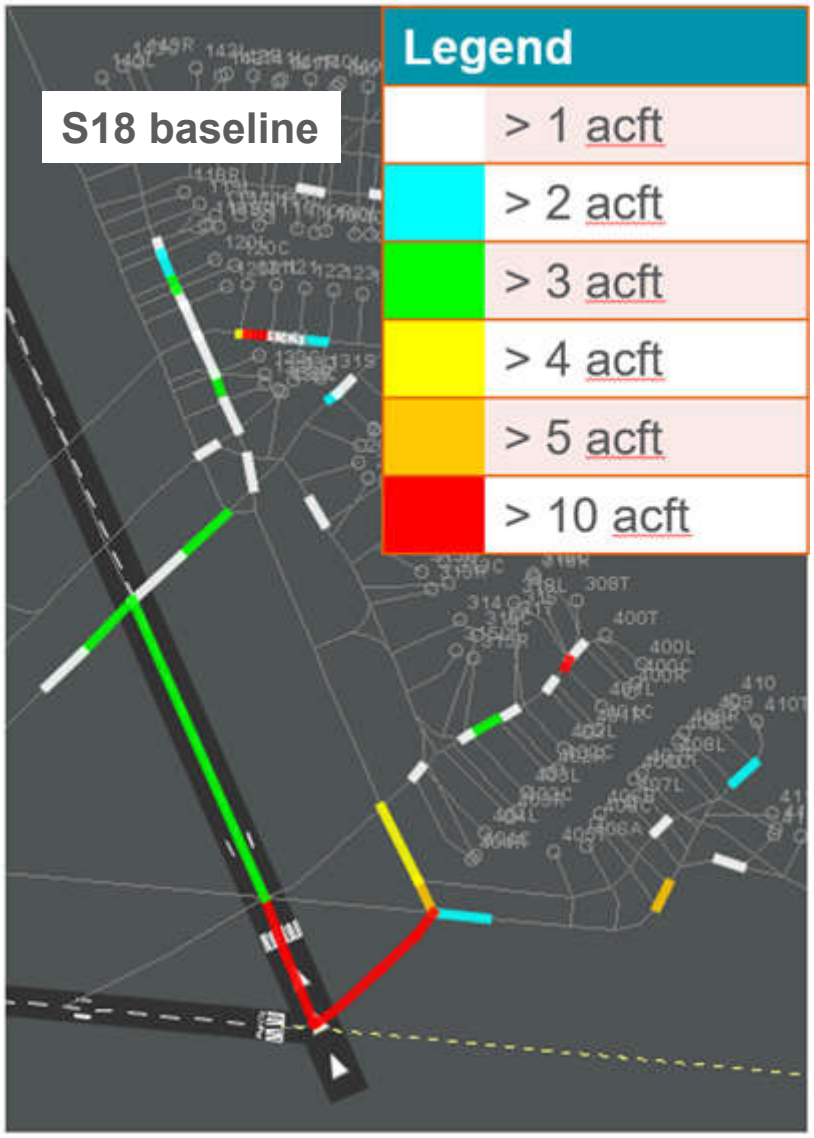
Delay accumulated on taxiway segments throughout the day

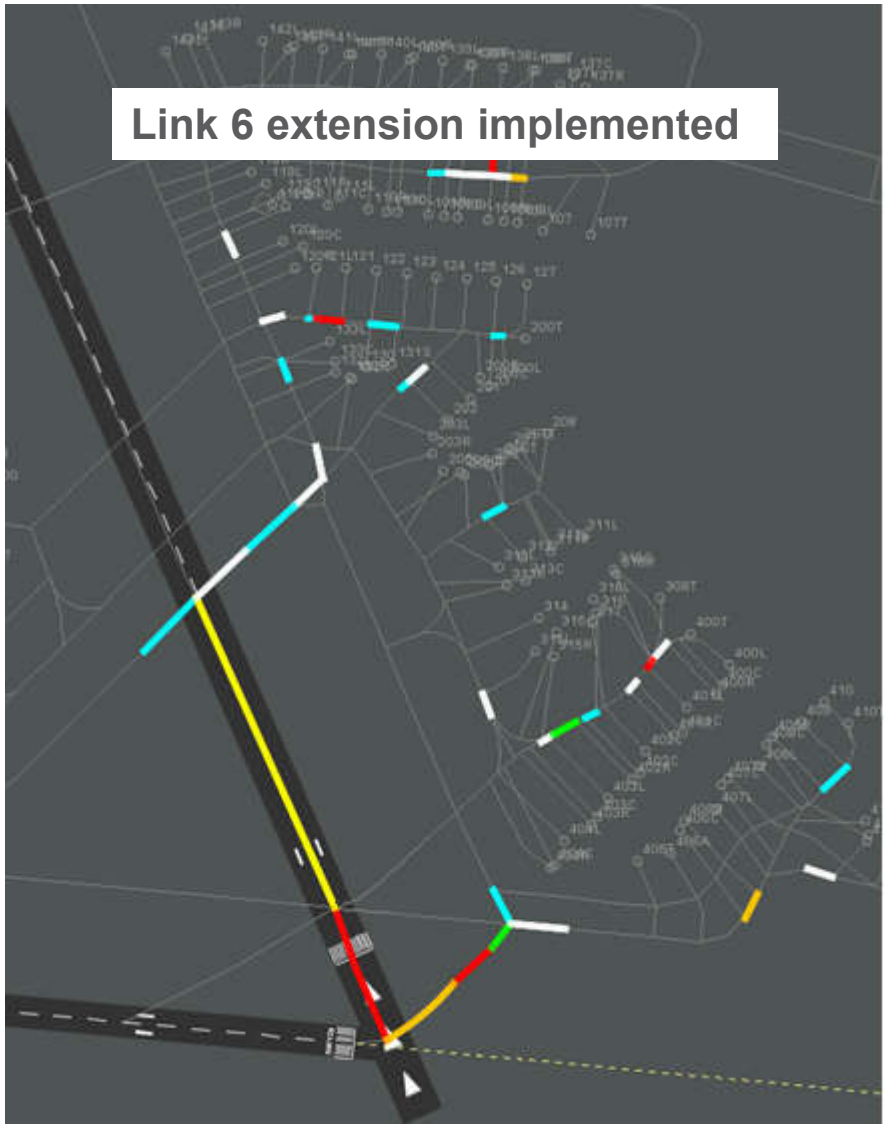




Link 6 extension (R28)

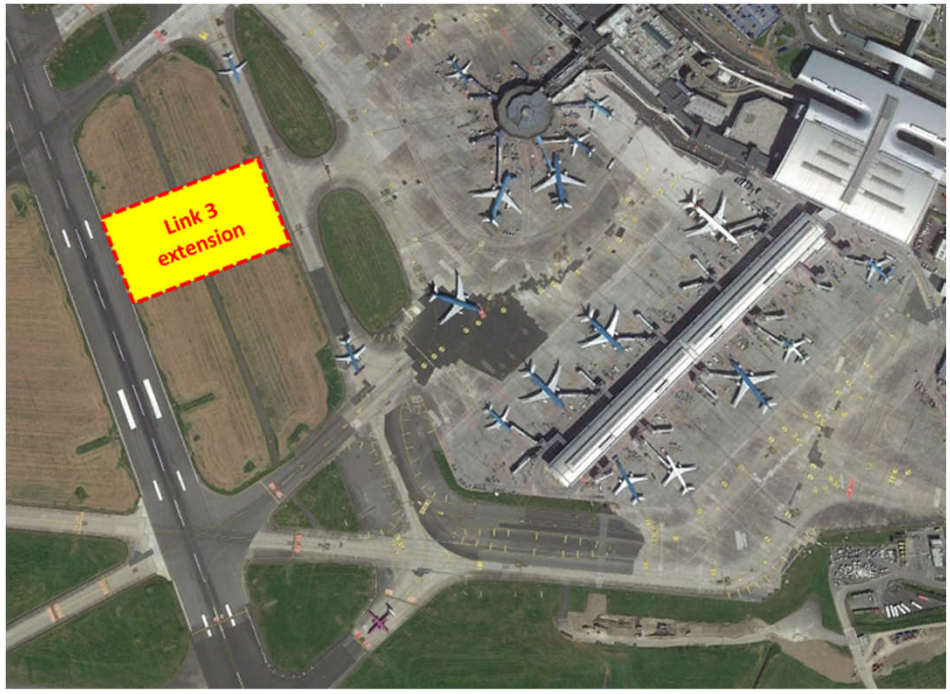
Aircraft stoppings on taxiway segments throughout the day





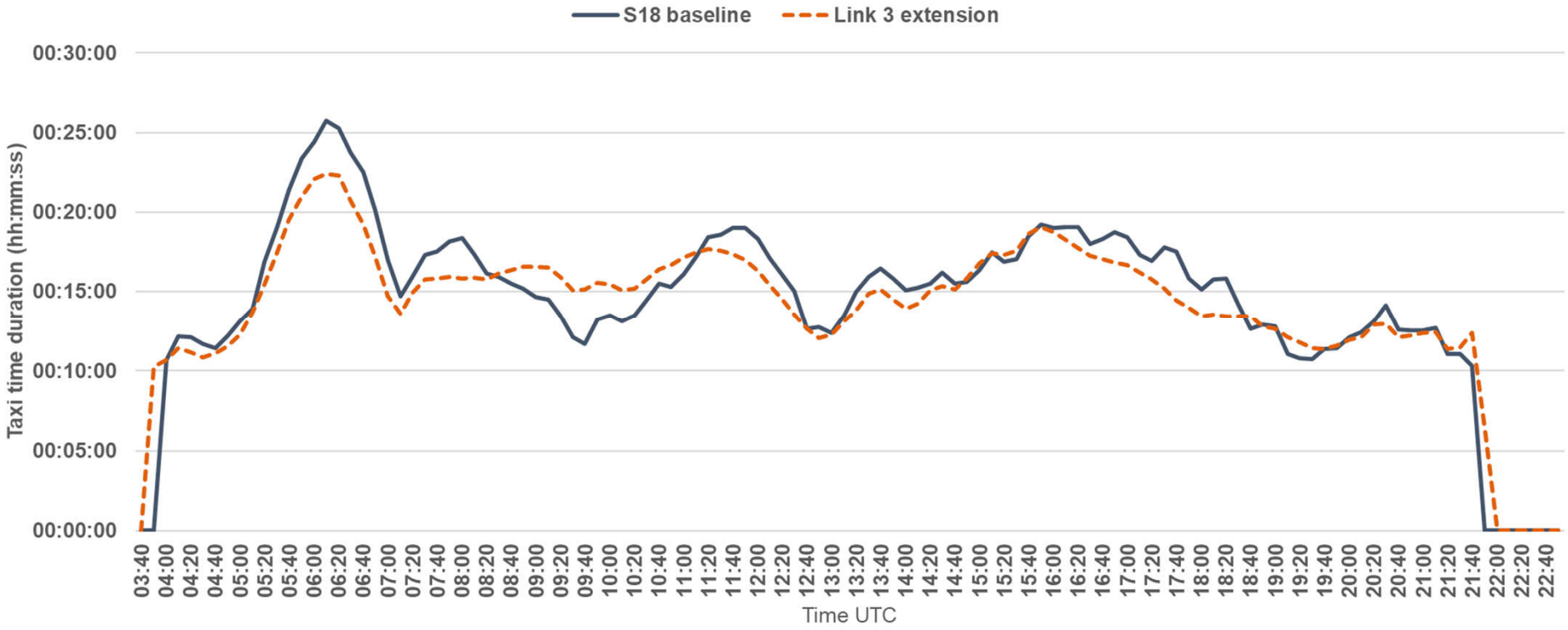
Link 3 extension

Link 3 extension (R28)
Operational rules modelled



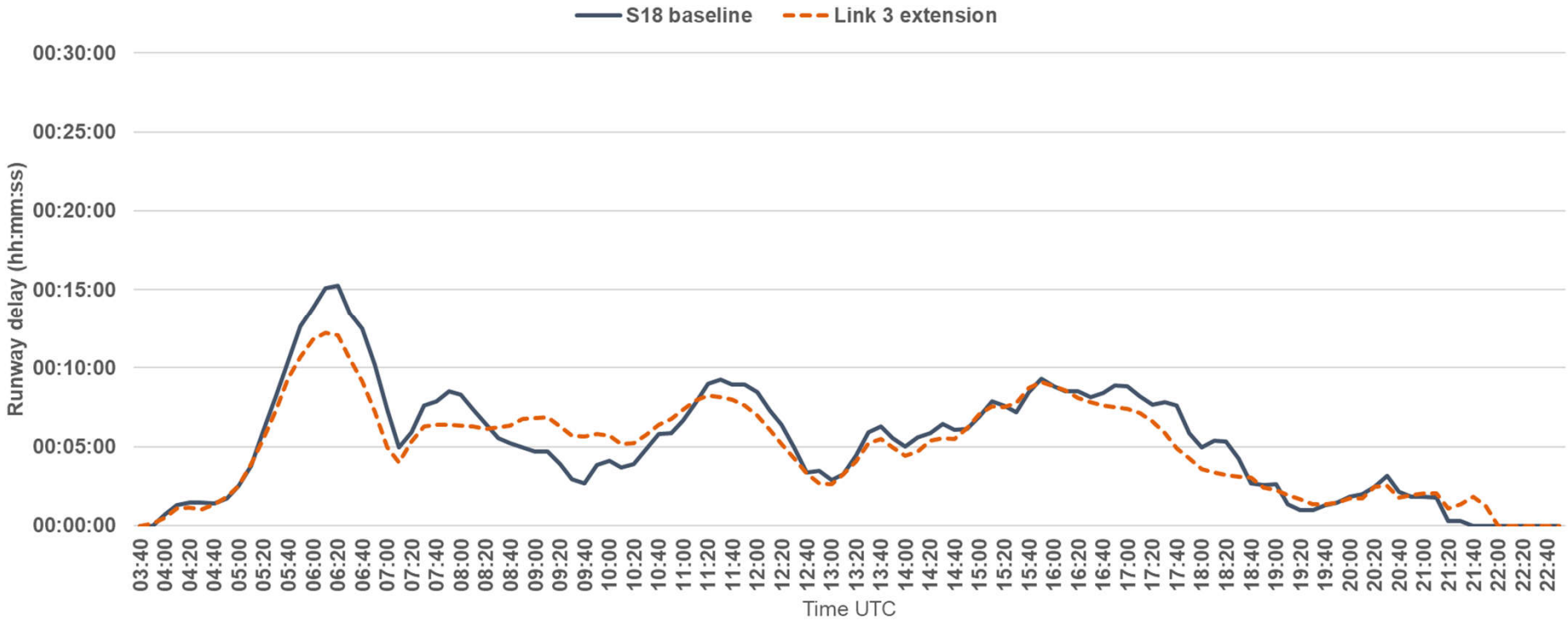
- Any aircraft of up to Code E size could use the Link 3 extension in both directions (in/out)
- Optional departure taxi route for aircraft from Pier 3 and Pier 4 through Link 3 extension to join the queue on RWY 16/34
- Optional arrival taxi route avoiding Link 4
- Towed aircraft were given an option to consider Link 3 extension in the towing routes

Link 3 extension (R28)
Departure taxi out time



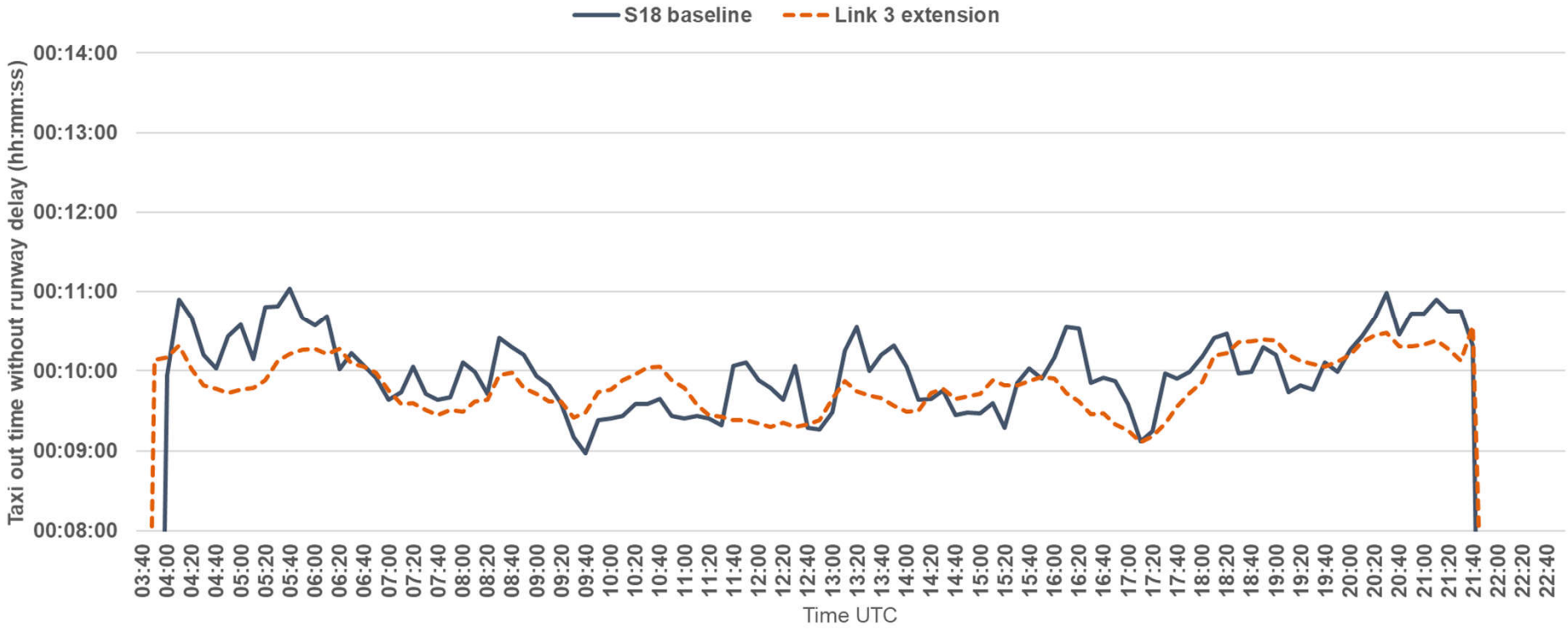
- Measured impact:
  - Peak change: -00:03:21
  - Average change: -00:00:33
- The key drivers for shorter taxi out times are less congestion on taxiway F, Link 2 and Link 1, and different departure sequence

Link 3 extension (R28)
Runway delay



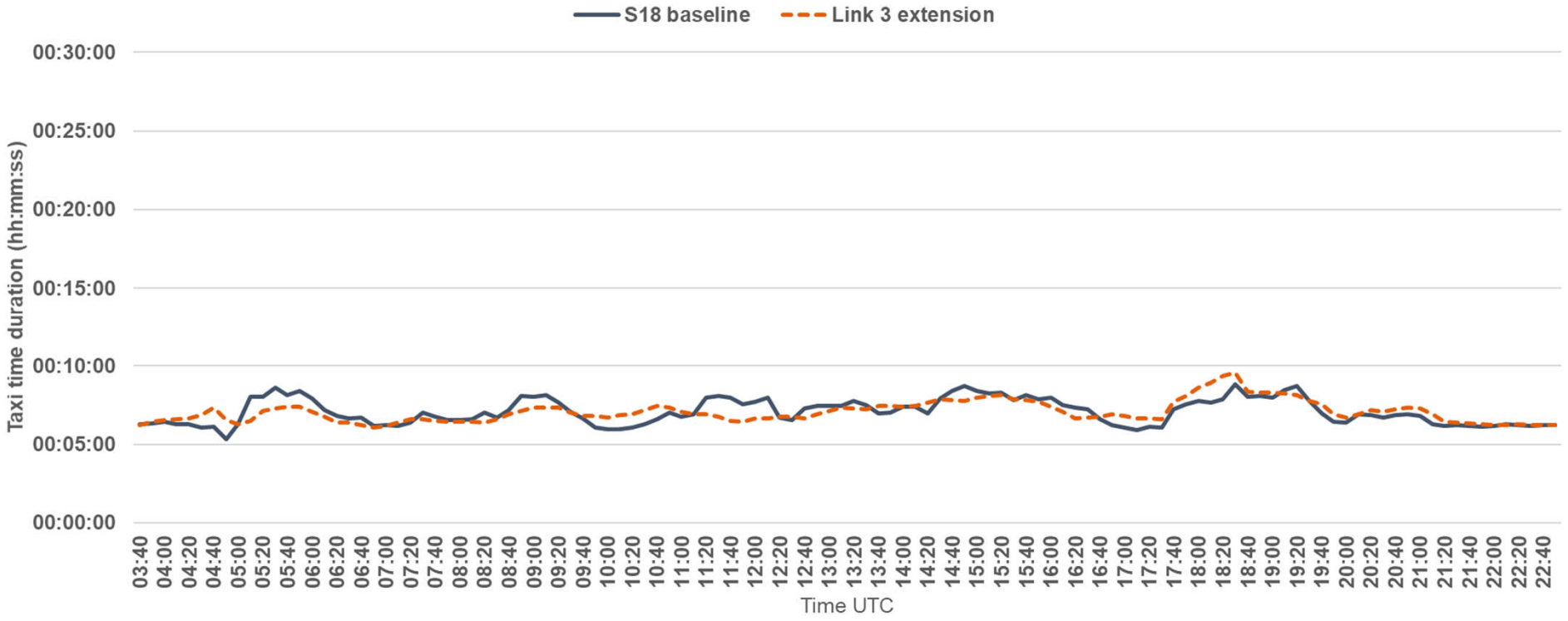
- Measured impact:
  - Peak change: -00:03:19
  - Average change: -00:00:22
- Decrease in the morning peak runway delay thanks to different departure sequence as part of the aircraft coming from Pier 3 use the new Link 3 extension to join the queue on RWY 16/34

Link 3 extension (R28)
Departure taxi time without runway delay



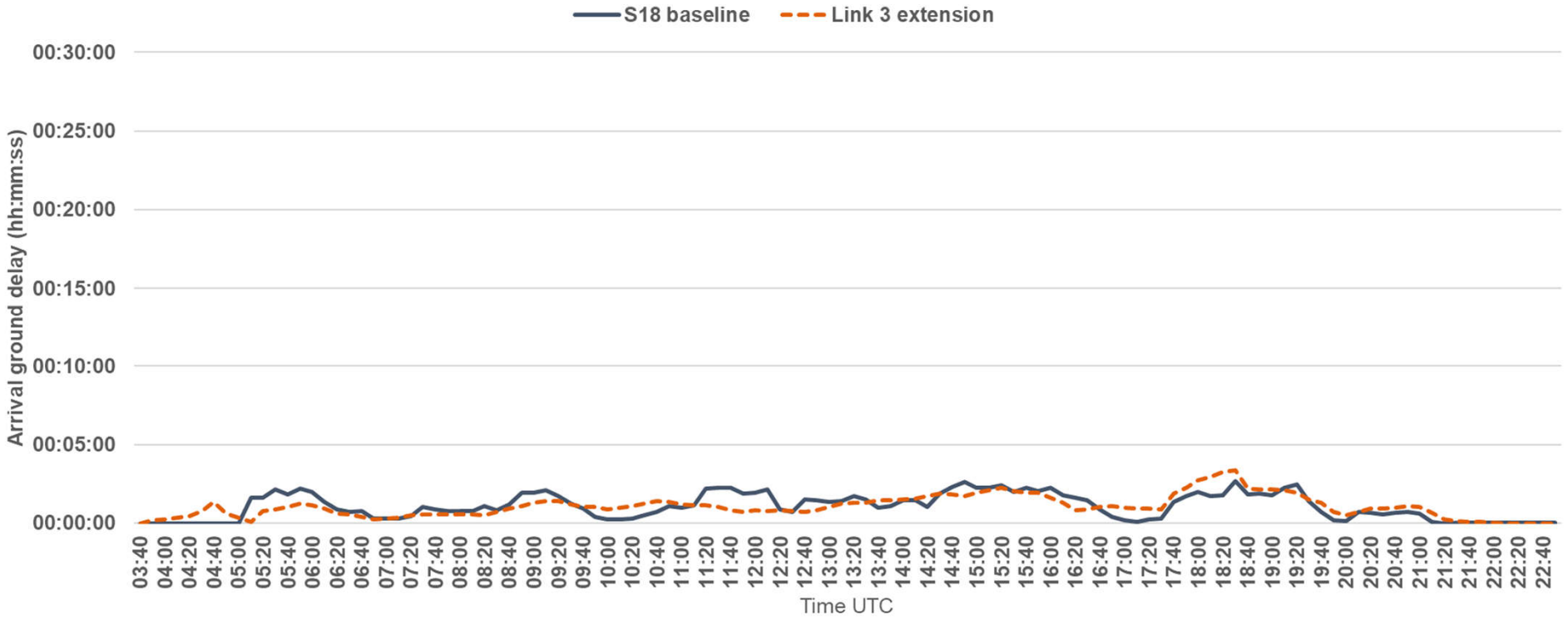
- Measured impact:
  - Peak change: -00:00:55
  - Average change: -00:00:10
- Shorter taxi times thanks to decreased traffic complexity near F2 and Link 2

Link 3 extension (R28)
Arrival taxi in duration



- Measured impact:
  - Peak change: -00:01:31
  - Average change: -00:00:01
- No significant improvement when averaged over the whole day

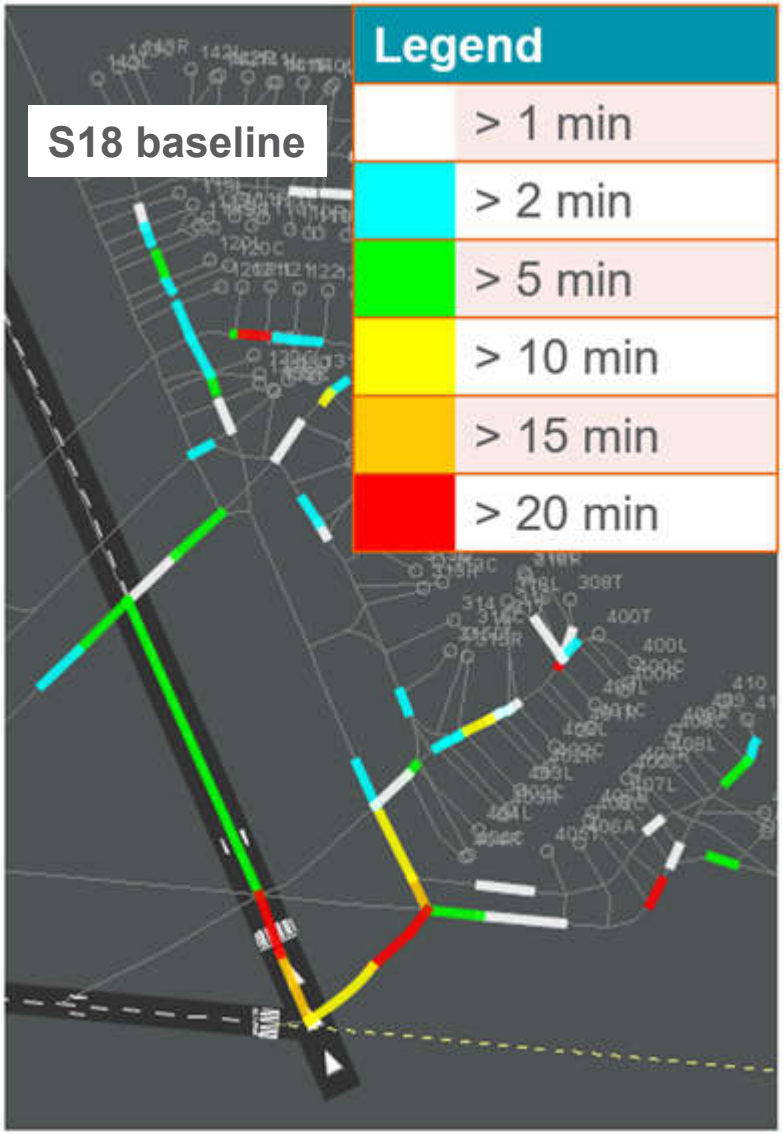
Link 3 extension (R28)
Arrival taxi delay

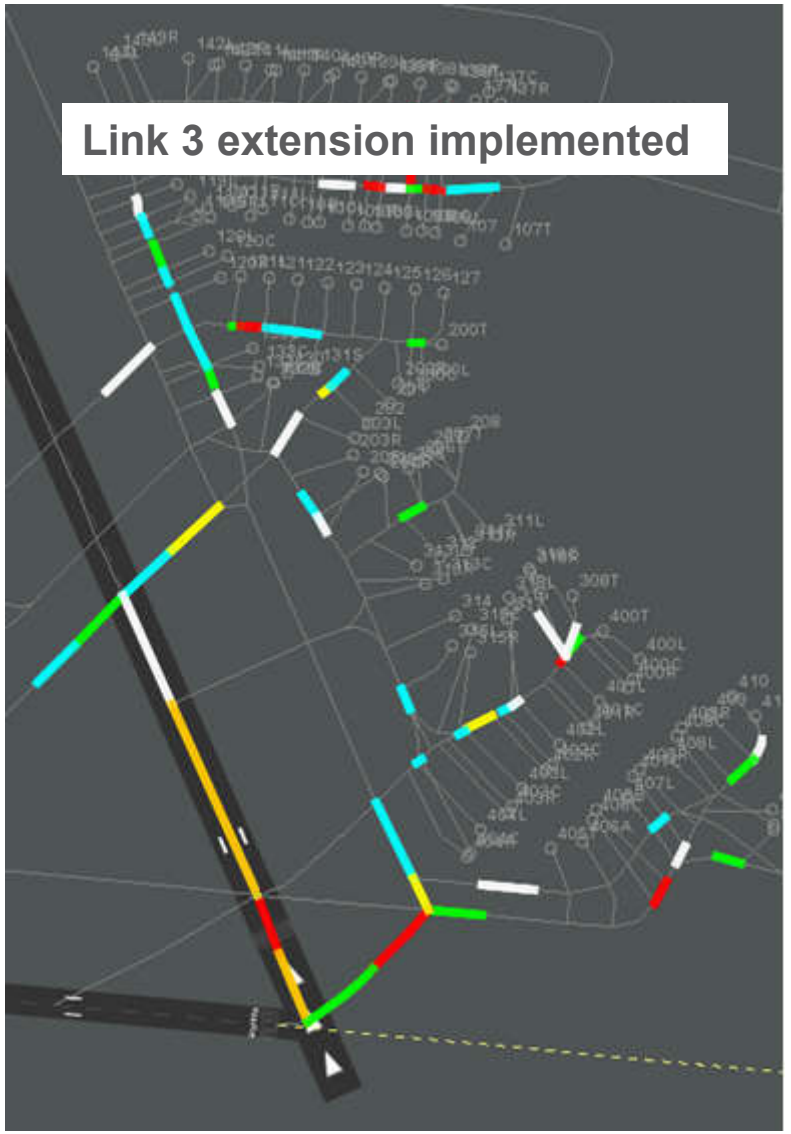


- Measured impact:
  - Peak change: -00:01:33
  - Average change: -00:00:01
- Minor local reduction in taxi delays thanks to congestion relief on F2 and Link 2

Link 3 extension (R28)

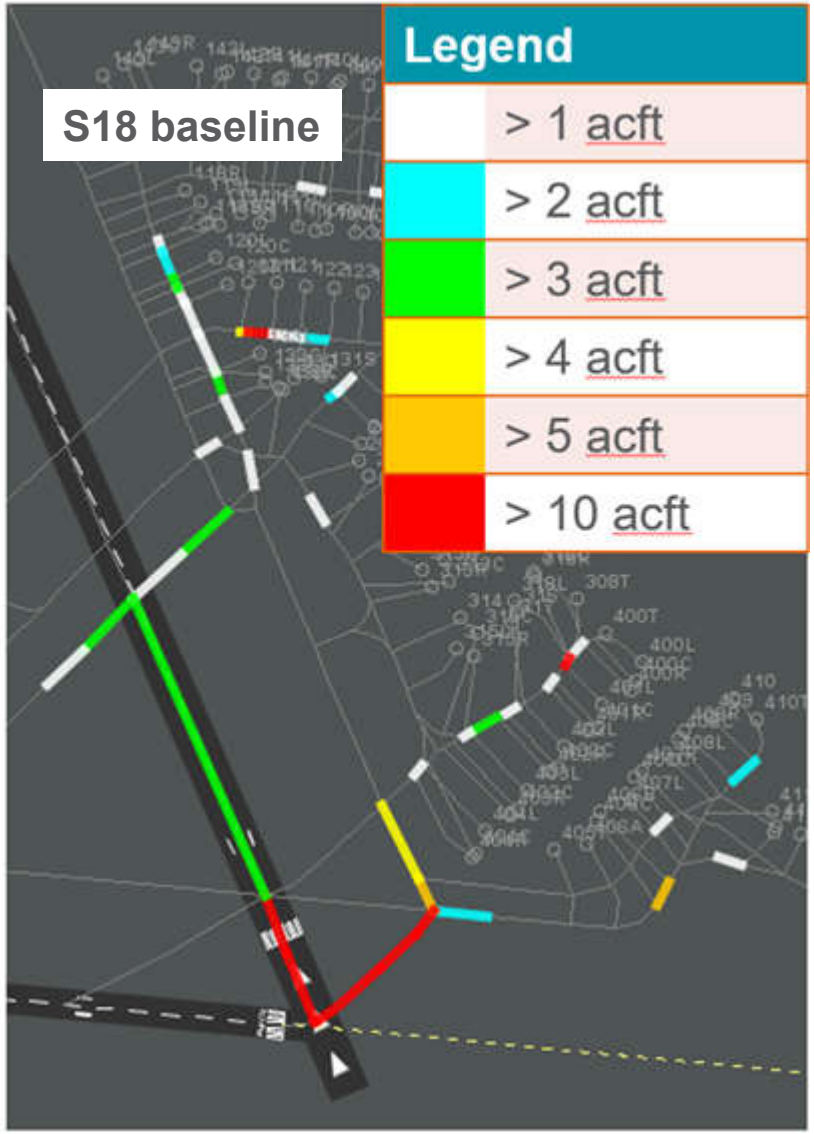
Delay accumulated on taxiway segments throughout the day

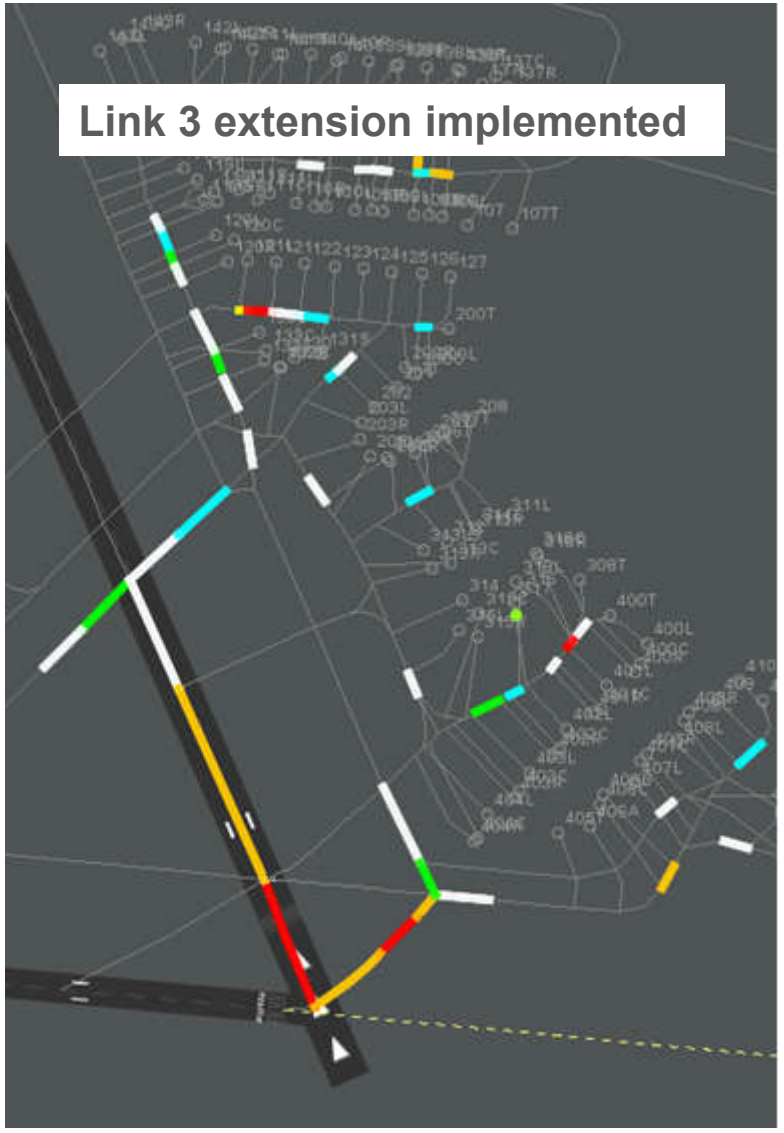




Link 3 extension (R28)

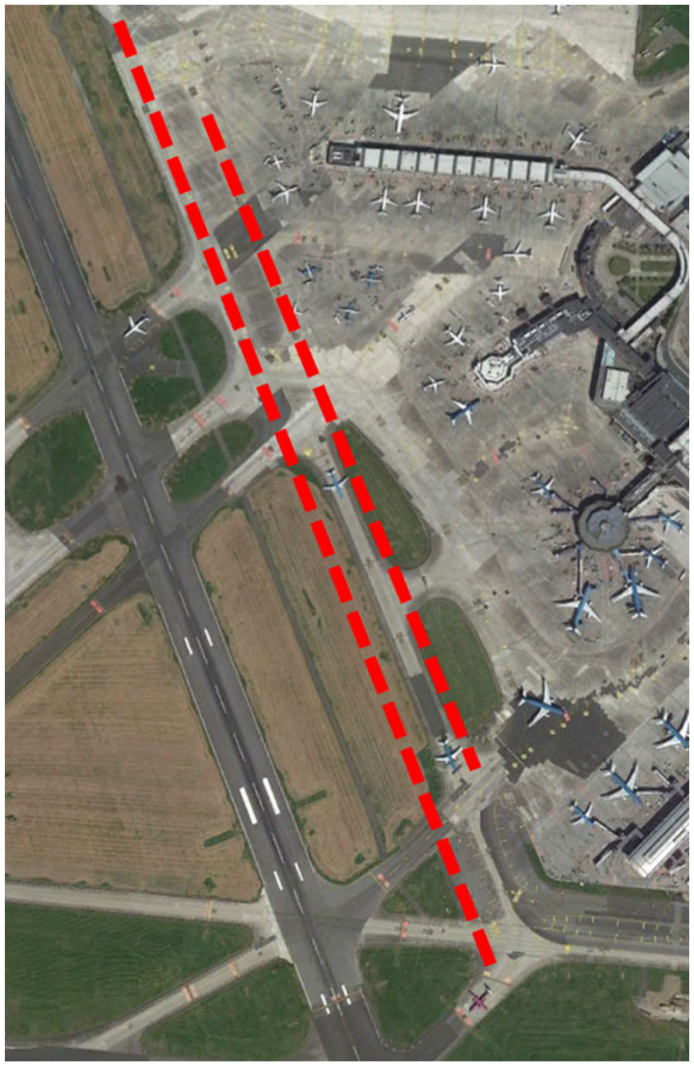
Aircraft stoppings on taxiway segments throughout the day





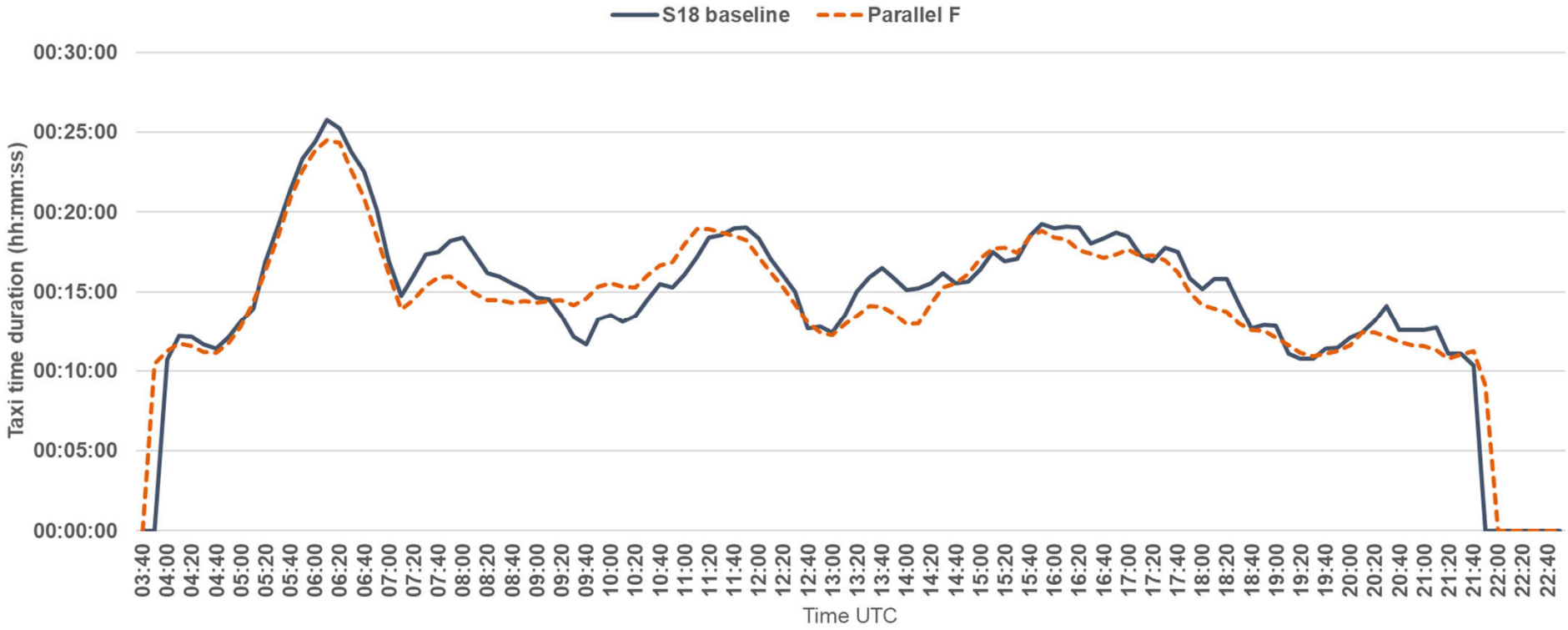
Dual taxiway F
(parallel Code E operations)

Dual taxiway F (R28)
Operational rules modelled



- Parallel operations of Code E aircraft on segments between Link 2 and Link 6 enabled
- F-outer to be used for arrival traffic
- F-inner to be used for departure traffic
- Aircraft in both directions given option to consider new segments of parallel F in their taxi routes
- All towed aircraft will be given option to consider new segments of parallel F in their towing routes

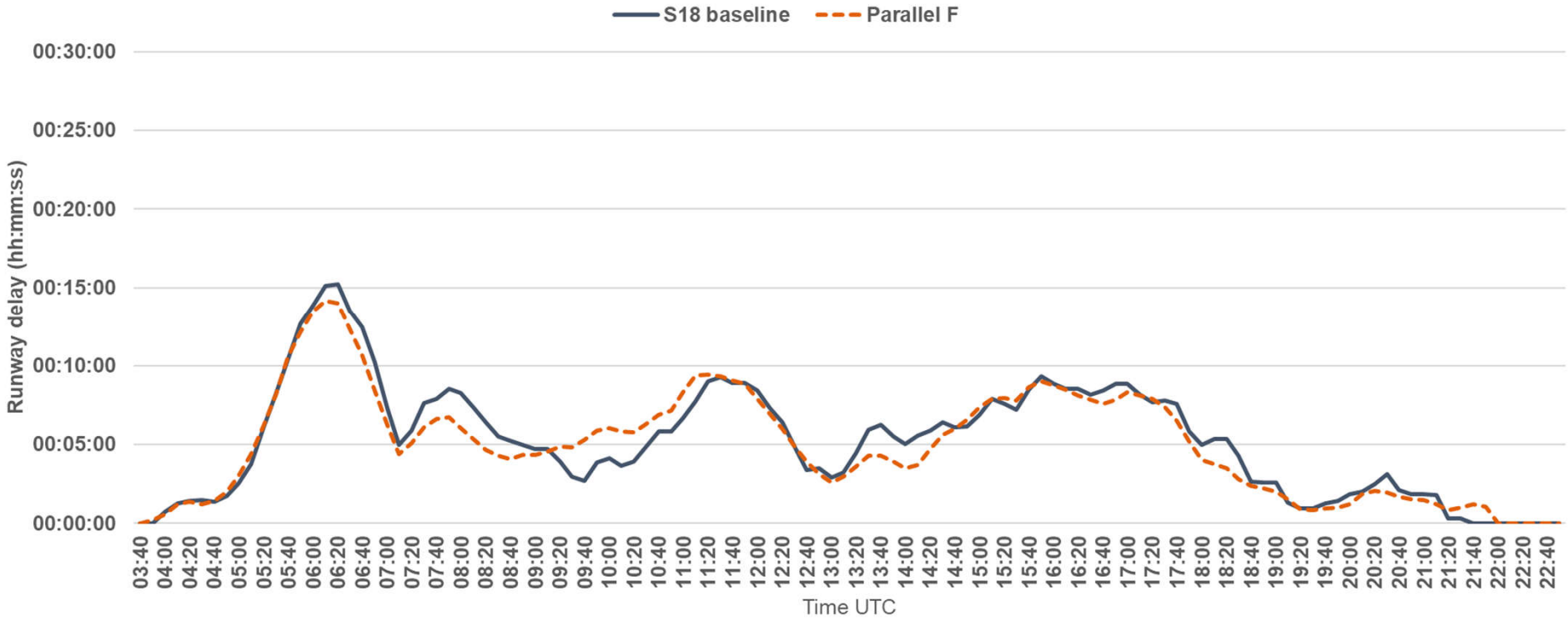
Dual taxiway F (R28)
Departure taxi out time



- Measured impact:
  - Peak change: -00:03:01
  - Average change: -00:00:28

- Simulations indicate rather large variability in impact of parallel F on taxi times in the first peak period. The 10 runs executed showed peak taxi times as low as 22 minutes but also in excess of 26 minutes.

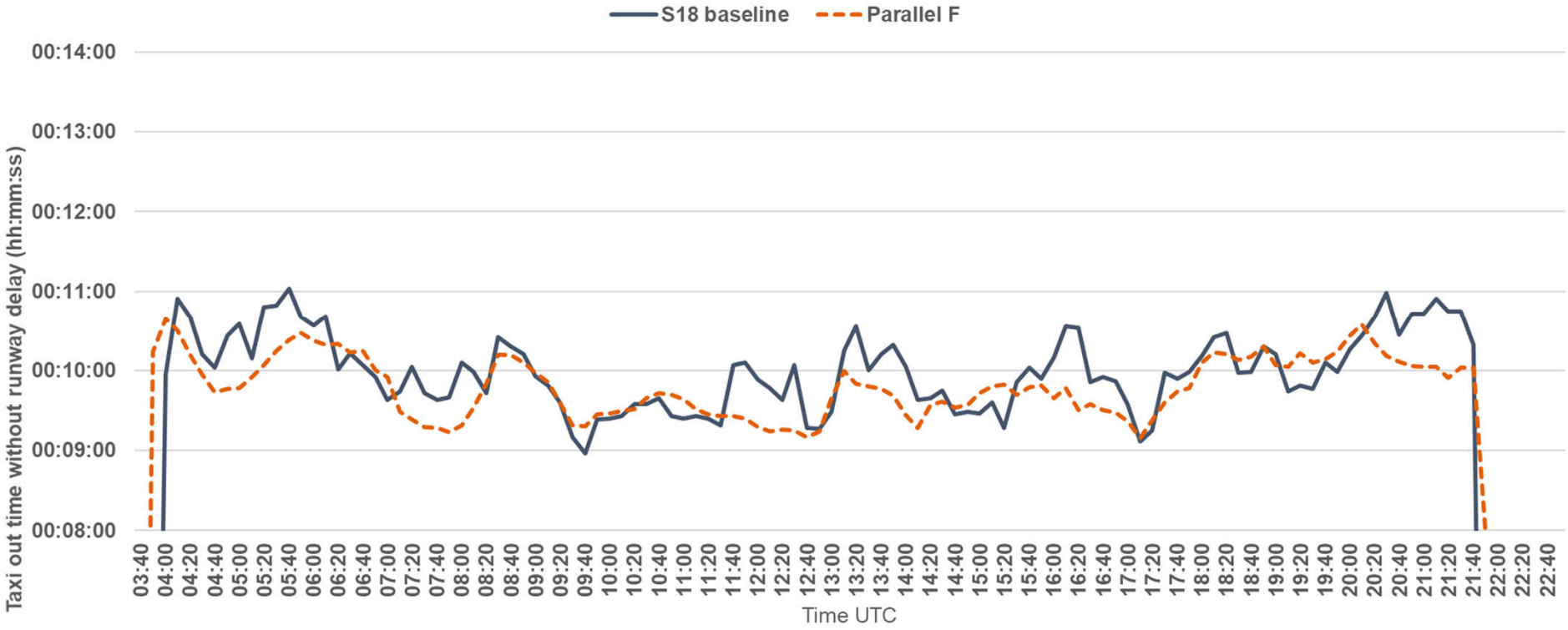
Dual taxiway F (R28)
Runway delay



- Measured impact:
  - Peak change: -00:02:13
  - Average change: -00:00:16

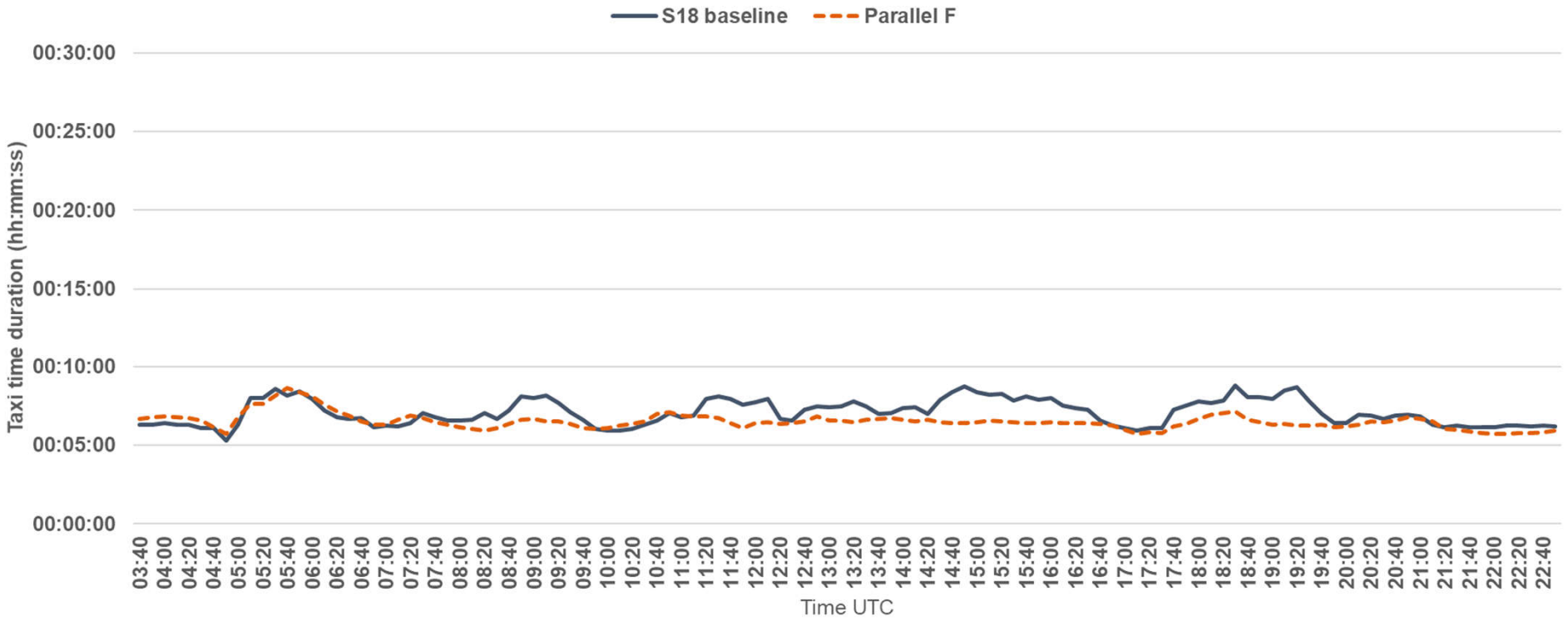
- Runway delay remains relatively constant throughout the day with minor improvements after the two main peaks (improved departure sequence).
- Increase between 0920 and 1120 can be attributed to randomized block times

Dual taxiway F (R28)
Departure taxi time without runway delay



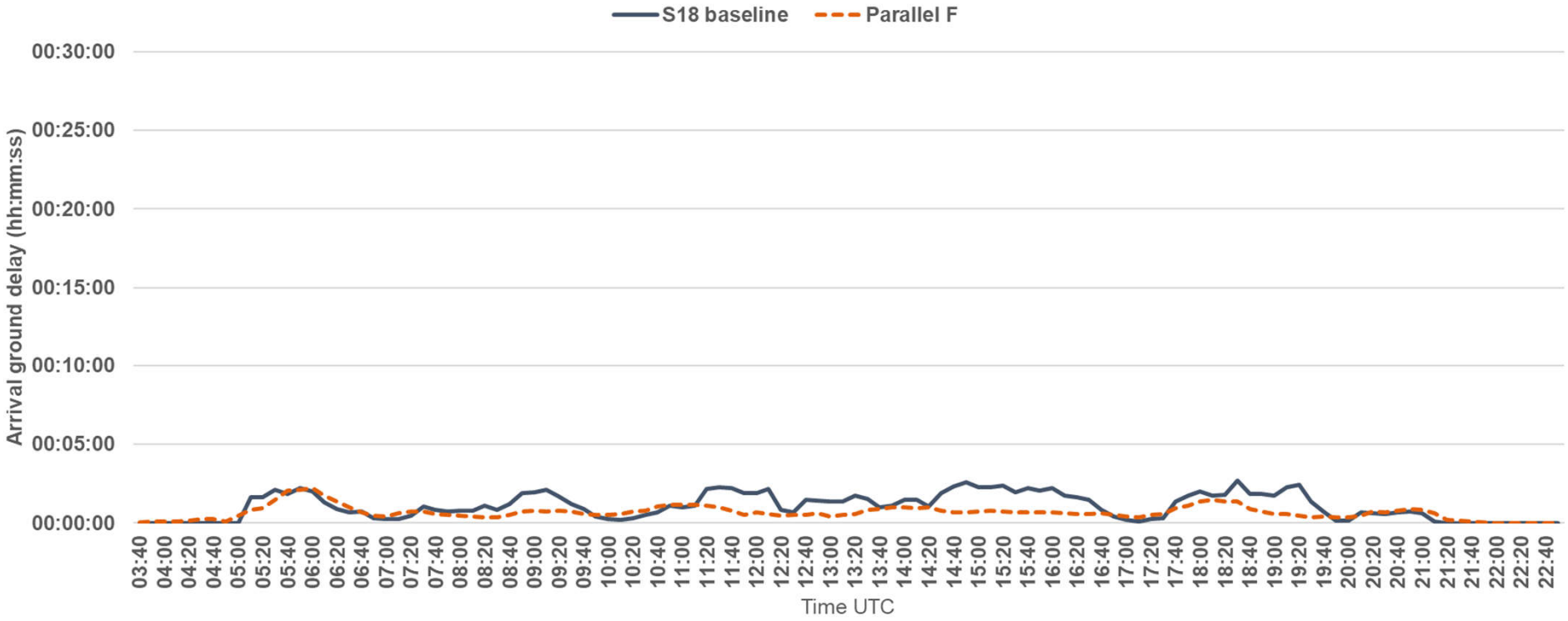
- Measured impact:
  - Peak change: -00:01:02
  - Average change: -00:00:12
- Although the average benefit seems relatively low (12 seconds), it should be noted this option has a potential to decrease traffic complexity (and increased safety) at Link 2 and Link 4

Dual taxiway F (R28)
Arrival taxi in duration



- Measured impact:
  - Peak change: -00:02:28
  - Average change: -00:00:35
- Noticeable decrease in arrival taxi in time (between half and two and half minutes) stemming from reductions in arrival taxi delays (next slide) and decreased traffic density on F

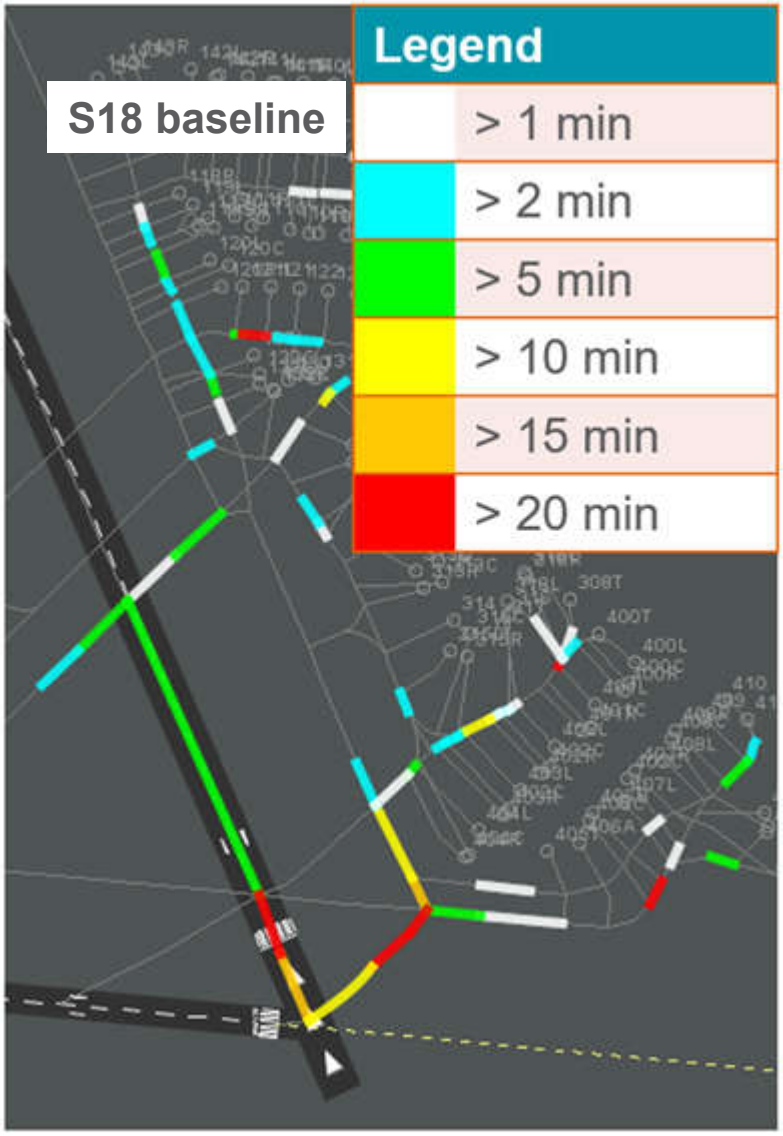
Dual taxiway F (R28)
Arrival taxi delay

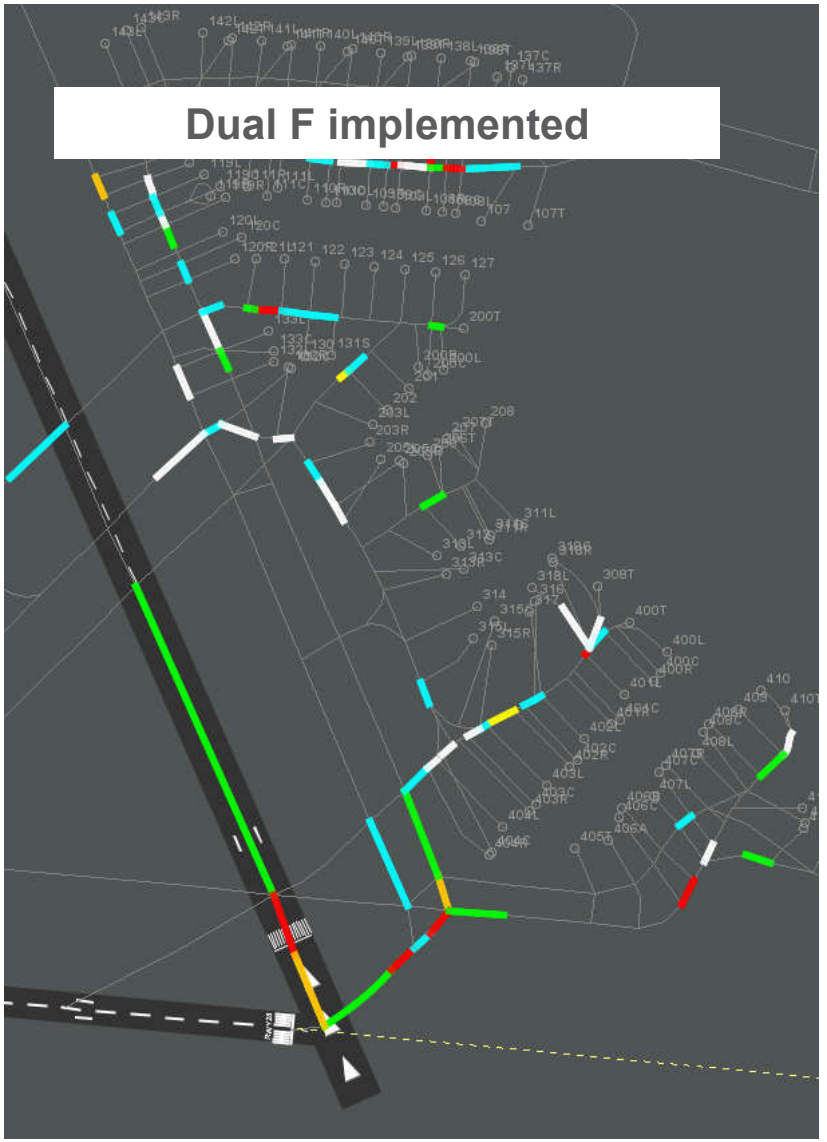


- Measured impact:
  - Peak change: -00:02:00
  - Average change: -00:00:25
- Noticeable decrease in arrival taxi in delay (up to two minutes) stemming from better access to Pier 4, South Apron and Pier 1 North and Apron 5G.

Dual taxiway F (R28)

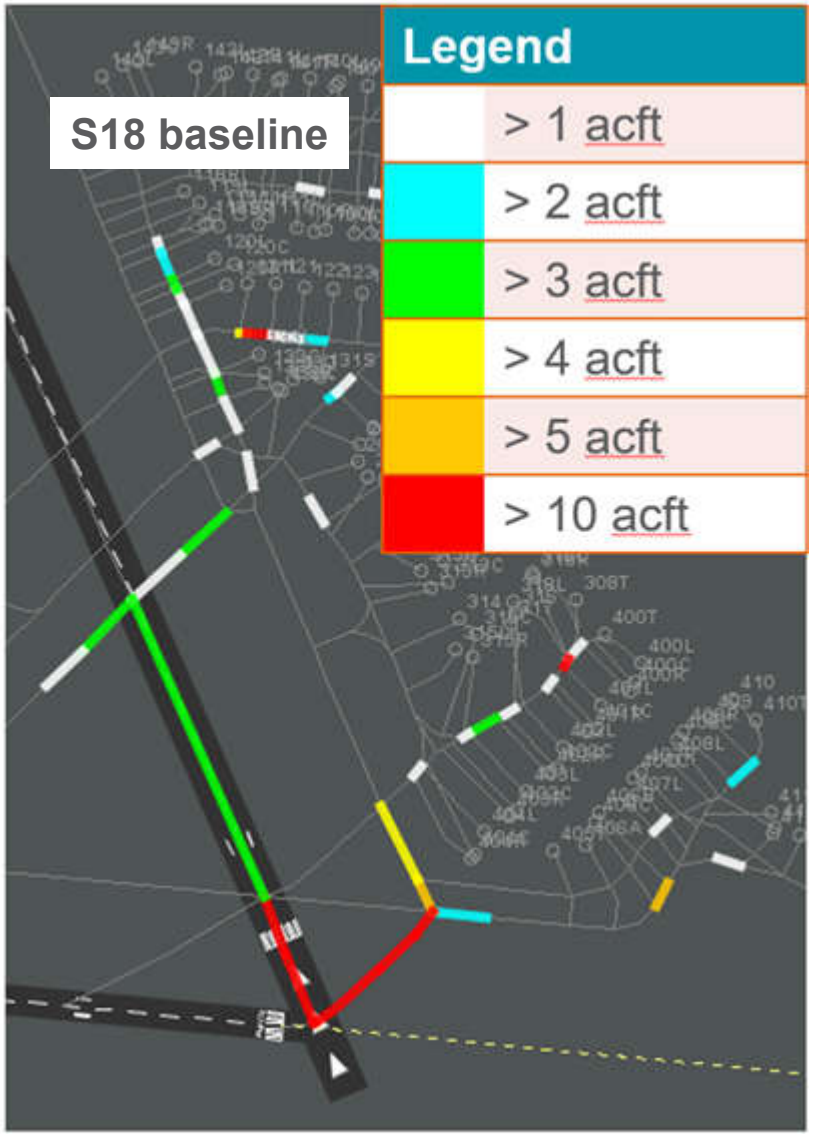
Delay accumulated on taxiway segments throughout the day

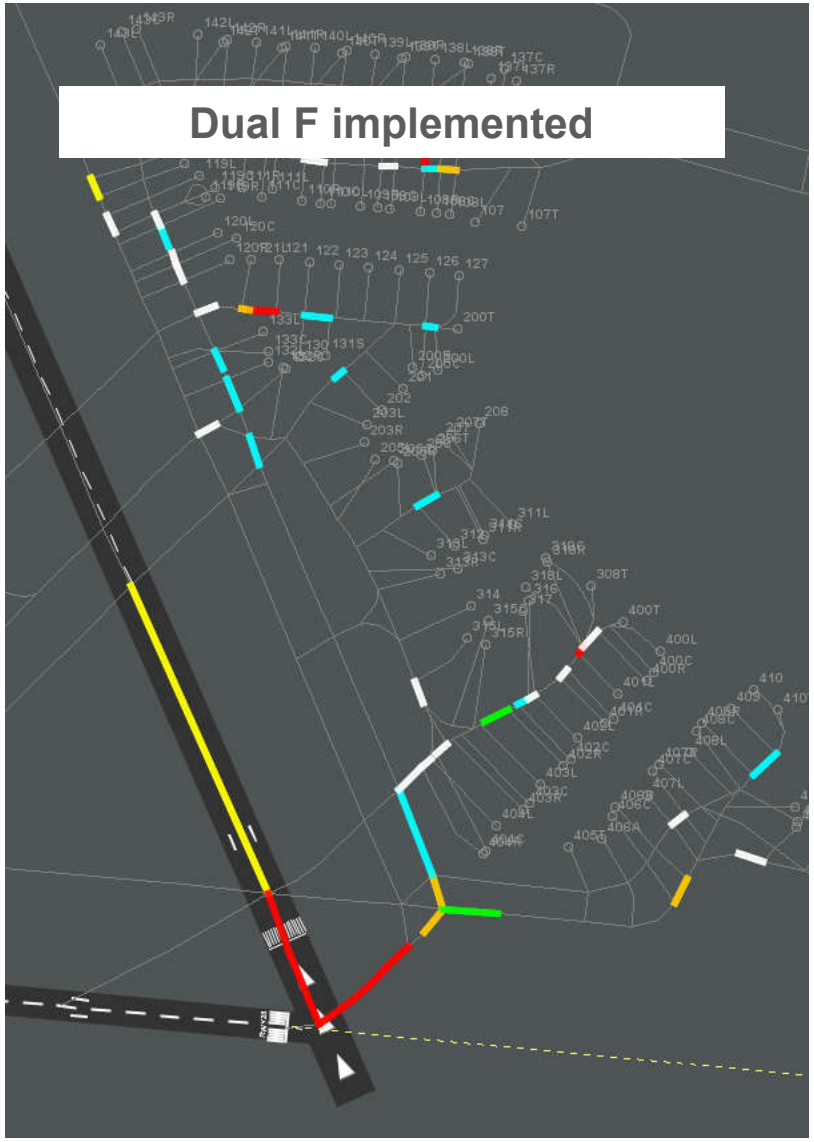




Dual taxiway F (R28)

Aircraft stoppings on taxiway segments throughout the day



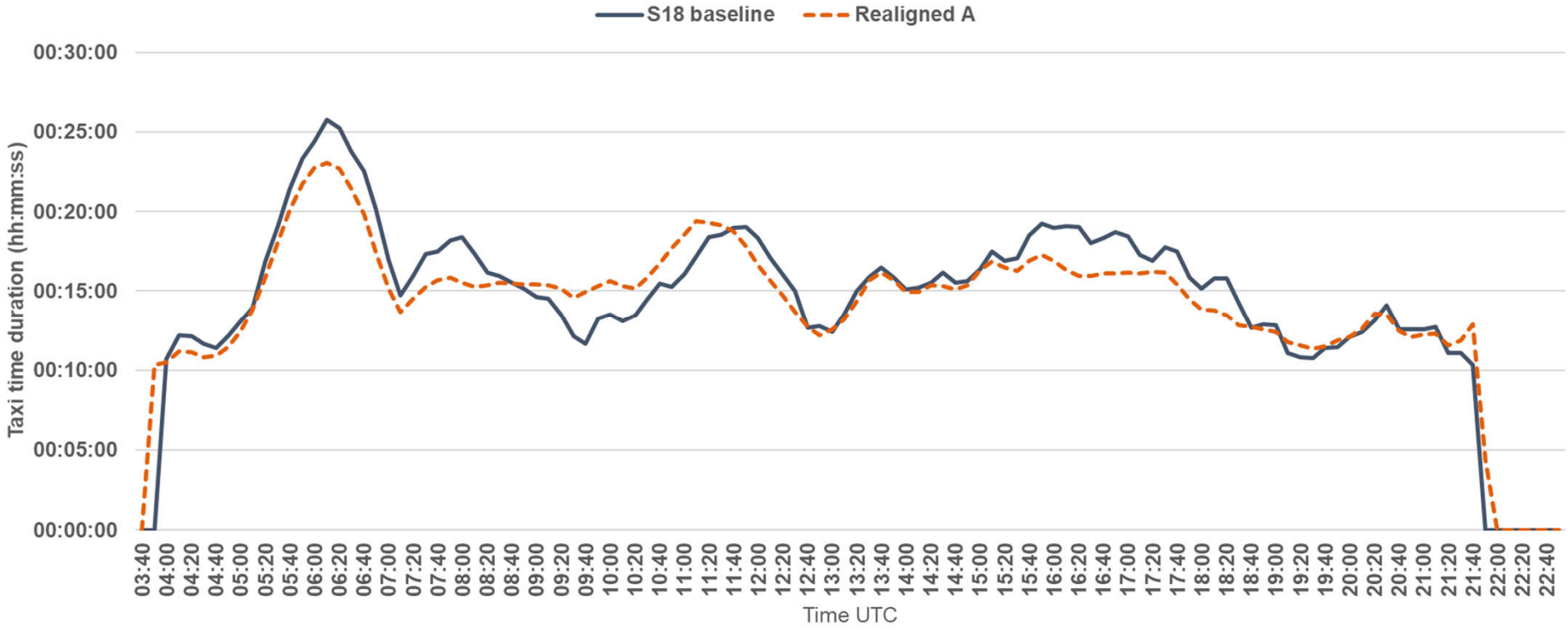


Re-alignment of taxiway A

Re-alignment of taxiway A (R28)
Operational rules modelled

- Any aircraft of up to Code E size could use the realigned A
- Taxiways A and B2 can be used at the same time
- Aircraft towed to/from Apron 5G or to West Apron will be given option to consider re-aligned A in their towing routes
- More options for balancing of departure queue for R28

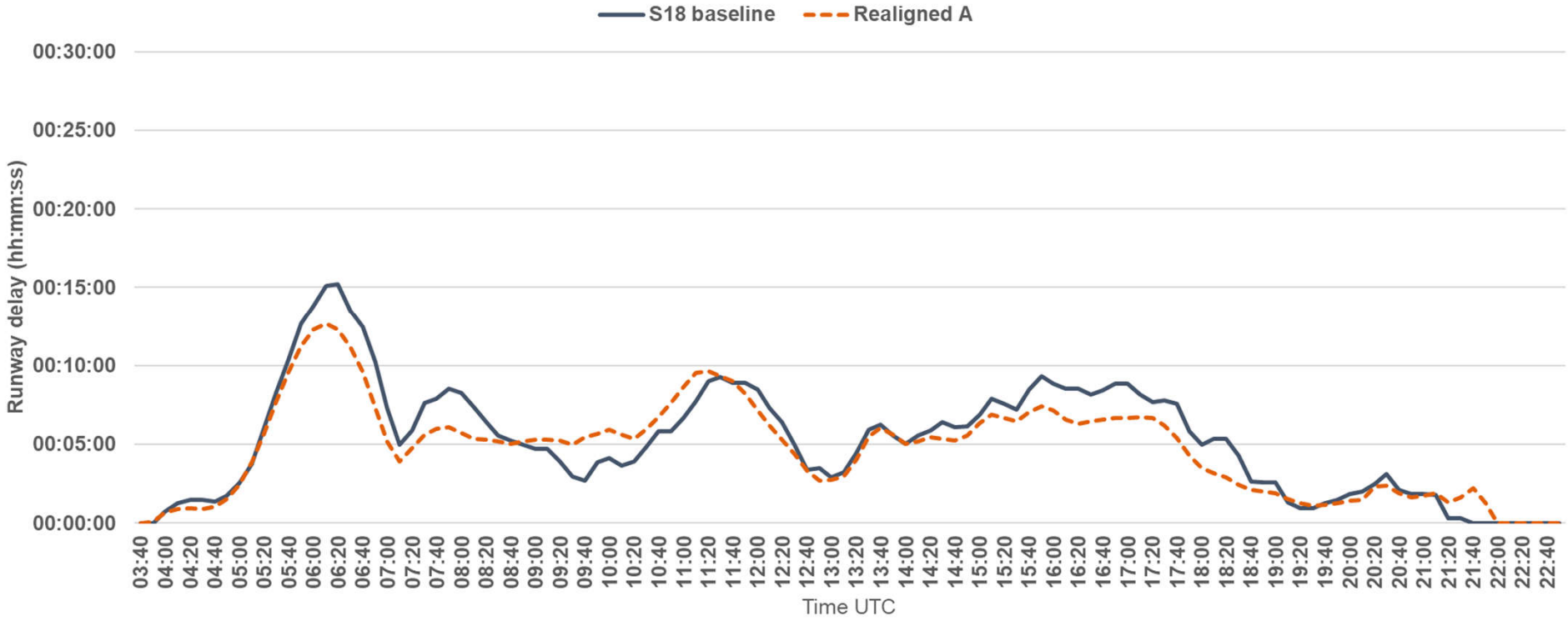
Re-alignment of taxiway A (R28)
Departure taxi out time



- Measured impact:
  - Peak change: -00:03:05
  - Average change: -00:00:31

- Most of the benefit comes from decreased runway delay
- Aircraft from Pier 2 South and Pier 3 using realigned A to get to the departure queue on R16/34 cause increased waiting times for aircraft queuing on R16/34 behind its intersection with Link 3 extension (morning peak only).
- Rerouting of these aircraft allowed a reduction in delay accumulated on F1, E1 and B1 and decreased traffic complexity in the hotspot area.

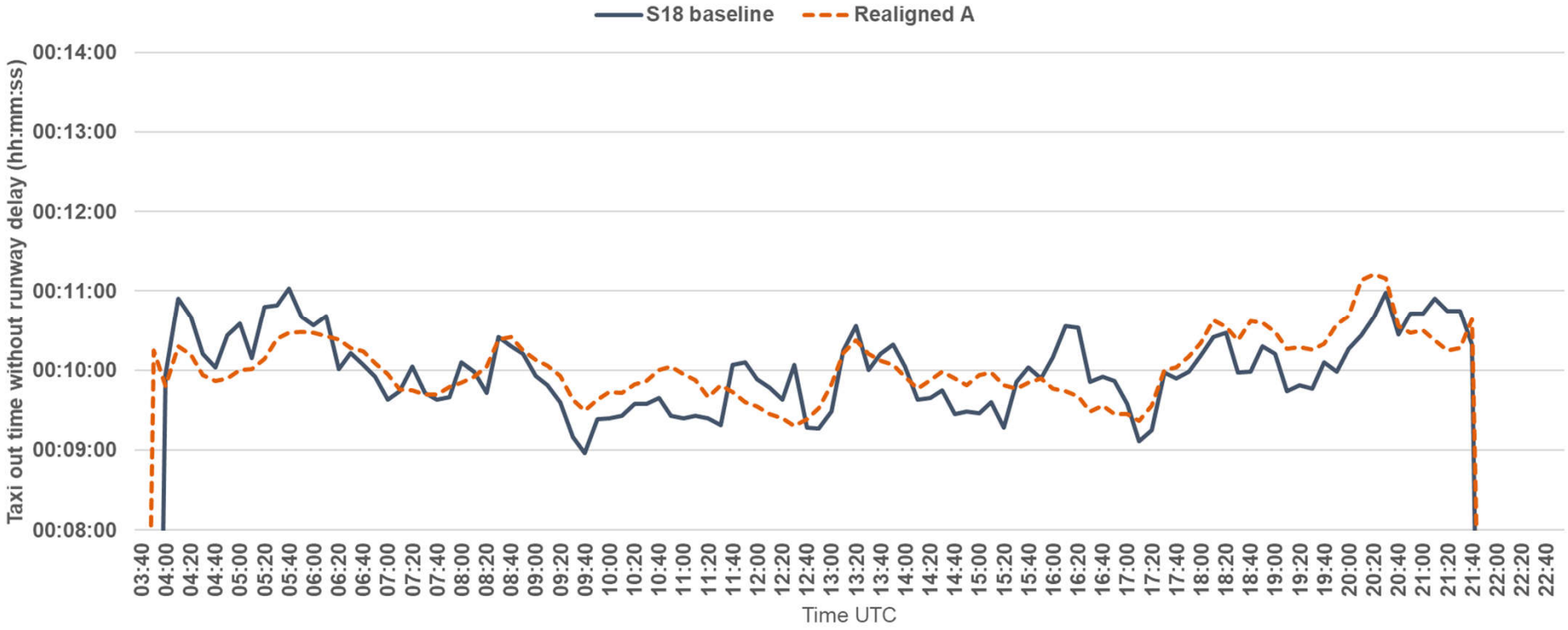
Re-alignment of taxiway A (R28)
Runway delay



- Measured impact:
  - Peak change: -00:02:56
  - Average change: -00:00:34

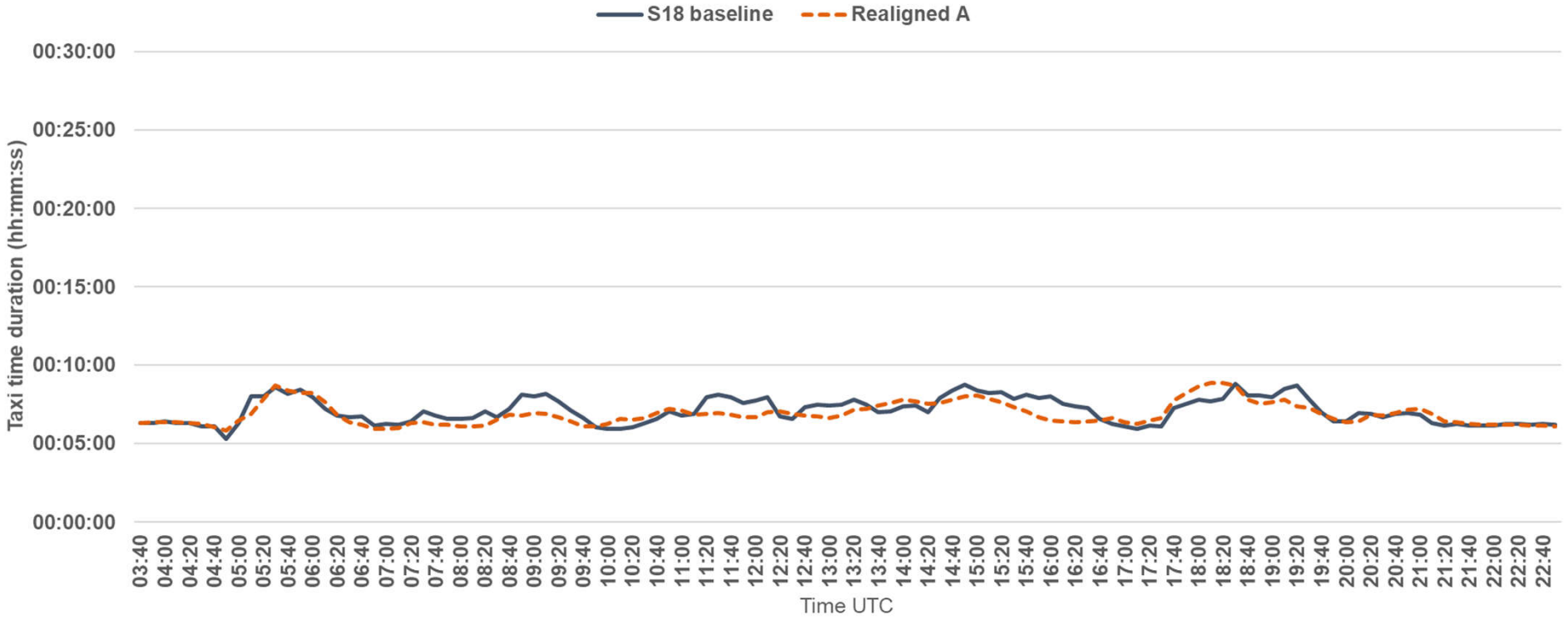
- Decrease in runway delay partly due to randomised block times and partly due to more options for departure queue sequencing
- The biggest impact on runway delay from all individually tested projects

Re-alignment of taxiway A (R28)
Departure taxi time without runway delay



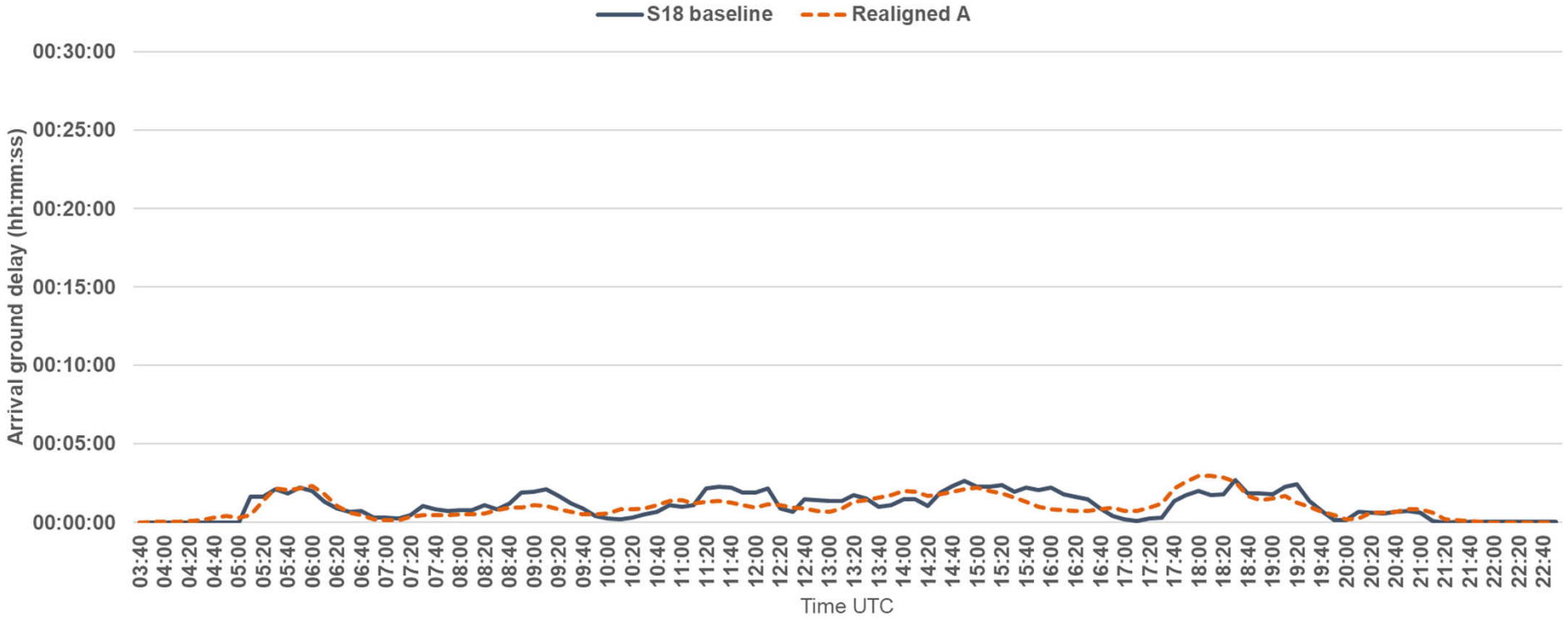
- Measured impact:
  - Peak change: -00:00:52
  - Average change: -00:00:02
- Almost no impact on improvement of taxi times stripped of runway delay (similar lengths of trajectories followed in the current and proposed new taxiways layout)

Re-alignment of taxiway A (R28)
Arrival taxi in duration



- Measured impact:
  - Peak change: -00:01:31
  - Average change: -00:00:12
- Minor improvements visible (almost) across the whole day. These can be attributed to decreased arrival taxi delay (next slide)

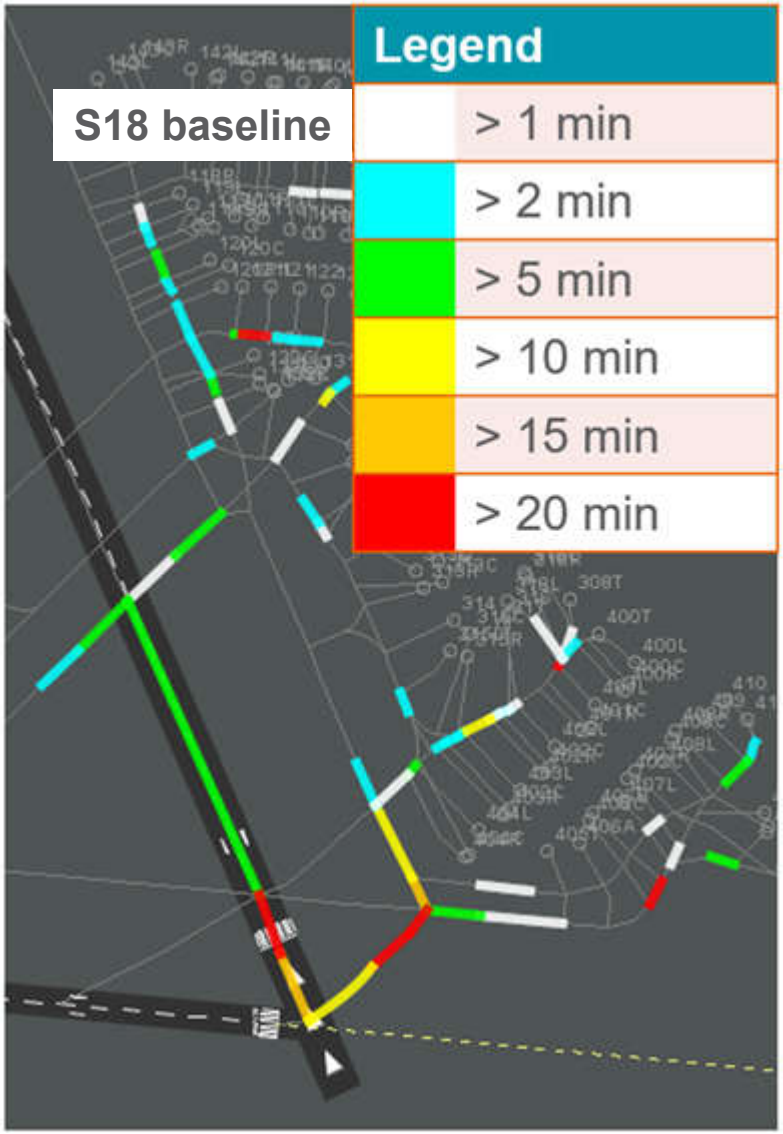
Re-alignment of taxiway A (R28)
Arrival taxi delay



- Measured impact:
  - Peak change: -00:01:23
  - Average change: -00:00:05
- Improvements thanks to reduced traffic density near Link 2 and Link 1 which allows faster access to Pier 3, Pier 4 and South Apron.

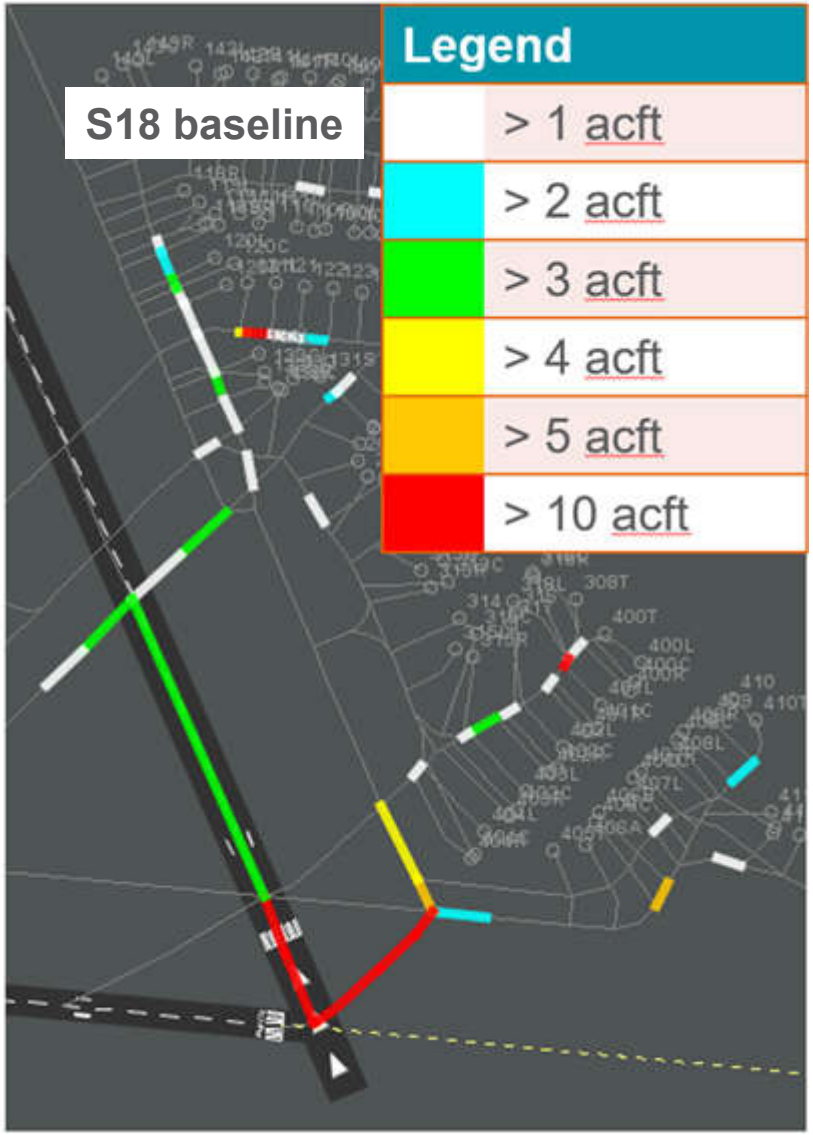
Re-alignment of taxiway A (R28)

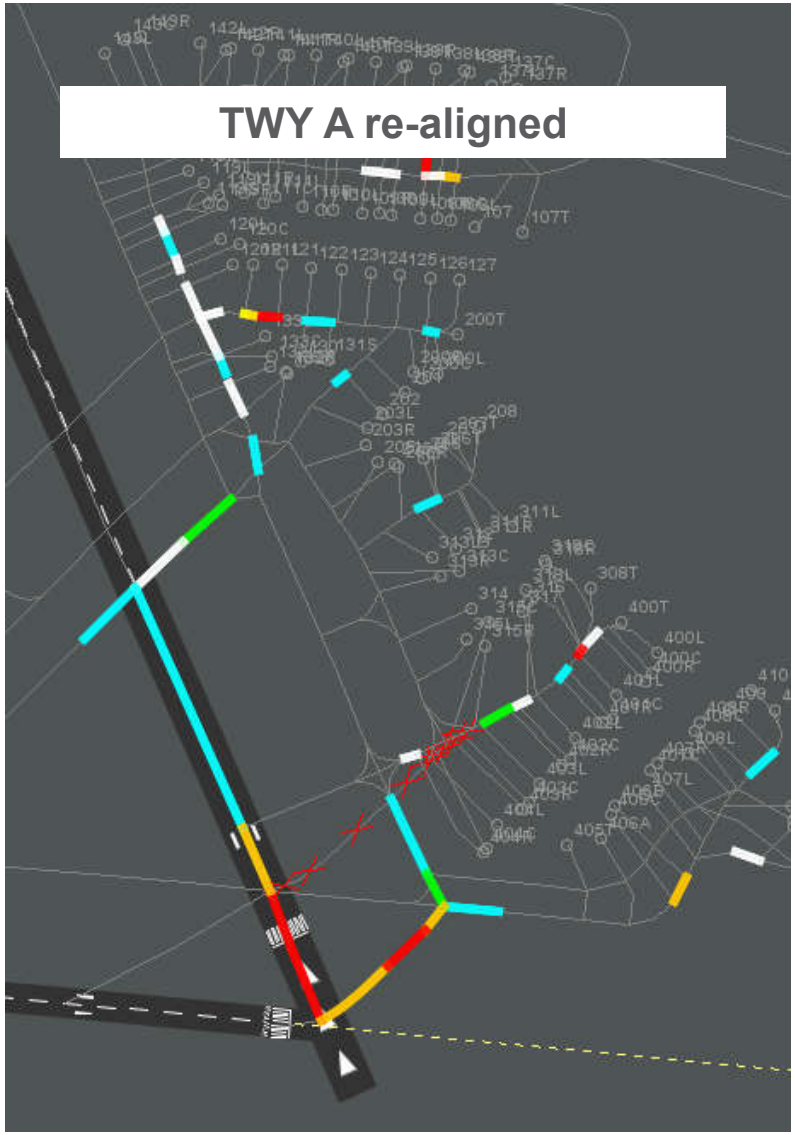
Delay accumulated on taxiway segments throughout the day



Re-alignment of taxiway A (R28)

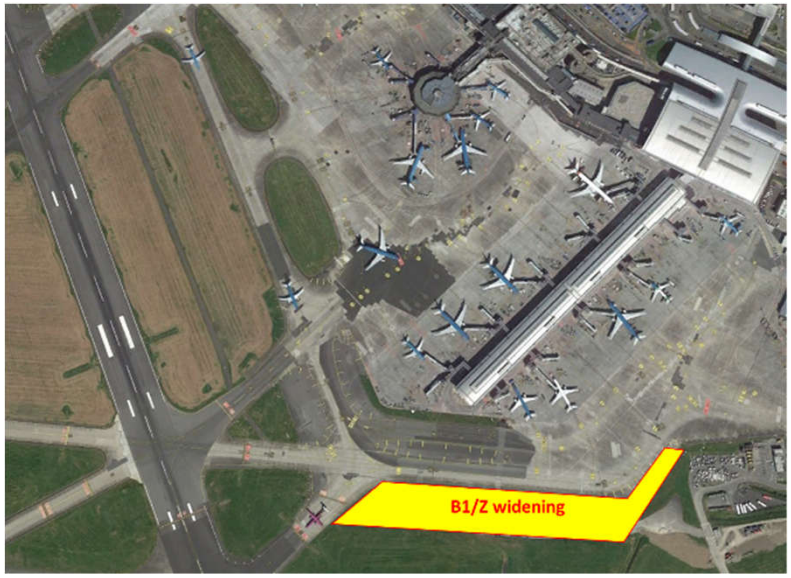
Aircraft stoppings on taxiway segments throughout the day





Widened taxiways Z/B1 (parallel Code E operations)

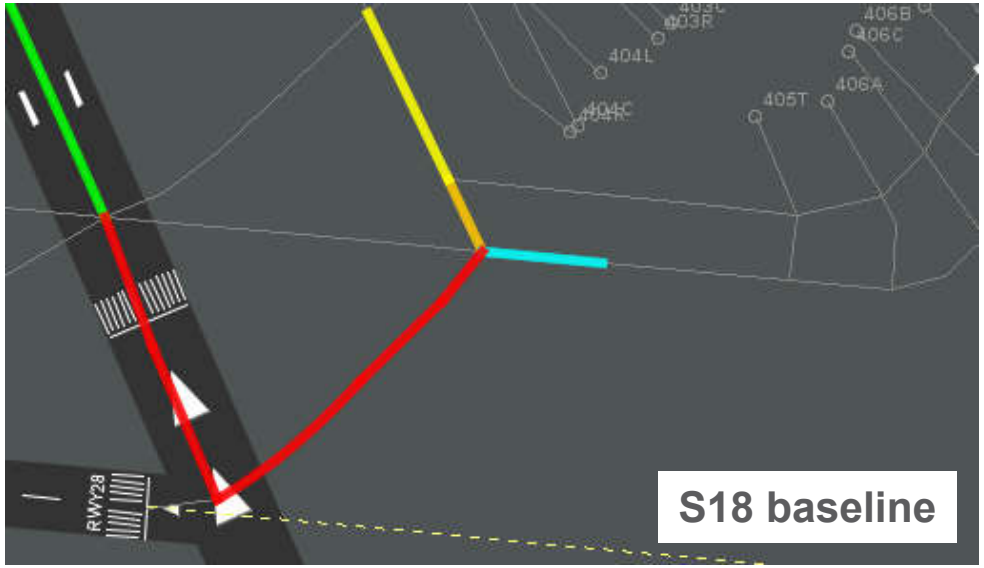
Widened taxiways Z/B1 (R28)
Operational rules modelled

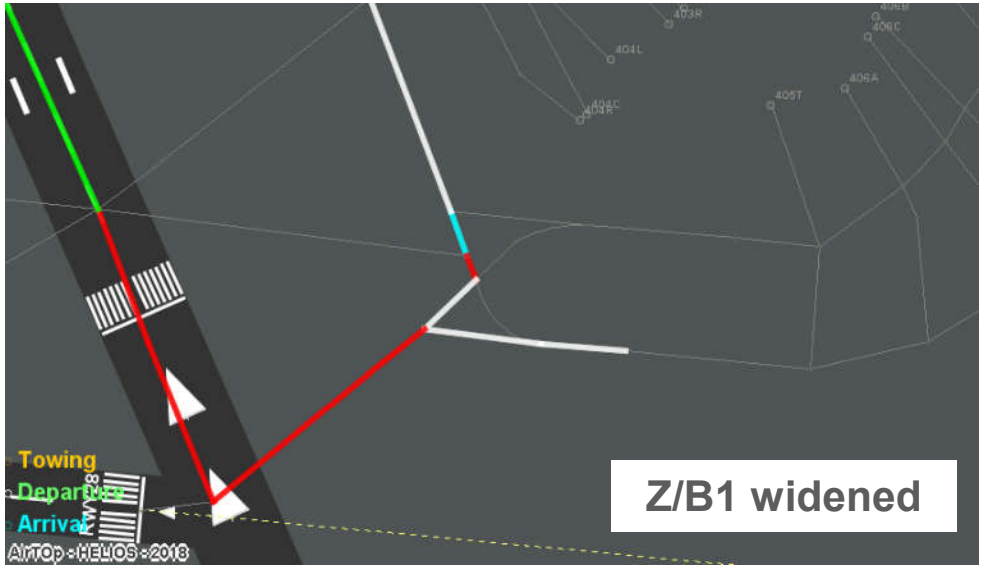


- Both Z and B1 could be used by any aircraft of up to Code E size simultaneously
- Taxiway Z to be used for taxi in to South Apron
- Taxiway B1 to be used for taxi out of South Apron

Widened taxiways Z/B1 (R28)

Aircraft stoppings on taxiway segments throughout the day



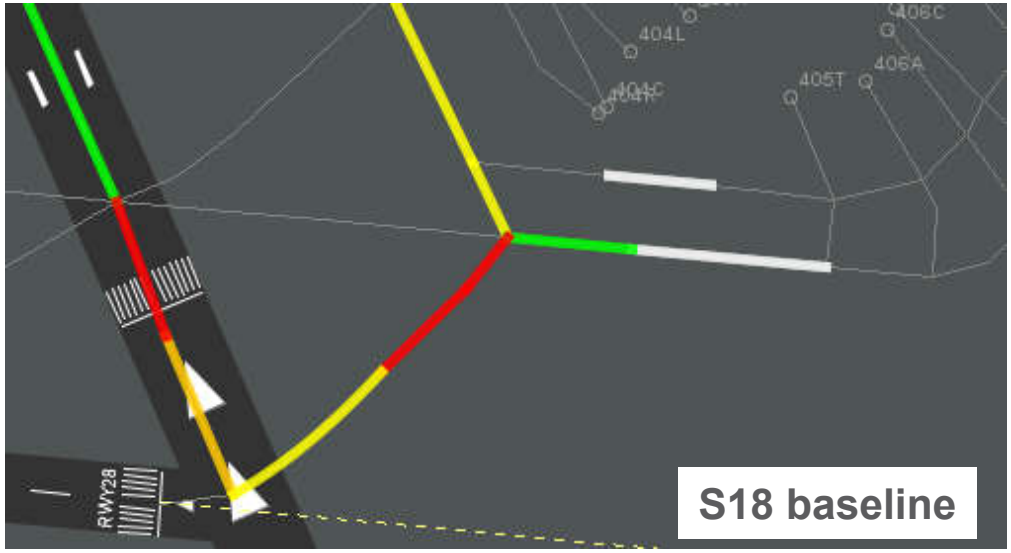


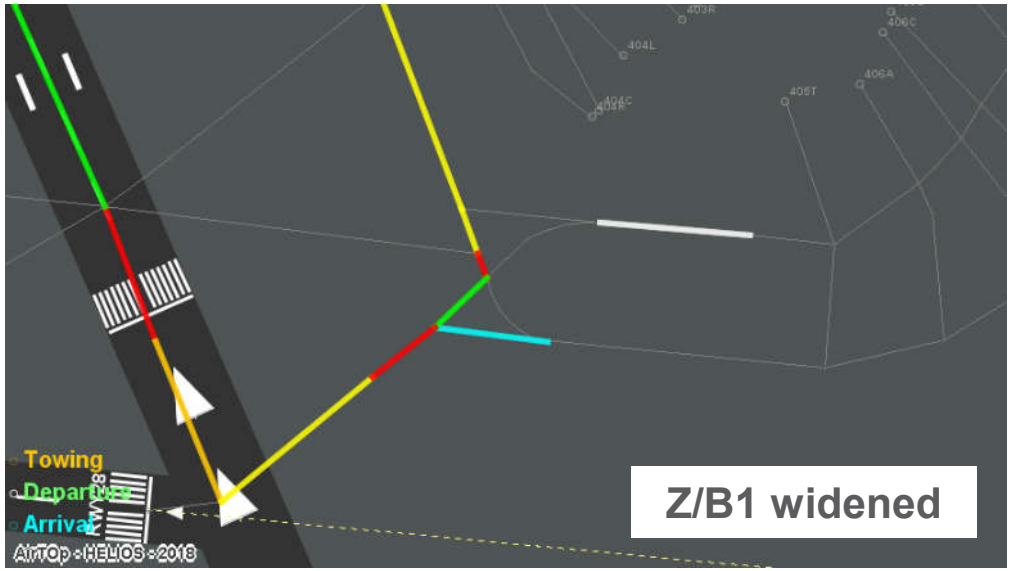
- Simulations confirmed that widening of Z/B1 taxiways will lead to decreased number of aircraft stoppings and smoother flow of traffic in the area.

Legend
> 1 acft
> 2 acft
> 3 acft
> 4 acft
> 5 acft
> 10 acft

Widened taxiways Z/B1 (R28)

Delay accumulated on taxiway segments throughout the day





- Simulations confirmed that due to widening of Z/B1 taxiways and decreased number of aircraft stopping, the delay accumulated on these taxiways will decrease.

Legend
> 1 min
> 2 min
> 5 min
> 10 min
> 15 min
> 20 min

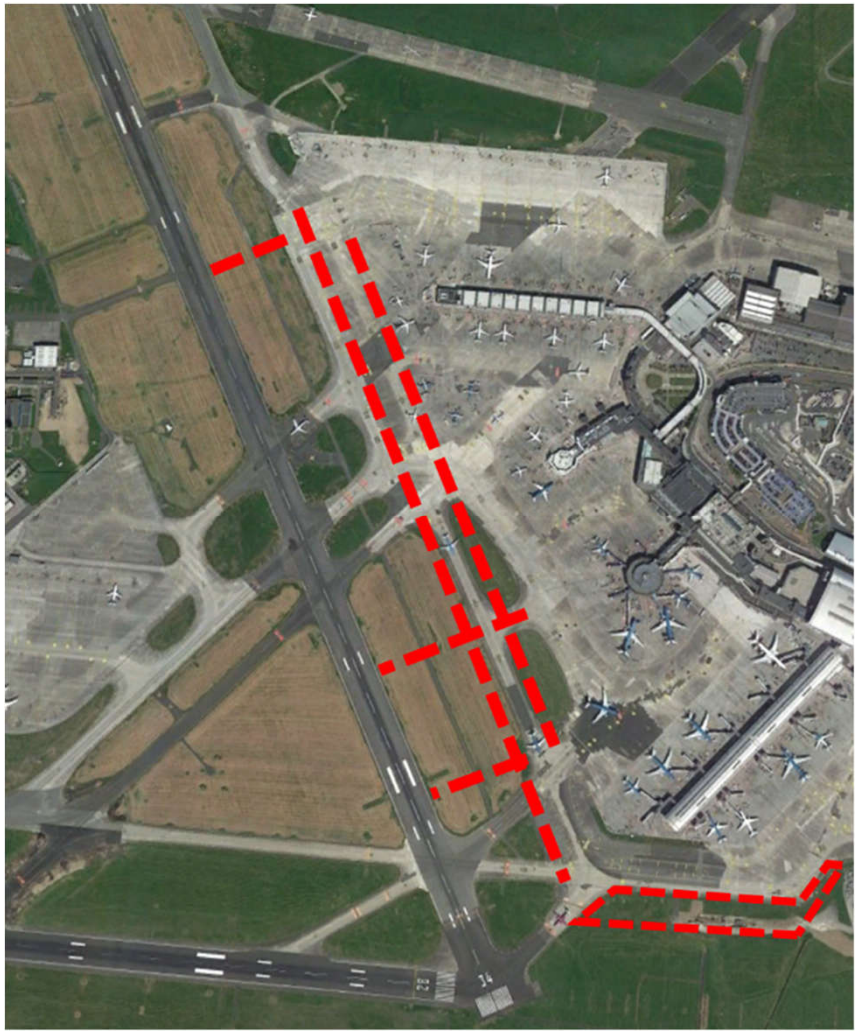
Widened taxiways Z/B1 (R28)

Note on other metrics

- Widening of taxiways Z/B1 will have local impact on operations around Pier 4 and to/from the South Apron.
- In wider scope, the impact on airfield metrics (measured across the whole airport) is minor and these results are not presented in this slide-deck

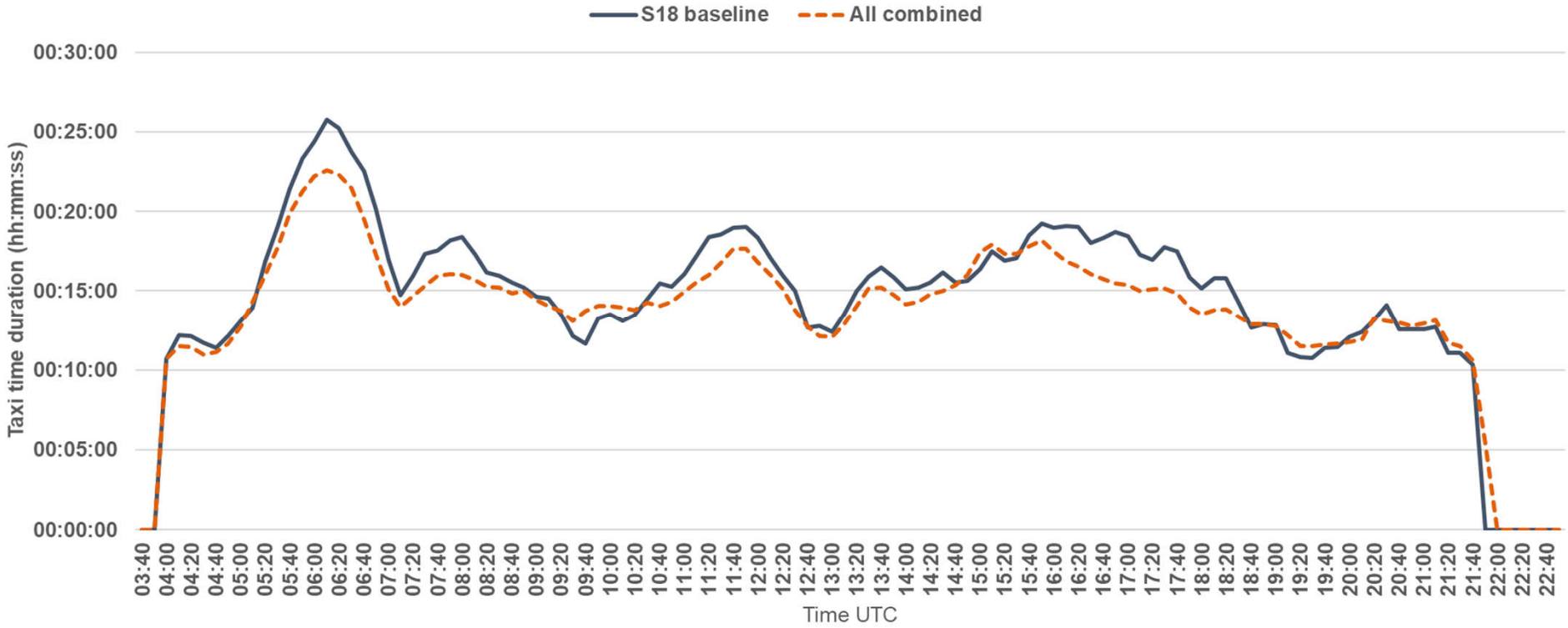
Combined impact of all projects (R28)

Combined impact of all projects (R28)
Operational rules modelled



- All of the rules described in the previous sections combined.

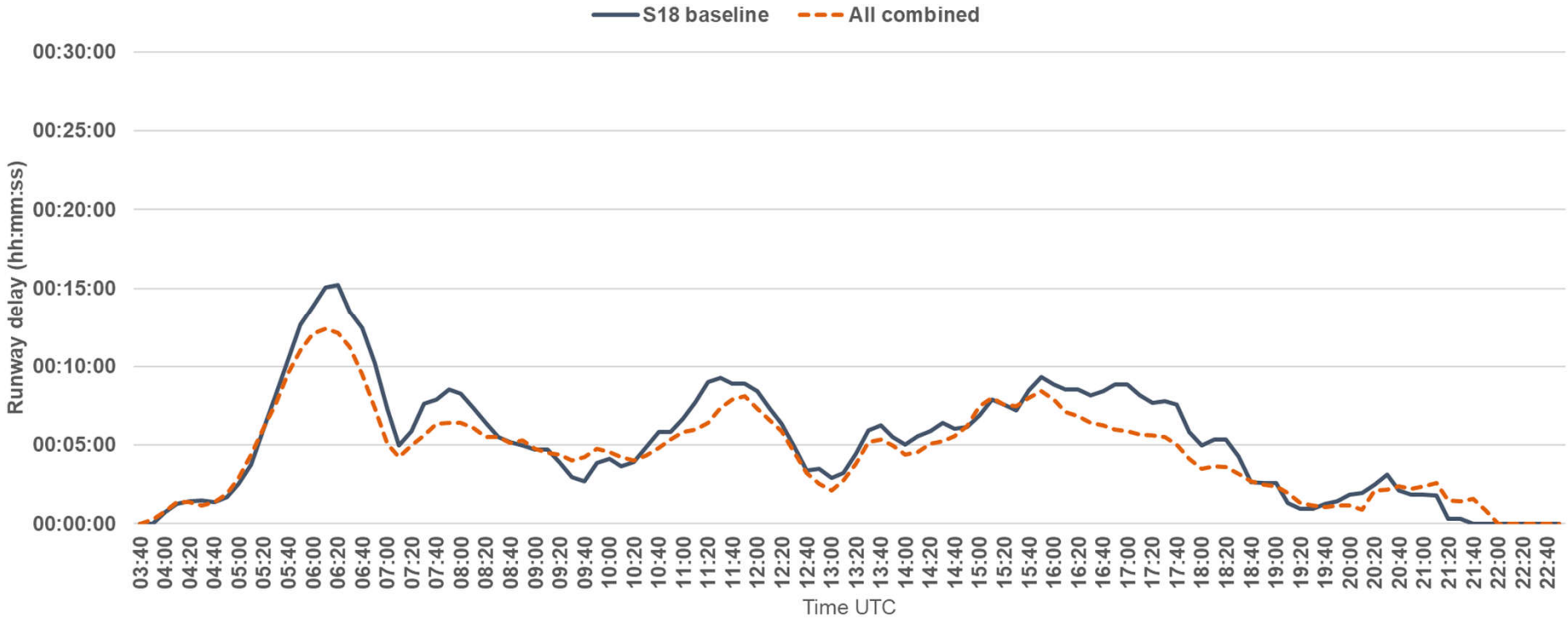
Combined impact of all projects (R28)
Departure taxi out time



- Measured impact:
  - Peak change: -00:03:14
  - Average change: -00:00:52

- Average improvement in departure taxi out time of almost one minute across the day is coming from decreased runway delay and improved efficiency of taxiway network.
- Reduction during the morning peak is 00:03:11 (12.4% against the baseline) and in the afternoon peak is 00:03:14 (17.3% against the baseline)

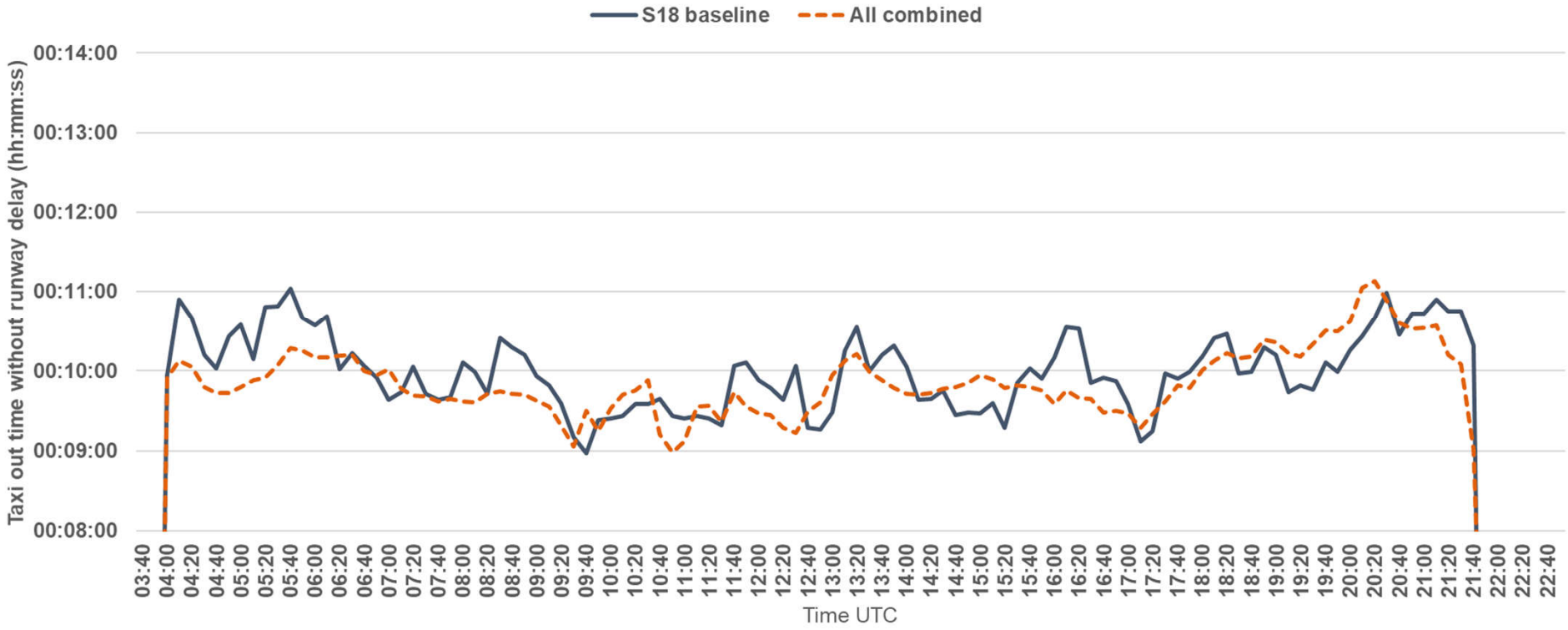
Combined impact of all projects (R28)
Runway delay



- Measured impact:
  - Peak change: -00:03:07
  - Average change: -00:00:39

- Decrease in runway delay due to more options for departure queue sequencing - re-aligned A and parallel F and (partly also due to randomised block times).
- Highest decrease in runway delay from all options modelled

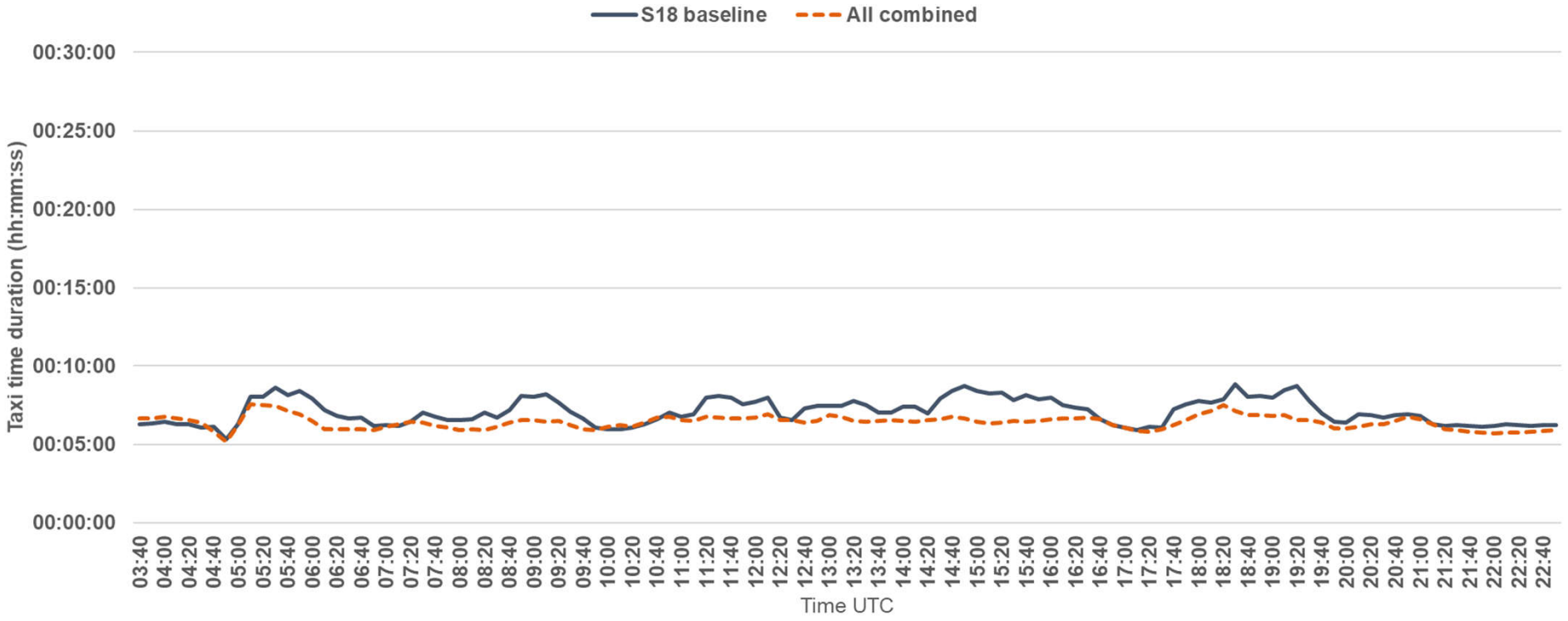
Combined impact of all projects (R28)
Departure taxi time without runway delay



- Measured impact:
  - Peak change: -00:01:19
  - Average change: -00:00:09

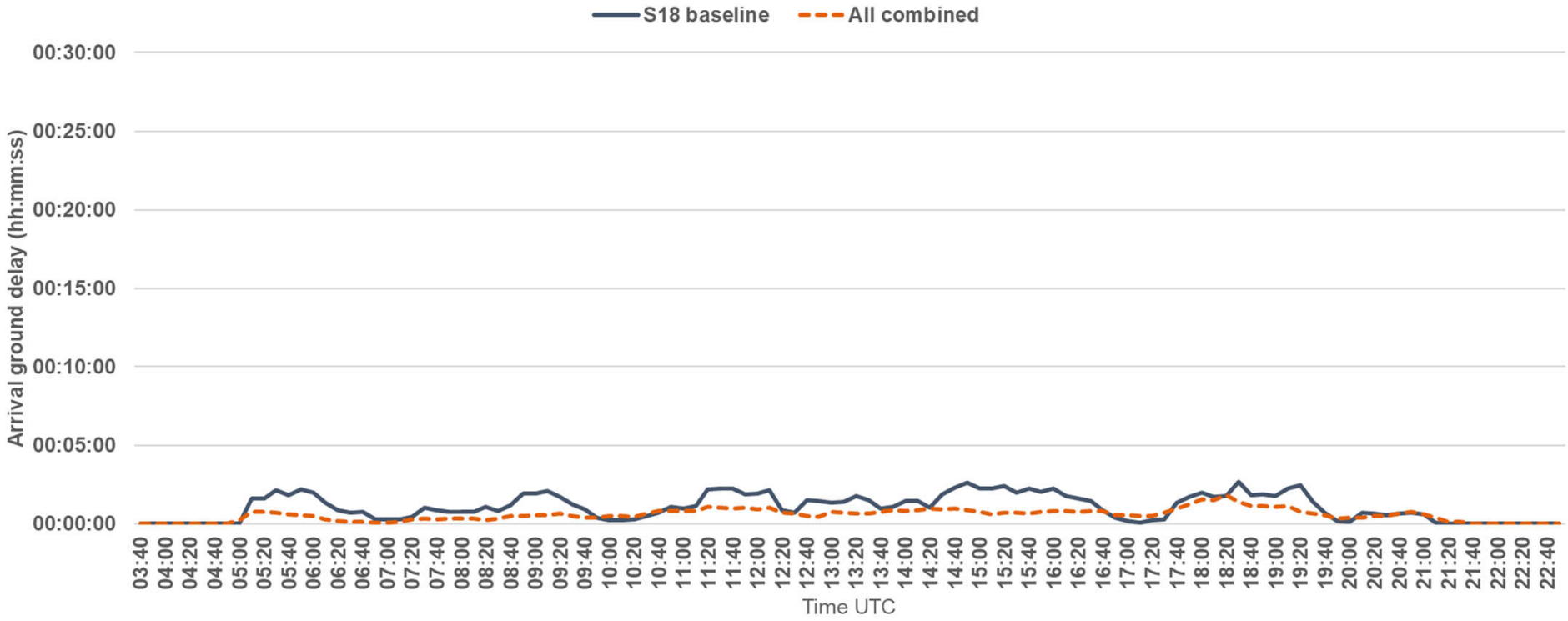
- Easier access to all parts of the airport
- Reduction of number of taxiway segments that accumulate delays or cause aircraft to stop (see heatmaps on further slides)

Combined impact of all projects (R28)
Arrival taxi in duration



- Measured impact:
  - Peak change: -00:02:11
  - Average change: -00:00:40
- Highest reduction from all scenarios modelled
- Benefits throughout the whole day

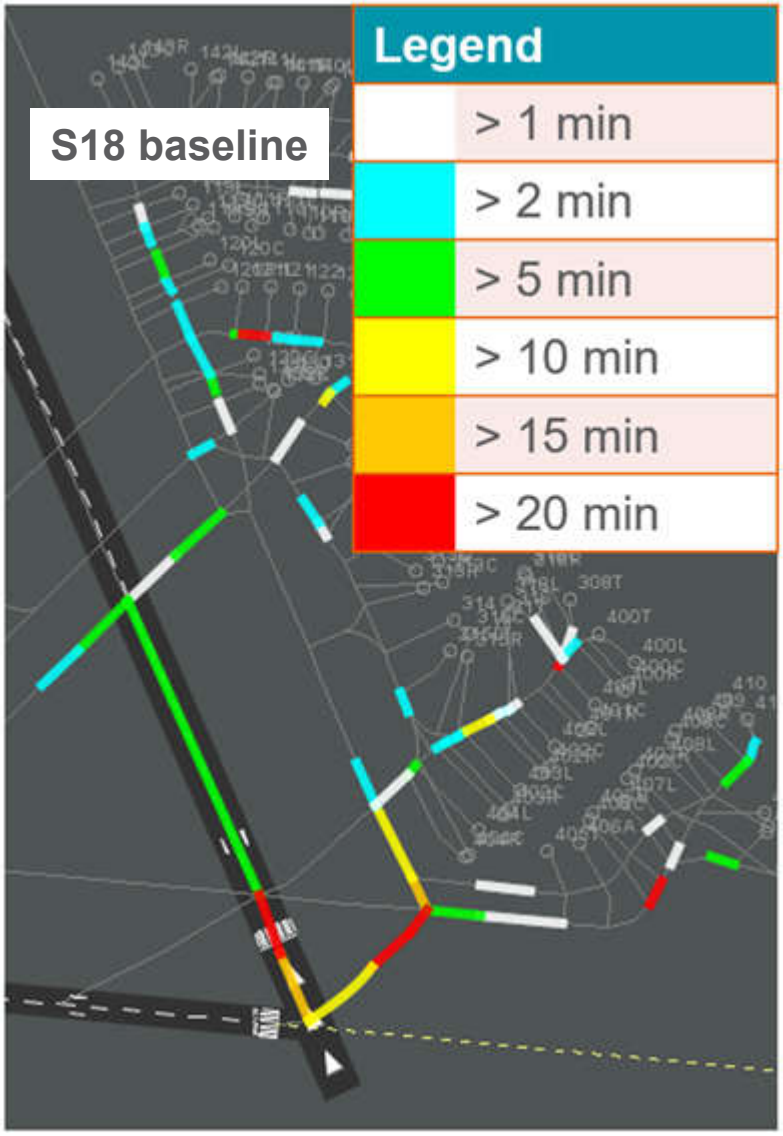
Combined impact of all projects (R28)
Arrival taxi delay

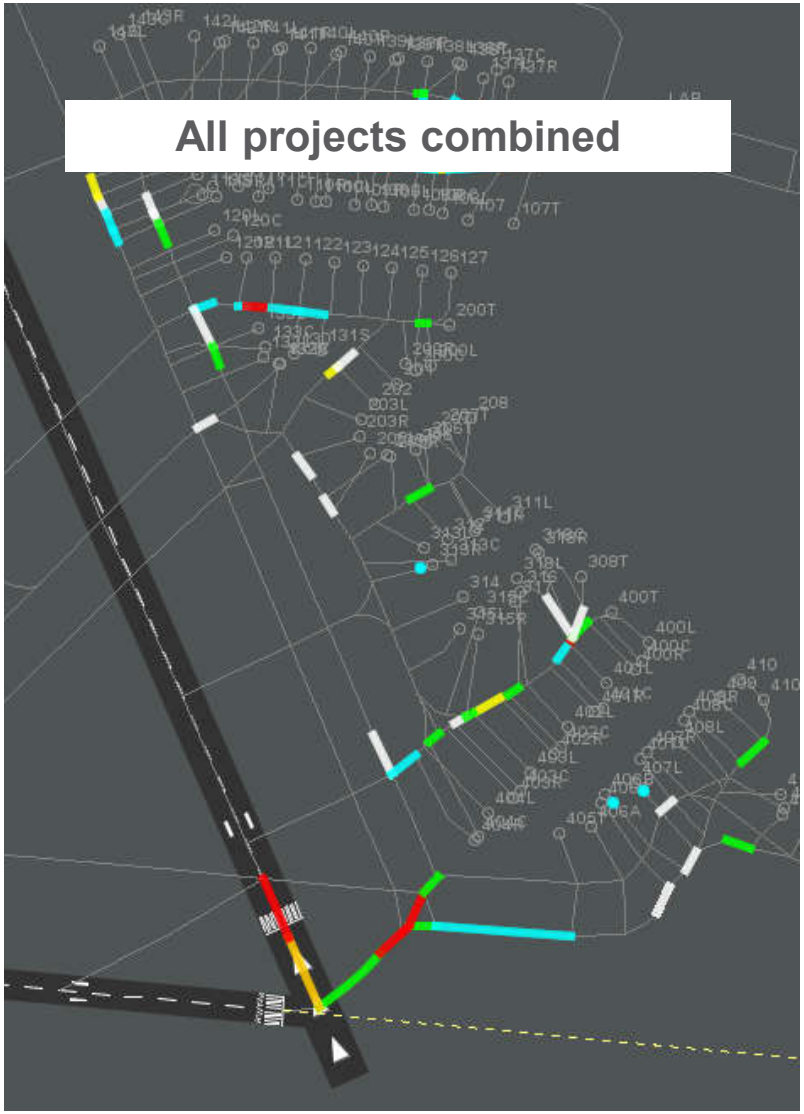


- Measured impact:
  - Peak change: -00:01:43
  - Average change: -00:00:30
- Decreased arrival ground delay is coming from easier access to all parts of the airport – dual F and widened Z/B1 allow better access to Pier 4 and South Apron, while Link 6 extension allows easier access to the north of the airfield

Combined impact of all projects (R28)

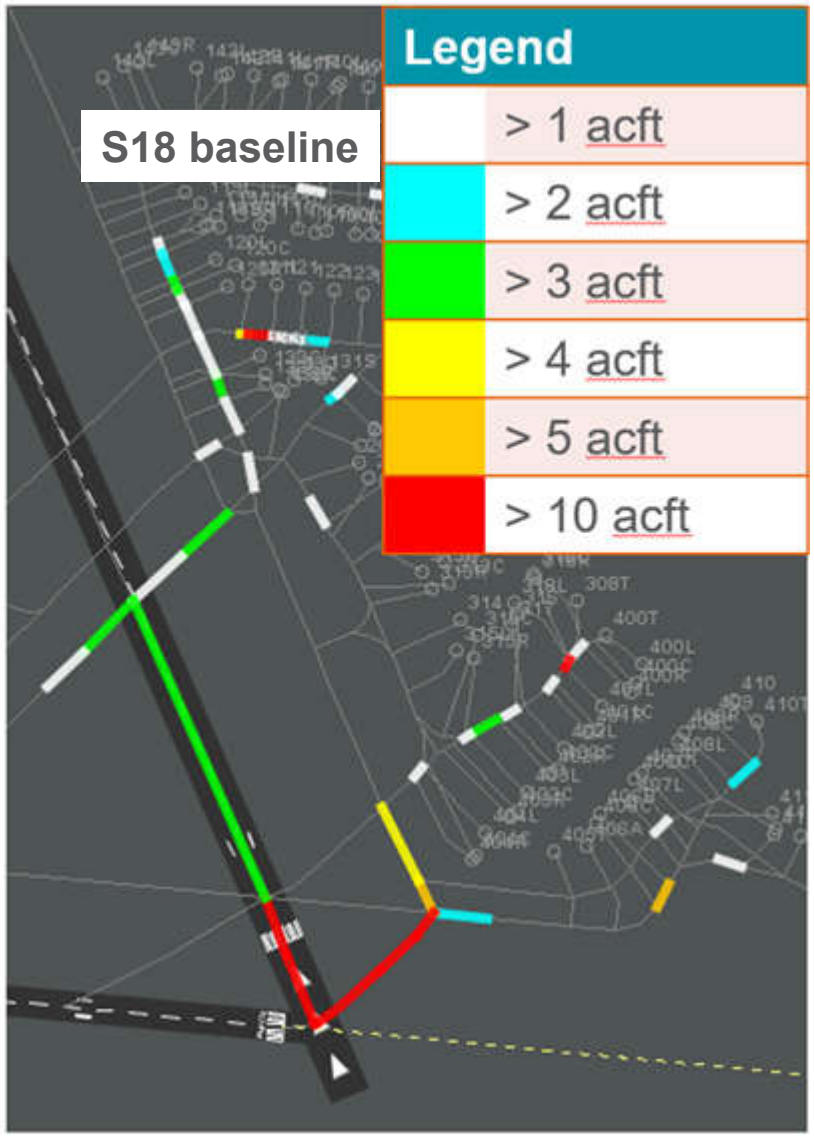
Delay accumulated on taxiway segments throughout the day

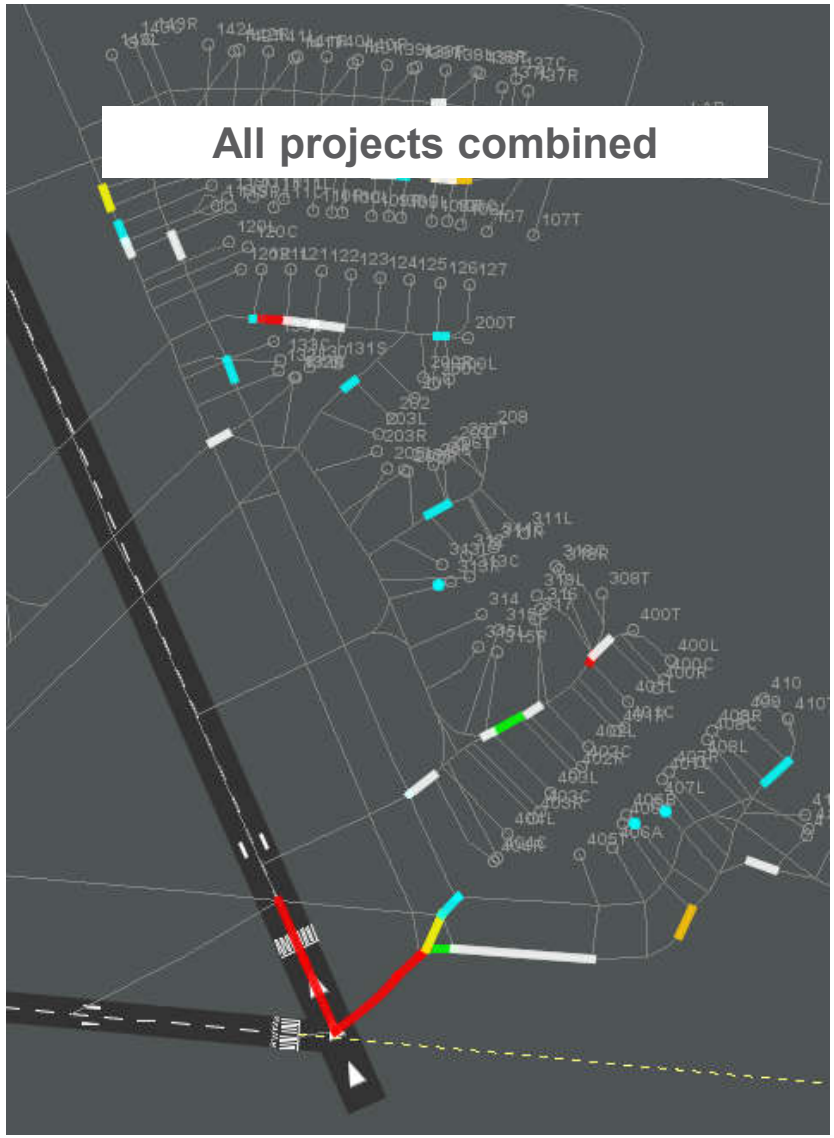




Combined impact of all projects (R28)

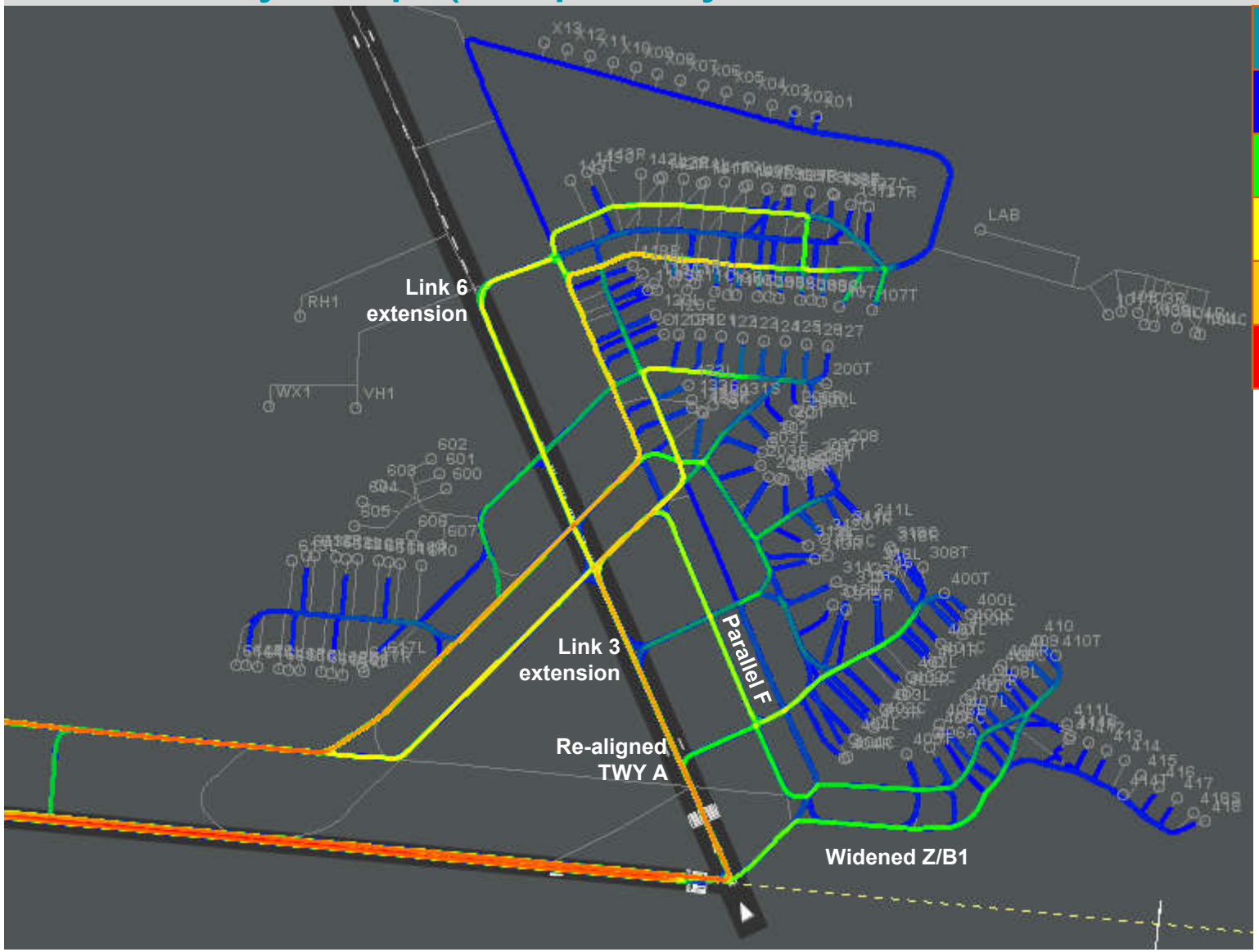
Aircraft stoppings on taxiway segments throughout the day





Combined impact of all projects (R28)

Density map (frequency of use of the taxiway network)



Legend
0 – 50 mvts
50 – 100 mvts
100 – 200 mvts
200 – 500 mvts
> 500 mvts

Combined impact of all projects (R28)
A note on the results

- The simulations were based on operational rules for all individual infrastructure changes combined.
- The combined impact of all the proposed infrastructure changes may be larger than results of these simulations would suggest, as operational rules for each project could be optimised to take account of the optimal use of other projects.

Summary (R28)

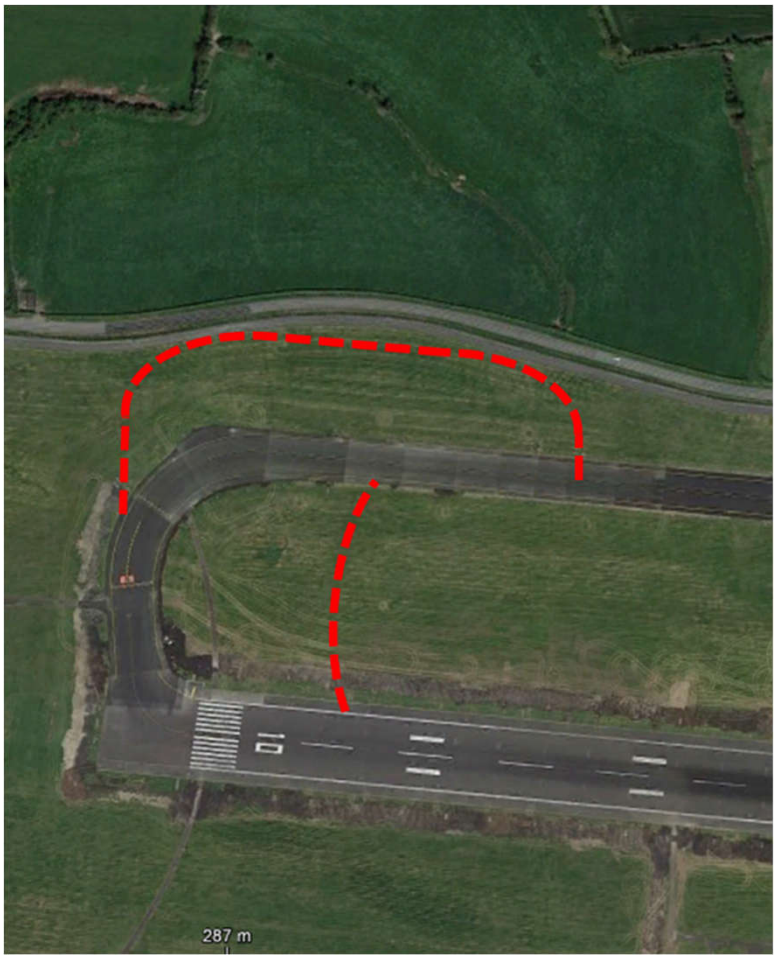
Overview of impact per project and metric (R28)

		Link 6 extension	Link 3 extension	Parallel F	Realigned A	Combined*
Departure taxi out time	Peak change:	-00:03:48	-00:03:21	-00:03:01	-00:03:05	-00:03:14
	Average change:	-00:00:46	-00:00:33	-00:00:28	-00:00:31	-00:00:52
Runway delay	Peak change:	-00:03:37	-00:03:19	-00:02:13	-00:02:56	-00:03:07
	Average change:	-00:00:27	-00:00:22	-00:00:16	-00:00:34	-00:00:39
Taxi out time without runway delay	Peak change:	-00:01:05	-00:00:55	-00:01:02	-00:00:52	-00:01:19
	Average change:	-00:00:19	-00:00:10	-00:00:12	-00:00:02	-00:00:09
Arrival taxi in time	Peak change:	-00:01:34	-00:01:31	-00:02:28	-00:01:31	-00:02:11
	Average change:	-00:00:22	-00:00:01	-00:00:35	-00:00:12	-00:00:40
Arrival ground delay	Peak change:	-00:01:25	-00:01:33	-00:02:00	-00:01:23	-00:01:43
	Average change:	-00:00:16	-00:00:01	-00:00:25	-00:00:05	-00:00:30

* Combined category includes also B1/Z widening

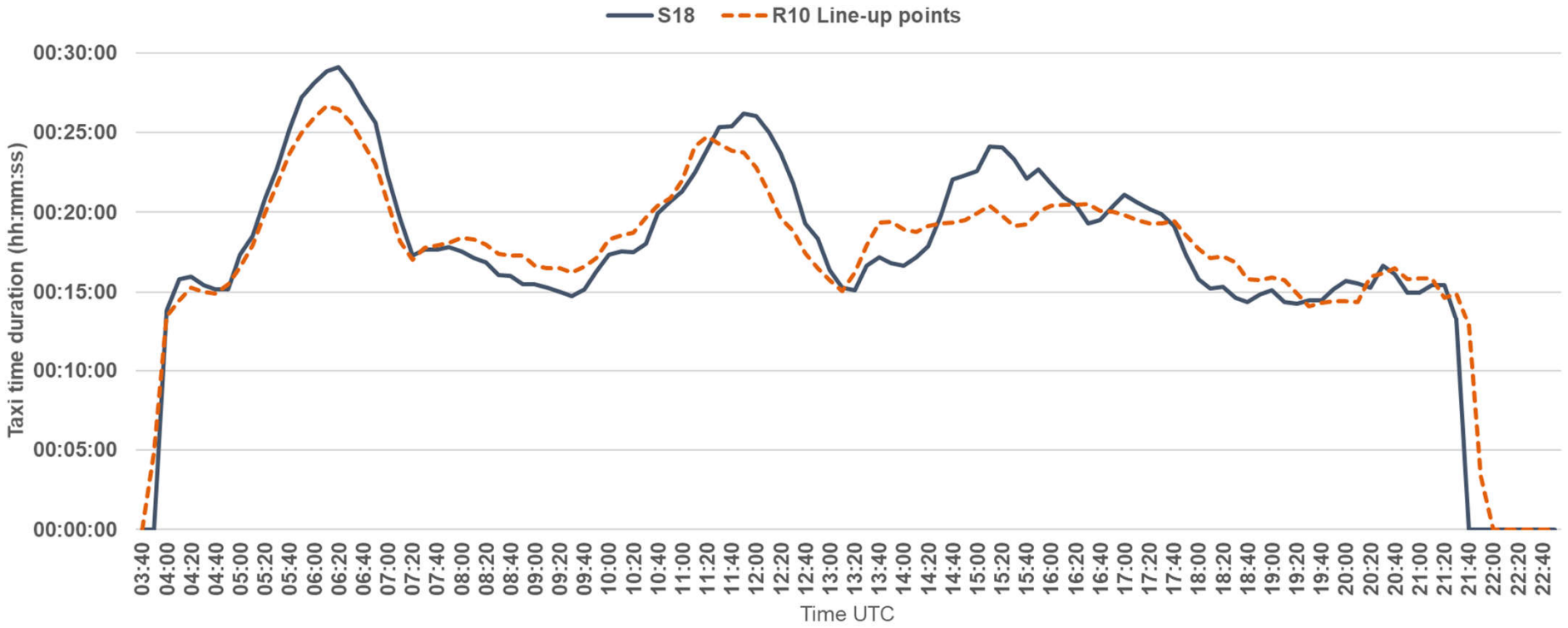
Additional Runway 10 line-up points

Additional Runway 10 line-up points (R10)
Operational rules modelled



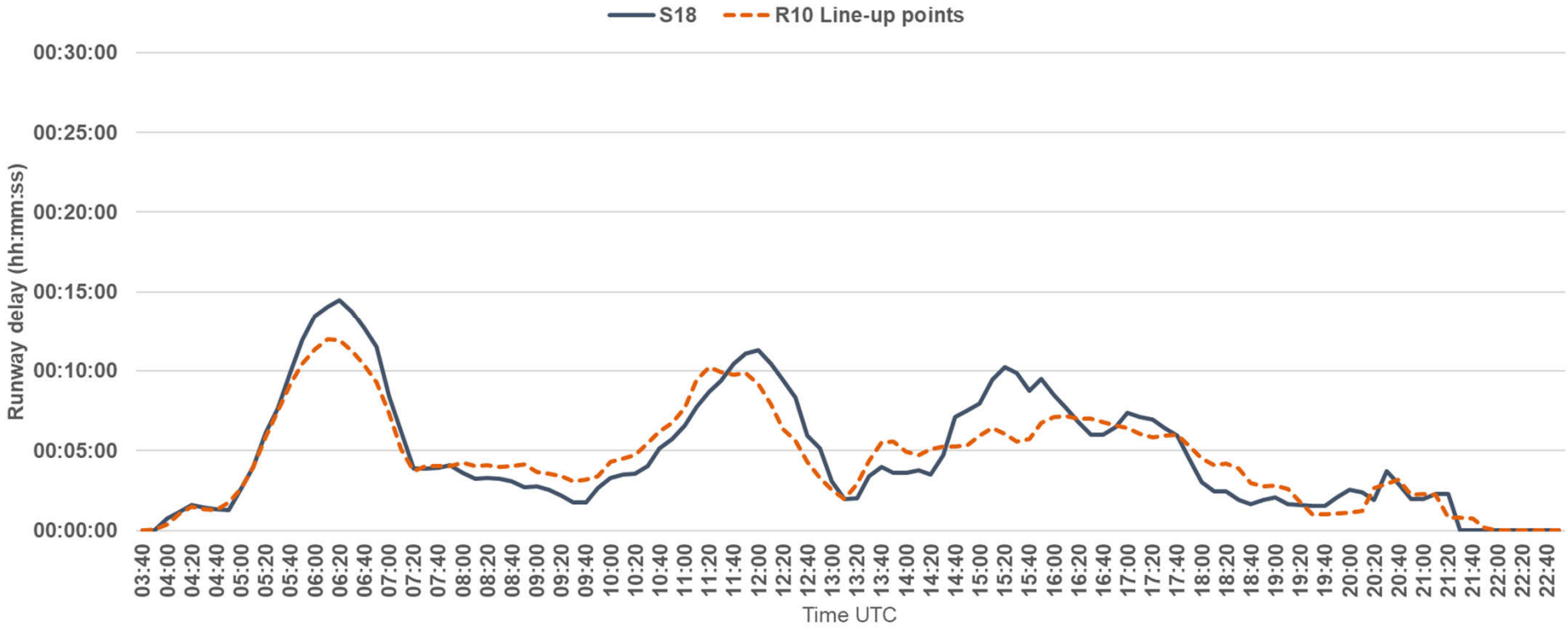
- Additional runway entry point allowed more options for departure queue optimization.
- Option to bypass queuing aircraft as necessary.
- All aircraft sizes can use both runway entry points (no preference for aircraft size and/or runway entry used).

Additional Runway 10 line-up points (R10)
Departure taxi out time



- Measured impact:
  - Peak change: -00:04:18
  - Average change: -00:00:15
- Duration between off-block and reaching runway stopbar reduced because the runway delay decreased (see the next slide).

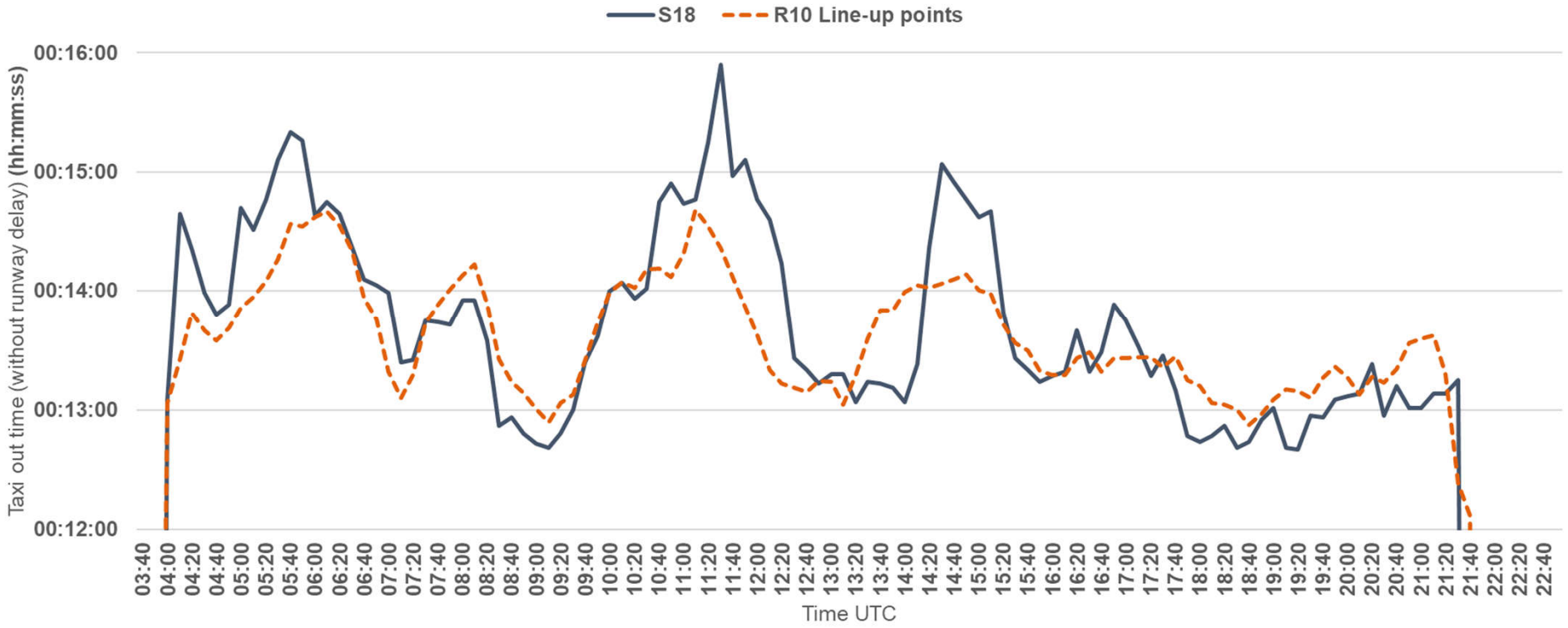
Additional Runway 10 line-up points (R10)
Runway delay



- Measured impact:
  - Peak change: -00:04:19,
  - Average change: -00:00:11

- Runway delay decreases as more runway entry points allow better sequencing of the departure queue and this leads to slightly higher runway throughput
- Out of the 10 runs there were 2 runs where a maximum throughput of 49 aircraft per hour was reached and 3 runs where a throughput of 48 aircraft per hour was reached.

Additional Runway 10 line-up points (R10)
Departure taxi time without runway delay

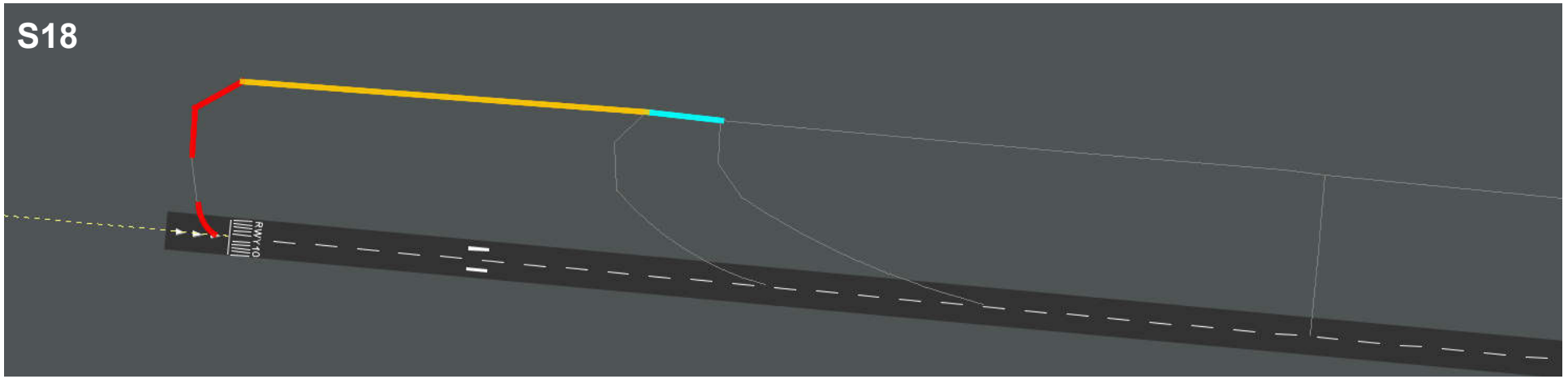


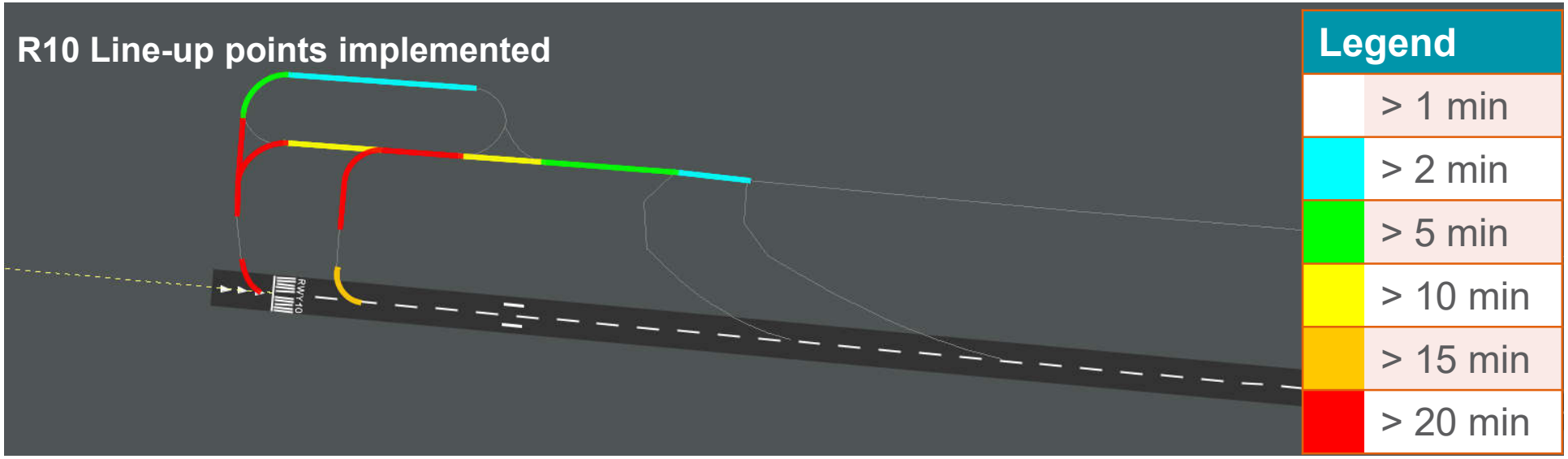
- Measured impact:
  - Peak change: -00:01:33
  - Average change: -00:00:06

- As there were no other changes to the taxiway layout but the new runway entry points, the overall taxi out duration stripped of runway delay did not change significantly. The marginal improvement is coming from peak periods when the additional line-up point was best utilised (e.g. aircraft taxiing to the new line-up point had slightly shorter trajectory to cover).

Additional Runway 10 line-up points (R10)

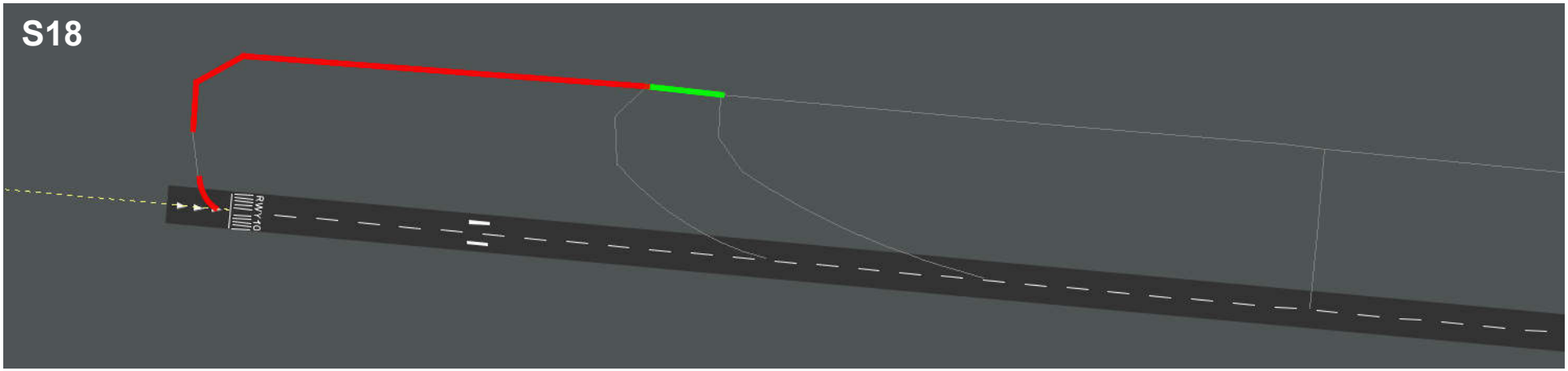
Delay accumulated on taxiway segments throughout the day

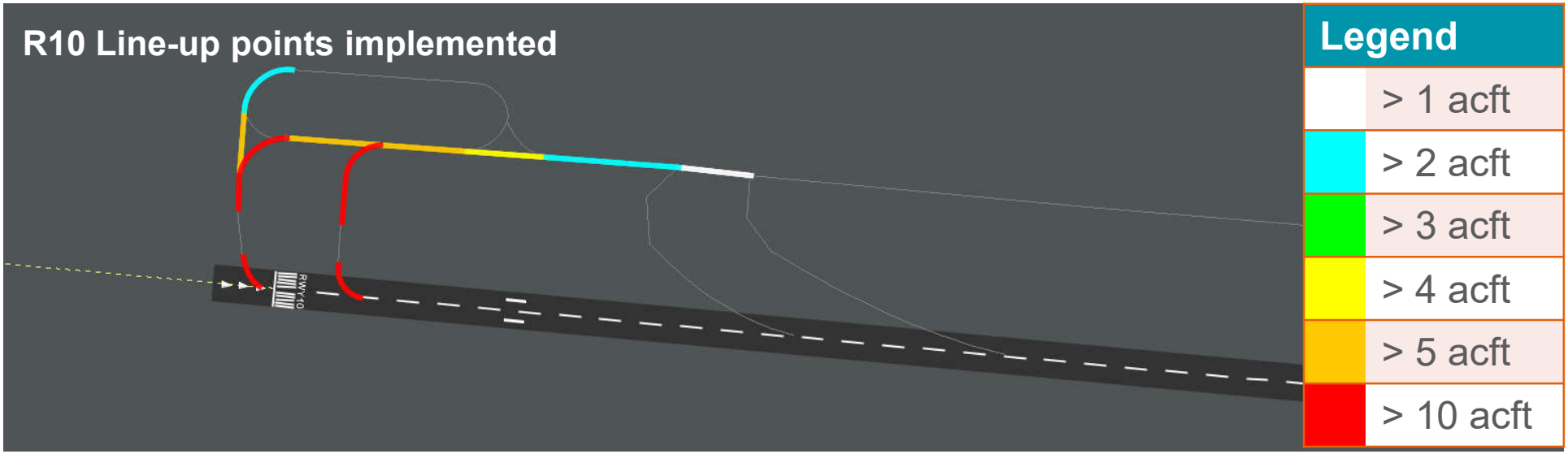




Additional Runway 10 line-up points (R10)

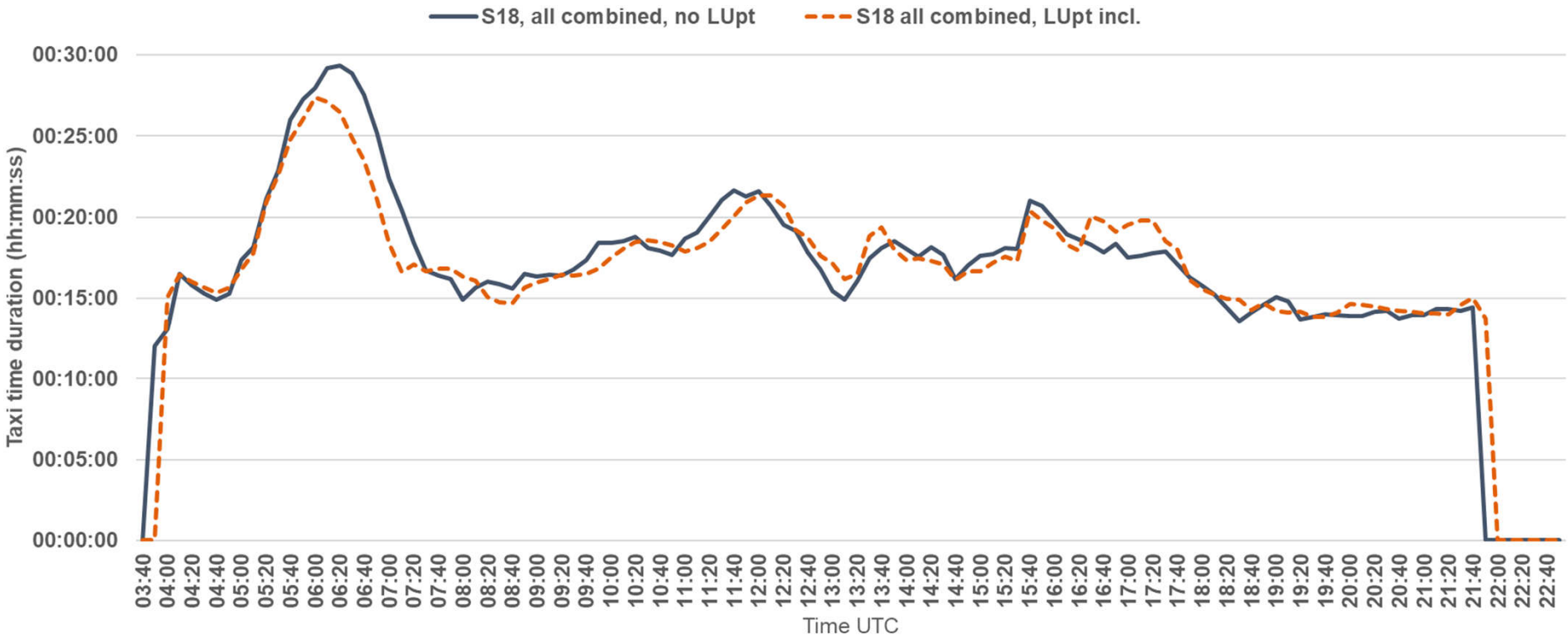
Aircraft stoppings on taxiway segments throughout the day





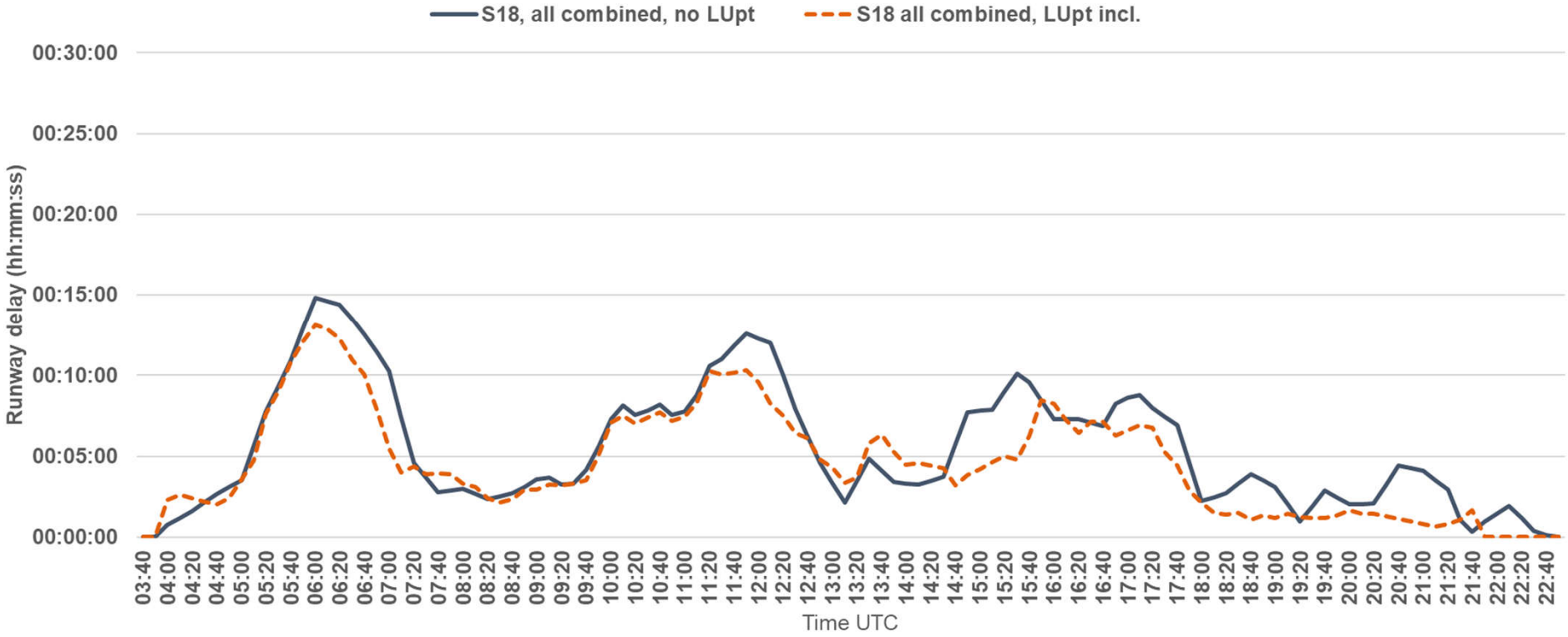
Impact of the new line up point on operations in the future scenario which includes all proposed taxiway improvements (R10)

Combined impact of all projects (R10)
Departure taxi out time



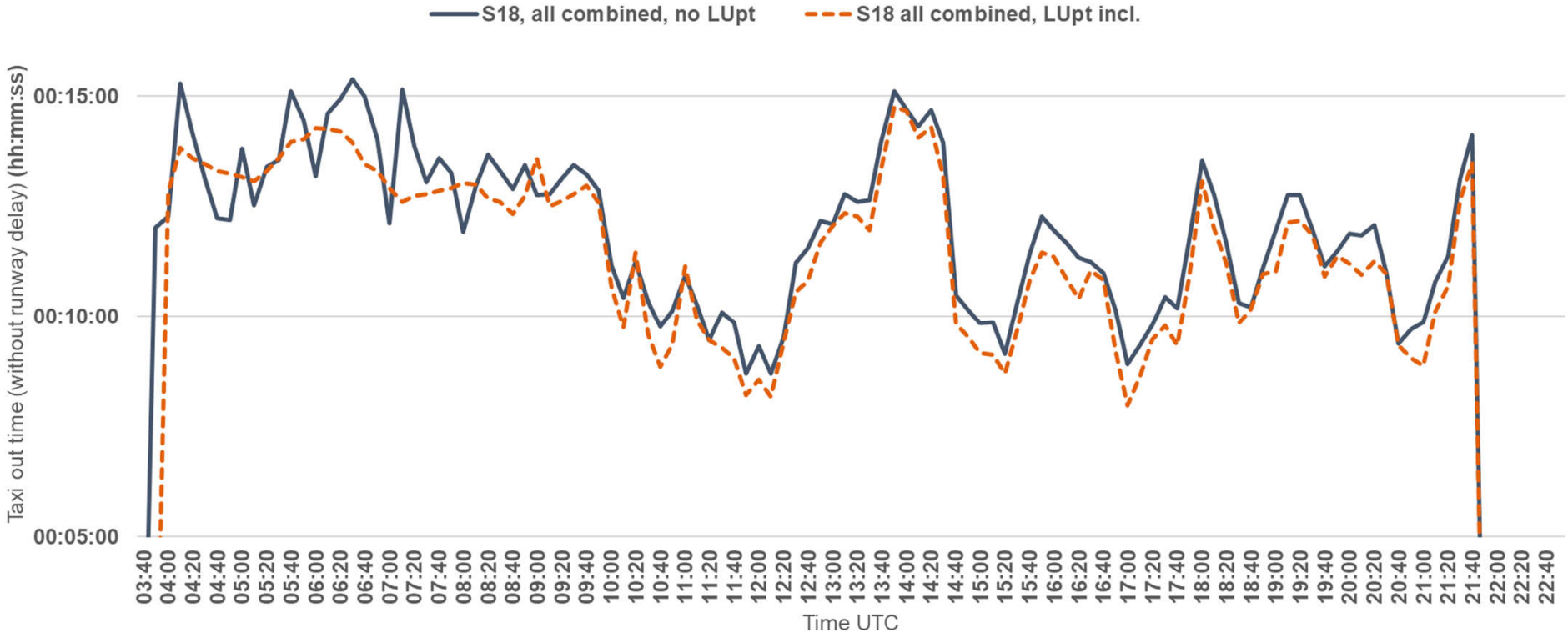
- Measured impact:
  - Peak change: -00:04:04
  - Average change: -00:00:13
- Taxi out time decreased in the first morning wave thanks to decrease in runway delay caused by the new line-up point

Combined impact of all projects (R10)
Runway delay



- Measured impact:
  - Peak change: -00:05:17,
  - Average change: -00:00:56
- New line-up point provides more options for sequencing the departure flow which helps decrease the runway delay

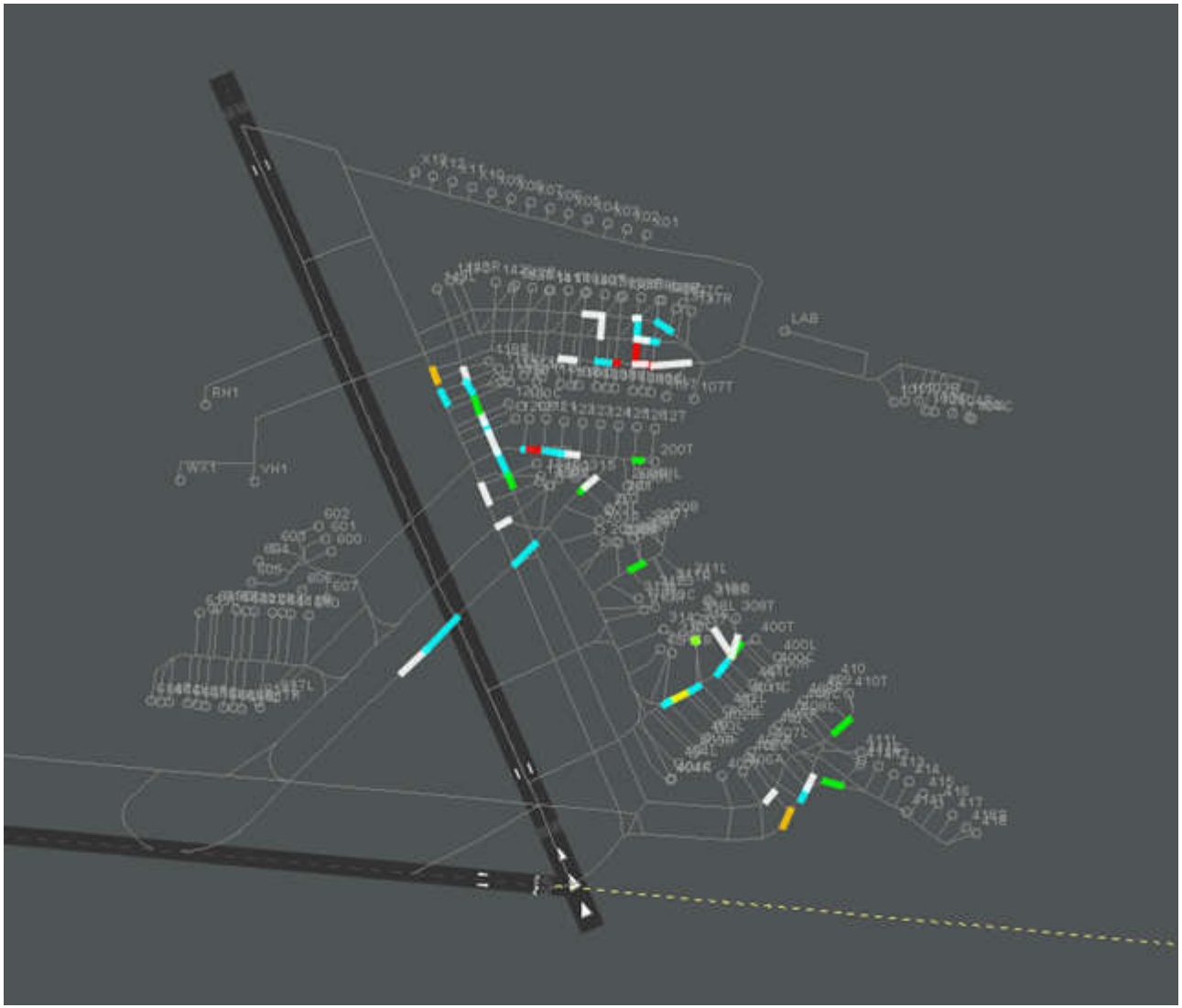
Combined impact of all projects (R10)
Departure taxi time without runway delay



- Measured impact:
  - Peak change: -00:02:33
  - Average change: -00:00:27
- No significant impact of additional line up point on overall taxi times

Combined impact of all projects (R10)

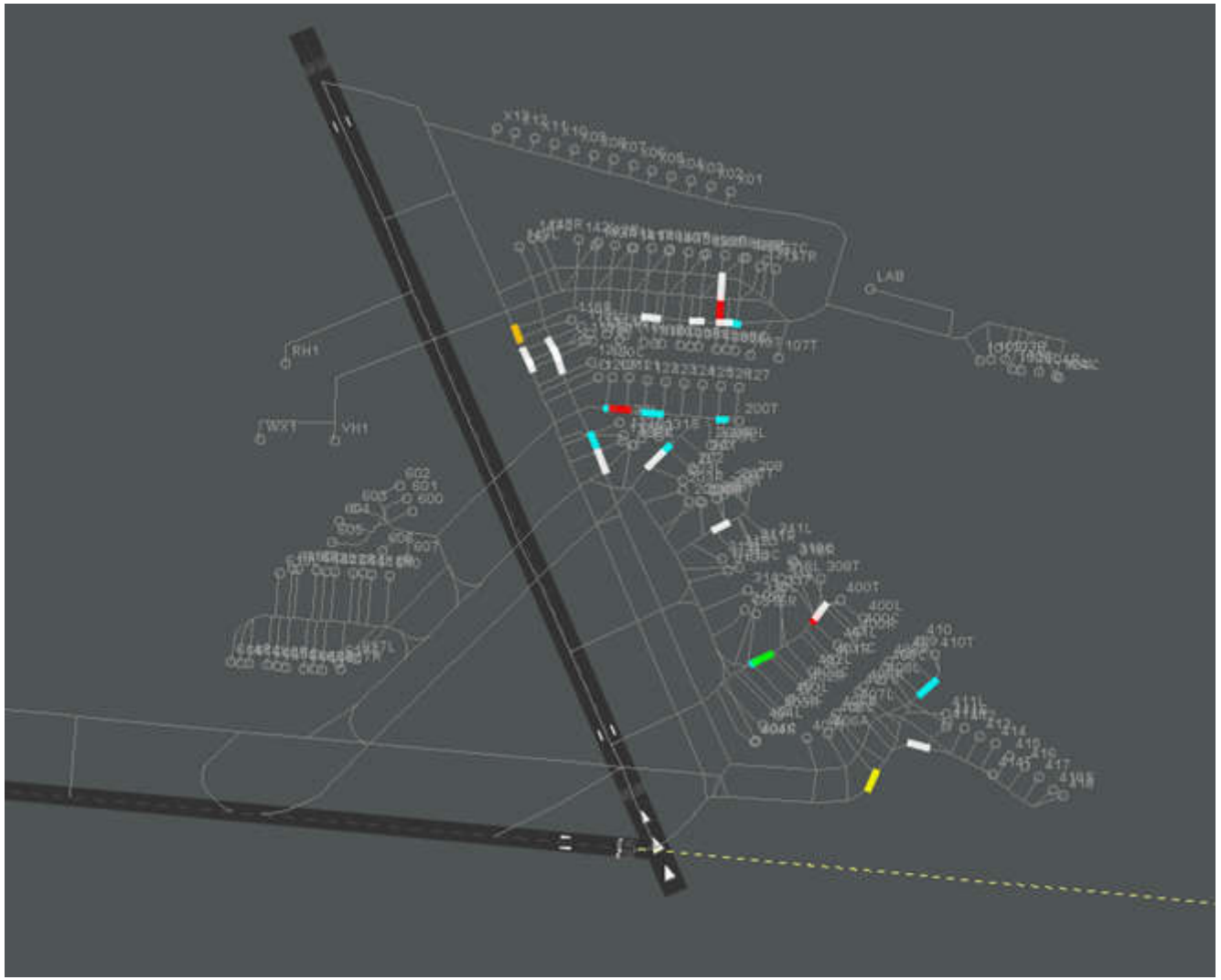
Delay accumulated on taxiway segments throughout the day



Legend
> 1 min
> 2 min
> 5 min
> 10 min
> 15 min
> 20 min

Combined impact of all projects (R10)

Aircraft stoppings on taxiway segments throughout the day



Legend	
	> 1 acft
	> 2 acft
	> 3 acft
	> 4 acft
	> 5 acft
	> 10 acft