5 Second Minimum Green: Times they are a changin'

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EVERY JOURNEY MATTERS

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Introduction

The Mayor's Transport Strategy (March 2018) sets out ambitious targets to transform transportation in London. For the first time, the Healthy Streets approach is applied to the whole of London encouraging active, efficient, and sustainable transport modes to improve health and human experience of travel on London's roads.

The aspiration to develop Healthy Streets and encourage active travel is set out in several targets, including:

- 80% of trips to be taken using sustainable modes of transport (walking, cycling and public transport) by 2041; and
- for all Londoners to do at least 20 minutes of active travel every day by 2041.

The latter is a big challenge, because only a third report doing this currently.[1] The strategy aims to reduce the dominance of motorised traffic on London's streets in order to improve air quality and reduce road danger.

Changes to Chapter 6 Guidance - More Flexibility?

TfL's Network Performance Delivery set up traffic signal operations across London to help deliver the Mayor's Transport Strategy. This includes optimising signal timings to promote sustainable modes of transport. While there are many techniques which can be used to optimise traffic signal timings, there are restrictions to these techniques which apply not only in London, but across the country. One of those restrictions is the minimum green time, which is the lower limit on the duration of a green signal.

Traffic signal standards are set by engineers within TfL Engineering's Traffic Control Engineering discipline. Current TfL Engineering design guidance is for all full traffic phase minimum green times to be set at 7 seconds. However, a change to Traffic Signs Manual – Chapter 6 in 2019 has given TfL more flexibility in how the minimum green time can be set. Chapter 6 provides the following guidance:

> 6.11.3. The shortest minimum green period normally used for traffic phases is 7 s [...] At sites with very low flows, a minimum of 5 s may be used with caution[2].

[1] http://content.tfl.gov.uk/healthy-streets-for-london.pdf
[2]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/851465/dft-traffic-signs-manual-chapter-6.pdf

Theoretical Benefits

A reduced duration for minimum green on phases with very low flows would facilitate better optimisation of the junction by:

- enabling the UTC (Urban Traffic Control) system to reallocate up to 2 additional seconds green time per stage to other stages; and / or
- allowing the UTC system to reduce the overall cycle time.

The extent to which the phases would run down to 5 seconds would likely be time and day specific based on demand, which would allow the UTC system to have greater flexibility of optimisation throughout the day and across the week. Not all junctions would likely be suitable for this reduction 24/7 and, therefore the benefit would be seen to increase or decrease across the day.

It was identified that this increased flexibility would benefit two specific sustainable modes – namely, buses and pedestrians.

For buses, reallocated green time could be given to opposing bus stages in order to improve bus journey times and bus journey time reliability. TfL's UTC system, through SCOOT, calculates where additional green time should be allocated and often oversaturated links which receive additional green carry bus routes. In addition, Network Performance Delivery have the facility to set up the junction on the UTC system so that additional time is always given to specific bus stages.

For pedestrians, a reduction in overall cycle time could result in a reduction of pedestrian wait time. Where junctions are undersaturated and carry no need for additional green time to be reallocated to traffic stages (e.g., late evening or overnight periods) the additional 2 seconds could be removed from the cycle time entirely. In addition, the benefit could be significantly greater than a 2 second reduction in wait time at SCOOT controlled junctions. This is due to restrictions on cycle times at these junctions.

The minimum cycle time for a junction is often restricted by the minimum node cycle time. As the minimum node cycle time usually works in factors of 4 or 8 seconds, a reduction of 2 seconds to a minimum stage length may actually result in a drop of 8 seconds in cycle time. This would be a significant drop to pedestrian wait time for a relatively small design change.

It is worth explaining that changes would only be to the minimum green time and not the maximum. Junctions with SCOOT and/or VA control would still have the capability to optimise allocated green according to traffic demand, so this change would only result in reduction should there be not enough demand to increase above 5 seconds or where Network Performance Delivery want to keep the phase artificially shorter. However, at junctions with no detection to optimise stage lengths, the phase would run operator defined stage lengths – which may be locked to 5 seconds. This would have to be justifiable based on flows.

The benefits which could be seen were likely to be significant and varied – especially at locations where there are numerous approaches with multiple phases which could be reduced at the same junction. It was hoped that a change to TfL Engineering standards could be developed in order for the deployment of minimum greens at 5 seconds to be implemented across all suitable junctions in London as a commonplace part of traffic signal design in order to deliver a more efficient network and promote the use of sustainable modes.

Initial TfL Engineering Work

While the Chapter 6 guidance had changed, TfL Engineering understood the requirement to ensure that a potential change to standards was evaluated in order to ensure TfL was putting safety first and complying with the national guidance.

The Chapter 6 guidance was not exhaustive and raised four areas of questioning.

- What was a “low flow”? Was this a low flow in comparison to other flows in London, or a low flow in comparison to the whole of the UK? What if flows were low during specific time periods, but high in others? What if the flow was only pedal cycles? What if the flow was only HGVs?

- Would there be a knock-on effect to safety-critical timings? The determination of intergreen periods is done in isolation to the amount of green time allocated to the phase, but would less time for a vehicle to get up to speed mean that intergreens would not be sufficient?

- Would traffic signal equipment be able to cope with this change? As there would be less time for a vehicle to get up to speed, would detectors designed to extend green be able to detect these possibly slower vehicles? Would all traffic signal controllers on the TfL estate be able to provide 5 second minimum greens?

- Would a minimum green of 5 seconds appear as “faulty” to a road user? Would road users start distrusting the traffic signal and be more likely to violate it?

From these four areas, TfL Engineering determined 5 conditions which had to be met in order to implement a reduced minimum green. These were:

1. The minimum green time must be of a duration long enough for a road user to pass the furthest probable collision point, in addition to all other safety critical timings;

2. If the phase has detection for extensions of green time, the minimum green time must be of a duration long enough so that a moving queue of traffic would be able to reach the minimum speed for detection at the point that the traffic entered the detection zone;

3. The minimum green time must be of a value which gives the signal credibility by not changing too quickly;

4. The traffic signal controller at the junction with reduced minimum green time must have a signal timings working value for phase minimum green which enables the minimum green time to be set at the reduced value; and

5. The junction with reduced minimum green time must satisfy requirements for very low flows, the definition of which would be investigated and expanded upon during the project.

The conditions would be examined at a selection of trial junctions which would be provided with traffic signal configurations which would have minimum green values of 5 seconds for nominated phases, with no other changes to the junction.

TfL Network Performance Delivery identified twelve junctions which had phases which could be suitable to have their minimum green times lowered. Selection was based on seeking to achieve a good variety of:

- flow levels (based on local knowledge);
- usual mode of control (whether UTC with SCOOT or VA);
- types of phases, both full traffic phases and phases exclusively for pedal cycles; and
- phases with specific uses (e.g., private estate exits, car park exits) alongside regular roads.

This was done to test a variety of factors which could come into play when designing and operating traffic signals across London.

Additionally, to demonstrate potential benefit of changes to bus performance, all selected junctions would have bus routes through the junction on stages which could be re-allocated the spare green.

It was acknowledged at this point that there would need to be further trials to test more complex junctions across the network. For this part of the trial, now named "Phase 1", junctions were selected for a proof of concept to allow certain types of phases to examined with the intention of facilitating roll-out at similar junctions across London. Issues identified on the back of Phase 1 could be investigated in further phases of the trial.

The junctions selected were categorised as below:

- CAT 1 – would likely run down to 5 seconds 24/7;
- CAT 2 – would likely run down to 5 seconds most of the day, but could have the occasional increase in flow and run higher;
- CAT 3 – would likely run down to 5 seconds overnight / early morning; and
- CAT 4 – pedal cycle phases which likely could be reduced to 5 seconds.

The trial junctions and their categorisations are presented in Table 1.

Junction reference	Location	Phase	Cat.	Group
00/000013	QUEEN VICTORIA STREET - QUEEN STREET	D	4	Cycle
01/000585	B507 LISSON GROVE - FRAMPTON STREET	E	4	Cycle
09/000019	A3 CLAPHAM COMMON NORTHSIDE - A216 CEDARS RD - CLAPHAM COMMON CYCLE ROUTE	D	4	Cycle
09/000140	STREATHAM HIGH ROAD - GREEN LANE	D	1	Ultra-low (private access)
28/000217	A407 CHICHELE ROAD - ANSON ROAD	F	1	Ultra-low (private access)
20/000039	CHIPSTEAD VALLEY RD - WOODMAN RD - LION GREEN ROAD - WOODCOTE GROVE ROAD	B	2	Ultra-low (public highway)
20/000272	COULSDON BYPASS - INDUSTRIAL PARK ACCESS	D	1	Ultra-low (public highway)
22/000017	COOMBE LANE - WEST BARNES LANE	E	2	Ultra-low (public highway)
09/000012	A23 BRIXTON ROAD - LOUGHBOROUGH ROAD	C	3	Other
10/000015	A3 BATTERSEA RISE - BOLINGBROKE GROVE	B & D	3	Other
10/000094	ROEHAMPTON LANE - CLARENCE LANE	C	3	Other
20/000093	DENNING AVENUE - GOODWIN ROAD - HILLSIDE ROAD	C & D	2	Other

Table 1: List of trial junctions

Designing the Data Capture

With trial junctions selected, TfL Engineering and TfL Network Performance Delivery determined what data would need to be captured in order for analysis to take place. It was decided that there would be three forms of data capture, namely:

- behavioural surveys – before and after;
- site observation reports; and
- signal timing messages – before and after.

Behavioural Surveys

Before and after surveys were undertaken each for a week day and a weekend day between the hours of 07:00 – 19:00.

During the period, the following data was captured each time the nominated phase was given right of way:

- queue length at the stop line immediately prior to phase being given right of way;
- vehicles passing stop line whilst phase was given right of way ("green"); and
- vehicles passing stop line whilst phase was not given right of way ("amber" / "red").

The vehicles in the data were classified. The data also captured whether vehicles which crossed the stop line during no right of way did so by creeping across the stop line and stopping after or on the stop line to better understand the behavioural element behind the violation. Video footage was also captured, which would allow engineers to undertake spot analysis to better interpret the data. In addition to this, UTC data was captured over this period in order to understand the amount of green which each phase was receiving.

Site Observation Reports

When any changes to a junction occur, a TfL Engineer will undertake a Local Acceptance Test (to ensure that the junction has been installed correctly) and a Traffic Signal Safety Check 3 (to ensure that the junction is operating as expected). In addition to these, the TfL Engineer was asked to complete a site observation report, designed to capture information which would be used later when interpreting the behavioural surveys.

The site observation reports would be completed while the junction was forced to run its nominated phases at the new minimum green time of 5 seconds, to allow the TfL Engineer to observe and characterise the behaviour of all road users at the junction in response to the change.

Signal Timing Messages

Signal timing messages were collected from the UTC system so the performance of the junctions could be monitored. These messages included:

- the green duration of the nominated phase, to show the level of optimisation of the green split;
- the degree of saturation on the phase, to show the success of the green time optimisation; and
- the cycle time of the junction, for future analysis on any changes to cycle times due to the reduction in the phase minimum.

Messages were collected before the after behavioural survey and on the after behavioural survey days themselves so that comparisons could be made.

Phase 1 – TfL Engineering Results

Through the trial, it became apparent that the characteristics of the junctions and phase(s) observed allowed the junctions to be put into one of four groups. Namely:

1. **Cycle**
2. **Ultra-low (private access)** – Junctions where the 5SMG phase(s) serve entry/exit from a private road or housing block;
3. **Very low (public highway)** – Junctions where the 5SMG phase(s) which are minor side roads with very low demand (e.g. cul-de-sacs); and
4. **Other** – all other traffic phases.

The trial junctions and their groups are presented in Table 1.

For each group, the question was posed as to whether all 5 of the conditions were met. This decision was made based on analysis of the behavioural survey data and the site observation reports. Particular focus was put on any difference in non-road green violation (NRGV) between the before and after surveys, as this would be evidence that either condition 3 or condition 5 were not met.

Summary of the analysis is shown in Table 2.

Group	Condition 1 – clearance time	Condition 2 – detection for extensions	Condition 3 – signal credibility	Condition 4 – traffic signal controller	Condition 5 – very low flows
Group 1 - Cycle	Met	Met[3]	Met	Met	Met
Group 2 – Ultra-low (private access)	Met	Met[4]	Met	Met	Met
Group 3 – Very low (public highway)	Met	Met[5]	Not Met	Met	Not Met
Group 4 – Other	Not Met	Met	Not Met	Met	Not Met

Table 2: Summary of analysis

[3] In absence of data – no junctions in this group had detection for extensions
[4] In absence of data – no junctions in this group had detection for extensions
[5] In absence of data – no junctions in this group had detection for extensions

Condition 1 – clearance time

Evidence gathered for Groups 1, 2 and 3 showed that clearance times remained sufficient for all road users after the introduction of a 5 second minimum green.

The condition was not met at one junction in Group 4 as both phases with reduced minimum greens opposed within the same stage, which in the site observation reports was stated as to compound existing issues related to clearing opposing right turn movements, causing the junction to become blocked. Although it was highly likely that unimpeded vehicles would be able to clear the furthest probable collision point, this was not demonstrated with the opposed movement due to the blocking of the junction.

It could be proposed that current solutions for blocking should be implemented alongside to alleviate said issues. However, solutions to alleviate blocking are limited in scope, as most junctions in London do not have space to expand to provide additional lanes. Therefore, solutions are extremely limited in their effectiveness, especially where blocking is caused by issues like slow moving right turning buses.

In conclusion, it was viewed as unlikely that a reduction in minimum green would have a knock-on effect as to the effectiveness of other clearance times at any junction.

Condition 2 – detection for extensions

Evidence gathered for all Groups showed that all detectors examined were capable of detecting road users after the introduction of a 5 second minimum green.

The majority of junctions did not have local extension detection for the phases which had reduced green. This was unsurprising, as most traffic signal junctions in London have UTC as a primary mode of control with CLF fallback, neither of which use above ground detectors for extension of green time.

In an absence of extensive study, the risk is further lowered by current TfL equipment standards which require applicable detectors to be registered against TOPAS 2505A, which states that:

> 2.7 i) The low speed threshold setting shall be 6 kph (-2 kph / +2.5 kph), no detection shall occur below this setting.[6]

As the impact of a reduction of minimum green time would be reduced speed, it would be helpful to have a design acceleration values, to determine the time it takes for the vehicles queuing at the stop line to move off and to accelerate to a normal running speed and – therefore – ensure that 5 seconds would be sufficient to meet the 6 kph threshold. However, although the Traffic Signs Manual: Chapter 6 provides design acceleration values for pedal cycle values, it doesn't provide any design acceleration values for other traffic.

In the absence of such a study, it was concluded that it was unlikely that a reduction in minimum green would cause local extension detection to lose effectiveness, although TfL Engineering would strengthen existing guidance to ensure that all detection is working for all road users at Local Acceptance Test.

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[6] https://topasgroup.org.uk/specification/topas-2505a/

Condition 3 – signal credibility

Evidence gathered for Groups 1 and 2 showed either no change or insignificant change for NRGV violations and showed increase in NRGV for Groups 3 and 4. This data is presented in Table 3.

Junction reference	Group	NRGV Before (% 0 d.p.)	NRGV After (% 0 d.p.)	Comparison
00/013	1	69	64	No change / insignificant change
01/585	1	66	67	No change / insignificant change
09/019	1	61	59	No change / insignificant change
09/140	2	58	37	Reduction
28/217	2	100	100	No change / insignificant change
20/039	3	11	20	Increase
20/272	3	9	6	No change / insignificant change
22/017	3	10	25	Increase
09/012	4	8	25	Increase
10/015 – Phase B	4	6	11	Increase
10/015 – Phase D	4	13	17	No change / insignificant change
10/094	4	2	14	Increase
20/093 – Phase C	4	1	34	Increase
20/093 – Phase D	4	1	19	Increase

Table 3: Non-road green violations

<u>Group 1</u>

In group 1, there was no change / insignificant change, although NRGV was noted as high both before and after. From analysis of the video footage, it is observed that non-compliance to the red at all junctions in this group was not related to the amount of green time provided to the phase, but the behaviour of pedal cycle users to proceed into the junction where there is a gap in traffic or when a pedestrian stage is operating under a personal interpretation of a lack of conflict.

<u>Group 2</u>

In group 2, the interpretation of the behavioural survey data showed exceptionally poor stop line compliance by all vehicle types in both the before and after scenarios, especially at 28/217 where 100% NRGV with the traffic signal was observed. During the periods of NRGV, vehicles were observed exiting into gaps in traffic. As these are private exits, it can be theorised this may be worsened due to historical problems with the traffic signals resulting in a lack of trust or being poorly served in terms of allocation of time within the traffic signal cycle.

From this, it can be assumed that non-compliance to the red was not related to the amount of green time provided to the phase, but rather the behaviour of the road users to proceed into the junction under a personal interpretation of a lack of conflict.

Group 3

In group 3, the interpretation of the behavioural survey data shows negligible change in non-road green violation at junction 20/272 and an increase in non-road green violation at junctions 20/039 and 22/017. The junctions were examined more thoroughly to attempt to ascertain a reason for the increase in NRGV.

At junction 20/039, NRGVs were noted as being traffic proceeding through a red after green had expired, likely not wishing to wait for the next cycle. As it was noticed that a substantial proportion of the traffic were 3.5T long wheelbase vans accessing and egressing from the nearby private access, this could be interpreted as reluctance from the van drivers to stop progression due to momentum of the vehicle.

At junction 22/017, a very low sample size may have contributed to the increase in NRGV. It was further noted from analysis of the video footage that the NRGV appeared to be predominantly caused by two factors. Firstly, some vehicles exiting the side road on the phase were blocked by queuing traffic on the main road, so therefore proceeded on red once traffic has sufficiently cleared. Secondly, the detection was noted to not always detect the vehicle due to poor alignment. Some vehicles moved in gaps in traffic, then triggered the detector to put in a demand which was served shortly after. Although both issues provide a justification for NRGV, it does not explain why there was an increase in red light violation, as the change in minimum green should not have caused these situations to worsen.

As road users were not interviewed to determine why they decided to violate the non-road green, it could not be stated conclusively that it was not a result of loss of signal credibility.

Group 4

In group 4, all junctions showed increases in NRGV. This was despite the UTC System often affording the phases additional green. As road users were not interviewed to determine why they decided to violate the non-road green, it could not be stated conclusively that it was not a result of loss of signal credibility.

Condition 4 – traffic signal controller

Evidence gathered for all groups showed that all traffic signal controllers examined were capable of holding a minimum green time of 5 seconds as a defined parameter. Traffic signal controllers evaluated were Siemens ST900, ST800 (LV) and Optima-J.

It was not surprising that this was met, as current TfL equipment standards require that all traffic signal controllers are registered against TOPAS 2500B, which states that the boundary of working values for a phase minimum green must be between 3 to 30 seconds.[7] However, although most traffic signal controllers on the TfL estate do meet TOPAS 2500B, there will be some obsolete traffic signal controllers which will not. It is TfL Engineering policy to not undertake configuration changes on obsolete traffic signal controllers, so this risk is mitigated.

[7] https://topasgroup.org.uk/media/TOPAS-2500B.pdf

Condition 5 – very low flows

Counts gathered for all groups allowed TfL Engineering to investigate what flow amounts should be considered "very low". This data is presented in Table 4.

Junction reference	Group	Highest captured average flow (count / hour 0 d.p.)
00/013	1	82
01/585	1	10
09/019	1	82
09/140	2	2
28/217	2	1
20/039	3	20
20/272	3	49
22/017	3	8
09/012	4	286
10/015 – Phase B	4	192
10/015 – Phase D	4	360
10/094	4	416
20/093 – Phase C	4	200
20/093 – Phase D	4	132

Table 4: Flows

Group 1

Evidence gathered for Group 1 showed comparably high flows for junctions 00/013 and 09/019, as presented in Table 4. Unexpectedly, regardless of how many pedal cycles were waiting to use the stop line, all pedal cycles were able to clear the stop line within the 5 seconds of green, with some only needing a few seconds. This appears to be a combination of a pedal cycle users' acceleration speed, the ability for pedal cycle users to stack side by side to utilise the length of the stop line and a likelihood for some pedal cycle users to violate the traffic signals and treat the junction as a give-way facility.

The guidance in Chapter 6 of the Traffic Signs Manual does not indicate whether "low flows" should consider the classification of the vehicles which make up the flow, however it can be considered likely that this statement was meant to refer to vehicles other than pedal cycles. As such, there is a strong indication that a "high" pedal cycle flow will be significantly higher than a "high" vehicle cycle flow. There is a persuasive case to make that any pedal cycle flows in London can, therefore, be considered "low" for the purposes of compliance to Chapter 6 guidance.

Group 2

The junctions in this group showed significantly low flows, indicating that they would meet any definition of “low flow”. It was observed through analysis of the video footage that, on the single instance where two vehicles waited to enter the junction at the same time, both vehicles were able to enter the junction within the 5 seconds allotted.

Group 3

Going against an initial assumption that higher average flows will result in higher red-light violations, an increase in red light violation was recorded at 20/039 and 22/017, and not 20/272.
It is of note that both 20/039 and 22/017 have single lane approaches, whereas 20/272 has a two-lane approach. This would mean that a higher flow would be able to be spread over two lanes. When average flows per lane are considered, the figure at 20/272 is 24 vehicles per hour per lane. This is still higher than 20/039 and 22/017.

Due to 20/272 having two lanes, waiting queues on approach were rarely above 3 vehicles per lane. On site observation, 3 vehicles were observed as being able to clear under a 5 second green time. In contrast, it was observed at 20/039 that traffic proceeded through a red at the end of the green, with the assumption they were unwilling to wait for the next green.

The increase in red light violations at 20/039 were noted from footage review to result from traffic proceeding through the leaving amber – an increase from 12 to 26. It was noted that this was more prevalent at this junction due to the nature of the vehicles, a significant percentage of which were recorded as being 3.5T long wheelbase vans from the nearby builders’ merchants. As the violations came from leaving amber violation, it can be assumed this could be related from the drivers being unable or unwilling to lose momentum of the large vehicles.

It was also noted on video footage review that violations at 22/017 were calculated, either due to queuing traffic blocking their path through the junction or due to a distrust in the traffic signals resulting from poor detection coverage.

Therefore, it can be inferred that an increase in the behaviour of drivers to violate the red is related to:

- a perceived reduction in service related to a waiting queue of more than 3 vehicles per lane;
- a lack of credibility in the traffic signals as resultant from poor detection coverage; and
- a reluctance or inability to halt the momentum of large vehicles.

As an increase in red light violations was recorded at flows of 8 vehicles per hour, it cannot be stated conclusively that any value higher than this for a junction with this group’s characteristics should be considered “very low”. Therefore, it could not be stated conclusively that the junctions in this group satisfied requirements for very low flows.

Group 4

The junctions in this group did not demonstrate flows which would be immediately classed as low, and this was reflected in the amount of green time which SCOOT allotted to them beyond the minimum. Of note was junction 10/094, which operated on a reduced green for less than 1% of the cycles where it appeared in the “after” survey, indicating that the UTC system and SCOOT believed there to be significant enough flows to require above the minimum green. In fact, it only received less than 10 seconds of green time on 15 occasions.

For 09/012, 10/015 and 10/094, this was consistent with the initial categorisation of these junctions when they were nominated for trial, all three being categorised as likely only running down to 5 seconds overnight or in the early morning.

20/093 was recorded as working well during the off-peak periods, noted as being able to operate on short cycle times and reduced green minimums. The reason 20/093 appeared to work could be due to several factors, but of note in particular this was the only junction which fell back onto VA mode during the off-peak periods, which may demonstrate that VA mode is more reactive to clearing vehicles than UTC with SCOOT.

As an increase in red light violations was recorded at all junctions, it cannot be stated conclusively that these junctions could be considered to have "very low" flows.

Phase 1 – Signal Timing Results

From the two after survey days where the trial junctions had capability to run down to a minimum of 5 seconds, calculations were undertaken to identify the time re-allocated to other stages on the junction. As a result of the limited time for data capture, analysis on junction operation has been minimal.

Using the call-rate data from the UTC system, it was proven that the time re-allocated to the junctions varied between 1 minute per day and 11.5 minutes per day. This calculation was performed by identifying the nominated phases at the trial junctions which UTC never increased green length, both during normal operation and during operation of the trial, always running the selected stages at minimum. UTC would therefore always re-allocate the extra 2 seconds of green time back to other stages on the junction every cycle. This is shown in Table 5.

Junction reference	Benefits (s)	Benefits (min)
00/013	290	4.8
01/585	496	8.2
28/217	60	1.0
20/039	176	2.9
20/272	420	7.0
22/017	222	3.7
09/019	200	3.3
09/140	692	11.5

Table 5: Benefit of re-allocated green time

Additionally, new phase minimums could allow the cycle time to drop at six of the trial junctions. The reduction of the stage from 7 seconds to 5 seconds meant that the minimum node cycle time (MINN) dropped by 4 seconds at 3 junctions and by 8 seconds at 3 junctions. This is shown in Table 6.

For this trial, cycle times did not drop as the green time was re-allocated to opposing bus stages. However, there would be the opportunity to allow minimum node cycle times to drop and provide benefits to pedestrians.

Junction reference	Previous MINN (s)	New MINN (s)	Reduction in MINN (s)
10/015	56	52	4
09/019	88	80	8
20/039	80	72	8
09/012	56	52	4
20/093	80	72	8
22/014	60	56	4

Table 6: Potential changes in junction cycle time

Next Steps and Future Trials

The initial trial for the 5 Second Minimum Traffic Green has been a very successful one, with future trials and proposals in place to test the changes further at more complex and differently designed junctions.

From this trial, TfL Engineering will change its guidance to permit a five second minimum green value for:

- all on-road pedal cycle phases which run exclusively in their own stage;
- all traffic phases which present with ultra-low traffic demands (less than 3 cars per hour); and
- all traffic phases which:
  - have a demand of less than 500 vehicles per day and no more than 3 vehicles per lane per cycle; and
  - have no evidence that the traffic phase will be used by a high proportion of vehicles larger than a short wheelbase van.

Junctions which meet these criteria from the trial will be put into business-as-usual operation. Junctions which do not meet these criteria will either be rolled-back to previous operation or will be moved to the next phase of the trial.

Initial topics of study have been developed for Phase 2 of the trial, including:

- blocking and if / how blocking can be mitigated to provide a five second minimum green without NRGV increase;
- junctions operating two opposed 5SMG phases at the same time in a stage;
- junctions which have flows between 500 – 2500 vehicles per day, in order to determine whether a flow threshold can be determined;
- junctions which have asymmetric flows, with low off-peak flows in the region of 2 – 4 per lane per cycle, to determine whether a flow threshold can be determined;
- junctions where cycle time is between 50 – 80 seconds, to investigate the link between 5SMG and low cycle times;
- queue length and its effect on proportion of non-road green violations;

- how SCOOT could be controlled to reduce significant reduction of service where phases require more time;
- junctions with more complex design considerations, in particular junctions with early starts for pedal cycles; and
- junctions with VA fallback during the off-peak in comparison to sites with 24/7 UTC control.

Conclusion

In conclusion, the changes to Chapter 6 guidance has provided Network Performance Delivery an opportunity to reduce the minimum traffic green on very low flow approaches to 5 seconds. This change allows traffic signals to operate more efficiently and effectively to help Network Performance Delivery deliver the Mayors Transport Strategy to improve performance of sustainable modes. The re-allocation of 2 seconds at junctions back to stages carrying bus routes or to help reduce pedestrian wait time are both ways in which TfL can encourage the use of sustainable modes.

Results of data analysed show that TfL Engineering can be satisfied with reducing green minimums to 5 seconds at sites which meet specific criteria in terms of risks (with a focus on safety to users) and, as such, TfL Engineering will change its standards to enable business-as-usual design, installation, and operation on the TfL road network.

Data analysed shows that pedal cycle phases which run exclusively in their own stage and phases with ultra-low flows can be approved for minimum greens of 5 seconds by default. At these sites:

- non-road green violations remained the same / similar after implementation at pedal cycle phases; and
- non-road green violations remained the same / similar after implementation at phases with flows below 3 vehicles per hour which serve private accesses.

TfL Engineering has determined that phases with higher flows (less than 500 vehicles per hour), but which are not ultra-low could be suitable for minimum greens of 5 seconds, however this must be assessed on a site-by-site basis, with caveats that it must be proven that there will be a demand of no more than 3 vehicles per lane per cycle and there must be no evidence that the traffic phase will be used by a high proportion of vehicles larger than a short wheelbase van.

TfL Engineering has determined that there appears to be no specific equipment constraints required to be considered in the design process.

TfL Engineering has determined that there is not sufficient evidence to prove the safety of sites which have flows of more than 1000 vehicles per day and notes that this may be the result of additional factors.

Those trial junctions with phases which do not meet the new criteria require further investigation and will be reviewed in Phase 2 of the trial in order to try and expand the reach of this beneficial change to guidance.

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