TfL Bus Priority Update - extracting more and more value out of our bus priority system

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EVERY JOURNEY MATTERS

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Introduction

At last year's symposium, Michael Bloomfield and David Oram outlined a number of innovative techniques that have allowed TfL to maximise the usefulness of our BP equipment and increase our BP capability.

The past 12 months has seen this work continue, with numerous other projects initiated. All these work streams again have the objective of helping buses to get through the network with lower delays, saving time and increasing reliability for the travelling public.

Bus Priority in London and the UTC System

Transport for London's Network Performance Delivery (NPD) team is responsible for setting up, operating and optimising London's UTC traffic control system. A key part of this includes Bus Priority (BP) in SCOOT, known as PROMPT (**PR**iority and inf**O**r**M**atics for **P**ublic **T**ransport).

Bus Priority (BP) at junctions works by either extending the current green signal time at the end of a stage to allow a bus through (an "Extension"), or by shortening opposing stages to give the bus green more quickly (a "Recall").

At junctions where Standard BP (SBP) is not suitable Differential Bus Priority (DBP) can be implemented. DBP uses bus schedule information and typically prioritises only delayed buses. This allows an increased amount of priority to be given to late-running buses.

Below is a summary of BP equipment and configuration in London (data taken from August 2021);

- 1925 sites with Bus Priority
- 1534 sites with BP on UTC
- 1128 on UTC running SBP
- 406 on UTC running DBP
- 391 sites with BP on VA
- 6280 VDPs (Virtual Detection Points)

The following three graphs give an overview of BP activity on the UTC system. Figure 1 represents the daily total of buses seen and shows an increasing number from October 2018 to April 2021. This figure represents every bus detected at a VDP (Virtual Detector Point) by the UTC system. A similar graph was presented at last year's symposium and Figure 1 represents an update to this with data from the past 12months included.

Figure 1 – Daily total (average) of buses seen by the UTC System

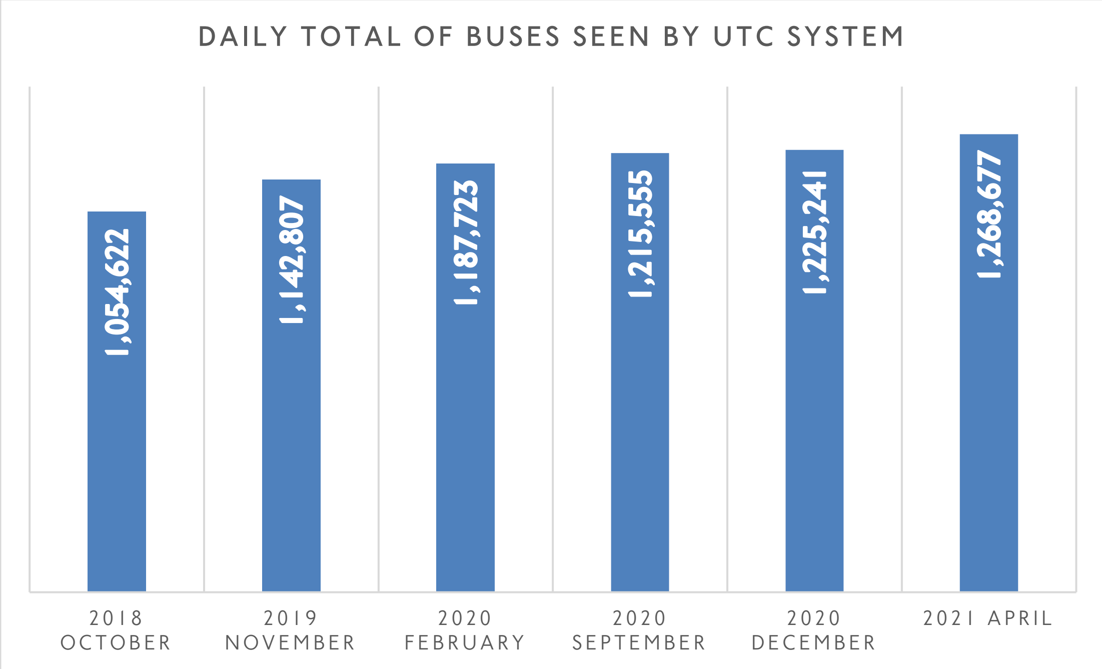
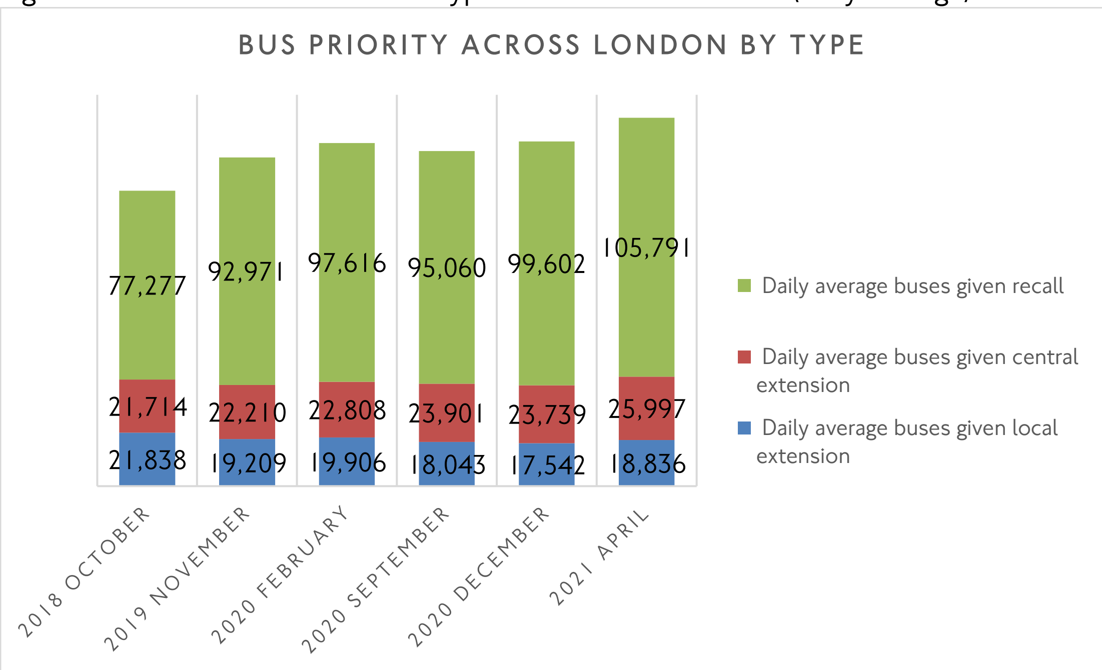


Figure 2 shows the breakdown of different types of BP granted at signals. Recalls comprise the bulk of BP activity, with Central and Local Extensions being similar to each other in number. Extensions are rarer as a form of priority as the bus must approach the signal in a smaller time "window" for this type of BP to be possible.

Figure 2 – Breakdown of different types of BP across London (daily average)

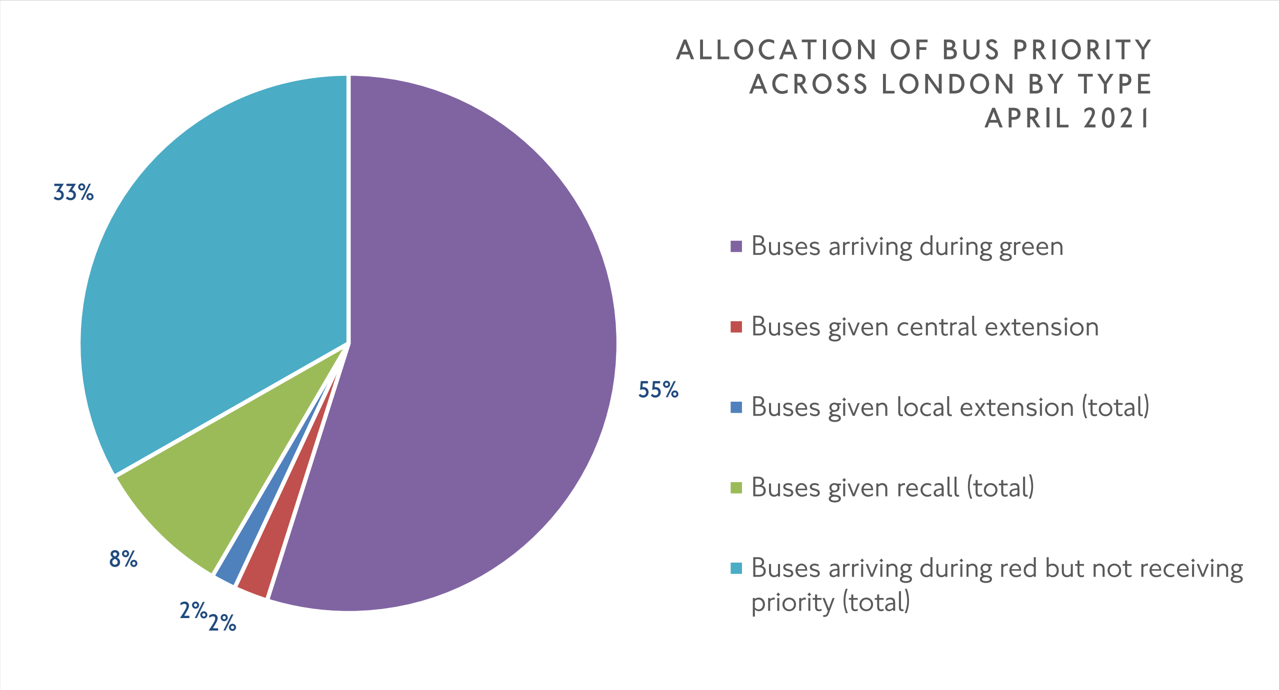


Both Figures 1 and 2 show increases which are reflective of NPD's continued work to install and implement BP and make system changes to give as much priority to buses as possible. The innovative techniques described last year, and in this paper are helping to contribute to these positive figures.

One trend to highlight is the recent increase in Local Extensions (in April 2021). The number of Local Extensions has been falling since October 2018 but some specific work undertaken in the past 8 months has sought to reverse this trend. More details are given in Section 4 below.

Figure 3 shows data from April 2021 only, giving a percentage breakdown of BP activity for all buses detected. Over 50% of buses receive no priority as they arrive during green, and therefore none is required. Another 33% of buses are detected but receive no priority, due to network and system constraints (this is a reduction of 1% on February 2020's figure).

Figure 3 – Allocation of BP across London by type (April 2021)



As highlighted last year, due to limitations in BP hardware availability and funding, London's BP network is currently only being maintained, not expanded. It is for these reasons that the innovative techniques described last year, and in this paper have been explored and are now being implemented.

Innovative Techniques to Increase Levels of BP on the UTC System

1. Bus Priority Optimisation Reviews

The use of SCOOT data (specifically time spent in "BP Override") to identify poor performing bus priority junctions was discussed in Michael and David's presentation last year. A successful pilot programme of "Bus Priority Optimisation (BPO) Reviews" followed. 32 such reviews were then completed between September 2020 and March 2021 (giving a total of 728.5 passenger hours saved per day, 22.8 hours per day on average per location).

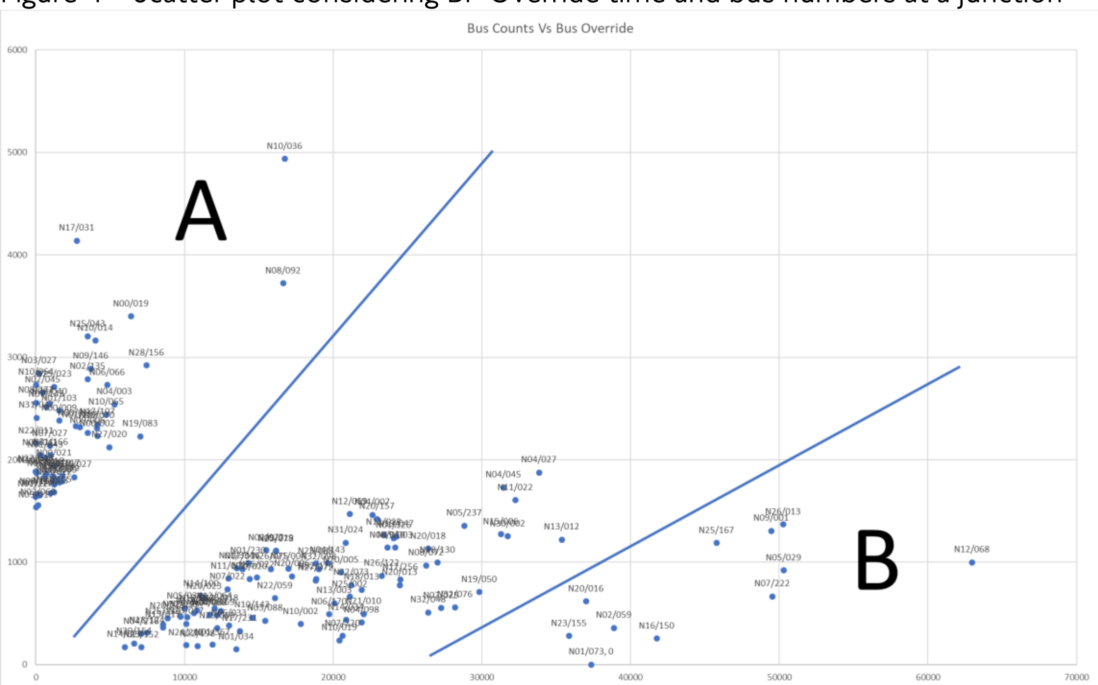
This success has led to a further 50 BPO reviews being added to the NPD Timing Review Programme for 2021-22. However, one key additional data set has been added to allow this year's BPO review programme to be even more targeted – bus numbers at the junction.

For example; a junction spending not much time in BP Override may be performing in such a way due to the simple fact that very few buses pass through it. Low numbers of buses would naturally give few opportunities for bus priority to occur and therefore have a low override time. Such a site would not offer great opportunity for improvement, but purely considering "BP Override" data alone would've indicated it needed a BPO review.

Therefore, by combining both override time with bus numbers we're able to identify sites that fall outside of an expected operating threshold (e.g. a high override time per bus indicates a poor performing site in need of review).

An analysis was undertaken to formulate the BPO Programme for 2021-22. The scatter graph below (Figure 4) represents these two data sets.

Figure 4 – Scatter plot considering BP Override time and bus numbers at a junction



Using this data, we have been able to more accurately identify those junctions which would benefit from a BPO review. Those falling within the middle section of the graph, show a good positive relationship between bus numbers and BP Override time, this is as expected and these junctions do not need a review based on the data. Those junctions falling in the shaded zones represent locations where:

A - there are lots of buses, but the total BP Override time is low, suggesting “under-active” BP and where there is greater potential for BP to occur (Area A).

B – there are few buses, but the total BP Override time is high, suggesting “over-active” BP, and where a review is required. This is to ensure that after BP is granted the junction can recover and return to UTC SCOOT control as quickly as possible (Area B).

This year’s 50 BPO reviews have been taken from zones A & B, allowing us to concentrate our efforts on the junctions in most need of attention.

2. Bus Virtual Detection Point review

A Virtual Detection Point (VDP) is the location at which buses are detected, typically on the approach to traffic signals. “Seeing” the bus is the first step towards assigning it priority. VDPs can have different stop conditions associated with them, “0” if a bus is approaching the signals in free flow (i.e. not stopping), and “2” if there is a bus stop on the approach.

A recent project has been able to identify all VDPs with a stop condition of 0 and with a bus journey time (BJYT) of 4seconds or lower (a low BJYT reduces the likelihood of extensions occurring). The stop condition is critical here as stop condition 0 VDPs may be able to be moved as they are not constrained by a bus stop being present. Stop Condition 2 VDPs with low BJYTs are not movable as these are located by bus stops.

156 VDPs were identified that fit these criteria (stop condition 0, bus journey time 4seconds or lower) and each is being investigated to assess whether they could be moved further from the stop line. This would give an increased BJYT and more time for the signals to grant an extension.

This review is currently ongoing but follows a pilot study where 11 VDPs were moved, with BJYTs being increased from 4seconds or lower to a new (higher) value. These 11 VDPs, once moved, saw an increase in Central Extensions of over 53%.

Given that VDPs are not a physical piece of infrastructure, moving them only requires an update to coordinates and this represents a low-cost way of delivering more BP on our network.

3. Virtual Detection Point (VDP) to stop line distance compared to UTC system entered Bus Journey Time (BJYT)

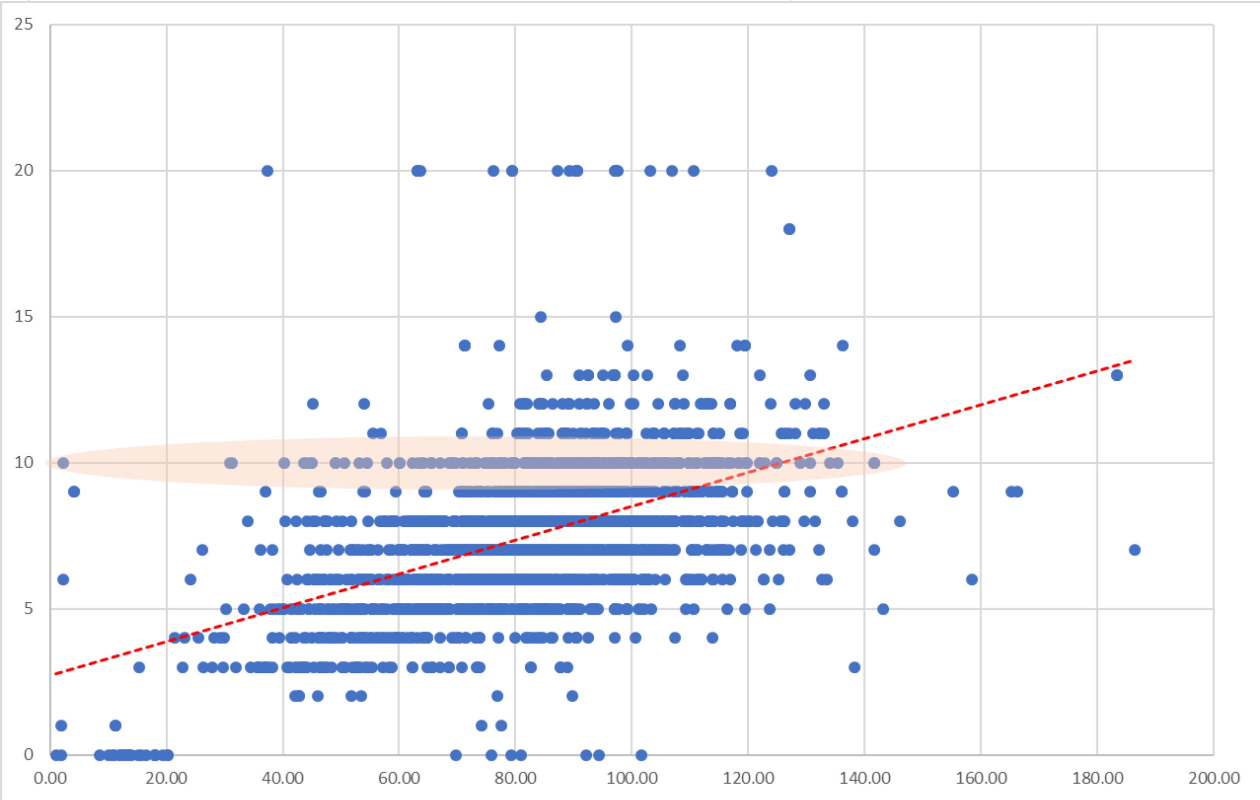
The importance of bus journey time was briefly mentioned in the previous section. Not only does this value govern the likelihood of extensions occurring, but it also determines how effective the bus priority granted really is.

An incorrect bus journey time could result in buses clearing the stop line (as modelled in the UTC System) but not actually clearing the stop line on street. In this scenario, the bus would have benefitted from a BP extension but did not receive one. Conversely, the bus could clear the stop line on street but not clear in the system and bus priority could be granted in error, causing unnecessary disruption to junction operation.

Logically, one would expect the relationship between VDP to stop line distance and BJYT to be positive and reasonably linear, i.e. as the VDP distance increases, so too would BJYT.

By extracting both datasets from our system and comparing their relationship, the following scatter plot (Figure 5) was created, and with a line of best fit added this linear relationship is visible.

Figure 5 – Relationship between VDP distance FSL and UTC system BJYT



However, there are also many data points that fall outside the expected location. For example, the shaded area represents all data points with a bus journey time of 10seconds. These points fall anywhere from 2m FSL up to 142m FSL. Some variation in FSL distance for a 10second BJYT would be expected, but not as wide as this.

We are now using this data set in our review work and specifically targeting the remeasuring of BJYTs to improve not only the accuracy of our BP data. This ensures buses clear the stop line in the extension time they are given, and also increases opportunities for BP where BJYTs are too low (and buses on street are not receiving the priority they require).

A recent review of such data for all VDPs on the Bus Route 63 (from Kings Cross to Honor Oak) revealed 32 BJYTs falling outside the expected value, and has led to these all being remeasured and corrected in our system.

Again, this is a low-cost initiative, using data, to target our resource and to ensure our BP system is operating optimally.

4. Local Extension (LEX) Upskilling & Local Extension Timer update

As mentioned in the introduction, the amount of LEXs granted on our system has been in decline since we started recording detailed data in 2018. To reverse this trend, some recent investigative work has broadened our understanding of LEXs. This work took on multiple strands;

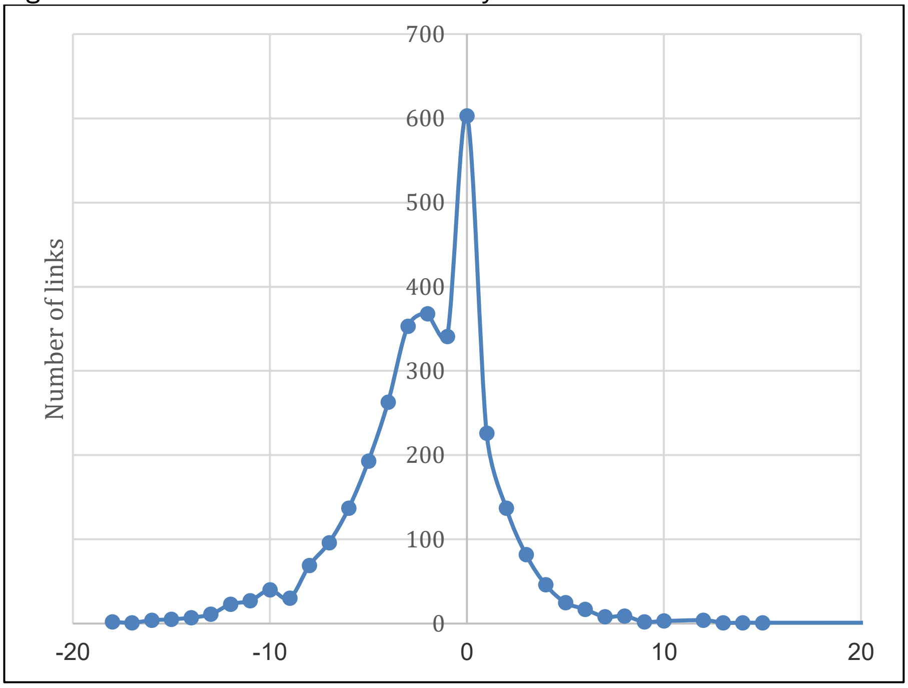
1 – Through **detailed SCOOT & BP message analysis** we now fully understand how we can influence and increase the likelihood of LEXs being granted, and therefore can update system parameters. LEXs are not the "poor cousin" to Central Extensions that we once thought, they are granted differently and have potential advantages.

2 – A study has been completed to assess the impact of **allowing LEXs to occur at Differential Bus Priority (DBP) sites**. This was previously not advised due to the potential for disruption and for granting priority to buses that were not behind schedule. However, the study proved a success; the level of disruption was low with the overall benefits being high. Our guidance on allowing LEXs to occur at DBP sites has now been updated.

3 – An **update to our "LEX Calculator" tool** has been completed – this update accounts for the findings (from point 1 above) and gives Network Managers an easy to use method to configure and review LEX timers set in the controller.

4 – A **mass data extraction of all LEX timers** configured in controllers was completed. This data was then compared to UTC System BJYT values to see if the two align (which they should!). The graph below shows the output (Figure 6).

Figure 6 – Difference between UTC System BJYT values & Controller PROM LEX Timers



From over 3000 bus links analysed, 600 of those have the correct extension values (i.e. the UTC system value and Controller Spec match). Values within 1-2secs of a perfect match are acceptable given the variability in bus journey time.

However over 1900 links have higher extension values in the Controller Spec. The consequence of this being that LEXs could be granted to buses that have already passed the stop line. This would cause unnecessary junction disruption as BP is incorrectly granted.

Having access to this data has allowed us to highlight a potential problem in LEX operation and correct the discrepancy between extension timers set in the controller compared to bus journey times in our system.

We are already using this data to target updates and corrections as part of our Timing Review work.

For all four strands of work mentioned above, departmental wide training has been delivered to upskill Network Managers to enable them to increase LEX BP activity on our network and ensure those LEXs granted are both necessary and of suitable length. The recent increase in LEXs (see Figure 2) is reflective of these recent initiatives and hopefully the start of a trend.

5. Bus Route Configuration Tracker

For buses to be detected and BP to be granted at a junction a BP configuration must be completed, detailing which routes travel through the junction and are therefore expected to be "seen" at the VDP. The configuration is often completed at the time of BP implementation / enabling.

However the 675 bus routes in London undergo both schedule and route alterations over time as travel patterns change and TfL responds to customer demands. This results in buses no longer travelling through the junctions they did previously, but importantly also results in them now travelling through new junctions on their route. When such changes occur, BP configurations are not automatically updated and therefore buses are not detected and would not receive BP.

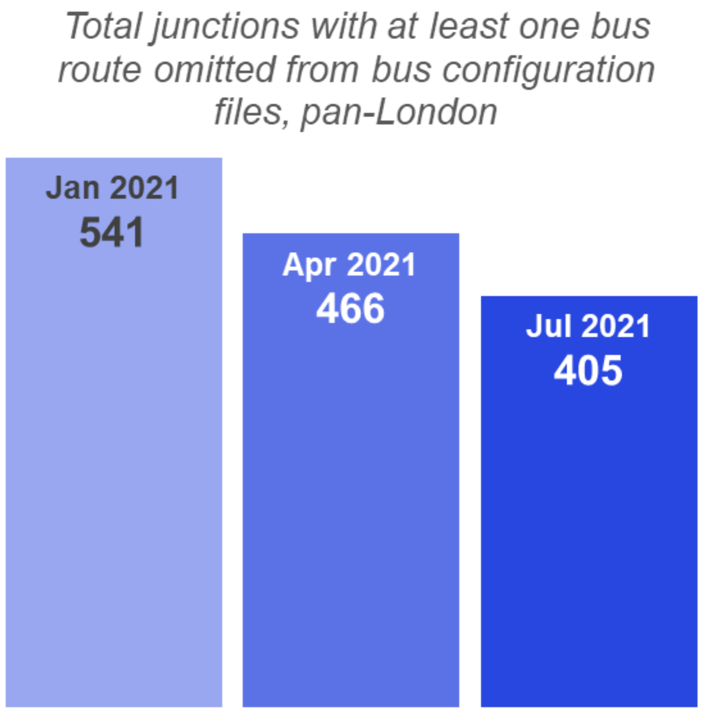
One of the checks a Network Manager will undertake during a Timing Review is to assess the accuracy of the BP configuration. However, there are many more junctions in London than we can review on an annual basis, and bus route changes are continually occurring.

Therefore, a recent project has been delivered whereby geospatial data was extracted for every route in London. This dataset was then cross referenced with system BP configuration data, resulting in a list of junctions where buses are not coded into the configuration but should be.

Using this information, we have been able to target those junctions with the most out of date configurations, adding in routes where they should feature but do not. Rather than resolve these inaccuracies during Timing Review as we find them, we are now able to proactively update these configurations. Once configurations are updated, buses are once again detected and able to receive BP from the UTC system.

Since its launch in March 2021 a total of 146 junctions have had their configurations checked and updated as a direct outcome of the configuration checker. This has resulted in a ~25% reduction in the number of sites with at least one route missing from their configuration, as per Figure 7:

Figure 7 – Total junctions with at least one bus route omitted from their configuration



These figures largely account for the increase in buses detected in April 2021 (see Figure 1) and contribute to the increase in BP activity (shown in Figure 2).

This project sought to deliver more BP on our network not through deploying more BP equipment, but by focussing on managing our datasets more proactively to ensure accuracy and help the system to deliver more BP. With that in mind it has been an absolute success.

Conclusion

In a continuation from last year's theme, this paper has outlined five new projects that have been initiated since the last JCT symposium, again, with the objective of maximising the usefulness of our existing BP equipment. Each of the projects described are contributing to more opportunities for buses to travel through our network with lower delay and have been delivered at extremely low cost. This is especially the case when compared to the high costs of civil schemes or deploying new BP equipment. By accessing, analysing and acting upon the vast datasets we hold, we can target our limited resources at those junctions which will benefit the most from our attention.

Consistent with those initiatives presented last year, TfL's Network Managers have been trained on how to use these techniques / new datasets and the BP statistics we collect provide evidence that their application has been a success.

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