Professor Peter White – Supplementary written evidence (TTS0063)

A note on bus and cycle road capacity

Supplementary note to evidence from Prof Peter White to the House of Lords' Built Environment Committee inquiry into Public Transport in towns and cities, following oral evidence on 22 March 2022 (see pp 18 and 19 of corrected oral evidence transcript)

The capacity of road system can be defined either in terms of vehicles, of the volume of people and/or goods moved. Many of the traffic engineering measures introduced from the 1960s onward were based on the former criterion, and could be seen as a response to the rapid growth in use of cars. Typical measures included restriction or removal of kerbside parking (increasing space for moving traffic), one-way streets (reducing conflicting movements at junctions, and hence increasing their capacity) and traffic signals co-ordinated to produce a 'green wave' for that traffic moving at typical average speeds would encounter a sequence of junctions in the green phase. Traffic flow is usually defined in terms of passenger car units (pcus), and could be shown to increase on this indicator. Some of these measures benefitted buses, notably removal of kerbside parking (as seen in the 'red routes' in London, for example), but others less so (one-way systems took buses away from passenger objectives, and the green wave did not necessarily benefit buses as they run at lower speeds than other traffic due to serving kerbside stops).

From the 1970s onward there was a shift to measuring road capacity in terms of people and/or goods moved, reflecting the more efficient use of road space by buses than cars, due to their higher occupancy. This is reflected in provision of bus priority lanes (usually the kerbside lane), priority at signalised junctions, and reversion of previous one-way streets to two-way running. Well-established economic evaluation criteria enable an assessment of the net economic benefits to be made in monetary terms

By definition, a car has a pcu value of 1. For buses a value of 2.5 is generally used, and for cycles 0.5. There is some debate about the latter, and under conditions of high density cycle flows, a lower value may be appropriate. I am using 0.25 here as a sensitivity test. To convert these to people moved per unit area of road space an estimate of average vehicle occupancy is needed. The following approximate values may be assumed (rounded to one decimal place):

Cars - overall average	1.6[1]
Cars - journeys to/from work	1.2
Buses outside London	9.4[2]
Buses in London	14.4
Bus overall average (England)	10.8
Cycles	1.0

Note that these data relate to the pre-Covid situation, i.e. 2018 or 2019. Bear in mind that the seemingly low average for bus covers all bus-km run, including evening and Sunday journeys, and the contra-peak flow direction at peak times. Even if the all-day average load for the round trip were the same in the peak as at other times of day, it would correspond to about twice that figure in the peak direction (e.g 28.8 rather than 14.4 in the London case).

For example, if car has an average load of 1.6 people, then this is also the number moved per pcu. For a bus with an average load of 10.8, 4.32 people are moved per pcu (i.e. 10.8 divided by 2.5), likewise outside London 3.76, or 5.76 in London. However, in the peak cars only carry about 1.2 people and buses somewhat greater (for example 25). In this case, people moved per pcu would be 1.2 for cars and 10 for buses. It can thus be seen that buses are much more efficient users of road space than cars, even at modest loadings well below their maximum capacity. This comparison can be extended to cycles, which carry 2 people per pcu (or 4 people at a value of 0.25 pcu for a cycle). At 0.5 pcu/person for cycles, a bus with at least 5 passengers is using road capacity more efficiently than cycles.

The extent to which road capacity is reduced by measures such as bus or cycle lanes (typically using the nearside lane) will depend on whether these lanes are taken up to the stop line at junctions, since the main capacity constraint on road networks is determined by junction capacity. Most with-flow bus lanes terminate shortly before the junction stop, enabling left-turning or straight-ahead traffic to filter into the nearside lane. The effect of bus priority is to enable buses to arrive earlier at the junction, improving service speed and reliability. Bus occupant time savings generally exceed marginal delays to car occupants. These criteria can

[1] Derived from the National Travel Survey (NTS) for England, which collects data on driver and passenger trips separately, by trip purpose, enabling an estimate of average occupancy to be made. Overall average derived from Table 0303 for 2019, showing average distance by mode (ratio of the sum total of miles per person per year by car or van as driver or passenger, divided by driver total). Journeys to/from work derived from table 0412 'Commuter trips by employment status and main mode', calculating the same ratio from 2019 data.

[2] London average load derived from bus-km statistics and passenger-km graph in TfL's Travel in London report no 13 (2020), pp 102-103 and supporting data passenger-km table available on the TfL website, using 2018-19 data. For the rest of England, DfT tables BUS 0103 and 0203 on passenger trips and bus-km, with average stage length (as main mode) from NTS Table 0303 for 2018, which gives an average load of 10.8. However, an adjustment is also needed for the boardings:stages ratio (i.e. more than one bus boarding in a trip stage made by bus, where more than one bus route is used in the course of a one-way trip), giving a lower average. which can be estimated from the ITC bus study as about 1.15, which would reduce average trip length per boarding, and hence average load, to about 9.4. The overall combined averages for London and rest of England are weighted by bus-km run, giving 11.3 on the 'boardings' average length.

also be applied to assessment of cycle priorities – for example, an assessment of five major cycle superhighways then planned in London in 2015 showed a positive outcome for four of them, but a large net loss for the East-West route (a cycleway for both directions of traffic using road space then available for all vehicles), due to additional journey times for other modes and additional bus operating costs[3].

Another option is for buses and cycles to share the same priority lane, but their characteristics are often very different, since cycles proceed at a steady speed whereas buses have a stop-start pattern associated with serving intermediate passenger trips. A study by Aldred and Jones suggests segregated cycle lanes cause less delay to buses than mixed cycle/bus traffic, based on a case study of London Bridge[4].

A further issue is the relocation of bus stops where the nearside lane is becomes cycle-only. One option is to place the bus stops on a new traffic island between the cycle lane and the lane used by buses, as can be seen in Chiswick High Road, west London. However, this itself will occupy more road space, with effects on capacity. Another option is an 'island bus stop' where the cycle route is routed closer to the pavement. In both cases bus users are required to cross the cycle lane to access the stop, an issue raised by Bus Users UK, of particular concern for bus users with disabilities[5].

Clearly, if space is taken for cycle lanes from existing road capacity and no shift from other modes occurs, overall capacity for person movement may be reduced, especially if cycle lanes continue up to the junction stop line (However, some new cycle traffic may be generated by introduction of the cycle lane). Other traffic will then experience much longer, and often more variable, journey time as a result. For buses, this will increase operating cost and well as passenger journey time. The ideal outcome would be one in which car users divert to cycles, especially in the peak, since at a value of 0.5 pcu, two cycles would take two car occupants when average car occupancy is only about 1.2. However, if passengers are diverted from buses the outcome is less favourable, and overall capacity may be reduced (as shown above) especially in the peak (albeit a sustained high-density cycle flow might justify a lower pcu value).

There is relatively limited hard evidence of actual diversion levels by mode, although data do exist to show flows handled by cycle lanes, which may show marked increases in the volumes of cycles previously observed in mixed traffic over the same section of road. It is, however, important to measure *person* movements, not vehicular flow (including cycles) as such.

At an aggregate level, there was undoubtedly a marked growth in cycling during the pandemic, especially in the early lockdown phase in 2020, an indicated in the daily estimates of travel by principal modes published by the DfT from March

---

[3] Andrew Forster 'TfL's cycle superhighways rewrite the rules on road space reallocation' Local Transport Today 6 February 2015, pp 10-11

[4] Rachel Aldred and Phil Jones 'Cyclists in shared bus lanes: could there unrecognised benefits on bus journey times?' Transport Proceedings of the Institution of Civil Engineers 2017 (as summarised in Local Transport Today 15 September 2017, page 8).

[5] See Local Transport Today 30 September 2020, page 9

2020. This coincided with a sharp drop in travel by other road modes, especially bus. At the time, road capacity was not critical factor. However, much of the highest cycle use was at weekends, not during the working week, suggesting that cyclists may have benefitted from health and well-being effects of cycling, but not necessarily have diverted their everyday trips from other modes. Long-term trends also show that much of the cycle use growth was seasonal, reverting to levels in early 2021 similar to March 2020.

Also at an aggregate level, international comparisons may be made with other countries where high levels of cycle use (throughout the year). As Metz[6] has indicated, Denmark and the Netherlands fall into this category, but evidence there indicates that the main effect appears to be a markedly lower level of bus use, rather than in car use which remains largely unaffected.

In conclusion, it is therefore desirable assess the impact of cycle priorities in a systematic and comprehensive manner, especially in terms or urban road capacity and effects of other modes. Variables assessed should include:

- Changes in total capacity (in terms of vehicles and persons moved) by time period (peak and other periods)
- Changes in average journey time and its variability (which affects bus passenger waiting time at stops)
- Changes in operating costs (which for buses will include the effects of increased journey time on the number of buses and drivers to maintain the required service frequency)
- Benefits in terms of health and well-being
- Changes in safety, especially for serious injuries and fatalities to road users.

Existing economic evaluation criteria enable values to be placed on all of these components to determine the net outcome.

19 May 2022

[6] David Metz 'The active travel revolution will not reduce car use' Focus (Chartered Institute of Logistics and Transport journal) February 2021 (pp44-45)