



Theoretical Public Transport Accessibility Levels (PTAL) for combinations of local rail and bus services

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Summary

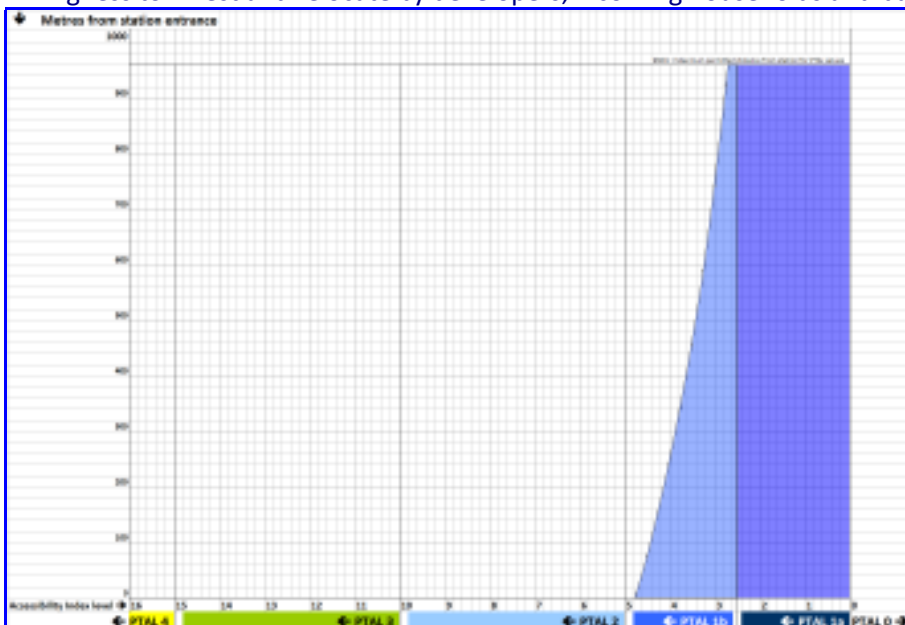
1. This JRC report has modelled a combination of Accessibility Indices for a rail service and bus route density at development area – testing 4 and 6 trains per hour, bus service frequency and proximity of access to bus stops.
2. On its own, a 4 tph service would achieve an Accessibility Index (AI) of 2.7-4.7, and a 6 tph service an AI of 3.3-6.95. This is only just a PTAL 2 score (achieved at 5.01 and above), but not PTAL 3 (10.01+) nor PTAL 4 (15.01+). PTAL 3 and 4 are required, in order to be validated for higher housing densities under Greater London Authority (GLA) planning rules. So there is major reliance on the volume and proximity of a local bus network to drive the AI values up to PTAL levels 3 and 4.
3. Extensive modelling of a single bus route, through to a 4-bus route network, at varying levels of frequency, shows that the Accessibility Index is most sensitive to distance from a bus stop (=access time), followed by volume of routes and overall service frequencies. Modelling points to the best options being with effective bus stop catchments limited to 160-210 metres, and with a 3 or 4-bus route network in operation.
4. These principles can be applied to different areas within a development area, and some general judgments reached on how to optimise the bus routeing and stop locations. The solutions vary according to the sub-sector served within the development. When applied to specific projects (not discussed in this paper), sensitivities will be identified, including the choices to be made in relation to existing or neighbouring bus routes, or the use of a new bus-only corridor within the area.
5. The potential for cycling facilities to enhance AI values and help the PTAL score has also been reviewed. These have a small benefit (up to a quarter-point of AI), of most use at development locations facing a long distance to reach the station.

Measuring Public Transport Accessibility Level in London

6. The philosophy behind Public Transport Accessibility Levels (PTAL) is to measure on a comparable basis the quality of service available at the doorstep of an office or household or other location. PTAL is therefore influenced by the walking time to a station entrance or bus stop, and by the differential between types of service and their frequencies.
7. Highest values are awarded to the closest, most frequent service, with only one stop scored per route, while other services available are marked down in merit. Rail scores more than bus, and also has a larger acceptable catchment area (960 metres, compared to 640 metres for a bus stop). These limits are equal to 12 or 8 minutes walk, at 80 metres per minute.
8. 'Equivalent doorstep frequencies' are created through a statistical process, and these are converted into an weighted Accessibility Index (AI). There is then some crude banding of the AI scores, into a PTAL number, as shown in the diagram below.

PTAL	Range of Index	Map Colour	Description
1a (Low)	0.01 – 2.50	Dark Blue	Very poor
1b	2.51 – 5.00	Blue	Very poor
2	5.01 – 10.00	Cyan	Poor
3	10.01 – 15.00	Light Green	Moderate
4	15.01 – 20.00	Yellow	Good
5	20.01 – 25.00	Orange	Very Good
6a	25.01 – 40.00	Red	Excellent
6b (High)	40.01 +	Dark Red	Excellent

9. There is no mitigating factor if the AI is close to but hasn't reached the next PTAL level. Typically a 4 tph rail service on its own will only achieve a PTAL score of 1b (as set out below), even though that service level may be sufficiently attractive to be a major influence on the willingness to invest and relocate by developers, incoming households and businesses.



Accessibility Index values for rail at 4 tph

10. It is therefore clear that the bulk of PTAL scores are dependent on local bus services, where the rail service is constrained to 4 tph.

11. The Accessibility Index values for a 4 tph rail service are stated in the table below, for quarter-point changes in AI value, plus the gap to be covered by bus services to raise accessibility to achieve PTAL values of 3 or 4. This is a large requirement, with the buses having to achieve 3-4 times as much accessibility improvement as a local station, with still greater effort required for locations distant from the station:

metres from stn	Rail only AI @ 4 tph	bus extra for PTAL 3 gap to achieve AI 10.1	bus extra for PTAL 4 gap to achieve AI 15.1
3	4.75	5.35	10.35
73	4.5	5.6	10.6
152	4.25	5.85	10.85
240	4	6.1	11.1
340	3.75	6.35	11.35
454	3.5	6.6	11.6
586	3.25	6.85	11.85
740	3	7.1	12.1
921	2.75	7.35	12.35
960	2.7	7.4	12.4

Accessibility Index values for a single bus service

12. Bus services also have a high dependence on distance from the bus stop, with AI tailing off quickly until the bus catchment limit of 640 metres is reached. The AI of a single bus service is shown below, at frequencies from 4 to 12 buses per hour (bph), and at various distances from a bus stop. The colouring is NOT the same scheme as for PTAL levels, it is merely a way of differentiating banding within the Accessibility Index output:

metres from bus stop	1 bus only AI @ 4 bph	1 bus only AI @ 5 bph	1 bus only AI @ 6 bph	1 bus only AI @ 7 bph	1 bus only AI @ 8 bph	1 bus only AI @ 9 bph	1 bus only AI @ 10 bph	1 bus only AI @ 11 bph	1 bus only AI @ 12 bph	
10	3.12	3.69	4.21	4.68	5.11	5.5	5.85	6.18	6.49	bus AI => 6
40	3	3.53	4	4.42	4.8	5.14	5.45	5.74	6	
90	2.82	3.29	3.69	4.05	4.36	4.65	4.9	5.13	5.33	bus AI => 5
140	2.67	3.08	3.43	3.73	4	4.24	4.44	4.63	4.8	
190	2.53	2.89	3.2	3.46	3.69	3.89	4.07	4.22	4.36	bus AI => 4
240	2.4	2.73	3	3.23	3.43	3.6	3.75	3.88	4	
290	2.29	2.58	2.82	3.03	3.2	3.35	3.48	3.59	3.69	
340	2.18	2.45	2.67	2.85	3	3.13	3.24	3.34	3.43	bus AI => 3
390	2.09	2.33	2.53	2.69	2.82	2.94	3.04	3.12	3.2	
440	2	2.22	2.4	2.55	2.67	2.77	2.86	2.93	3	
490	1.92	2.12	2.29	2.42	2.53	2.62	2.7	2.76	2.82	
540	1.85	2.03	2.18	2.3	2.4	2.48	2.55	2.61	2.67	bus AI => 2
590	1.78	1.95	2.09	2.2	2.29	2.36	2.42	2.48	2.53	
640	1.71	1.88	2	2.1	2.18	2.25	2.31	2.36	2.4	bus AI => 1

13. It is clear from the table that a single bus service is not going to achieve the required change in Accessibility Index at the bulk of development locations, even if they are close to the railway station, and won't begin to deliver enough access benefit at locations distant from a station. The distance from a bus stop is also self-evident as a critical factor.

14. The table below shown the addition of rail AI, on a simplistic basis, to a baseline single bus service. The distances values adopted are shown on the right. Both the rail and bus AIs are based on an increasing distance from a station or bus stop:

	metres	metres from	Cumulative AI at X bph and 4 tph								
	from stn	bus stop	AI @ 4 bph	AI @ 5 bph	AI @ 6 bph	AI @ 7 bph	AI @ 8 bph	AI @ 9 bph	AI @ 10 bph	AI @ 11 bph	AI @ 12 bph
bus AI => 6	3	10	7.87	8.44	8.96	9.45	9.86	10.25	10.6	10.95	11.24
		40									
bus AI => 5	73	90	7.52	7.79	8.19	8.55	8.86	9.15	9.4	9.65	9.83
	4.25	140	6.92	7.38	7.68	7.98	8.25	8.49	8.69	8.88	9.05
bus AI => 4		190									
	240	240	6.4	6.78	7	7.28	7.48	7.6	7.75	7.88	8
		290									
bus AI => 3	340	340	5.93	6.2	6.42	6.6	6.75	6.88	6.99	7.09	7.18
		390									
	454	440	5.5	5.72	5.9	6.05	6.17	6.27	6.36	6.43	6.5
		490									
bus AI => 2		540									
	586	590	5.03	5.2	5.34	5.45	5.54	5.61	5.67	5.75	5.78
bus AI => 1		640									

15. Extrapolation of the AI for a single bus service up to 24 bph shows that the AI range at 10 to 640 metres is 8.89 to 2.67. Combined with the 4 tph rail AI, a single bus service will just achieve a PTAL level of 3 at distances from the railway station of 0 to 140 metres, at bus frequencies of 16 to 24 bph. This is not a realistic planning basis, neither for single bus routes nor for high density housing.

16. It will also be observed from the earlier table, that increasing bus frequency is marginally inefficient with each step change in service level, as the gain in accessibility diminishes proportionately with increased service levels.

17. A similar proportional reduction also occurs with distance from the bus stop, so that, from the point of view of a property location, a high frequency service (eg 12 bph but requiring 490 metres to reach a bus stop), achieves the same Accessibility Index (2.82) as a 4 bph service only 90 metres distant.

18. The following table sets out the initial range of Accessibility Indices achieved when two bus services are operated, at different frequency levels, with differentials of up to 12 bph on one route and 4 bph on the other. The range shown in each cell in the table is: (high value) a 10 metre distance from the two services, and (low value) a maximum 640 metres distance:-

Accessibility Index (AI) range based on two bus routes, dependent on variable route frequency									
Secondary bus route freq ↓	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
route freq ↓	4	5	6	7	8	9	10	11	12
12									9.73 - 3.60
11								9.27 - 3.54	9.58 - 3.58
10							8.78 - 3.46	9.11 - 3.51	9.41 - 3.55
9						8.24 - 3.38	8.60 - 3.43	8.93 - 3.48	9.23 - 3.53
8					7.66 - 3.27	8.05 - 3.34	8.41 - 3.40	8.74 - 3.45	9.04 - 3.49
7				7.02 - 3.15	7.45 - 3.23	7.84 - 3.30	8.19 - 3.36	8.52 - 3.41	8.83 - 3.45
6			6.32 - 3.00	6.78 - 3.10	7.21 - 3.18	7.60 - 3.25	7.96 - 3.31	8.29 - 3.36	8.59 - 3.40
5		5.54 - 2.81	6.06 - 2.94	6.53 - 3.04	6.95 - 3.12	7.34 - 3.19	7.70 - 3.25	8.03 - 3.29	8.33 - 3.34
4	4.68 - 2.57	5.25 - 2.73	5.77 - 2.86	6.24 - 2.96	6.66 - 3.04	7.05 - 3.11	7.41 - 3.16	7.74 - 3.21	8.04 - 3.26

19. Adding a baseline rail Accessibility Index as set out earlier (a range of 4.75 high to 2.7 low), achieves a combined AI score range (maximum-minimum) shown in the following table:

Train AI based on 4 tph	4.75	max rail AI	2.7	min rail AI						
Bus AI as set out above, based on two bus routes										
Secondary bus route freq ↓	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)									
	4	5	6	7	8	9	10	11	12	
12										14.48 - 6.3
11									14.02 - 6.24	14.33 - 6.28
10							13.53 - 6.16	13.86 - 6.21	14.16 - 6.25	
9						12.99 - 6.08	13.35 - 6.13	13.68 - 6.18	13.98 - 6.23	
8					12.41 - 5.97	12.8 - 6.04	13.16 - 6.1	13.49 - 6.15	13.79 - 6.19	
7				11.77 - 5.85	12.2 - 5.93	12.59 - 6	12.94 - 6.06	13.27 - 6.11	13.58 - 6.15	
6			11.07 - 5.7	11.53 - 5.8	11.96 - 5.88	12.35 - 5.95	12.71 - 6.01	13.04 - 6.06	13.34 - 6.1	
5		10.29 - 5.51	10.81 - 5.64	11.28 - 5.74	11.7 - 5.82	12.09 - 5.89	12.45 - 5.95	12.78 - 5.99	13.08 - 6.04	
4	9.43 - 5.27	10 - 5.43	10.52 - 5.56	10.99 - 5.66	11.41 - 5.74	11.8 - 5.81	12.16 - 5.86	12.49 - 5.91	12.79 - 5.96	

20. The max-min range itself demonstrates that even with 2 bus services, the effective AI - and hence PTAL - is variable, and is dependent on distance from the public transport service. A long walk to a stop will negate much of the bus's benefits, even if there are two services.

Effect of bus stop proximity on accessibility

21. So it is essential to understand in more detail the required proximity of bus stops to the local catchment, and the effect on the combined rail + bus Accessibility Index.
22. Three tables are shown below in sequence for a 2-bus route network: taking a nominal mid-point for maximum access to a bus stop (ca. 315 metres), also a one-third location (210 metres) and a one-quarter location (ca. 160 metres maximum access to a bus stop). The range of rail AI at 4 tph is added:

Midpoint values for distance from bus stop (range 10-640 metres ~ 315 metres), with two bus routes, plus rail AI variable 4.75-2.7										
Secondary bus route freq ↓	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)									
	4	5	6	7	8	9	10	11	12	
12										11.42 - 9.37
11									11.16 - 9.11	11.33 - 9.28
10							10.87 - 8.82	11.06 - 9.01	11.23 - 9.18	
9						10.56 - 8.51	10.77 - 8.72	10.96 - 8.91	11.13 - 9.08	
8					10.22 - 8.17	10.45 - 8.4	10.66 - 8.61	10.85 - 8.8	11.02 - 8.97	
7				9.84 - 7.79	10.09 - 8.04	10.32 - 8.27	10.53 - 8.48	10.72 - 8.67	10.89 - 8.84	
6			9.41 - 7.36	9.69 - 7.64	9.95 - 7.9	10.18 - 8.13	10.39 - 8.34	10.58 - 8.53	10.75 - 8.7	
5		8.93 - 6.88	9.25 - 7.2	9.54 - 7.49	9.79 - 7.74	10.02 - 7.97	10.23 - 8.18	10.41 - 8.36	10.59 - 8.54	
4	8.38 - 6.33	8.74 - 6.69	9.07 - 7.02	9.35 - 7.3	9.6 - 7.55	9.83 - 7.78	10.04 - 7.99	10.23 - 8.18	10.4 - 8.35	

One-third values for distance from bus stop (range 10-640 metres ~ 210 metres), with two bus routes, plus rail AI variable 4.75-2.7										
Secondary bus route freq ↓	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)									
	4	5	6	7	8	9	10	11	12	
12										12.44 - 10.39
11									12.11 - 10.06	12.33 - 10.28
10							11.76 - 9.71	11.99 - 9.94	12.21 - 10.16	
9						11.37 - 9.32	11.63 - 9.58	11.86 - 9.81	12.08 - 10.03	
8					10.95 - 8.9	11.23 - 9.18	11.49 - 9.44	11.73 - 9.68	11.94 - 9.89	
7				10.48 - 8.43	10.79 - 8.74	11.08 - 9.03	11.33 - 9.28	11.57 - 9.52	11.79 - 9.74	
6			9.96 - 7.91	10.3 - 8.25	10.62 - 8.57	10.9 - 8.85	11.16 - 9.11	11.4 - 9.35	11.61 - 9.56	
5		9.38 - 7.33	9.77 - 7.72	10.12 - 8.07	10.42 - 8.37	10.71 - 8.66	10.97 - 8.92	11.2 - 9.15	11.42 - 9.37	
4	8.73 - 6.68	9.16 - 7.11	9.55 - 7.5	9.9 - 7.85	10.2 - 8.15	10.49 - 8.44	10.74 - 8.69	10.98 - 8.93	11.2 - 9.15	

One-quarter values for distance from bus stop (range 10-640 metres ~ 160 metres), with two bus routes, plus rail AI variable 4.75-2.7									
Secondary bus route freq ↓	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
	4	5	6	7	8	9	10	11	12
12									12.95 - 10.9
11								12.59 - 10.54	12.83 - 10.78
10							12.2 - 10.15	12.46 - 10.41	12.7 - 10.65
9						11.78 - 9.73	12.06 - 10.01	12.32 - 10.27	12.56 - 10.51
8					11.31 - 9.26	11.62 - 9.57	11.91 - 9.86	12.17 - 10.12	12.4 - 10.35
7				10.8 - 8.75	11.15 - 9.1	11.46 - 9.41	11.73 - 9.68	11.99 - 9.94	12.24 - 10.19
6			10.24 - 8.19	10.61 - 8.56	10.95 - 8.9	11.26 - 9.21	11.55 - 9.5	11.81 - 9.76	12.04 - 9.99
5		9.61 - 7.56	10.03 - 7.98	10.41 - 8.36	10.74 - 8.69	11.05 - 9	11.34 - 9.29	11.6 - 9.55	11.83 - 9.78
4	8.9 - 6.85	9.37 - 7.32	9.79 - 7.74	10.17 - 8.12	10.51 - 8.46	10.82 - 8.77	11.1 - 9.05	11.36 - 9.31	11.6 - 9.55

23. The **coloured-in green** above shows AI values wholly within PTAL 3. Within a wider range, **some** AI values will be within PTAL 3 (**outline green**), but not across the full distance range. The importance of a high level of penetration of bus services, and a close proximity of bus stops to residential and other locations, is self-evident. Even so, there is only a limited volume of wholesale conversion to PTAL 3, using two bus routes combined with a 4 tph rail service.

A 6 tph, 2-bus route network

24. JRC has therefore tested a 6 tph rail service plus two bus services, to see what the difference *could be*. Bus midpoint, one-third and one-quarter stop tables are shown below plus 6 tph AI:

Midpoint values for distance from bus stop (range 10-640 metres ~ 315 metres), with two bus routes, plus rail AI variable 6.95-3.3									
Secondary bus route freq ↓	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
	4	5	6	7	8	9	10	11	12
12									13.62 - 9.97
11								13.36 - 9.71	13.53 - 9.88
10							13.07 - 9.42	13.26 - 9.61	13.43 - 9.78
9						12.76 - 9.11	12.97 - 9.32	13.16 - 9.51	13.33 - 9.68
8					12.42 - 8.77	12.65 - 9	12.86 - 9.21	13.05 - 9.4	13.22 - 9.57
7				12.04 - 8.39	12.29 - 8.64	12.52 - 8.87	12.73 - 9.08	12.92 - 9.27	13.09 - 9.44
6			11.61 - 7.96	11.89 - 8.24	12.15 - 8.5	12.38 - 8.73	12.59 - 8.94	12.78 - 9.13	12.95 - 9.3
5		11.13 - 7.48	11.45 - 7.8	11.74 - 8.09	11.99 - 8.34	12.22 - 8.57	12.43 - 8.78	12.61 - 8.96	12.79 - 9.14
4	10.58 - 6.93	10.94 - 7.29	11.27 - 7.62	11.55 - 7.9	11.8 - 8.15	12.03 - 8.38	12.24 - 8.59	12.43 - 8.78	12.6 - 8.95

One-third values for distance from bus stop (range 10-640 metres ~ 210 metres), with two bus routes, plus rail AI variable 6.95-3.3									
Secondary bus route freq ↓	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
	4	5	6	7	8	9	10	11	12
12									14.64 - 10.99
11								14.31 - 10.66	14.53 - 10.88
10							13.96 - 10.31	14.19 - 10.54	14.41 - 10.76
9						13.57 - 9.92	13.83 - 10.18	14.06 - 10.41	14.28 - 10.63
8					13.15 - 9.5	13.43 - 9.78	13.69 - 10.04	13.93 - 10.28	14.14 - 10.49
7				12.68 - 9.03	12.99 - 9.34	13.28 - 9.63	13.53 - 9.88	13.77 - 10.12	13.99 - 10.34
6			12.16 - 8.51	12.5 - 8.85	12.82 - 9.17	13.1 - 9.45	13.36 - 9.71	13.6 - 9.95	13.81 - 10.16
5		11.58 - 7.93	11.97 - 8.32	12.32 - 8.67	12.62 - 8.97	12.91 - 9.26	13.17 - 9.52	13.4 - 9.75	13.62 - 9.97
4	10.93 - 7.28	11.36 - 7.71	11.75 - 8.1	12.1 - 8.45	12.4 - 8.75	12.69 - 9.04	12.94 - 9.29	13.18 - 9.53	13.4 - 9.75

One-quarter values for distance from bus stop (range 10-640 metres ~ 160 metres), with two bus routes, plus rail AI variable 6.95-3.3									
Secondary bus route freq ↓	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
	4	5	6	7	8	9	10	11	12
12									15.15 - 11.5
11								14.79 - 11.14	15.03 - 11.38
10							14.4 - 10.75	14.66 - 11.01	14.9 - 11.25
9						13.98 - 10.33	14.26 - 10.61	14.52 - 10.87	14.76 - 11.11
8					13.51 - 9.86	13.82 - 10.17	14.11 - 10.46	14.37 - 10.72	14.6 - 10.95
7				13 - 9.35	13.35 - 9.7	13.66 - 10.01	13.93 - 10.28	14.19 - 10.54	14.44 - 10.79
6			12.44 - 8.79	12.81 - 9.16	13.15 - 9.5	13.46 - 9.81	13.75 - 10.1	14.01 - 10.36	14.24 - 10.59
5		11.81 - 8.16	12.23 - 8.58	12.61 - 8.96	12.94 - 9.29	13.25 - 9.6	13.54 - 9.89	13.8 - 10.15	14.03 - 10.38
4	11.1 - 7.45	11.57 - 7.92	11.99 - 8.34	12.37 - 8.72	12.71 - 9.06	13.02 - 9.37	13.3 - 9.65	13.56 - 9.91	13.8 - 10.15

25. This is an improvement, with stronger coverage with the one-third and one-quarter stop range – maximum 160-210 metres from bus stops. The increase in AI value, compared to a 4 tph rail service, would be 2.2 at locations close to the station, reducing to an AI increase of only 0.6 at the maximum distance from the station.

26. Only the areas most distant from a low frequency two-bus service would experience a PTAL level less than 3.

A 3-bus route network

27. However, 6 tph is not always a practical option for rail service levels, particularly if a new service or station is being shoehorned into an existing railway operation. The precise railway operational circumstances will be important. So this outcome is noted, and investigation has continued with a 3-bus route offer.

28. In that case, for simplicity of analysis, one route is adopted as a main corridor service, at 4-12 bph, and the other two routes are assumed in principle to be local services whose frequencies are taken as the same as each other. Those local frequencies can themselves vary between 4-12 bph.

29. It will be appreciated that offering a high stopping density bus network, in addition to potentially high volume services, could have a significant impact on bus service funding requirements – as well as the obvious impact on road network specification within masterplanning for any development area.

30. However this modelling is directed at understanding the consequences of seeking to achieve a high PTAL level, to the point that higher housing densities are then accepted by the Greater London Authority (GLA) and other parties. Unless the public transport network can offer the required level of accessibility, the desired strategic scale of housing densities may not be authorised.

31. The following table looks at the accessibility implications of a 3-bus route network, in a similar way as before, with two of those routes being local in purpose and identical in service levels:

Midpoint values for distance from bus stop (range 10-640 metres ~ 315 metres), with three bus routes, plus rail AI variable 4.75-2.7									
Secondary bus	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
route freq	4	5	6	7	8	9	10	11	12
12									13.64 - 11.59
11								13.29 - 11.24	13.47 - 11.42
10							12.92 - 10.87	13.1 - 11.05	13.28 - 11.23
9						12.5 - 10.45	12.71 - 10.66	12.9 - 10.85	13.07 - 11.02
8					12.04 - 9.99	12.27 - 10.22	12.48 - 10.43	12.67 - 10.62	12.84 - 10.79
7				11.53 - 9.48	11.79 - 9.74	12.02 - 9.97	12.22 - 10.17	12.41 - 10.36	12.59 - 10.54
6			10.96 - 8.91	11.25 - 9.2	11.5 - 9.45	11.73 - 9.68	11.94 - 9.89	12.13 - 10.08	12.3 - 10.25
5		10.32 - 8.27	10.64 - 8.59	10.93 - 8.88	11.18 - 9.13	11.41 - 9.36	11.62 - 9.57	11.8 - 9.75	11.98 - 9.93
4	9.58 - 7.53	9.95 - 7.9	10.27 - 8.22	10.56 - 8.51	10.81 - 8.76	11.04 - 8.99	11.25 - 9.2	11.44 - 9.39	11.61 - 9.56
One-third values for distance from bus stop (range 10-640 metres ~ 210 metres), with three bus routes, plus rail AI variable 4.75-2.7									
Secondary bus	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
route freq	4	5	6	7	8	9	10	11	12
12									15 - 12.95
11								14.57 - 12.52	14.78 - 12.73
10							14.1 - 12.05	14.33 - 12.28	14.55 - 12.5
9						13.58 - 11.53	13.84 - 11.79	14.07 - 12.02	14.29 - 12.24
8					13.01 - 10.96	13.29 - 11.24	13.55 - 11.5	13.79 - 11.74	14 - 11.95
7				12.39 - 10.34	12.7 - 10.65	12.99 - 10.94	13.24 - 11.19	13.48 - 11.43	13.7 - 11.65
6			11.7 - 9.65	12.04 - 9.99	12.36 - 10.31	12.64 - 10.59	12.89 - 10.84	13.13 - 11.08	13.35 - 11.3
5		10.92 - 8.87	11.31 - 9.26	11.66 - 9.61	11.97 - 9.92	12.25 - 10.2	12.51 - 10.46	12.74 - 10.69	12.96 - 10.91
4	10.05 - 8	10.49 - 8.44	10.87 - 8.82	11.22 - 9.17	11.53 - 9.48	11.81 - 9.76	12.07 - 10.02	12.31 - 10.26	12.52 - 10.47
One-quarter values for distance from bus stop (range 10-640 metres ~ 160 metres), with three bus routes, plus rail AI variable 4.75-2.7									
Secondary bus	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
route freq	4	5	6	7	8	9	10	11	12
12									15.68 - 13.63
11								15.21 - 13.16	15.44 - 13.39
10							14.69 - 12.64	14.95 - 12.9	15.18 - 13.13
9						14.12 - 12.07	14.4 - 12.35	14.66 - 12.61	14.9 - 12.85
8					13.5 - 11.45	13.81 - 11.76	14.09 - 12.04	14.35 - 12.3	14.59 - 12.54
7				12.82 - 10.77	13.16 - 11.11	13.47 - 11.42	13.75 - 11.7	14.01 - 11.96	14.25 - 12.2
6			12.07 - 10.02	12.44 - 10.39	12.79 - 10.74	13.1 - 11.05	13.37 - 11.32	13.63 - 11.58	13.88 - 11.83
5		11.22 - 9.17	11.65 - 9.6	12.02 - 9.97	12.37 - 10.32	12.68 - 10.63	12.96 - 10.91	13.21 - 11.16	13.46 - 11.41
4	10.28 - 8.23	10.76 - 8.71	11.18 - 9.13	11.55 - 9.5	11.89 - 9.84	12.2 - 10.15	12.48 - 10.43	12.74 - 10.69	12.98 - 10.93

32. The results show a much more useful outcome across the development area, based on a 3-bus route network plus rail at 4tph, compared to a 2-bus route network with rail at 6 tph. Even so, in no option is a full PTAL at level 4 achieved, although some locations with high bus frequencies and close to the station will attain that result. The results also confirm that having several bus routes rather than just a single high frequency service, increases the Accessibility Index because of the way the AI is calculated. It also a token of the benefits of offering a wider range of services and destinations, even if this is only reflected nominally.

33. A 3-bus route network plus 6 tph rail would achieve greater coverage at PTAL 4, as shown in the table below. As noted previously, the increase in AI value, compared to a 4 tph rail service, would be 2.2 at locations close to the station, reducing to an AI increase of only 0.6 at the maximum distance from the station. So proximity to a bus stop, overall bus volume, and proximity to the station are all important elements in achieving a high AI at individual locations. It is unlikely that a 6 tph rail service would be achieved until during the 2020s, therefore this could affect the phasing of developments distant from the station.

Midpoint values for distance from bus stop (range 10-640 metres ~ 315 metres), with three bus routes, plus rail AI variable 6.95-3.3									
Secondary bus	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
route freq	4	5	6	7	8	9	10	11	12
12									15.84 - 12.19
11								15.49 - 11.84	15.67 - 12.02
10							15.12 - 11.47	15.3 - 11.65	15.48 - 11.83
9						14.7 - 11.05	14.91 - 11.26	15.1 - 11.45	15.27 - 11.62
8					14.24 - 10.59	14.47 - 10.82	14.68 - 11.03	14.87 - 11.22	15.04 - 11.39
7				13.73 - 10.08	13.99 - 10.34	14.22 - 10.57	14.42 - 10.77	14.61 - 10.96	14.79 - 11.14
6			13.16 - 9.51	13.45 - 9.8	13.7 - 10.05	13.93 - 10.28	14.14 - 10.49	14.33 - 10.68	14.5 - 10.85
5		12.52 - 8.87	12.84 - 9.19	13.13 - 9.48	13.38 - 9.73	13.61 - 9.96	13.82 - 10.17	14 - 10.35	14.18 - 10.53
4	11.78 - 8.13	12.15 - 8.5	12.47 - 8.82	12.76 - 9.11	13.01 - 9.36	13.24 - 9.59	13.45 - 9.8	13.64 - 9.99	13.81 - 10.16
One-third values for distance from bus stop (range 10-640 metres ~ 210 metres), with three bus routes, plus rail AI variable 6.95-3.3									
Secondary bus	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
route freq	4	5	6	7	8	9	10	11	12
12									17.2 - 13.55
11								16.77 - 13.12	16.98 - 13.33
10							16.3 - 12.65	16.53 - 12.88	16.75 - 13.1
9						15.78 - 12.13	16.04 - 12.39	16.27 - 12.62	16.49 - 12.84
8					15.21 - 11.56	15.49 - 11.84	15.75 - 12.1	15.99 - 12.34	16.2 - 12.55
7				14.59 - 10.94	14.9 - 11.25	15.19 - 11.54	15.44 - 11.79	15.68 - 12.03	15.9 - 12.25
6			13.9 - 10.25	14.24 - 10.59	14.56 - 10.91	14.84 - 11.19	15.09 - 11.44	15.33 - 11.68	15.55 - 11.9
5		13.12 - 9.47	13.51 - 9.86	13.86 - 10.21	14.17 - 10.52	14.45 - 10.8	14.71 - 11.06	14.94 - 11.29	15.16 - 11.51
4	12.25 - 8.6	12.69 - 9.04	13.07 - 9.42	13.42 - 9.77	13.73 - 10.08	14.01 - 10.36	14.27 - 10.62	14.51 - 10.86	14.72 - 11.07
One-quarter values for distance from bus stop (range 10-640 metres ~ 160 metres), with three bus routes, plus rail AI variable 6.95-3.3									
Secondary bus	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
route freq	4	5	6	7	8	9	10	11	12
12									17.88 - 14.23
11								17.41 - 13.76	17.64 - 13.99
10							16.89 - 13.24	17.15 - 13.5	17.38 - 13.73
9						16.32 - 12.67	16.6 - 12.95	16.86 - 13.21	17.1 - 13.45
8					15.7 - 12.05	16.01 - 12.36	16.29 - 12.64	16.55 - 12.9	16.79 - 13.14
7				15.02 - 11.37	15.36 - 11.71	15.67 - 12.02	15.95 - 12.3	16.21 - 12.56	16.45 - 12.8
6			14.27 - 10.62	14.64 - 10.99	14.99 - 11.34	15.3 - 11.65	15.57 - 11.92	15.83 - 12.18	16.08 - 12.43
5		13.42 - 9.77	13.85 - 10.2	14.22 - 10.57	14.57 - 10.92	14.88 - 11.23	15.16 - 11.51	15.41 - 11.76	15.66 - 12.01
4	12.48 - 8.83	12.96 - 9.31	13.38 - 9.73	13.75 - 10.1	14.09 - 10.44	14.4 - 10.75	14.68 - 11.03	14.94 - 11.29	15.18 - 11.53

A 4-bus route network

34. A 4-route bus network has also been modelled. Modelling a 4-bus route network and 4 tph in place of a 3-bus route network and 6 tph, shows this would be more effective in achieving high AI values with greater PTAL 4 coverage. At long distances from the rail station, only lower housing densities would be do-able, unless a high bus volume was run with a close mesh of bus stops. This is shown overleaf:

Midpoint values for distance from bus stop (range 10-640 metres ~ 315 metres), with four bus routes, plus rail AI variable 4.75-2.7									
Secondary bus	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
route freq	4	5	6	7	8	9	10	11	12
12									15.86 - 13.81
11								15.43 - 13.38	15.6 - 13.55
10							14.95 - 12.9	15.14 - 13.09	15.32 - 13.27
9						14.44 - 12.39	14.64 - 12.59	14.83 - 12.78	15.01 - 12.96
8					13.86 - 11.81	14.09 - 12.04	14.3 - 12.25	14.49 - 12.44	14.66 - 12.61
7				13.23 - 11.18	13.48 - 11.43	13.71 - 11.66	13.92 - 11.87	14.11 - 12.06	14.28 - 12.23
6			12.52 - 10.47	12.8 - 10.75	13.05 - 11	13.28 - 11.23	13.49 - 11.44	13.68 - 11.63	13.85 - 11.8
5		11.71 - 9.66	12.03 - 9.98	12.32 - 10.27	12.57 - 10.52	12.8 - 10.75	13.01 - 10.96	13.2 - 11.15	13.37 - 11.32
4	10.79 - 8.74	11.16 - 9.11	11.48 - 9.43	11.76 - 9.71	12.02 - 9.97	12.25 - 10.2	12.46 - 10.41	12.65 - 10.6	12.82 - 10.77
One-third values for distance from bus stop (range 10-640 metres ~ 210 metres), with four bus routes, plus rail AI variable 4.75-2.7									
Secondary bus	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
route freq	4	5	6	7	8	9	10	11	12
12									17.56 - 15.51
11								17.02 - 14.97	17.24 - 15.19
10							16.43 - 14.38	16.66 - 14.61	16.88 - 14.83
9						15.79 - 13.74	16.04 - 13.99	16.28 - 14.23	16.5 - 14.45
8					15.08 - 13.03	15.36 - 13.31	15.62 - 13.57	15.85 - 13.8	16.07 - 14.02
7				14.3 - 12.25	14.61 - 12.56	14.9 - 12.85	15.15 - 13.1	15.39 - 13.34	15.61 - 13.56
6			13.44 - 11.39	13.78 - 11.73	14.09 - 12.04	14.37 - 12.32	14.63 - 12.58	14.87 - 12.82	15.08 - 13.03
5		12.47 - 10.42	12.85 - 10.8	13.2 - 11.15	13.51 - 11.46	13.79 - 11.74	14.05 - 12	14.29 - 12.24	14.5 - 12.45
4	11.37 - 9.32	11.81 - 9.76	12.2 - 10.15	12.54 - 10.49	12.85 - 10.8	13.14 - 11.09	13.4 - 11.35	13.63 - 11.58	13.85 - 11.8
One-quarter values for distance from bus stop (range 10-640 metres ~ 160 metres), with four bus routes, plus rail AI variable 4.75-2.7									
Secondary bus	Primary bus route frequency (bph) → (range is from 10 metres to 640 metres from bus stop)								
route freq	4	5	6	7	8	9	10	11	12
12									18.42 - 16.37
11								17.82 - 15.77	18.06 - 16.01
10							17.17 - 15.12	17.43 - 15.38	17.67 - 15.62
9						16.46 - 14.41	16.75 - 14.7	17.01 - 14.96	17.24 - 15.19
8					15.69 - 13.64	16 - 13.95	16.28 - 14.23	16.54 - 14.49	16.78 - 14.73
7				14.84 - 12.79	15.18 - 13.13	15.49 - 13.44	15.77 - 13.72	16.03 - 13.98	16.27 - 14.22
6			13.9 - 11.85	14.28 - 12.23	14.61 - 12.56	14.92 - 12.87	15.21 - 13.16	15.47 - 13.42	15.7 - 13.65
5		12.85 - 10.8	13.27 - 11.22	13.64 - 11.59	13.98 - 11.93	14.29 - 12.24	14.57 - 12.52	14.83 - 12.78	15.07 - 13.02
4	11.67 - 9.62	12.14 - 10.09	12.56 - 10.51	12.93 - 10.88	13.27 - 11.22	13.58 - 11.53	13.87 - 11.82	14.13 - 12.08	14.36 - 12.31

35. With a 4-bus route network, more of the catchment is a guaranteed PTAL 4 as well as PTAL 3, depending on where the Accessibility Index exceeds 15. To be consistent, areas above with partial PTAL 4 have been coloured coded in the same way as previously, as PTAL 3, but much will be PTAL 4. This highlights that, in the final analysis, a closer mesh of bus stops can achieve a higher AI than an increment of bus service frequency.

Scope for cycling to raise Accessibility Index levels

36. The use of cycling as a means of speeding access to and from railway stations, should assist the AI scope, as the Index is a function of journey time between the transport service and the development location.

37. TfL does not yet attempt to measure cycling access to a station for AI purposes. It is proposed to show here the possible advantages of cycling, and how this could benefit AI. Because cycling will be a virtual extension of the station, it is possible to gauge the potential usage as a % of station users, which should increase AI from distant locations.

38. The judgments which are required are:

- Comparative start/finish times for the station as a foot passenger compared to a cyclist. From the station entry/exit point, a cyclist may need to walk to a specific cycle rack, and don headgear/hi-vi, place light luggage on the cycle, and at times of darkness deal with lights, before heading away (and v.v. for the opposite journey).
- Average cycling speed compared to walking.
- Putting the cycle away (or v.v. retrieving it, etc) at the other end of the access sector.

39. Essentially there will be a start/finish penalty time for a cyclist, compared to walking, but over a distance the cyclist will have a time advantage. The 12 minute access limit applied with PTAL for pedestrian access to a station is therefore maintained, but with a 3 minute cumulative penalty applied for each journey (allowing 1½ minutes at each end). This enables 9 minutes of useful cycling time.

40. A slow 10 mph will also allow for junctions/intersections/other road users. It converts to a maximum cycling catchment of 2,640 metres. This is 2.75 times the extent of a station walking catchment.

41. Taking two examples of cycling volume, at 10% and 20% of station access volume (and walking at 80-90%), shows the following improvement in AI values over a 960 metre catchment:

Rail service at 4 trains per hour, walking at 80 metres/minute, cycling at 10 miles per hour																								
Walk minutes from station	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
Walking distance (metres)	40	80	120	160	200	240	280	320	360	400	440	480	520	560	600	640	680	720	760	800	840	880	920	960
Accessibility index, walking	4.62	4.48	4.35	4.23	4.11	4.00	3.90	3.80	3.70	3.61	3.53	3.45	3.37	3.30	3.23	3.16	3.09	3.03	2.97	2.91	2.86	2.80	2.75	2.70
Accessibility index, cycling	0	0	0	4.59	4.55	4.51	4.47	4.43	4.39	4.35	4.31	4.28	4.24	4.21	4.17	4.14	4.10	4.07	4.04	4.00	3.97	3.94	3.91	3.88
if cycle proportion is X%:	50%	(and assumed cycling NOT used for first 1% minutes distance)																						
Walking AI = 90%	4.62	4.48	4.35	3.807	3.699	3.6	3.51	3.42	3.33	3.249	3.177	3.105	3.033	2.97	2.907	2.844	2.781	2.727	2.673	2.619	2.574	2.52	2.475	2.43
Cycling AI = 10%	0	0	0	0.459	0.455	0.451	0.447	0.443	0.439	0.435	0.431	0.428	0.424	0.421	0.417	0.414	0.41	0.407	0.404	0.4	0.397	0.394	0.391	0.388
Combined, proportioned AI	4.62	4.48	4.35	4.27	4.15	4.05	3.96	3.86	3.77	3.68	3.61	3.53	3.46	3.39	3.32	3.26	3.19	3.13	3.08	3.02	2.97	2.91	2.87	2.82
Net gain in AI with cycling %	0.00	0.00	0.00	0.04	0.04	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.12	0.12
if cycle proportion is X%:	20%	(and assumed cycling NOT used for first 1% minutes distance)																						
Walking AI = 80%	4.62	4.48	4.35	3.384	3.288	3.2	3.12	3.04	2.96	2.888	2.824	2.76	2.696	2.64	2.584	2.528	2.472	2.424	2.376	2.328	2.288	2.24	2.2	2.16
Cycling AI = 20%	0	0	0	0.918	0.91	0.902	0.894	0.886	0.878	0.87	0.862	0.856	0.848	0.842	0.834	0.828	0.82	0.814	0.808	0.8	0.794	0.788	0.782	0.776
Combined, proportioned AI	4.62	4.48	4.35	4.30	4.20	4.10	4.01	3.93	3.84	3.76	3.69	3.62	3.54	3.48	3.42	3.36	3.29	3.24	3.18	3.13	3.08	3.03	2.98	2.94
Net gain in AI with cycling %	0.00	0.00	0.00	0.07	0.09	0.10	0.11	0.13	0.14	0.15	0.16	0.17	0.17	0.18	0.19	0.20	0.20	0.21	0.21	0.22	0.22	0.23	0.23	0.24

42. This is not a large change, with AI up 0.04-0.12 with 10% cycling, and up 0.07-0.24 with 20% cycling. It is unlikely to make any significant difference at locations close to the station. However a quarter point increase at the further distances could be termed as 'every little helps', where the PTAL level might be close to but not quite achieving PTAL 3 or 4.

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