Flow Weighted Vehicle Speeds on Local Authority Managed 'A' Roads – Methodology

10 November 2011

Introduction

1. This document sets out the methodology used to calculate the Department's estimates of vehicle speeds on local authority managed 'A' roads and provides some indication as to the quality of the estimates produced.

2. This statistical series was first published in November 2010 - using data from the last 3 academic years - and has been updated since then with new monthly and quarterly statistics showing how speeds on locally managed 'A' roads have changed since September 2006.

3. The statistics for the most recent academic year, that is September to July, are provisional and will be finalised along with the publication of the annual estimates in the following November.

User feedback

4. We are always keen to receive comments from users of transport statistics and are encouraged to seek user views by the UK Statistics Authority. Your views about the new series, how it is presented and analysed, and the frequency you would like to see it updated would be particularly helpful.

5. If you have any comments, suggestions or questions on any of the above, please email them to us at: congestion.stats@dft.gsi.gov.uk.

Matching the congestion and traffic count road networks

6. The Department's congestion and traffic data are currently matched against 2 different interpretations of the road network.

7. The congestion data provided to the Department by Trafficmaster are matched to the Ordnance Survey Integrated Transport Network (ITN). This network provides a highly accurate representation of roads on the ground and is constructed in such a way that any individual section of road between 2 junctions – however minor they may be – can be separately identified. The complete network for England consists of around 3.4 million separate 'links', many of which are bi-directional, and is therefore ideal for matching high resolution GPS-data to in order to estimate average traffic speeds on any given part of the actual road network.

8. The Department's traffic count data, however, are collected against a schematic representation of the major road network, consisting of all 'A' roads and motorways. Each stretch of road between major road junctions is defined as a 'link', upon which traffic is counted, but these links are represented as simplified straight lines in the network rather than following the actual road layout. In this way, the start and end points of each link will be accurately positioned at the site of the relevant junctions but the link itself will deviate from the actual formation of roads on the ground. While simplified, this network is effective for the organisation of traffic counts as it can be easily maintained and managed and it can reasonably be assumed that traffic levels do not deviate significantly across the length of each link.

9. An example of how these 2 networks differ in their representation of the actual road layout is shown below.

Figure 1: Example of actual road layout

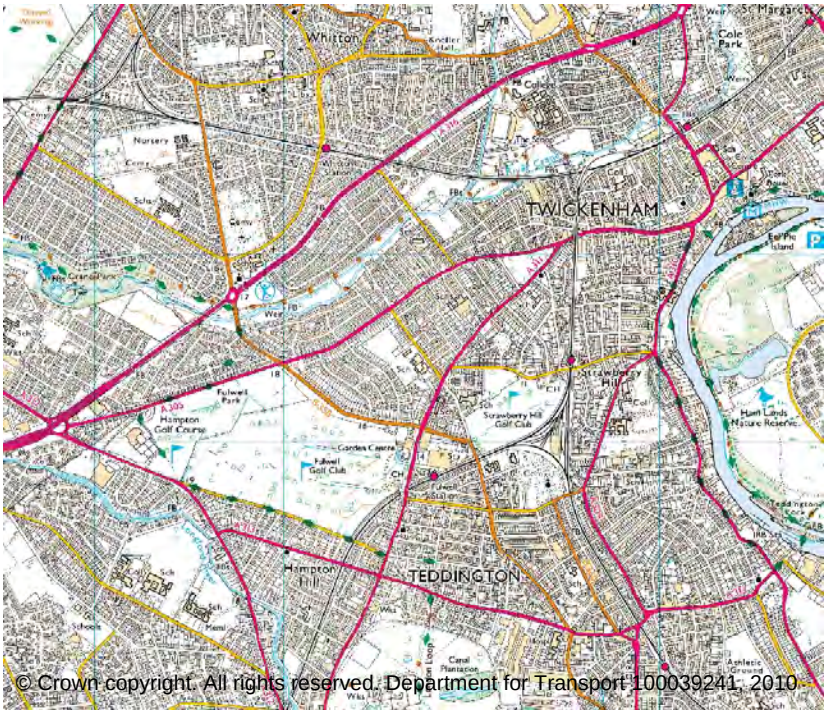


Figure 2: ITN representation of example network (major roads shown in red)

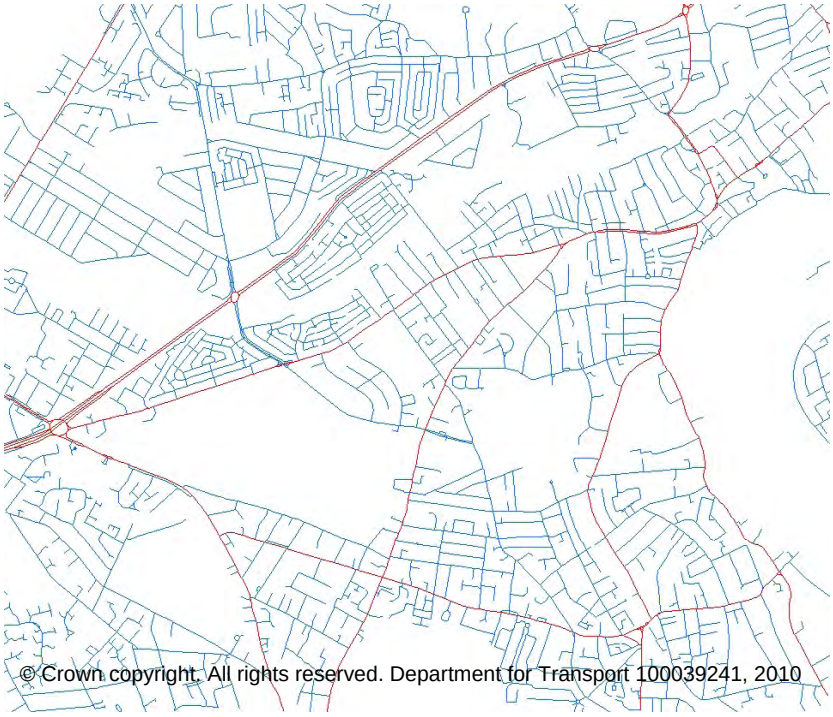
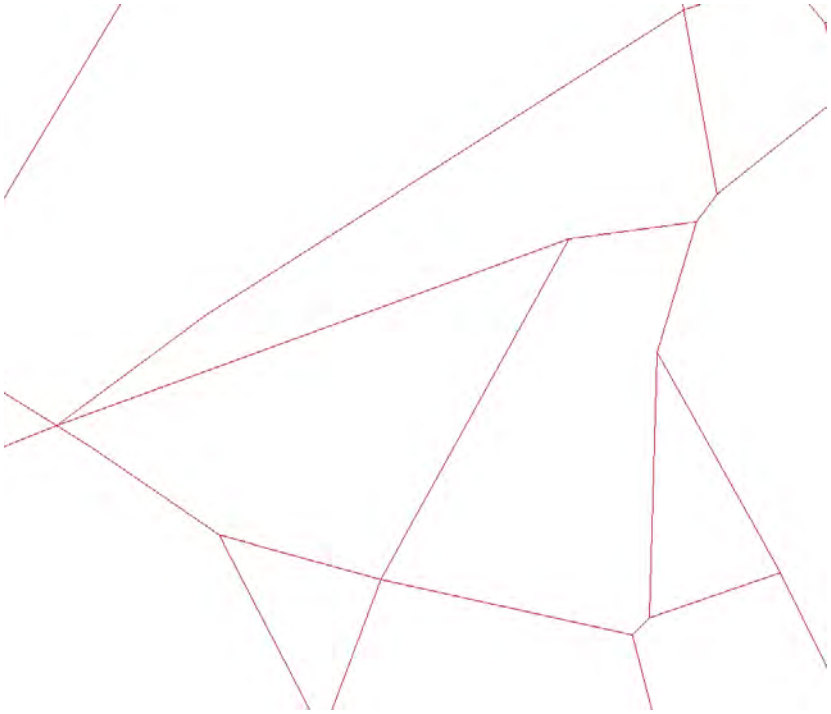


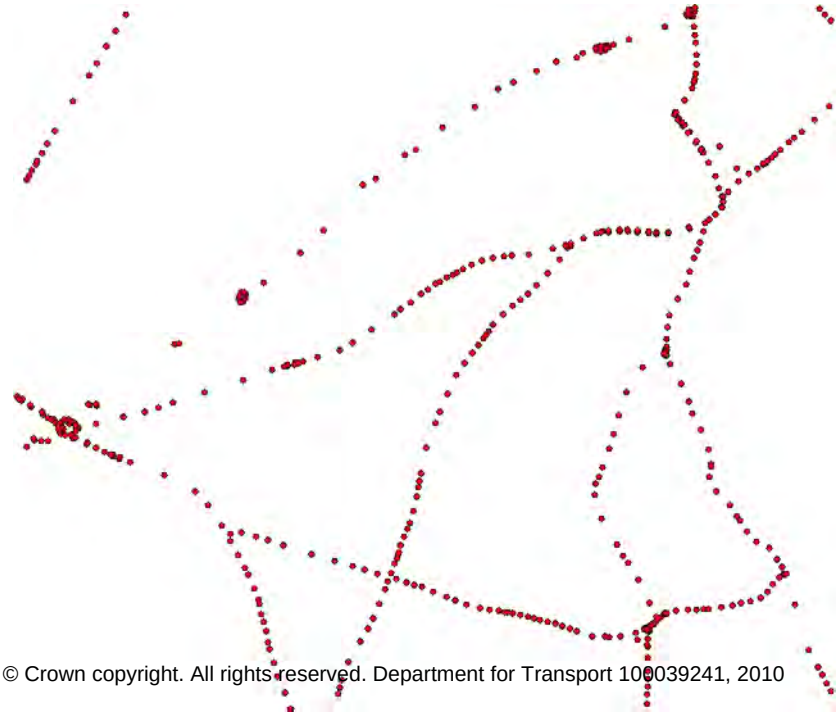
Figure 3: Schematic representation of major roads within example network



10. In order to allow the Department's traffic count data to be used constructively alongside the congestion data, these 2 different representations of the road network must be matched.

11. For the purposes of this project, the matching of these 2 networks was performed using Geographic Information Systems (GIS) software. Each link within the ITN representation of the major road network (the red lines shown in figure 2) was first distilled to its centroid – the geometric centre point of its line – as shown in the example below.

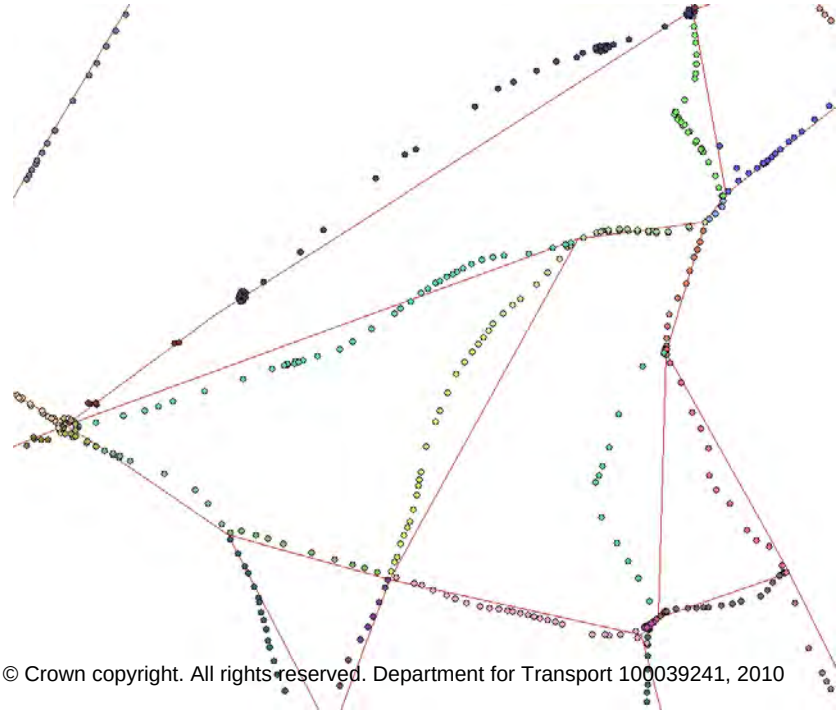
Figure 4: Centroids of links within example ITN major road network



12. Each of these centre points were then matched through the GIS software to the link within the Department's schematic traffic count network falling closest to it. However, in order to prevent issues of mismatching, particularly around road junctions, a further restriction was put in place so that centre points from links in the ITN network were only matched against schematic traffic count links that shared the same road classification (A1, A40, A406, etc). In addition, an upper limit was introduced so that ITN links could not be matched to traffic count links more than 7.5 kilometres away.

13. An example of the results of this geographic matching exercise is shown in figure 5. The colours of the centroids in the example indicate that the points have been matched to a different traffic count link.

Figure 5: Example of matched network results (colours represent matching to traffic count links)



14. Despite the precautions outlined above, it is not possible to remove all occurrences of incorrect matching between the 2 networks. For example, around particularly complex junctions some ITN link centroids may have been matched to the traffic count link on the wrong side of the junction and, due to the different timing of network updates, there will some issues of new roads being incorrectly matched or not matched at all. However, these issues are infrequent and, as the example matching shown above indicates, the vast majority of ITN links match to an appropriate traffic count link.

15. As the ITN and traffic count networks are updated annually, a matching exercise is carried out each year in order to generate the annual flow weighted congestion statistics. The individual versions of the ITN and traffic count networks matched, along with the number of matched and un-matched links, are shown below.

Figure 6: Summary results of ITN vs. traffic count network matching

Academic year	ITN version(s) matched	Traffic count networks matched	No. ITN links matched	No. ITN links unmatched
2006/7 [1]	9 Mar 2007	2007	306,807	429
2007/8 [2]	9 Mar 2007	2007	306,807	429
	9 Oct 2007		310,288	524
2008/9	12 Jun 2008	2008	316,390	475
2009/10	7 Jul 2009	2009	315,860	495
2010/11	8 Jun 2010	2010	318,831	623
2011/12 [3]	22 Jun 2011	2010	320,217	715

1. Congestion data for 2006/7 were matched against the 2007 traffic count network due to the unavailability of the 2006 network at the time of matching.
2. Congestion data for the 2007/8 academic year were matched against 2 versions of the ITN - Sep 07 to Jan 08 data were matched against the 9/3/07 version and Feb 08 to Jul 08 data were matched against the 9/10/07 version. Both versions have therefore been matched with the 2007 traffic count network.
3. The 2011/12 ITN will be re-matched against the 2011 traffic count network next year before the statistics are made final in November 2012. It is expected the number of unmatched ITN links will reduce at this point.

Estimating vehicle journey times on the ITN

16. The Department currently purchases data about vehicle speeds and journey times from Trafficmaster.

17. These data are generated through in-vehicle GPS units as part of the satellite navigation and stolen vehicle tracking services Trafficmaster provides to their customers. The specific raw data used to derive the Department's journey time statistics consist of 10-second GPS location reports for these vehicles for the period during which their ignition is on.

18. As part of the service provided to the Department, Trafficmaster map these GPS location reports to the Ordnance Survey ITN (described earlier) and then use this information to reconstruct the routes taken by their customers as they move through the road network.

19. These reconstructed journeys, combined with the time stamps on the associated GPS location reports, allow Trafficmaster to estimate the time taken by these vehicles to traverse each ITN link. The data also allows journey times to be associated with a particular link direction if the ITN link in question can be traversed in either direction. Where the 10-second GPS location reports don't fall exactly on the start and end of each link, interpolation is used to estimate the time taken by the vehicles to complete each link.

20. An example of how this process works is given below.

Figure 7: Example of 10-second GPS vehicle location reports

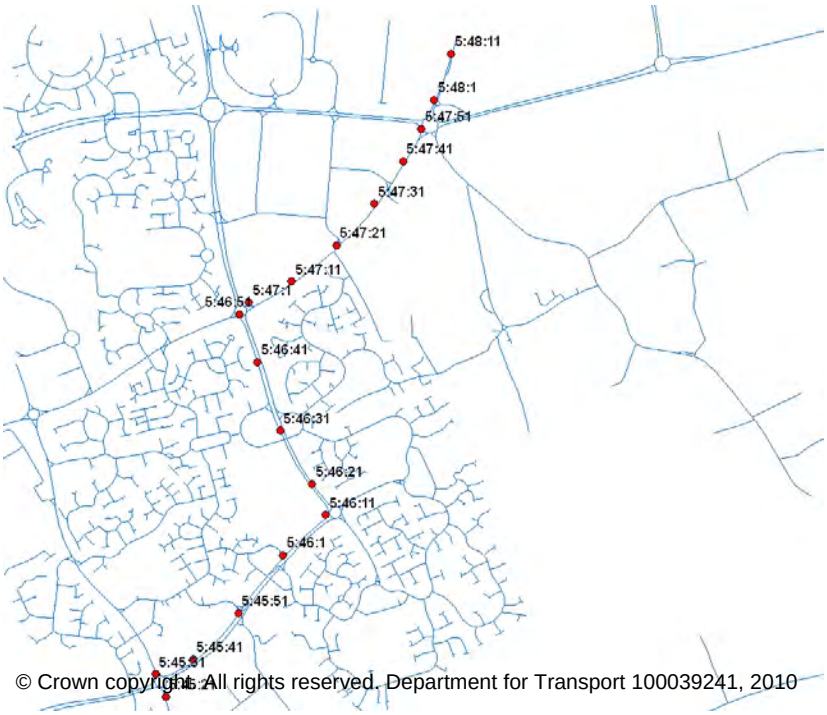


Figure 8: Example of route reconstructed from GPS location reports

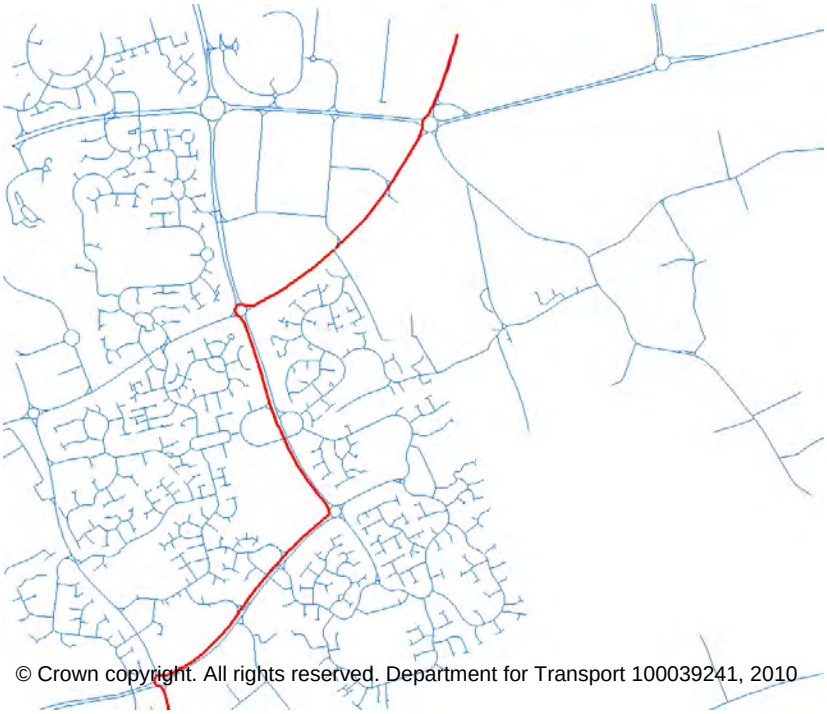
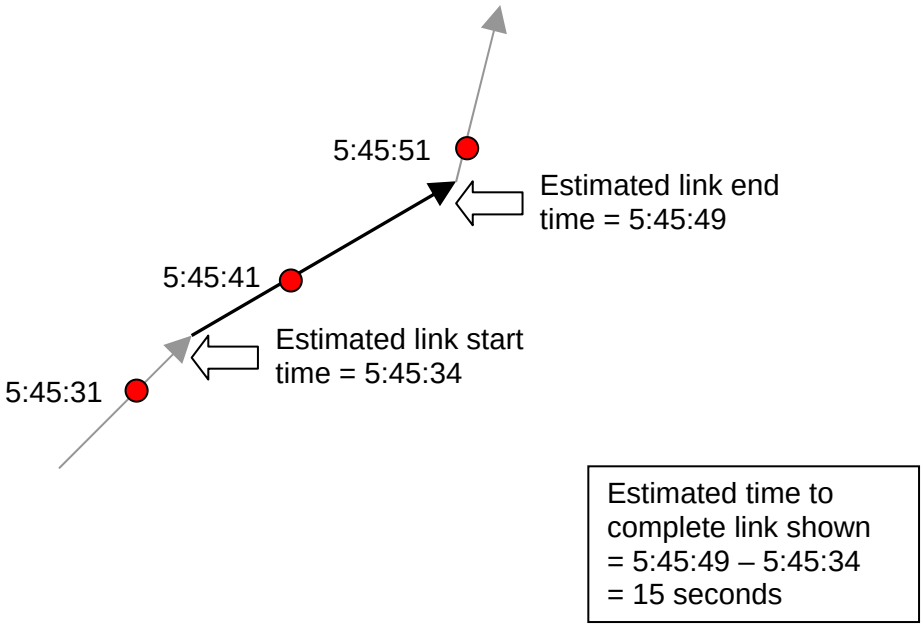


Figure 9: Example of how individual link journey times are estimated



21. It is important to note, however, that while these data are created from high resolution GPS traces, the data the Department receive are anonymised so that individual vehicle or ownership details can never be linked to individual journeys. In addition, the first and last 500 metres of each journey are excluded from the raw data to prevent complete, door-to-door, journeys being identified.

22. For the purposes of this project, only data generated from cars, light goods vehicles and heavy goods vehicles were used to estimate journey times. All public service vehicles (e.g. buses) were excluded from the statistics as their frequent stopping/starting would report much slower journey times than actually prevail on the road.

23. In addition, in order to make the data representative of conditions during the most congested times, data were only included for journeys made during the morning peak, defined as 7am to 10am, and weekends and school holiday periods were excluded from the statistics.

24. The individual link journey times were then averaged for each ITN link and direction for all relevant journeys made during each academic year - that is from September to July each year. This process resulted in a single average journey time, in minutes, for each link and direction for each year and additionally, in the case of the quarterly and monthly series, for each quarter and month.

25. Clearly, the robustness of these link level averages will be largely dependent on the number of vehicles generating the data with more vehicle movements along a link increasing the confidence that the journey time estimate for that link is accurate. The treatment of journey times based on small samples is dealt with later in this paper but a summary showing the reassuringly large number of vehicles generating data for most links/direction combinations is shown below.

Figure 10: Number of vehicle movements generating link level journey time estimates for local authority managed 'A' roads

No. vehicle movements generating journey time estimate	No. ITN links/directions[1]				
	2006/7 academic year	2007/8 academic year	2008/9 academic year	2009/10 academic year	2010/11 academic year
0-10	6,484	5,722	4,477	4,729	3,277
11-50	10,220	6,273	4,248	3,567	4,997
51-100	16,642	8,778	5,511	4,809	7,059
101-250	69,471	39,051	23,970	20,813	31,137
251-500	120,337	89,434	59,544	54,796	78,647
501-1,000	121,085	144,253	135,621	132,427	148,789
1,001+	56,454	117,281	183,428	194,278	144,250

1. Data for 2011/12 will be shown in November 2012 when the full year's data are available.

Estimating vehicle flow on the major road traffic count network

26. The Department estimates the traffic flow along each schematic link of the major road traffic count network (described earlier) through the use of manual surveys.

27. Individual links on the major road network are surveyed on an 8-year rolling schedule although those carrying the greatest flow of traffic are surveyed every year. In addition, a number of links are not physically surveyed at all as their traffic flow is known to be wholly dependent on that of another link or on the flows from a combination of other links. A summary of the number of links counted in each of the last 3 years is given below.

Figure 11: Number of major road network links by count type

	Year			
Count type	2007	2008	2009	2010
Counted in year (includes all those counted annually and some on 8-year schedule)	4,753	4,635	4,624	4,296
Dependent on flow from other link(s)	2,323	2,330	2,375	2,398
Not counted in year	10,850	10,961	10,927	11,206

28. The survey period runs between March and October each year and individual surveys take place on a selected weekday, outside of school holidays, during the 12 hour period 7am to 7pm. Daily surveys typically consist of teams of enumerators observing the traffic during this period and recording the observed traffic flow in each direction for each vehicle classes on an hourly basis.

29. In order to estimate annual traffic, these data are then expanded to 24-hour estimates through factors derived from the Department's series of automatic traffic counters and, in the case of links which have not been surveyed for a number of years, grown or shrunk depending on changes observed on these types of links in the intervening period.

30. More details of how these traffic estimates and those for minor roads are derived are available at: http://assets.dft.gov.uk/statistics/releases/traffic-estimates-2010/traffic-estimates-2010-methodology.pdf

31. For the purposes of this project, estimates of traffic flow on each major road link during the weekday morning peak were required so that the data could be used in a meaningful way alongside the vehicle journey time estimates outlined in the previous section.

32. In order to derive these morning peak flow estimates, the following approach was used.

- For all major road links where a manual survey had been carried out that year, the observed 7am to 10am vehicle flow in each direction of the link was simply extracted from the Department's central database.

- For those major road links where a manual survey hadn't been carried out that year, it was assumed that the proportion of the daily flow accounted for by the morning peak the last time the link was surveyed had not changed. These proportions were calculated for each vehicle class within each link direction and applied to the latest all-day flows in order to derive flow estimates for the morning peak.

  <u>Example of calculation of morning peak flow for selected link direction (repeated for each vehicle type):</u>

  No. of cars observed between 7am and 10am during last survey: 3,000

  Daily flow estimate for cars during last survey: 15,000

  Proportion of daily car flow accounted for by the morning peak: 3,000 / 15,000 = 0.2

  Daily flow estimate for cars in current year: 20,000

  Estimated flow of cars between 7am and 10am in current year:
  0.2 x 20,000 = 4,000

- For those major road links whose flow is assumed to be dependent on that of another link, or on a combination of other links, the morning peak flows from these 'parent' links, as calculated above, were taken as the link estimates.

Combining the journey time and traffic data to derive flow-weighted speed estimates

33. In order to derive a single flow-weighted speed estimate for each local authority, the journey time data were aggregated in 2 separate stages.

Aggregation of journey times within traffic count links

34. Firstly, the ITN link journey times (as outlined previous) were combined to produce an estimated journey time for each of the Department's traffic count links. To aid comparability, these estimates were calculated in minutes per mile rather than the absolute journey times derived for each ITN link.

35. In order to provide the most accurate estimate of the actual journey times experienced within each traffic count link, the Trafficmaster data were allowed to 'self-weight' during the aggregation process. In this way, sections of road with relatively few Trafficmaster observations on them will count less towards the average journey time for each traffic count link than sections with many observations.

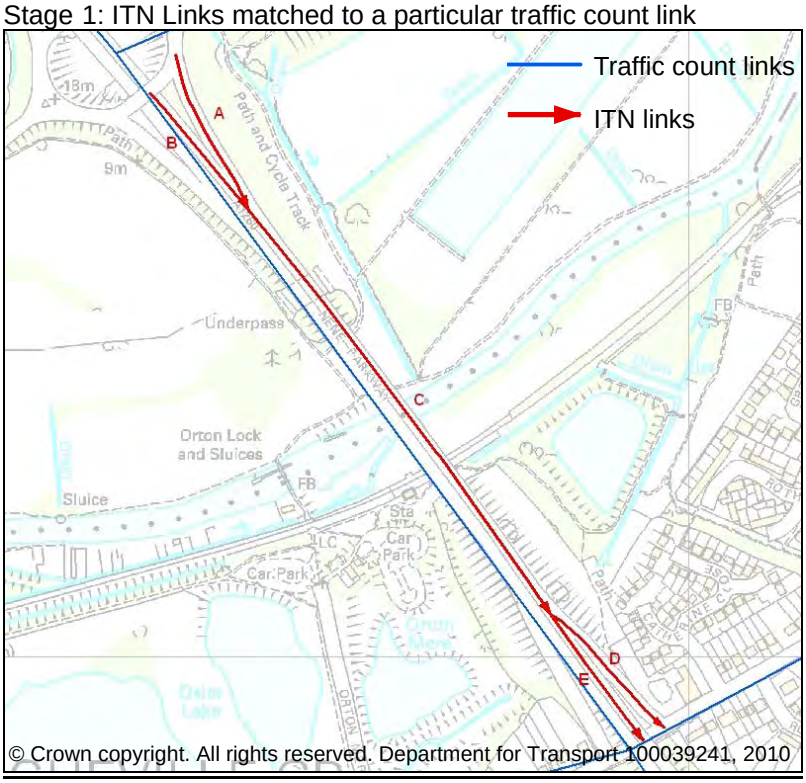
36. While this method should prevent slip roads, for example, having too much impact on the overall estimate for each traffic count link, it does assume that the distribution of Trafficmaster vehicles is representative of the general traffic.

37. This would be a very bold assumption if made at network level –Trafficmaster's customers are unlikely to be evenly spread across the country for example - but, as the data are only taken to be representative within the realm of each traffic count link, it is a much more reasonable assumption.

38. An example of how ITN link journey times were aggregated to traffic count link level is shown overleaf.

Figure 12: Example of how journey times were aggregated within traffic count links

Stage 1: ITN Links matched to a particular traffic count link



Stage 2: Journey time data extracted for ITN links

ITN Link	Number of observations	Average journey time (mins)	Link length (miles)
A	250	3.0	1.0
B	500	2.0	1.0
C	750	4.5	5.0
D	600	6.0	1.5
E	150	2.0	1.5

Stage 3: Journey time data aggregated for traffic count link

Aggregate data	Description	Value
Vehicle minutes	Total time spent travelling by observed vehicles within selected ITN links: *[number of observations]*[average journey time], summed across ITN links*	9,025
Vehicle miles	Total distance travelled by observed vehicles within selected ITN links: *[number of observations]*[link length], summed across ITN links*	5,625
Average journey time (minutes per mile)	Average journey time, in minutes per mile, for selected traffic count link: *[vehicle minutes]/[vehicle miles]*	1.6

39. This aggregation was carried out similarly for all ITN links recorded by the Ordnance Survey as being part of a locally managed ‘A’ road with the small exception of roundabouts.

40. Journey times for roundabout links within the ITN were removed from the data before aggregation as the flow around them are complex and cannot simply be estimated by the flow of one or other of the traffic count links that join at them. In addition, congestion does not usually occur on roundabouts themselves and is more commonly associated with the links leading up to these types of junction.

Imputation of journey times for links with small sample sizes

41. Although the journey time estimates for the majority of ITN links are based on very large sample sizes – see figure 10 – the data for some links are based on much smaller samples and cannot be treated with the same level of confidence.

42. As such, any aggregated data at traffic count link level that were based on fewer than an average of 10 observations per ITN link were replaced with imputed journey times based on the following:

    - The average journey time, in minutes per mile, for that particular road in the local authority - if this itself was based on an average of 50 or more observations per ITN link;

      Otherwise,

    - The average journey time, in minutes per mile, for all locally managed 'A' roads in the local authority.

43. Detailed imputation tables for published statistics can be found online in the technical information section at:

    http://www.dft.gov.uk/statistics/series/congestion-and-reliability/

Aggregation of journey times within local authorities

44. Once any necessary imputations were carried out, the aggregated journey time statistics for each relevant direction of the Department's traffic count links were weighted by their appropriate 7am to 10am traffic flow (as described previous).

45. These weightings were then used to calculate an overall journey time estimate for each local authority and for England as a whole.

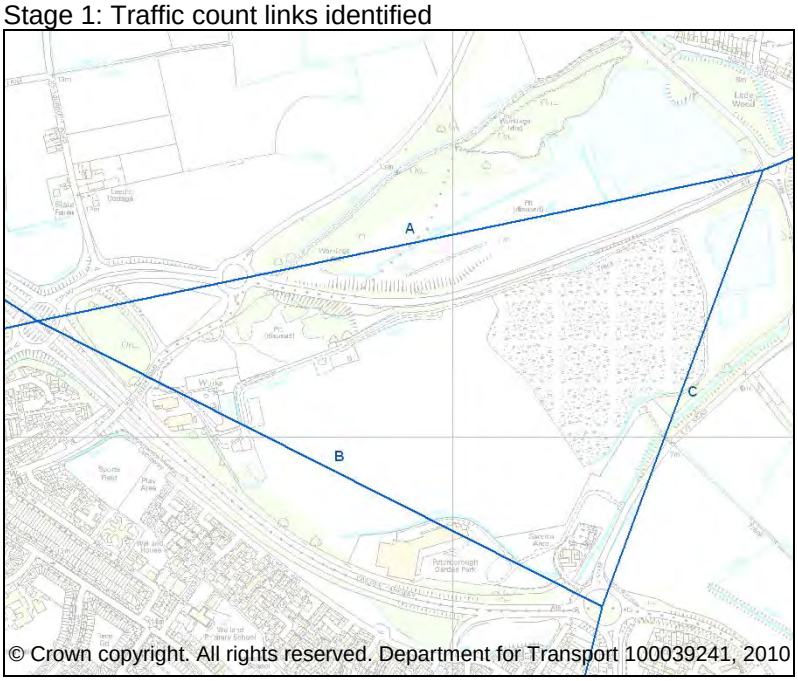
46. By taking account of the traffic flow, journey times for traffic count links with relatively low morning peak flow were given appropriately less weighting in the overall statistics than journey times for links with much higher flow.

47. For the small number of ITN links that could not be matched against an appropriate traffic count link – see figure 6 – the average flow from other similar types of link in that local authority were used as the weighting factor.

48. An example of how the data were aggregated across traffic count links is shown below.

Figure 13: Example of how journey times were aggregated within local authorities

Stage 1: Traffic count links identified



Stage 2: Journey time and flow data extracted for traffic count links

Traffic count link	Average journey time (minutes per mile)	Link length (miles)	Morning peak traffic flow
A	1.5	10.0	3,000
B	2.0	8.0	10,000
C	4.5	6.5	5,000

Stage 3: Journey time data aggregated across traffic count links

Aggregate data	Description	Value
Vehicle minutes	Total time spent travelling by vehicles during the morning peak within traffic count links: *[average journey time (mins per mile)]*[link length]*[morning peak flow], summed across traffic count links*	351,250
Vehicle miles	Total distance travelled by vehicles during the morning peak within traffic count links: *[link length]*[morning peak flow], summed across traffic count links*	142,500
Average journey time (minutes per mile)	Average journey time, in minutes per mile, across selected traffic count links: *[vehicle minutes]/[vehicle miles]*	2.46

Application of methodology to ‘A’ roads managed by Transport for London

49. In order to create separate speed statistics for those ‘A’ roads managed by Transport for London (TfL), the journey time data for each ITN link was combined with information provided by TfL about the roads under their control.

50. The data were then aggregated to traffic count links and then complete network level in a similar manner to that outlined above, although any traffic count links based on fewer than 10 observations on average were replaced with the following:

    - The average journey time, in minutes per mile, for that particular road in the inner/outer TfL managed network - if this itself was based on an average of 50 or more observations per ITN link;

      Otherwise,

    - The average journey time, in minutes per mile, for all locally managed ‘A’ roads in the inner/outer TfL managed network.

51. As details about which sections of the ITN network are managed by TfL are only available towards the end of each academic year, these flow-weighted speed statistics are updated on an annual basis.