Transport for London

ROADS TASK FORCE
Thematic Analysis

Roads Task Force - Technical Note 11

To what extent is congestion and unreliability on the road network caused by factors that can be influenced by TfL's road network management?

Introduction

This paper forms one of a series of thematic analyses, produced to contribute to the Roads Task Force Evidence Base. It investigates the extent to which congestion and unreliability on the road network can be influenced by TfL's network management.

Summary

- The cost of annual vehicle delay on the London Network of Interest is £4 bn. The Transport for London Road Network (TLRN) accounts for 37 per cent of this (£1.5bn) and the Borough Principal Road Network 45 per cent (£1.8bn).
- The average weekly AM journey time reliability (JTR) on the TLRN weighted by motorised vehicle kilometres across a recent 4 year period in London is 88.8 per cent.
- A model shows that as an example road link saturates above a level of 80 per cent of potential traffic carrying capacity, journey time reliability decreases. In this example, 100 per cent saturation provides a JTR of 77.7 per cent.
- Seven factors that account for congestion and unreliability on the road network are identified and modelled; traffic incidents, road works, the weather, fluctuations in traffic levels, special events, traffic control devices and physical bottlenecks ("Capacity").
- Seventy nine per cent of unreliability in journey times is explained by the volume of traffic and day-to-day variability in traffic demand; twenty one percent by accidents and breakdowns and other events.
- The influence of a 'Serious' and 'Severe' event (as defined by the London Traffic Information System – LTIS) considered and included in the model had approximately 4 times the influence of 'Moderate' LTIS event.
- Recommendations are provided for further research to improve our models and subsequent understanding of these relationships.

Congestion / Delay

The concept of delay relates to factors that affect capacity (temporary or permanent) leading to the situation such that demand exceeds capacity on a section of road at a particular time resulting in speeds that are slower – often much slower – than normal or free-flow speeds. Normally such congestion conditions means stopped or slow-moving traffic.

Journey Time Reliability

Journey time reliability (JTR) is defined as how much travel times vary over the course of time. All root sources of congestion – especially traffic-influencing "events" such as traffic incidents, weather, and work zones – that contribute to total congestion also conspire to produce unreliable travel times, because these are never the same from day-to-day. This event-driven variability in travel conditions is known as non-recurring congestion since it happens differently every day. Journey time reliability is a more formal way of describing non-recurring congestion. Hence journey time reliability is a facet of congestion. Any consideration of the total impact or cost of congestion, normally calculated only in terms of direct observed delay, should also include a component that costs and accounts for the variances in journey times arising from non-recurrent congestion. This metric as measured by TfL on the TLRN in the AM weekday peak is defined in TfL's Travel in London reports.

Factors that can account for congestion and unreliability on the road network

Multiple factors account for congestion, often interacting with one another. These "sources" can be grouped into 7 factors in three broad categories (US FHWA, 2005):

Category 1 – Traffic-Influencing Events

1. **Traffic Incidents** – disruption to the normal flow of traffic usually by physical impedance.
2. **Road Works** – activities that result in temporary physical changes in road capacity.
3. **Weather** – certain conditions can lead to changes in driver behaviour that affect traffic flow.

Category 2 – Traffic Demand

4. **Fluctuations in Normal Traffic** – Day-to-day variability in demand leads to some days with higher traffic volumes than others. If the capacity of the network is fixed this can lead to variable travel times without any Category 1 events occurring.
5. **Special Events** – Are a special case of demand fluctuations where traffic flow in the vicinity of the event will be radically different from "typical" patterns.

Category 3 – Physical Highway Features

6. **Traffic Control Devices** – Intermittent disruption of traffic flow by control devices such as poorly timed signals can contribute to congestion and travel time variability.
7. **Physical Bottlenecks ("Capacity")** - the maximum amount of traffic capable of being handled by a given highway section. Typical bottlenecks in London are caused by fixed bridge and tunnel capacity. Other factors that impact traffic

capacity include bus lanes and cycle lanes.

The interaction between these multiple sources is complex and varies greatly from day-to-day and road-to-road. The problem is that with the exception of the physical bottlenecks, the sources of the congestion can occur with maddening irregularity – nothing is ever the same from one day to the next!

Estimate of Congestion on the TLRN and BPRN

The TLRN is comprised around 1100 km of main road network (counting both directions) and makes up 4% of all roads in Greater London but carries approximately 30% of all the traffic. The BRPN is comprised of around a further 2210 km of strategic main road network (counting both directions) and is managed by the boroughs. It has been estimated that total cost of annual vehicle delay on the London Network of Interest (NOI) is £4.0 billion. The TLRN accounts for 37% of this (£1.5 billion) and the BPRN 45% (£1.8 billion).

Congestion on the network is estimated on a daily basis using journey time data from automatic number plate recognition technology. The congestion level is defined as follows:

Congestion level = (level of journey time / reference level observed at night [10pm-6am]) – 1

Three sets of weights are used in this calculation in order to account for the varying levels of demand across links and directions, for a standard working day, during the following three periods: morning peak (7am-10am), inter peak and evening peak (4pm-7pm). The congestion level is equal to 1 when motorists experience a level of journey times which is double the one they usually experience at night.

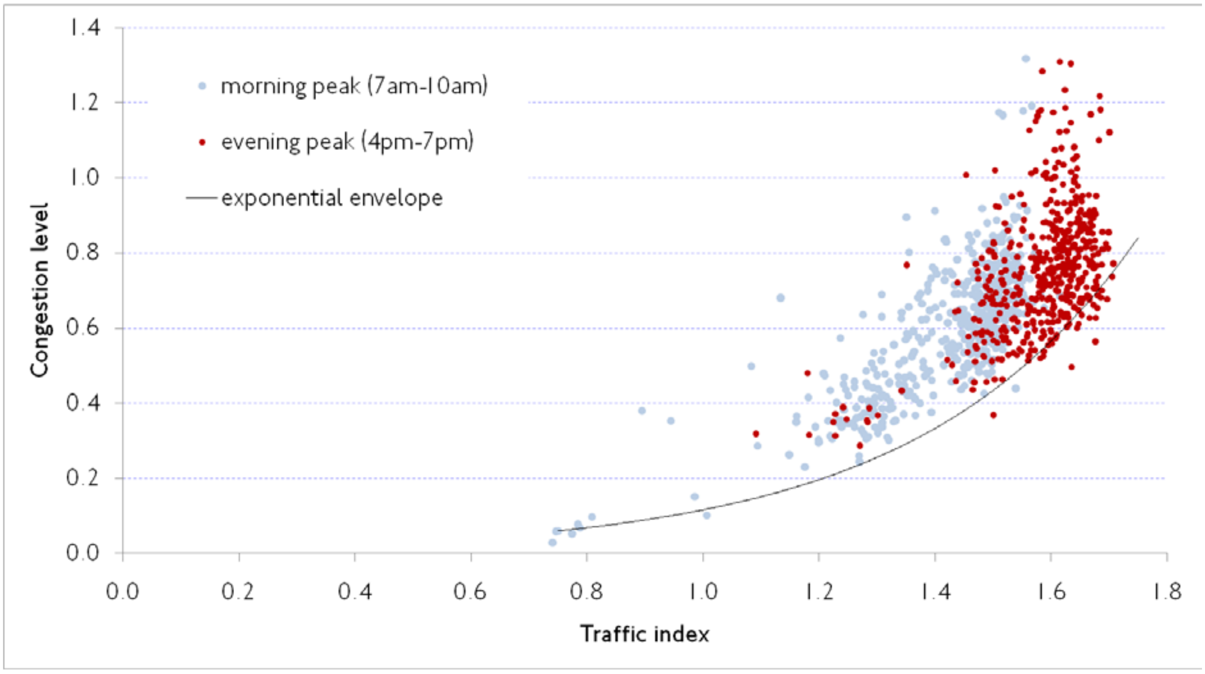
On the other hand, traffic volumes across the network are monitored with automatic traffic counters. An index is built where the value of 1 represents the median level of traffic across the year. Figure 1 is the scatter plot showing the effect of the traffic index on the congestion level. It displays separately the morning peak and the evening peak.

The chart shows that, on most days, traffic volumes are close to a limit. Because of the very tidal and heterogeneous use of the network in the morning, the morning peak limit is lower than the evening peak limit. These limits could be interpreted as the capacity of the network, under peak-specific patterns of demand.

On days when the traffic index is close to this limit, the chart indicates that there is a greater risk of experiencing serious delays. Looking at the evening peak, when traffic index is above the median level of 1.6, there is an 11% chance of observing journey times which are double their night reference level. For the less busy days, with a traffic index below the median level, there is a 6% chance of experiencing such a level of congestion.

Finally the charts indicate that congestion is almost always above an envelope curve. Data points along this envelope can be interpreted as days when very few events occurred on the network. This envelope suggests that congestion is highly elastic with regards to traffic.

Figure 1 Impact of traffic on congestion, TLRN+BPRN, daily data, Mon-Fri, Jan 2009 - Dec 2010

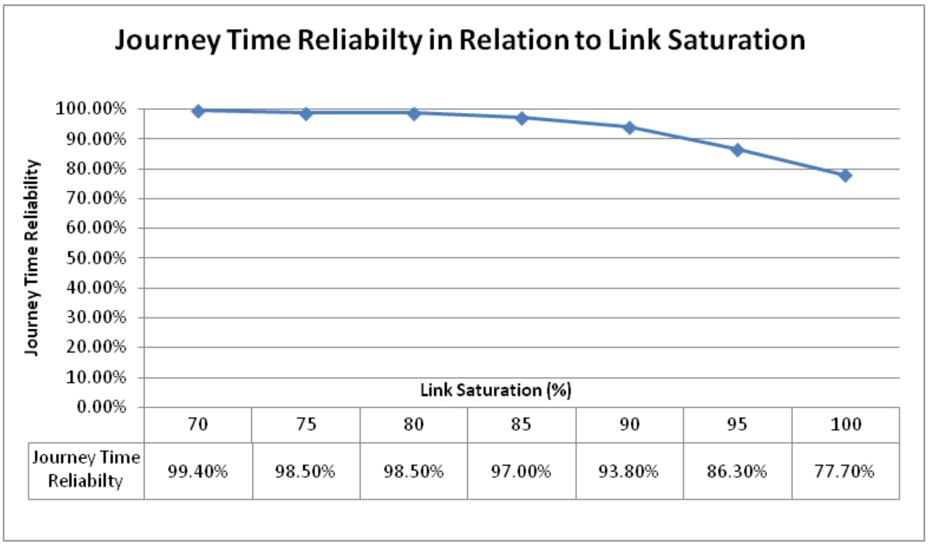


At low levels of flow, there is little congestion, but more important, little additional congestion is caused by either an increase of traffic or an effective reduction in road space. But when traffic flow approaches the maximum capacity of the network, then small increases in traffic, or small reductions in effective road space (such as incidents reducing capacity short term), have disproportionate effects on journey times leading to congestion.

Establishment of a Relationship between Degree of Saturation and Journey Time Reliability

A VISSIM model of Victoria Embankment developed as part of the 2010/11 signal timing review programme was used as the basis for tests to examine the relationship if any, between link saturation and journey time unreliability as part of the preparations for the establishment of the Olympic Route Network (ORN). Link saturation describes the volume of traffic using the link in relation to its maximum capacity. These tests simplify network operations to examine what would be achieved along a single segregated traffic lane.

Figure 2 The Relationship between Link Saturation and Journey Time Reliability on Victoria Embankment



	70	75	80	85	90	95	100
Journey Time Reliabilty	99.40%	98.50%	98.50%	97.00%	93.80%	86.30%	77.70%

This relationship developed, Figure 2, shows that as the link saturates above a level of 80% journey time reliability decreases.

Understanding the Contribution of Cause and Effect Factors to Journey Time Unreliability

Research has been undertaken by the Traffic Analysis Centre to examine the effect on Journey Time Reliability (JTR) of available influencing factors. Daily JTR data has been provided from April 2010 through to February 2013. Further data sets have been sought in order to determine the impact of various factors on JTR on a daily basis, reflecting the known influences on congestion detailed at the start of the paper.

- Physical bottlenecks (capacity) – This is currently assumed to be constant throughout the period, ignoring the impact of improvements to junctions and roadways throughout London, therefore no data has been collected.
- Traffic Incidents – LTIS information has been downloaded on a daily period showing the severity and duration of events for use in the model.
- Work Zones – LTIS data includes planned and unplanned work zones. These have not yet been modelled.
- Weather – Weather data on a daily basis but has not yet been included in the model.
- Traffic Control Devices – Impacts of traffic control devices have been updated and reviewed throughout the time period.
- Special Events – Across the large London network, it is expected that 'Special Events' will be confined to a small area and have minimal impact on city-wide

JTR. An obvious exception to this principal was the 3 month period of the 2012 Olympic and Paralympic Games.

- Fluctuations in Normal Traffic – Traffic flow data has been collected at approximately 50 sites across the network. These are assumed to be representative for the purposes of initial analysis, further work will be undertaken to determine spatial representativeness.

JTR data is measured across all links of the network from journey time data derived from ANPR cameras, see thematic note 2a. The data is provided per link on a daily basis. For provision of weekly or monthly reports on JTR, where data is missing or is recording zeros, the JTR values are patched based on what the expected value would have been based on historic data. In the analysis data was not patched to preserve the integrity of the initial data set. The average weekly AM JTR weighted by vehicle kilometres across the 4 year period in London is 88.8%. This figure correlates with TfL published JTR figures.

The analysis undertook a step-wise linear regression analysis to determine the impact which each factor has on JTR. The data was available on a daily level. JTR data was only available for weekdays and the initial analysis has focused on the AM Peak period.

For modelling purposes, the JTR was converted to an unreliability level (the difference from 100% reliability which is called the Journey Time Unreliability (JTU). The regression was run on weekly average figures rather than daily figures to remove bias from different days of the week. It also accounts for the method of calculating JTR which involves dividing the daily travel time by the average across the week.

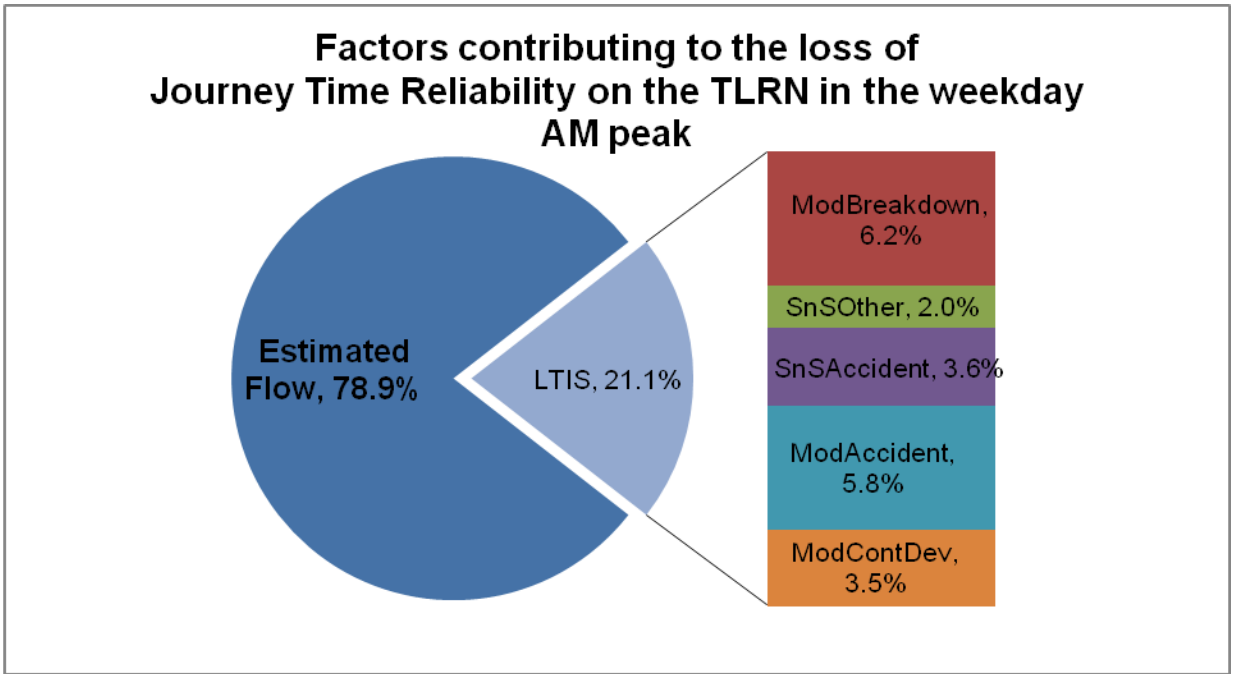
The traffic flow data has been indexed against the average across the period to provide a London-wide traffic flow index which indicates the level of traffic for a given AM peak period. There is evidence (see Figure 1) to suggest that the impact of flow is exponential rather than linear, therefore the flow factor was transformed to an exponential derivative for more accurate representation in the linear regression modelling.

Incident data was collected and refined down to match the time period and dates required by other data sets in the model. The data has been separated into two categories, Moderate events (Mod) and Serious and Severe events (SnS) as defined in Appendix A, for the main unplanned incident categories recorded by TfL.

By multiplying the explanatory factors variables by the modelled coefficients from the regression, we can determine the average overall influence of each factor on the TLRN in the weekday AM peak, see Figure 3.

The figure above shows only the influence of factors which have been measured. For example, at the moment the model does not include planned or unplanned roadworks. Roadworks are difficult to detect in a model such as this. Typically most roadworks because they have management plans in place, and occur outside of traffic sensitive times do not disrupt traffic. Of the few that do, their impacts depending on their size and duration are often diffused widely across the network as drivers change their traffic patterns to adapt to diversions in place.

Figure 3 The proportional contribution of explanatory factors to the loss of JTR in the weekday AM peak.



There are other factors that currently can't be modelled due to data constraints that may have an influence on the observed JTR. A number of potential contributing factors have also been tested to see if they have an influence on overall JTR, however, these have not currently been shown in the regression to be significant.

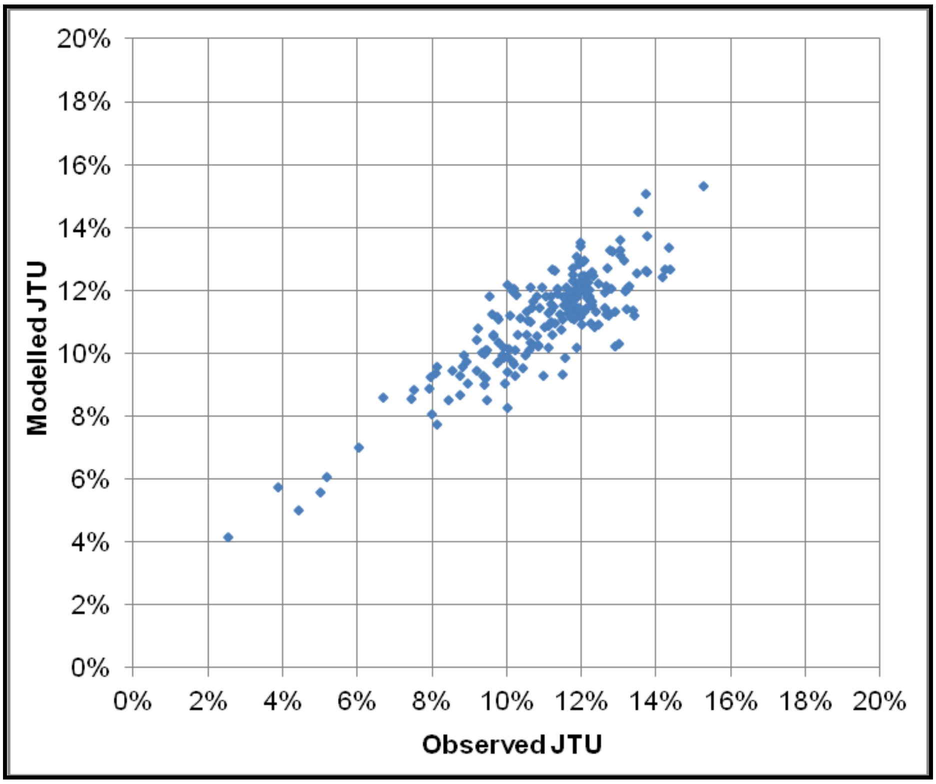
Other insights from the regression model used to explain journey time unreliability

The modelled JTR and observed JTR using average values across a week were more closely correlated than the daily JTR values. This is to be expected, JTR is calculated using weekly average journey times, so the JTR contribution of a given day is not independent from travel conditions on the other days of the same week.

To understand daily changes in unreliability a dummy variable was included based on the day of the week. This showed that Tuesdays and Wednesdays had a negative impact on JTU (made traffic worse) while Fridays had a positive impact on JTU (made traffic better). These were significant in the model with Friday's positive impact being the greatest, Wednesdays negative impact was moderate, while Tuesday had a minimal but 'statistically significant' impact.

A scatter plot of the modelled JTU by observed JTU shows that the larger observed events were less accurately modelled than the majority of events, see Figure 4.

Figure 4 A scatter plot showing the correlation between modelled journey time unreliability and modelled unreliability in the weekday AM peak on the TLRN.



The anomalies pinpointed between the observed and modelled JTU values can mostly be explained by the occurrence of tube strikes and public holidays which had an impact on the overall JTR in the week in which they occurred. Dummy variables were not effective in modelling the influence of public holidays as they were observed to be influenced by time of year and other factors. For example, the Queen's Jubilee extended public holiday in 2012 had a greater impact than the May Day public holiday in the previous month. Due to there being only 4 years of data, the use of these dummy variables was not considered appropriate to deal with this issue.

Conclusions

The model as currently configured explains that the majority of the current unreliability, 79% of it on the TLRN in a weekday AM peak is accounted by volume of traffic and day-to-day variability in traffic demand. This reinforces the previous analysis in this paper that also shows the exponential impact of increased traffic volume on observed congestion in the AM and PM peak on the broader network when both the TLRN and BPRN are considered, Figure 1. The importance of reserving capacity on the road network in being able to deliver more reliable journeys was also brought out in the analysis that showed JTR was more effectively delivered once the degree of saturation on the TLRN is reduced to about 80%.

Modelling work has shown that accidents and breakdowns account for about 21% of current journey time reliability and it is vitally important that effective response to such events to return the network quickly and efficiently to its planned, steady state operation as soon as possible.

The influence of individual Serious and Severe LTIS events considered and included in the model had approximately 4 times the influence of individual Moderate LTIS events. This was consistent across two main LTIS categories, and this result suggests that there is good consistency in the severity grading of incidents and events by TfL's Streets Traffic Control Centre (LSTCC).

While traffic volumes and severe and moderate LTIS events were shown to have a measurable impact on JTR, these factors do not fully explain all observed daily variations in JTR.

There are several improvements that can be made to improve our understanding of these factors. These include:

- Work to disaggregate the analysis spatially (by region perhaps) and temporally (by year). This may help to describe trends across the network in both space and time.
- Work to include new factors into the model to determine if they influence journey time unreliability. This analysis does not entirely explain all JTR events and variability. Attempts to model several other elements for significance have been unsuccessful. It is not clear if this is due to the data used or simply the lack of influence of various factors. As new data sets become available they will be modelled to determine influence, if any.
- Work to improve the current model. The relationship modelled was chosen as a linear relationship which had the origin as the intercept. Further modelling can be investigated to determine if a better model can be derived that would fit the data better. For example, the flow factor has already been transformed to an exponential derivative.

Strategies that can be used to reduce congestion and improve reliability fall into 3 general categories:

- Adding more base capacity
- Encouraging travel and land use patterns including mode shift, to form new patterns that use roads in less congestion producing ways,
- Operating existing capacity more efficiently – Getting more out of what we have, for example, by redesigning specific bottlenecks such as interchanges and intersections, and/or introducing new urban traffic control and signalling to increase their effective capacity

All of these strategies can lead to a reduction in congestion. The results of our analysis provide evidence that those strategies that either provide more capacity overall or act to preserve and lock in capacity following reductions in overall traffic volumes, with follow up actions to make day-to-day variations in traffic volume more stable will be most effective in making our journeys more reliable.

References

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