SERVICE LEVELS AND MAJOR ROAD NETWORK VARIATION BY TIER

A: Introduction

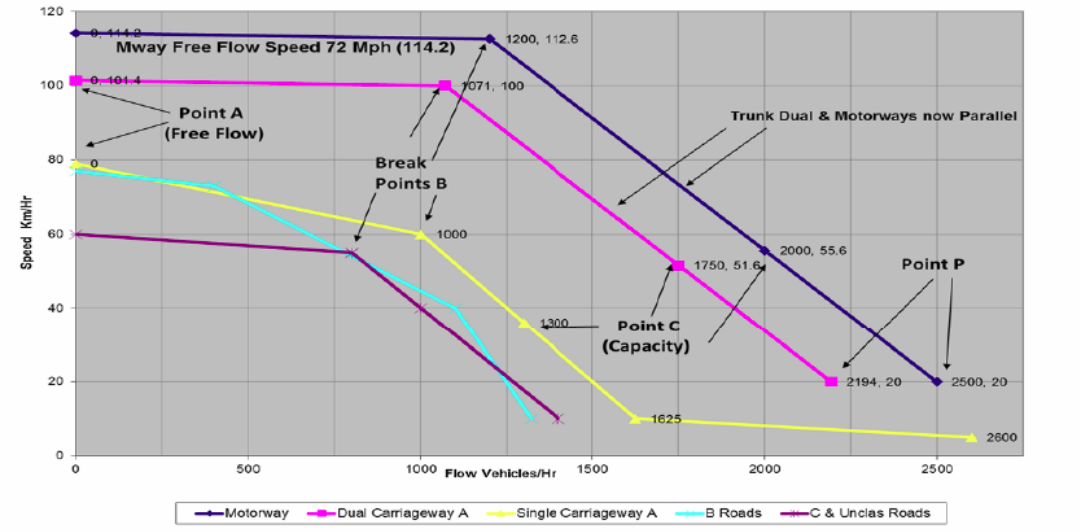
This paper outlines the theoretical background to determining the capacity of a road network, and then considers how the service it offers can be optimised and measured in the real world.

The service level offered by the network operator will depend on the theoretical capacity of the network and the management measures the operator puts in place to realise that capacity. It will fall to the strategic client (for the Major Road Network, DfT and local highway authorities or sub-national transport bodies) to determine and monitor the performance regime on behalf of users and other stakeholders.

B: Theoretical capacity

Capacity can be defined as the amount of traffic (in vehicle units per period of time) that a road can accommodate, and this will vary by the average speed of the traffic. The Department for Transport's National Transport Model uses the Forge methodology to derive speed flow curves for different road types, motorway and all-purpose, urban and rural (see example DfT chart below). In all cases, as traffic increases, then traffic speeds will fall.

Figure A.5: Rural speed flow curves



Source: Road Traffic Forecasts 2015, Department for Transport, March 2015, Annex A, page 69

In practice, as traffic volumes build up speeds fall to the point where flow stalls and the speed flow line turns back on itself - less capacity, rather than more, as speeds continue to fall. At that point the flow may even stop as the traffic stream locks up. However flow will then restart and, as traffic spaces out after restarting, volumes will fall and flows return to the normal 'stable' range. Speed flow curves used in most transport models do not represent this transient dynamic, but rather average speeds and flows over an extended period – they average out the periods of instability with periods of stable flow.

An effective traffic management strategy, where flow is heavy, should seek to keep traffic flowing at this optimum speed, regulating volumes to avoid 'shock waves' in traffic flow.

Capacity primarily depends on the standard of the road, which in the Major Road Network (MRN) will vary greatly by tier (see Supporting Document 2 - Defining the MRN). It will be determined by the least well-performing of the distinct components: at-grade junctions, rather than the lesser constraint of a free-flow merge at junctions, or the limitations of the carriageway itself between junctions. On most roads, there will be a mix of vehicle types, capable of safely travelling at different speeds; and the scale of slower non-motorised traffic will have a significant impact on overall capacity. Given the exceptional range of pressures on urban major roads, those Tier 3 roads will only be able to offer a low level of performance.[1]

Even where a road has been purpose-built or upgraded for high-volume motorised traffic, its geometry may in places still be sub-optimal because of topography, settlement patterns, construction to earlier standards or simple resource constraints. These pinchpoints will further reduce the safe operating speed.

Limited-access roads will generally have the fewest pinchpoints; the absence of frontages means the network operator has some possibility of controlling what traffic types use the road, and how many of each; and in most cases can reap the benefit of multiple lanes in a carriageway to separate traffic types moving at different speeds and to minimise risk of conflict when overtaking. Limited access does however bring the particular challenge in incident management of providing access for emergency services and of releasing trapped traffic.

[1] TfL's London Roads Task Force carried out in 2013 an analysis of the capacity of the London road network for private motorised traffic.

C: Effective capacity

The effective capacity of a road will be lower than its theoretical capacity, allowing for random influences such as individual driver behaviour, inconsistent quality of road, and weather. Effective network operation should seek to reduce the impact of each of these: the importance of *driver behaviour* in avoiding collisions is considered in Supporting Document 8 (Safety Management on the MRN), and the MRN framework overall has the primary goal of increasing *consistency* in standards across the network. Alongside actions taken to mitigate the impacts of adverse weather, a well-run network will provide extra resilience by means of alternative routings where weather-related disruption is localised and prolonged.

Management measures: the network operator has a wide range of tools at its disposal to optimise performance of the road. Some approaches, such as the regulation of user types (e.g. barring cyclists and pedestrians) or speed limits, need to be established in statute, and the ability to vary speed limits by time is an important tool in the operator's direct control, on certain sections of motorway. One main area where the operator can make a difference is in controlling traffic signals in response to variation in traffic flow, and in speed of response to incidents, including the rapid activation of adequate diversion routes. A key consideration here will be the agreed split of responsibility with police forces.

The potential impact of increasingly automated vehicles: Section 7.3 in the main report, and Supporting Document 10, explore the potential impact of connected and autonomous vehicles (CAVs) on the capacity of the MRN. CAV technology can be expected to spread across the vehicle fleet in stages, not on a continuum, but the network operator might have some discretion to pre-empt the attainment of critical mass by determining at what point individual lanes on its road, or even a whole carriageway, might be reserved for connected vehicles. The capacity gains thus resulting from closer headway between vehicles may not however be as great as that from the steady emergence of partially-autonomous vehicles, bringing the great benefit of avoiding collisions and hence disruption to traffic flow. Further work is needed to quantify the potential gains for capacity from CAVs, in particular on the technical and commercial practicality of HGV platooning on limited access roads (Tier 1 of the MRN), and on the specific measures the network operator needs to take to adapt its infrastructure to maximise the benefits of CAVs.

D: Determining service levels

The essence of the service proposition for the user will be journey time (in the form of the average speed that can be attained), and how reliable that will be. Beyond the standard of the road, variation in demand over time is the key factor determining the combination of speed and reliability. All roads will have variability in traffic flow across the day and week, and to a large extent this will be predictable; the average safe speed that the road can support therefore has to be qualified by recognition of a percentage congested time, to be kept to a minimum, when the target performance cannot be met.

There will also be unpredictable variation from the safe average speed, as a result of irregular disruption: not just accidents and infrastructure failings, but also planned roadworks and unexpected levels of traffic. Over the longer term there is sufficient accrued knowledge of the aggregate effect of such delays to be able to calculate a 'planning time index' for the road - the extra time that needs to be allowed for a journey to remain on-time for a set percentage of trips (see section E below).

These two concepts – the predictable variation and the unpredictable variation – are incorporated in the latest generation of Satnav devices. These bring to the driver planning a particular journey information about the expected journey time for that specific time of day/day of week, as well as notifying unpredictable delays occurring during the journey (see Supporting Document 10 - Opportunities and Challenges of Technology*).*

As noted in the main report, these three indicators can be combined to produce **a service proposition for the MRN**, but this must vary by tier; for example, the greater control which the network operator has over the limited-access Tier 1 and 1A roads means that unpredictable variation there should be much lower. We propose the following matrix of expected service levels for the four tiers, in respect of average speed (ranging from + to +++), as then qualified by the extent of predictable and unpredictable variation (ranging from − to −−−).

Matrix of expected service level by tier:

	Average speed baseline	**Predictable variation: extent of congestion**	**Unpredictable variation: extra time needed**
Tier 1	+++	–	–
Tier 1A	++	– – –	–
Tier 2	++	–	– –
Tier 3	+	– – to – – –	– – to – – –

The average speed banding of '+++/++/+' could be expressed approximately as 60 mph/40 mph/20 mph, but more work is needed to develop the other

indicators, exploiting valuable new analytical opportunities now arising from the wealth of mobile phone data on vehicle movements.

E: Developing a network-wide service proposition

Of greatest value to road users would be a deliverable service offer for each journey on the MRN, or, more realistically, for types of road as above. Actual performance is already measurable, and Highways England, working with DfT, is now building up impressive capability in this area. DfT's reporting of average delay on the SRN has recently been expanded[2] to set out three components of performance, for car users only, across the network as a whole:

- Average delay, in seconds per vehicle per mile compared to freeflow conditions;
- Average speed - actual recorded, rather than solely in freeflow;
- Reliability - as a Planning Time Index, the additional time drivers need to allow when using each link in the network to be 95% sure of arriving on time.

The current performance regime for Highways England in the first Road Investment Strategy period uses the first of these, average delay, as a Key Performance Indicator, but no target has been set, and there is no monitoring of average speed or reliability. It is possible that DfT, as strategic client for the SRN, will incorporate these elements in some way in the second Road Investment Strategy period, from 2021.

[2] Travel Time Measures for the Strategic Road Network, England, January to March 2016, Department for Transport, May 2016