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Capacity of the Oslo tunnel

Introduction

The demand for passenger railway travel in Norway has increased significantly in recent years, especially in the Oslo area. This has been driven both by economic conditions (e.g. increasing population, and the development of the area around Oslo Sentral station) and by improvements to the train service (notably the introduction of new trains and a 10-minute frequency service between Drammen & Lillestrøm).

However, almost all train services in S E Norway run through the Oslo tunnel, a two-track line opened in 1980 linking the original terminal stations serving the East and West of the country. This line is clearly the busiest in Norway, and is now nearing capacity, and it is important to understand the factors (including rolling stock) which affect that capacity and hence the need to construct a costly second tunnel.

Theoretical Background

The capacity of a mainline railway is usually determined by the signalling system, since this provides the authority for trains to proceed at a given speed. The critical line section is that which takes the longest time for the slowest train to traverse. In Norway, one must also recognise the curvature and gradient of lines as other features which impinge upon line speed and hence capacity.

However, for urban railways, the time spent at key stations is often more critical than that theoretically afforded by the signalling system. Passenger movement rates, combined with the detailed operation of rolling stock (door and despatch procedures) determine the time spent. Unfortunately, because a train cannot depart until all procedures at all parts of it are completed, the minimum station stop time is entirely dependent upon the detailed operational processes which occur at the busiest or critical door.

The stages involved in the operation of a train at a station in an urban area include:

- doors open
- passengers alight
- passengers board
- check of passenger movements complete, and signal clear
- door closing alarm
- doors close

- confirmation of doors closed and further check of signal clear

Note that a number of these processes involve humans (whether passengers or staff) and are therefore subject to considerable variability. Confirmation of door closure, however, is often undertaken through physical systems, with traction interlocking preventing train departure if the doors are not all recognisably-closed. We distinguish, in the text below, between passenger (movement) time and function time, the latter comprising all the other processes mentioned.

The Oslo Tunnel

Whilst the cross-Oslo line is only double-track, its planners had the foresight to provide four platforms (an island platform, with two platform faces, in each direction) both at Skøyen (to the West of the city centre, where some trains reverse) and (perhaps more importantly) at Nationaltheatret (in the heart of the city centre, under Karl Johan's Gate). As Nationaltheatret is a very busy station, this is of vital importance, because it enables trains to run into alternate platforms; if one train is slightly delayed, the following train can at least run unimpeded into the station.

Theoretically, one might run as many as 40 trains per hour in each direction through the Oslo tunnel (Skovdahl, 2009). This is because the signalling of two-track sections can cope with a train as often as every 90 seconds, whilst the dual platforms at Nationaltheatret might reasonably be expected to cope with a train every 3 minutes.

Operational research at Nationaltheatret over the years has shown that passenger movement at the critical door typically takes just over 20 seconds, but the 'function' time is usually over 35 seconds (and often rather more in the Eastbound direction, where adverse signals are often encountered, preventing departure towards Sentral station). In addition to the total station stop time of around one minute, line capacity is also affected by the platform reoccupation (run-out/run-in time). In work carried out by the Railway Consultancy in 2006, the minimum recorded values of this were 82s (Eastbound) but 136s Westbound (where there was a longer track section towards Skøyen). Since then, minor improvements to the signalling system undertaken about five years ago have rectified the bottleneck on the Westbound track between Nationaltheatret and Skøyen. The total minimum "headway" time per train is therefore around 140 seconds in each direction, a figure of 25.7tph (trains per hour) which is broadly consistent with Skovdahl's analysis. Potential improvements in this as a consequence of the introduction of ERTMS control systems are discussed in the section on automation, below.

The UIC has produced guidelines (UIC, 2004) about the maximum sensible proportion of capacity to use, given the inevitability of minor perturbation in the service (typically between 60 & 75% of capacity for a mixed-traffic line, with the higher figure being sensible only for peak periods, enabling the railway to recover during offpeak times). This would suggest a capacity of 24 – 30 tph (trains per hour), against a current maximum operated of around 24tph.

Ensuring Good Performance

In any railway, there is something of a trade-off between maximising capacity and providing an acceptable level of punctuality. After a major incident, service recovery on a busier railway will always be more difficult than on one with lower-frequency services. However, minor delays are much more common, and it is arguably more important to ensure that minor delays do not lead to major disturbances.

In terms of the operation of the Oslo tunnel, a number of measures have already been taken to minimise disruption: for instance, the long-distance services to Bergen do not call at Nationaltheatret, because the quantity of passengers involved, their unfamiliarity with the system (the trains are popular with foreign tourists), the need for them to find seat reservations in the relevant carriage etc. make it very unlikely to achieve anything like a 1-minute station stop, which is what is required in order to achieve line capacity.

Other operational practices can also encourage capacity – for instance, through the provision of indicators (giving advance notification of train length, occupancy and features (e.g. the location of wheelchair spaces)), platform staff (to spread passengers along the platform, and obviate the need for passengers needing help to disturb train-borne conductors during dispatch) and so on.

However, as a rolling stock provider, there is also a range of measures which Norske Tog can take, in order to assist this process:

(i) challenging train manufacturers as to the speed of door opening and closure: saving just one second of each on every train would total 40 seconds in the peak;

(ii) enabling efficient despatch procedures: many train companies have adopted a policy whereby the conductor must ensure himself/herself that all the passenger doors are closed before he/she starts the door closure process for their own door, which is a double-door close process which can add 15 seconds to all departures. However, it might be possible for this latter process to be designed not to impede the application of traction current, which would save several seconds; that might require train doors to have windows which were openable by staff, in case conductors wanted to view potential late boarders/alighters from within the train;

(iii) facilitating easy passenger movement (both for boarders and alighters) through the provision of wider doors; in practice, this means doors should be at least 130cms wide;

(iv) avoiding steps within the vehicle, and trying to ensure that the gap between the train and the platform is minimised (each 10cms of this broadly reduces passenger movement speeds by c. 0.1 pass/sec);

(v) providing standbacks (proven to improve boarding rates, with a 40cm standback typically increasing boarding rates by 0.1 pass/sec)

(vi) enabling easy access from the vestibule into the main seating area, for instance by removing some of the seats nearest the vestibule;

(vii) considering the negative impact of seating density on passenger movement rates (an issue at its worst with double-deck stock).

If rolling stock were improved so as to permit a 8-second reduction in station stop times, that would on its own permit yet another train per hour to be run.

Automation

The benefits of automation are as much in the standardisation of times as in their reduction; it is common for inter-station run times to vary by at least ±10% between (human) drivers. Variability in the timings of processes occurring in a pipeline-type system are a direct precursor to a loss of capacity and a reduction in performance.

A particular benefit of enhanced signalling systems such as ERTMS is their removal of a fixed-block system (which can lead to wasted capacity) by enabling trains to approach preceding trains more closely (albeit at lower speeds). ERTMS is to be introduced through the Oslo tunnel in the near future, and would be expected to reduce platform reoccupation times, but it is currently unclear by how much. Evidence from London Underground's Victoria line shows that minimum platform reoccupation times can be reduced by at least 10 seconds. However, we note that even just an 8-second reduction across 24 trains would allow another train per hour to be operated (24 x 8 seconds > the 2.5 minutes needed for a typical headway at 24tph), potentially carrying 1000 passengers.

Conclusions

The Oslo tunnel is the busiest railway in Norway, and is approaching the capacity at which it can operate at a reasonable level of performance. The factor which is likely to limit capacity first is that of station stop management at Nationaltheatret, where there are a series of constraints relating to run-our/run-in time, passenger movement time and process time. As a provider of rolling stock, Norske Tog can and should ensure that its trains are designed to minimise process time (e.g. in despatch) whilst also enabling the fastest possible passenger movement times.

References

UIC (2004) "Capacity", leaflet 406.

Skovdahl, O (2009) "Oslo S og Oslotunnelen; sporforbindelser, muligheter og umuligheter", Railconsult.