NEW TUBE FOR LONDON FEASIBILITY REPORT OCTOBER 2014

by John Hawkins

The above report was approved for publication at the TfL February Board meeting, but finally appeared in an updated form in connection with the King's Cross exhibition of designs for the proposed train. It is the first official detailed explanation of the NTfL project, which emerged after the collapse of the PPP to provide upgrades for the remaining deep-level lines employing a common design to reduce costs. These lines all date back to the pioneering period of deep tunnel construction, and are left with the problems of those times including inadequate ventilation to cope with increasing levels of heat from traction energy. These lines require specific solutions to their problems.

The current Bakerloo and Piccadilly Line trains are beyond their design life, with reliability difficult to maintain. Traditional signalling limits services to 22tph on the Bakerloo and 24tph on the Piccadilly Line. The Central Line trains have first generation traction control equipment which requires medium term work to ensure continued reliability and serviceability. The 1990s automatic train signalling system enables 34tph for only half-hour in each peak.

The NTfL feasibility stage considered the key challenges to modernising these lines, including capacity, saloon air cooling, managing tunnel temperatures, higher automation and an implementation strategy. These challenges are closely inter-related, calling for a comprehensive system-engineered design process.

The NTfL train concept offers:

- A 10% capacity increase over an equivalent length conventional train design.
- Fewer bogies, thus reducing overall train weight and energy consumption.
- Additional under-frame space for fitting of saloon air cooling systems.
- A fully walk-through saloon to reduce crowding in the busiest carriages.
- Accessibility.
- All double doorways to improve boarding and alighting times.

A table explains the 10% capacity improvement by comparing a 10-car NTfL proposed for the Piccadilly Line with a "conventional" 7-car tube train. Seating for 248 will be 4% up on 238, but standing of 566 will be 13% up on 501, giving a total capacity of 814, or 10% up on 739 in a conventional train. No comparison is provided for the Central Line, ideally equivalent to a "conventional" 8-car train, but with a common train design of shorter cars this will presumably receive new 12-car trains and two new cars will not match the length of one old car. A compromise will need to be made, rather than the new trains fully filling the platform lengths on both lines.

Diagrams of the first two cars of a train show a bogie beneath the adjoining car ends again, unlike earlier versions with a bogie fully under one car end to increase inter-car headroom (but see below). It would appear that all bogies will be motored, with a pick-up shoe shown on the first two, and only eleven bogies in a complete Piccadilly Line train, compared to fourteen in a conventional train with probably four of those unmotored.

These trains will hopefully serve London well into the second half of this century, and therefore provide for future increased automation. However, their initial introduction on the Piccadilly Line will be with the familiar staffed operation pioneered on the Victoria Line half a century earlier! There is mention of a forty year design life for the NTfL, but also a fifty year lifespan, which presumably allows for commissioning over a ten-year period.

A general strategy for introducing NTfL to any line includes the following points. The new trains should operate on the new signalling from first introduction, although initial testing should be on the railway but out of traffic hours. The replacement of current trains with new trains will take place over time, resulting in both types operating together. An increase to services must await the removal of all old trains, when platform edge doors can also be installed. Fully automated operation must await this whole process.

The industrial design concept incorporates key elements considered timeless, such as Leslie Green station exteriors, 1938 Tube Stock[1] and the roundel symbol. The colour palette reflects this, as seen

[1] Is this the reason that the new trains are illustrated with numbers 38000, 38002 and 38004?

at the King's Cross exhibition. However, it should be noted that the ultimate design for manufacture will be influenced by the engineering elements of the selected supplier's train.

FEASIBILITY CHALLENGES

Remote monitoring and management of the train service and supporting assets and systems requires high bandwidth telecommunications. Fully integrated control will use at least two discrete communication networks, one for signalling and train control and the other for business and railway information. The cast-iron deep-level tunnels make wireless communications difficult, and a trial was undertaken on the Aldwych branch line. Given fast evolving technology, a decision on specifications will be determined prior to procurement.

Widespread renewal of the traction power system will be required to meet the higher demands of enhanced services. The University of Huddersfield has been engaged to study the interaction of bogie design and track wear, and an ultimate choice on this, articulation, gangway arrangements and underframe space will depend on their findings. Existing depots will require significant modification to cope with larger fleets of modern trains. Some capacity pinch points will be relieved with localised tunnel modification to ease speed restrictions.

Saloon air-cooling on a conventional deep level train would require passenger accommodation to provide sufficient space for equipment. However, the NTfL will require less bogies with its articulated design, freeing under-floor space for the necessary equipment. Of course, all the short areas under conventional cars ends are also combined into useful space under the three additional cars. Discharged waste heat in tunnel sections will need to be dealt with.

A diagram shows four air vents from floor to ceiling between the double doors on each car side, leaving room for only three small car windows between them. Conventional cooling systems use refrigerants to cool air, and this will be a minimum in the new train specification. However, studies continue on a hybrid system which could operate in open sections to store energy for tunnel sections, so discharging less heat in the tunnels and reducing cooling needs there. On train temperatures are expected to fall by over five degrees in the summer months.

In managing tunnel temperatures, trains will use regenerative braking to avoid dissipating heat. An increased traction supply of 750 volts will reduce transmission losses and increase regenerative gains. Together with modern composite conductor rails, energy efficiency can be increased by up to a third. A chart shows that even with saloon cooling, the new trains will emit less heat than current trains. However, faster and more frequent services will result in around a third more heat and so infrastructure cooling solutions must also be considered, such as the over-platform air handling units on the Victoria Line at Green Park.

FULL AUTOMATION

The NTfL programme, when fully implemented, can provide capability for full automation for use as required during the lifetime of the upgraded system. This would allow greater flexibility of operations since the scheduling of trains for service can be decoupled from the planning and rostering of train operators' duties. The key changes required are listed. The train design focuses on significant reduction of extended delays between stations by increasing component reliability, increasing automatic handling of defects, and real time information coupled with remote diagnostics without the need for operator intervention. There is no mention of battery propulsion in the absence of traction current, presumably a continuing desire. A design standard of five incidents per million car kilometres has been defined. 2009 Tube Stock is now achieving more than 100,000km between service affecting failures according to the Commissioner's report to the TfL November 2014 Board meeting.

Open section security enhancements will include upgrades to boundary fencing and provision of barriers between NTfL and adjacent rail lines, and caging of bridge and tunnel parapets. Platform edge doors are considered necessary for fully-automated operation, as adopted by most modern metro systems. Full height doors as used on the Jubilee Line are preferred to half-height gates as used in Paris. They could be transported through tube tunnels on low wagons to be installed overnight from an engineering train. It is noted that platform edge doors will shorten useful platform lengths since the end doorways will need to allow room for a door leaf to open clear of the tunnel mouth, where currently trains can stand with the end doorway beside the tunnel mouth.

Obstacle detection trials were undertaken with four systems: laser LIDAR scanners, RADAR radio frequency scanners, video analytical systems and ultrasonic transponders; all proved below NTfL

requirements, providing many false positives. Platform edge doors are therefore the preferred solution at the majority of stations. However, curved platforms will employ LIDAR scanners to detect obstructions between the train and platform doors.

Gap fillers will also be employed at curved platforms. These are metal extensions of the platform which move out to fill any gap between the train and the platform after the train arrives, retracting before it departs. The Piccadilly Line has 14 platforms which will require around 100 such machines. They are currently used on four metro systems, including in Tokyo where over 200 units have been installed for ten years.

For full automation, to allow trains to be brought into service as demand requires, the automatic train control system will need to be extended into depot reception and stabling sidings.

LINE DETAILS

Expected capacity improvements remain those recently publicised, with over 60% boost on the Piccadilly Line, over 25% on the Bakerloo and Central lines and up to 50% on the Waterloo & City Line. The Piccadilly and Central lines will offer 33 to 36tph, the Bakerloo only 27tph, and the Waterloo & City Line 30tph with a remodelled track layout at Waterloo.

A review of service patterns concluded that the current Metropolitan and Piccadilly Line services to Uxbridge should continue. However, the Ealing Broadway branch could be served by additional trains on the Piccadilly Line, allowing District Line trains to be diverted to support services to Richmond and Wimbledon. This would require the Chiswick Park platforms to be relocated to the Richmond branch, linked to the current ticket hall, so doubling the service currently available there. Piccadilly Line trains would also call at Turnham Green throughout the day to maintain the link with Acton Town, but with three times the current train frequency between those stations.

A review of the Bakerloo and Overground services towards Harrow & Wealdstone found no reason to change the current pattern. Platform edge doors cannot be fitted where the NTfL serves platforms shared with larger trains, and full automatic operation would not therefore be feasible in such areas. The upgrade to the Bakerloo Line would permit a future southern extension of that line.

Given that the largest service improvement will be achieved on the Piccadilly Line, it is listed for first implementation. The Bakerloo Line seems to have been given precedence over the Central Line again in order to replace the oldest trains on LU.

The Waterloo & City Line will probably be modernised alongside the Central Line, but consideration is being given to using the line to trial and test the NTfL concept, which would mean earlier modernisation alongside the Piccadilly Line. It should be noted that the oft quoted figures of 250 new trains, with 100 on both the Piccadilly and Central Lines, 40 for the Bakerloo and 10 on the Waterloo & City Line are obviously approximations, and are not included in this report.

An implementation timetable sees the rolling stock invitation to tender issuing in 2015, with the contract awarded in 2016. Resignalling on the Piccadilly Line would then commence in 2019, with the first new train delivered for testing in 2022. The first train should enter service in 2023, with the whole fleet commissioned by 2025 when capacity enhancements can begin. Platform edge doors will also be fitted by 2025 to improve the customer platform experience and to allow full automatic operation when needed.

The Bakerloo Line would follow on by 2027 but without platform edge doors and therefore no full automatic operation. The Central Line is promised the full package by 2032, as is the Waterloo & City Line if it is not used for earlier testing.

Of course, by then the Jubilee and Northern Line trains will be nearing 40 years in service, and their currently new signalling will be approaching its 25th year. No doubt growing passenger demand will justify new trains to fill their platforms rather than the current extra long cars. But that must be in the following tranche, since there is no mention of those lines in the feasibility study. The Northern Line was once listed to be included, but the Battersea extension has made its need for additional trains more urgent, and a short-term solution for both lines has been found. The NTfL project is now in the design and specification stage before going to tender in 2015.

Above and Left: Two further images of “The New Tube for London”, the lower one showing a roundel mounted on the car exterior rather than transfers.

Images: PriestmanGoode
Courtesy: Christopher Westcott