PICCADILLY LINE UPGRADE PROGRAMME

by John Hawkins

An October 2016 TfL document called the Sponsor's Remit reveals concepts for the Piccadilly Line upgrade when funds become available. At this stage only sufficient trains have been ordered to run under current signalling, and one hopes they do not wait as long as 1995 Tube Stock and 1996 Tube Stock did. Both trains and signalling are expected to have a 40-year life from delivery of last train or last signal area. The new trains fit current platforms, with no use of end-door cut-out, and no platform extension works. Three of the new trains may be fitted with remote track monitoring equipment, to enable this to be undertaken by trains in passenger service, as on other lines.

The Victoria Line upgrade provides lessons, with its performance boost producing unexpected dust problems which caused equipment failures. But its overall power consumption was lowered from pre-upgrade times, with composite conductor rails, reduced sectionalisation, inverting sub-stations, and 750V nominal supply voltage (1,000V, 6000A regenerative braking capability).

Heritage vehicle operation will be restricted to the 23km of fast Metropolitan Line between Harrow-on-the-Hill and Amersham (as traditional signalling and train-stop protection will be provided for Chiltern trains on top of the new CBTC). Therefore, heritage vehicles located at Acton Museum and Ruislip Depot must be able to transfer to the Metropolitan Line when required, presumably between suitably equipped engineering locos. Stabling for heritage vehicles will be retained at Ruislip Depot after reconstruction, in conditions comparable to pre-upgrade; so covered stabling where it currently exists.

	Proposed Peak tph	Current Peak tph	Proposed Off-peak tph	Current off-peak tph
Cockfosters – Arnos Grove	24.75	18	22.5	18
Arnos Grove – Acton Town	33	24	30	21
Acton Town – Northfields	15	12	15	15
Northfields – Hatton Cross	15	12	15	12
Hatton Cross – Heathrow T5	7.5	6	7.5	6
Hatton Cross – Heathrow T4	7.5	6	7.5	6
Acton Town – Ealing Broadway	6	–	6	–
Acton Town – Rayners Lane	12	12	9	6
Rayners Lane – Uxbridge	8	8	6	6

Whilst Arnos Grove will normally reverse a quarter of the service as now, under failure conditions Cockfosters must continue to be capable of reversing the full service. It is noted that Arnos Grove is currently a crew change location, but may operate without crew change in future to accommodate the higher service levels.

In the event of closure of the Northfields branch, South Harrow must accept 22tph and Ealing Broadway 8.25tph, presumably leaving Acton Town to reverse 2.75tph. South Harrow will reverse 4tph, Rayners Lane 6tph, with the remaining 12tph reversed at Ruislip siding and Uxbridge. Currently, the Uxbridge branch is capable of only an extra 2tph from Acton Town.

Note that under fully automatic operation, which may possibly commence on the Piccadilly Line after 2037, conventional auto-operation must remain west from there for inter-working with the Metropolitan Line. This will require provision of a train operators depot at South Harrow to meet crew change requirements. In the event of degraded working, insufficient staff would be available to work diverted trains forward, so up to 8tph could reverse there, presumably leaving 4.75tph to reverse at Acton Town. This could continue until a suitable platform-train interface becomes available for mixed rolling stock.

The Heathrow branch has the greatest passenger demand, and additional degraded operation alternatives are provided. The full 15tph service will reverse at T2,3 when T4 and T5 are

unavailable, but 7.5tph will reverse there if T4 is unavailable whilst the 7.5tph service operates through to T5. Currently the full service can reverse at T5 should T4 be unavailable. Should the Ealing Common line be blocked, the full 33tph service will be accepted to Northfields, with additional trains reversing there and also at T2,3, T4 and T5. The full main line service can currently be reversed in a similar fashion.

Capacity uplift to now %	**New trains**	**New signalling**
Cockfosters – Earls Court	19	64
Wimbledon branch	–	25
Earls Court – Turnham Green	10	22
Richmond branch	–	50
Turnham Green – Acton Town	13	14
Acton Town – Ealing Common	10	-4
Ealing Broadway branch	–	-31
Ealing Common – Uxbridge	19	19
Acton Town – Heathrow	19	49

Figures provided for percentage capacity uplift, compared to the current service, show that the new trains will provide a 19% improvement due to longer trains with inter-car connections. By incorporating the parallel District line service, of larger S stock trains, into the comparisons reduces the uplift factor. It is now planned to operate 27tph with the new trains rather than the current 24tph, which will improve this comparison, but the service pattern has yet to be revealed. The new signalling, when finally installed for the new trains, will allow the planned change of service pattern with a cumulative 64% improvement through the core. The Uxbridge branch expects no frequency uplift then.

The use of tube stock trains to Ealing Broadway results in a 31% reduction in capacity there, although current demand does not fill the S Stock trains. The Ealing Broadway service, with all day stopping at Turnham Green, will be introduced when a 30tph service is provided through the core, although current plans aim for 33tph, and may stretch to 36tph. A comparison of projected inter-station run times for timetable compilation shows an expected saving of almost 15%, or almost 9 minutes in an hour's journey.

PICCADILLY LINE NEW GENERATION TRAINS

by John Hawkins

We still await details of the new generation trains ordered from Siemens. However, I have recently seen the 296-page NTfL Rolling Stock Technical Specification of 2014 which outlines the principles behind the new train order. We have long known that the intention was to eventually equip four lines with similar trains to ease operational and maintenance training, spares holdings, etc. However, I was surprised to read that trains for each line will operate exclusively on their line and shall comply with the restrictions of that line. So, there is no intention of transferring stock as needs arise, as practiced with S7 trains covering for S8 stock.

Variations between lines are detailed, with the first trains limited to 113 metres long, which is over 6 metres longer than current Piccadilly Line trains, but over half a metre shorter than the current Bakerloo trains. On the Central Line the trains can be 134.4 metres long, a couple of metres longer than current trains, and longer than other recent LU 8-car trains. On the Waterloo & City Line they are limited to 70.2 metres, over four metres longer than current trains. End door cut-out may be required due to minor platform over-run, and during the withdrawal period of old trains, whilst platform-end video screens etc will need to be retained.

Details of the sharpest curves on each line show that the Central Line is the most demanding, with the steepest gradient at 1 in 26, and the tightest radius curves of 63 metres with cant and 45 metres without. They also have the tightest reverse curve with cant, although the Waterloo & City features the tightest reverse curve without cant at 50 metres both ways. The Central Line also features the tightest vertical hog and sag curves.

Whilst the new trains are to feature actively steered bogies, these will not be fitted for the Piccadilly Line to reduce development risks for the first fleet. LU currently primarily uses track-mounted grease-based lubricators but is working towards their replacement with train mounted lubrication systems. LU has experience of solid stick lubrication dispensers, fitted evenly along each train on both wheel-sets of individual axles at 30% of positions.

The Automatic Track Monitoring System is a bespoke LU condition monitoring system, consisting of cameras, lasers, accelerometers and auxiliary equipment, which is being fitted on a few trains on each line. Space, power, mountings, enclosures and cable routes shall be provided on the underframe of two trains for each of the Central, Bakerloo and Piccadilly lines, and on one train for the Waterloo & City Line. This space could be shared with that allocated to other equipment fitted to a proportion of the fleet, e.g. de-icing tanks.

Heavy overhaul for all four lines will be scheduled at the new Trains Modification Unit now under construction at Acton Town. For the Waterloo & City Line, this will require a half-life line blockade. Normal maintenance will be undertaken at the Waterloo & City Line depot, with component overhaul and wheel turning done off site. Stonebridge Park depot will maintain the Bakerloo Line fleet with component overhaul done off site, and some minor works undertaken in London Road Depot. The split of works between the Central and Piccadilly Line depots will be determined based upon maintenance requirements of the successful tender. Earlier plans to support both lines' trains from a new facility at Ruislip Depot have not been pursued due to limited available land and planning restrictions. Any testing or inspection that is required on trains more often than weekly will be fully automatic, so no more daily train preparation and easier Night Tube operation. This will not of course apply to cleaning and litter picking.

INTERNAL ADVERTISING

There will be two distinct rows of information in the space above saloon windows. The lower row of vinyl labels will be used for line diagrams, central area diagrams, priority seat information and other fixed customer information. The upper row will be used for a mix of card advertising and Customer Information System (CIS) digital screens. Between any two passenger doors, and between passenger doors and the car end, there shall be at least one CIS digital screen, with the remaining space being used for card advertising. Commercial advertising frames shall be provided throughout the train on the upper row of information. It is specifically noted that commercial advertising frames will not be positioned such that a passenger looking at the advertising material could be taken to be staring at another passenger! These frames will accept the advertising card materials and dimensions, including frame overlaps, printed on smooth cartridge paper 135g/m² or art paper 160 – 190g/m². Advertisement cards dimensions are 610mm ± 1.5mm x 279mm ± 1.5mm. The minimum visible display area for advertising cards inside their frame shall be 593mm x 264mm. Advertisement card fixings shall be such that unskilled staff are able to remove and replace any card within a maximum time of 5 seconds, without use of tools or repositioning the card.

The train shall include passive provision for a potential upgrade which would involve replacing card advertising space with digital advertising space throughout the train. The passive provision for digital advertising shall include space allocations for suitable digital displays; interface to receive data/content updates via WiFi at stations; controller hardware; power interface; and a Railway Control System data interface.

The train exterior shall be capable of being fitted with removable film to carry advertising. The exterior finishes shall support the application and removal of film to the painted finish without degradation.

BATTERY BACKUP

Load shedding shall initially be set to commence 20 seconds after the loss of traction power. All non-essential services shall then be switched off in a controlled manner, to include:

- Main car saloon lighting.
- Infotainment and digital advertising.
- Some Visual Electronic Information Displays in each car.
- Passenger Emergency Alarm indicator status.
- Compressor air dryer.

• CCTV Monitor/OPO Platform CCTV system.
• Heating, Ventilation and Cooling functions, except emergency ventilation.
• Operator identification system.

Train essential services retained for a minimum of 2 hours shall include:

• Train Data Recorders.
• Passenger Emergency Alarm communication facility to Train Operator and Railway Control System.
• Some Visual Electronic Information Displays in each car.
• Cab to cab communications.
• Public Address.
• Train number indicator display.
• Doors open and close functions and door closed proving circuits.
• Yellow Indicator light, head lights, tail lights, detrainment lights, emergency saloon lights and cab lights.
• CCTV recording and transmission to the Railway Control System.
• Emergency ventilation.
• Railway Control System.
• Sufficient control functionality to enable train to be powered-up if traction supply returns.
• Sufficient control functionality to enable self-powered movement.
• Fire detection.
• CO_2 sensing.
• M Door (cab end door) lock status detection.
• Monitoring.

When the battery voltage drops below a low-battery detection limit, the remaining train circuits shall be load shed except the tail lights which shall be retained for 24 hours. However, elsewhere, batteries shall provide sufficient power to support continuous use of tail lights when the train is powered down for a minimum period of one week.

EMERGENCY EQUIPMENT

The list of emergency equipment in each cab would probably look familiar to train crew of a century back.

• One Fire Extinguisher.
• One Electromagnetic Short Circuiting Device.
• Two Shoe Paddles.
• Six Detonators (in a detonator box).
• One Red Flag and Stick.
• One Train Mode Selector Key.
• One Spare J-Door Key.
• One Carry Sheet.
• One Rail Ice Scraper.
• One Tunnel Telephone *(Withdrawn from use 26 June 2017)*.
• One set of Network Rail Track Circuit Clips.
• One set of Detrainment Steps.
• One Detrainment Bridge.

PLATFORM EDGE DOORS

The Technical Specification gives plenty of dimensions for the siting of Platform Edge Doors (PEDs), which will eventually be fitted to suit the doorways of the new trains. To allow for the stopping tolerance of ±300mm at a station, each PED aperture will be 600mm wider than the train door aperture. PEDs will open fully so that no part obstructs the aperture.

The width of a pair of PEDs will be wider than the aperture so that the trailing edge of a closed PED overlaps the fixed frame. There will also be a space allowance behind the trailing edge of an open PED to accommodate operating mechanism and structure, the dimension of the overlap and an allowance to prevent two PEDs from touching each other when fully opened (taking into account platform curvatures). The total allowance for these is 200mm for each leaf.

The minimum spacing of PEDs on the platform and train doors is therefore calculated from the width of the train door, e.g. for 1,600mm doors, door spacing = 4,800mm i.e. a train door opening of 1,600mm will require to be spaced at a minimum PED spacing of 4,800mm. Train door openings of 1,700mm would require spacing of 5,000mm. Train door openings of 1,800mm would require spacing of 5,200mm.

The location of the end passenger doors shall be sufficiently far away from the end of the train such that the PEDs at the extreme ends of the platform can open fully without the trailing end of the door touching the platform end-wall. For a train with 1,600mm wide doors intended for the Piccadilly Line, the maximum distance between first and last door centres can be no more than 101.2m, for 1,700mm wide doors no more than 101.0m, and for 1,800mm wide doors no more than 100.8m. For the Central Line the same figures are 122.95m, 122.75m, and 122.55m.

Interestingly, the platforms on the Bakerloo Line are all longer than the proposed Bakerloo line train and so there is no platform length limit on the position of the train doors, although the rules for PED compatibility still apply when there is no current plan to fit them on this line. The intended solution for the shortest platform on the Waterloo & City Line is yet to be defined. At this stage, the measurements for the outer end car for the Piccadilly Line train shall be assumed and the Waterloo and City Line train length shall be 70.2 metres, as stated earlier.

CONCLUSIONS

The new trains are expected to serve their lines for at least 40 years once each complete fleet is delivered. They are designed with the prospect of eventually freeing the train operator from the front cab. With this in mind, there is a principle of keeping people and moving trains separate to prevent unauthorised persons accessing the railway. The LU railway is already well fenced, but platform edge doors with level platforms will eventually be fitted. Where the Piccadilly and District lines run side by side, between Barons Court tunnel mouth and Chiswick Park, they will need to be separated by fencing to prevent unauthorised access to the Piccadilly track from the adjacent District line platforms. District Line trains will only operate empty west of Turnham Green once the new Piccadilly Line trains take over the Ealing Broadway branch.

New safety features mentioned include obstacle detection on the track ahead, and derailment detection on the first two bogies of a train, both of which would apply the emergency brake. Fully automatic operation on the Piccadilly Line is currently slated for 2037, but this date was fixed when funding was expected to become available after the new trains were on all four lines. The Central Line trains are now expected to follow some 10 or 15 years after the Piccadilly Line, which suggests technical advances in the meantime. The Waterloo & City Line will be dealt with alongside the Central Line. The Bakerloo Line will not now receive new trains until the Lewisham extension is funded. The Northern and Jubilee Line trains will by then also be coming due for replacement. The 1973 Tube Stock has never made use of the ATO selector switch option so thoughtfully provided when new, and maybe these new trains will never make use of all the new provisions ...