NORTHERN LINE UPGRADE 2
PROGRAMME FEASIBILITY STUDY – NOVEMBER 2015
by John Hawkins

The plans announced to the March 2016 TfL Finance & Policy Committee meeting provide for 30 tph on the Northern Line by April 2023, requiring 17 new trains. Although the aim was to achieve the new upgrade by 2021, the target for all options became April 2023 due to the extensive power upgrade works required. This upgrade has sometimes been labelled a World Class Capacity upgrade, along with the Victoria and Jubilee lines, but at only 30 tph it seems to have slipped back to be Upgrade 2 again. The feasibility study mentioned at the March meeting has recently been received but with significant redacted paragraphs, including a third of recommendations.

Eight service options were considered in the first stage of the study, shown in the following table. All include two three-hour peak periods (07.00 to 10.00 and 16.00 to 19.00). Partial separation is not defined, but could mean the removal of remaining through trains to/from Morden and the Charing Cross branch (but see below). Sustained operation over 30 tph requires full separation, again not defined. Only options 5, 6 and 7 were taken forward to the second stage, when further study revealed that they cannot be achieved within the current project budget. Option 9 was therefore developed to meet that restriction, and was recommended to the TfL Finance and Policy Committee's March 2016 meeting.

However, the Committee was told that the optimal service would provide at least 36 tph on the Bank and Morden branches, with 32 tph on the Charing Cross branch. This was not one of the options considered, but would presumably provide the maximum service without expensive modifications at Edgware. It would require perhaps 35 new trains. Maybe it was this option that was meant with the suggestion that a further upgrade could be incorporated into the 30 tph upgrade within 15 months, since the quantity of rolling stock ordered will not be finalised until mid-2018.

Option	Service Pattern	Separation	No. of Additional Trains
1	30 tph	Partial	18
2	30 tph (+4 push-ins † northbound)	Partial	22
3	34.3 tph	Full	34
4	34.3 tph Bank / 30 tph Charing Cross	Full	28
5	36 tph	Full	42
6	30 tph (+6 push-ins † northbound)	Partial	24
7	36 tph Bank / 30 tph Charing Cross	Full	31
8	36 tph Bank / 30 tph Charing Cross (+6 push-ins † southbound)	Full	37
9	30 tph	Partial	17

† Push-in trains are used to increase tph in a given direction for one hour during the peak period.

Options 2 and 6 presumably provide push-ins from Morden to the Bank branch in the morning peak, with southbound push-ins in the evening peak. In option 8 push-ins are presumably from Edgware to the Charing Cross branch in the morning peak, but where can they go but return northbound, and again in the evening peak.

The number of required trains has been reduced since the first study for two key reasons, the first of which is redacted. My guess is that it will require auto-reversing in sidings, which was apparently envisaged in the Jubilee Line World Class Capacity study, although this is less common on the Northern Line. The other key reason is enhanced reversing at East Finchley, although how this can be achieved is not mentioned. Perhaps it was previously intended to reverse from platform 2 to 3 via the siding, and now will use a scissors crossover south of the station to reverse in both platforms. The start-up of service northbound to the Charing Cross branch is a problem which is now to be resolved by working nine trains through from Morden depot. Allowing for these, the split of services for option 5 is therefore really 77 to 55. This suggests that an integrated fleet will remain, even with ‘full separation’. The number of maintenance roads in the new Highgate Depot has been cut. This was to have been

the delivery point for the new trains to be purchased, but they will now be delivered to Edgware and hauled to Highgate for testing and commissioning.

To minimise the number of additional stabling roads required, outstabling is planned at a number of locations. This will require traction power modifications to allow over-night supply to these trains. It also requires signalling modifications to prevent losing train positioning when a train is powered down overnight.

Outstabling will be part of the migration strategy developed to minimise service disruption whilst meeting the new train delivery timetable. This has four stages, with Highgate the maintenance depot for the new trains. Existing trains stabling there must be relocated to High Barnet and Morden before work can start, and so additional stabling at those two locations must come first. Stabling at Finchley Central will be provided which, together with stabling at Highgate, will then enable stabling at Edgware to be suspended whilst it is used for delivery of new trains. Battersea will provide for three trains to be stabled there. Finally, stabling at Edgware can be recommissioned to provide the end-state upgrade. This allows Highgate Depot, Finchley Central and Edgware sidings to be segregated from the operational railway to enable unrestricted site access for works. This produces economic benefits by reducing the risk of frustrated access claims and allowing the contractor to work longer site hours.

Final distribution of trains for option 5 – 36 tph both branches.

	In-service	**Out-service**	**Spare roads**	**Outstabled**	**Total**	**2014 service**
BANK BRANCH:						
Morden	48	3	1	1	53	42
Highgate	15	4	1	–	20	16
Finchley Central	12	–	1	–	13	–
High Barnet	11	–	–	2	13	8
Total:	**86**	**7**	**3**	**3**	**99**	**66**
CHARING CROSS BRANCH:						
Battersea	3	–	–	–	3	–
Golders Green	20	4	2	–	26	17
Edgware	23	–	1	2	26	13
Total:	**46**	**4**	**3**	**2**	**55**	**30**
OVERALL TOTAL:	**132**	**11**	**6**	**5**	**154**	**96**

Column names are taken from the report. It is presumed that the in-service figures are for the scheduled train service, and the out-service figures are for booked maintenance requirements. Spare roads will be vacant roads in case of stabling disruption, not spare trains available. Outstabled presumably refers to trains over-nighting in platforms, although at least one of the Battersea trains will need to do so, the others being in the over-run tunnels. I have added the 2014 service requirement, taken from the current timetable, for comparison.

The feasibility study details the work required to achieve Option 5, 36 tph on both branches, which is the top option. However most of these changes, especially power and cooling works, are required under the current Upgrade 1 service to comply with standards, and have been postponed on the understanding that they will be achieved within the further upgrade. The optimal service of at least 36 tph on the Bank and Morden branches, with 32 tph on the Charing Cross branch must be based on the high cost of providing stabling at Edgware, and the lower demand on that branch. However, ‘at least’ could indicate a possibility of 36 tph on both branches. Further studies continue on most of these topics to refine the proposals. Station congestion modelling has yet to be considered. Camden Town is crucial for full service segregation, but the currently planned reconstruction claims to provide for that by 2023/24, with perhaps new low level passages available before full completion.

The planned service patterns for 36 tph on both branches can be determined from a table of performance requirements. On the Edgware branch 24 tph will reach the terminus, with 6 tph reversing

at Golders Green and 6 tph at Colindale. The split between reversing at Battersea and Kennington is not mentioned, but presumably Edgware trains will go through, with Colindale and Golders Green trains turning on the loop. One assumes that a 30 tph service would avoid reversing at Colindale with associated platform staff costs. On the Bank branch unsurprisingly, all trains reach Morden. 12 tph are to reverse at East Finchley, with 5 tph to Mill Hill East and 19 tph through to High Barnet.

TRACK LAYOUTS

Edgware is the main location for additional trains on this branch. Unused roads will be recommissioned, with a new short spur to link them with the mainline. A longer southbound spur will also be required to avoid double-shunts, with the depot fan realigned. Additional roads in the track maintenance depot area and by the vehicle entrance road will require some asset relocations. For less than 36 tph some of these works can be avoided. Colindale requires no modification. At Golders Green depot no track works were found to be viable, but the station layout will be simplified.

At High Barnet, three unused roads will be recommissioned with a new southbound spur to avoid the double-shunt. At Finchley Central 13 stabling roads are proposed on the former coal yard site, which closed in 1962, although alternative car parking will have to be provided. This is the source of most additional trains for the Bank branch. At East Finchley a new scissors crossover is proposed on the bridge to allow for service reversing (presumably linked with the running lines) although Hanger Lane Junction has recently been moved off a bridge.

Highgate Depot will maintain the new trains with six roads, including three 'swimming pool roads', one flat road and roads for deep cleaning and heavy lifting. Stabling for up to 21 trains will be provided. At Morden the depot test track will be relocated, allowing the current road to stable two trains. Some roads will need extending, with existing assets relocated. The track fans will be reconfigured to even up the north and south sides of the depot. To meet reversing requirements at the station and the performance requirements of the depot, track works at the south end of the station will provide a new underpass under the current bridge with relocation of points, crossings and sand drags.

CREW ROOMS & TRAIN WASH

A table of proposed train crew accommodation locations and capacity, together with required additional car parking, has been completely redacted. These figures were based on an allocation of 7 train operators per new train, which must allow for crewing through the day, and coverage for rest days, holidays, sick leave, etc. Spare capacity currently exists at East Finchley and High Barnet. Battersea will also receive train crew accommodation as part of the extension works.

Current Northern Line trains are washed at least every three days through two wash units at Morden Depot, but these will be insufficient for an enlarged fleet. The desire to segregate the branches also justifies a new wash unit at Edgware Sidings, although this could only wash trains every four days. Another new wash unit is recommended for Highgate Depot, and the current Morden machines are to be converted for bi-directional cleaning. It is noted that the current Morden machines are operated by Alstom, and if their contract could be modified to include the new trains then a machine at Highgate would not be necessary. However, the reduced scheme for Edgware with less than 36 tph on both branches will have no space for a wash unit, requiring use of the Highgate unit. Morden will wash the nine trains to be provided for the Charing Cross branch (see above), but this will not ensure a wash every three days. If these trains are rotated nightly then all Charing Cross trains could visit Morden within a week.

SIGNALLING CHANGES

Signalling improvements are listed to bring trains safely closer together. Dwell times are to be limited to 40 seconds, with a recovery margin of only 10 seconds. There are also site-specific modifications listed to increase braking and acceleration rates for improved run-out to run-in times. At Morden, stepping-back is proposed in platforms 2 and 3. The section on depot control has been redacted, but will involve introducing Programmable Logic Controller based systems at Morden and Highgate, revealed at the TfL Finance and Policy Committee's March 2016 meeting. It is expected that new sidings at Finchley Central and all sidings at Edgware will be brought under the new signalling system. Signalling modifications are required for performance capability, outstabling and energy efficient coasting, and are already being developed for the Jubilee Line Upgrade 2. Coasting would be used off-peak if trains were not running late, and is a requirement of the cooling project team.

TRACTION POWER SUPPLY/COOLING

A proportion of the power and cooling upgrade works are required for the current Northern Line service to operate in compliance with standards. To go from the current 24 tph to the maximum 36 tph will require half as much power again. A detailed list of works required is shown, with most still required for 30 tph. A diagram shows that most of the line south of Old Street through to Morden currently *(no pun intended!)* has composite conductor rail. It is proposed to fit this also to most sections south of Belsize Park/Tufnell Park for energy efficiency and tunnel cooling purposes. Only two cooling schemes are then required, to replace out of service fans at Warren Street and Lambeth North. Ventilation fan upgrades are also required at Highgate substation, South Kentish Town, King's Cross, Weston Rise, Leicester Square, Union Road and Balham substation.

FLEET MAINTENANCE

The new trains to be ordered will offer automatic train preparation, and therefore require less night staff, with a 28-day service exam, double that of the current trains. However, they can be stabled and prepared wherever the current trains are. Timetabled paths would rotate the fleets around all depots, but the old and new trains will not be inter-coupled. Under full line segregation the new trains would be confined to the Bank branch, although both branches will still be operated and timetabled as one line. Upgrades to existing depots would be required for full separation, including a new wheel lathe at Morden, but partial segregation does not require such works.

A power upgrade is redacted, but appears to involve a voltage upgrade as currently being undertaken in connection with the introduction of S Stock and as envisaged for the coming NTfL fleets. This will require modifications to the current rolling stock. A list of planned modifications to existing trains has also been fully redacted. This came from the Jubilee Line upgrade 2 plans, which could include such works in the coming mid-life stock refurbishment which has already been completed on the Northern Line. It would therefore need to be a separate Northern Line project justified in its own right. A paragraph on the new trains has also been redacted.

OPERATIONS

Operations studies of all proposals have been severely redacted. It is recommended that the level of service reliability and regularity is no worse than that currently experienced. With full line separation it is recommended that the junctions at Camden Town and Kennington remain functional for both operational and engineering flexibility (including Night Tube services). However, speed uplifts across pointwork could favour the main timetabled routes to assist in reduction of journey times.

For outstabling, Upgrade 2 and Battersea Extension are looking at different technical solutions for signalling and traction current. Operations therefore recommend that a consistent approach is adopted at all outstabling locations for ease of operation and maintenance. The new trains will feature innovations for the customer environment and to reduce whole life costs. Currently the restricted manual speed modifications are feasible for retrofitting to the existing fleet and would add reliability and performance benefits to enable the successful introduction of 36 tph. All other additional functions on the new trains are not feasible to retrofit on the existing fleet, due to the amount of work required and limited benefit to achieving 36 tph.

It is proposed that the currently vacant signalling desks, proposed for Jubilee Line back up service control, which are already in the Highgate Service Centre control room, be utilised for 'this' (refers to redacted sentence) purpose to minimise any disruption during migration. Some supplementary works at Highgate Control Centre may be required with increased staffing numbers, e.g. car park. Operations have recommended that the service be evenly split on both branches so as to avoid issues with customer flows at interchanges. This appears incompatible with the preferred service of at least 36 tph on the Bank and Morden branches, with 32 tph on the Charing Cross branch. Operations have strongly recommended that depot capacity be in line with the number of trains and train operators required for each service pattern. Also, there should be no requirement to cross trains over between the branches to supplement the service as this would reduce reliability and could impact on service levels during disruption. Again, this seems incompatible with the plan to operate nine early northbound trains on the Charing Cross branch from Morden depot.

RECOMMENDED OPTION 9

Most of the study is about top-of-the-range Option 5. We come now to bargain-basement Option 9, which is a de-scoped version of option 1 (requiring one less train) developed at a late stage to

determine what could be achieved within the current budget figure. The implications of a reduced scope will result in certain performance trade-offs and increased risk, outlined as follows:

- Based on the current timetable, the morning peak service will not be achieved until 07.42 on the Charing Cross branch and 07.28 on the Bank branch (the aim is for 07.00). There is potential to achieve this earlier if reduced engineering hours are acceptable. Further modelling will be carried out to investigate opportunities to achieve an earlier peak.
- System modelling has indicated that a 30 tph service pattern is achievable. However, there is a risk that further assessments will result in a slightly reduced service pattern.
- Outstabling will be maximised during migration and required at terminus stations at final state.
- Concessions will need to be agreed for not meeting the three-day train wash requirement.
- Increased operational costs for local control of Morden Depot, rather than control from Highgate.

Details of this option are provided in a three-page table. 17 trains are required, which are considered to include only 12 for Upgrade 2 together with 5 for Battersea, although the Rail and Underground Panel meeting of 24 February 2016 was told if Upgrade 2 is dropped from the budget, the Battersea extension will be operated with the current fleet. The three shortlisted bidders for the new train contract have been deleted, although they are known as Alstom, Bombardier and CAF from that Rail and Underground Panel meeting.

The only track works required for Option 9 would be at East Finchley, Highgate and Morden. However, the current double-shunts at Edgware and High Barnet result in the later achievement of 30 tph each morning. Highgate will not receive the siding intended for trains which have failed entry, resulting in a small performance risk. Morden will not require the new underpass, or relocated points, crossings and sand drags. Without the Edgware wash unit, trains will only be washed every seven days rather than the current three. Other than Morden Depot, all signalling upgrades will be required in full, except for one which is redacted (perhaps auto-reversing in sidings).

Power upgrades can be simplified, but cooling upgrades and composite conductor rails are still required. The new train wash at Highgate is included, although the current Morden units would be sufficient if agreement can be reached with Alstom. Morden and Golders Green depots will not require upgrades. The current fleet will still require modification to cope with an increased power voltage, although other rolling stock modifications have been redacted.

The LU fleet maintenance strategy requires all new trains to be maintained by LU and not the incumbent maintenance contractor. It results in the need for an independent maintenance facility at Highgate which increases work scope and therefore cost. This seems extravagant for 17 new low-maintenance trains, and perhaps if the contract to build them goes to Alstom they could be persuaded to also maintain them at Morden, or alternatively maybe maintenance for the whole line can again be taken in-house, as it was on the Jubilee Line, to save building the Highgate facility.

A table of train crew accommodation has been fully redacted, but a footnote reports that Operations have recommended that Golders Green's capacity be reduced to 100. For option 9, it is proposed that Golders Green's capacity be reduced to 140 to de-scope the train crew accommodation building at Edgware. There is an inherent risk that this is not accepted by Trade Unions. However, there are on-going discussions to increase Battersea's capacity to 150 which will help resolve this issue i.e. reduce Golders Green capacity to 110. I was surprised at the projected size of Battersea train crew accommodation, which is obviously not just for three overnight stabling trains, but also for staffing the Charing Cross branch service. The results also show that the existing train crew accommodation building at East Finchley will not be required. For Option 5 it was noted that the existing building there will require refurbishment, including a new roof, which will presumably still be required for a Grade II listed building, but not at the cost of this Upgrade.

It would appear that a split service will require little new signage since the current maps, line colour and name could be retained. It might be preferable to modify the presentation of Camden Town and Kennington junctions to make clear the normal routes followed. It would also be necessary to display signs advising: Passengers for other branch should change at Camden Town/Kennington.

RECOMMENDATIONS

The Study makes the following unredacted recommendations:

- The project team continue to generate documentation required for concept design.
- Value management to be applied to the single option during concept design.

- The migration strategy be further investigated and ‘stress tested’ to ensure that the sequencing can work without a major impact on line operability. The strategy should also be aligned with the proposed power infrastructure timeframe.
- The rolling stock procurement project be maintained.
- The potential impacts on service recovery/reliability of the more severe performance requirements should continue to be investigated in order to develop viable mitigations.
- An incremental delivery approach is recommended (i.e. increasing the peak period and tph via independent biannual timetable uplifts).