MEETING REPORT
THE NORTHERN LINE UPGRADE
by Mike Palmer, Upgrade Operations Manager Jubilee & Northern Upgrade Programme (JNUP)

A report of the LURS meeting at All Souls Club House on 10 May 2011

Our speaker outlined his background with LU over nearly thirty years, mainly in control rooms but starting on the trains, proved with photos of R stock enjoyed by those present. He has held his current position over the life of the upgrade programmes, now eight years. To start the presentation, an apology was made for the number of TLA (Three Letter Acronyms) necessary!

JUBILEE LINE UPGRADE UPDATE

Since the Northern Upgrade follows that of the Jubilee, we started by reviewing progress on that line. The programme was well behind schedule, but since commissioning between Dollis Hill and Stratford on 29 December 2010 it has proved a great success. Trains went straight into automatic mode (ATO), although some ran in Protected Manual when the train was not ATO ready, or the driver was reluctant to accept automation. System performance has exceeded expectation, other than some big failures which received widespread publicity. When the system fails, it tends to fail in a big way but problems have generally been overcome with software updates which are delivered at 8-weekly intervals. Trains now stop within 10cm of platform marks, when only 50cm is required at tunnel stations and 100cm in open sections.

At the time of this talk, the section north from Dollis Hill had already been tested on three weekends, with no issues on the main line or with Stanmore platform 3. Difficulties were experienced in and out of Neasden Depot, and modifications were being made with the System Management Centre (SMC) and interface to the Metropolitan Line Control System and Interlocking Machine sites. Four more trial operation weekends were planned in May and June before the section is due to go live in late June.

A new timetable from 31 July will provide 27 trains per hour each way in the peaks (an extra 3 or 6 trains) and 18 trains hourly off-peak (plus 2). This is an increase from 51 to 57 trains from the fleet of 63. The end-to-end run time will be cut from around 64.5 minutes to 61.5 minutes. A further timetable revision due March 2012 will provide the Olympics service of around 30 trains per hour, and will be based upon experience with the July timetable. Charts of excess platform wait times, and average run times, showed continuing improvement since commissioning of the new system south of Dollis Hill.

WHAT IS THE NORTHERN LINE UPGRADE?

Both the Jubilee and Northern Line Upgrades were initially Journey Time Capability (JTC) driven solutions chosen by Tube Lines, who were to carry the risk. JTC consists of both fixed and variable measurements on a typical journey, especially excess on-train time, platform waiting time, and inter-station run time. The biggest single improvement to JTC comes from resignalling, allowing faster and more frequent trains. The Northern Line plans to go from 24 trains per hour to 27tph, and then to 30tph, with 97 of 106 trains in service, an increase of six.

Tube Lines selected the Seltrac40 Transmission Based Train Control (TBTC) system provided by Thales (formerly Alcatel). It is a proven system currently in use on the Jubilee Line, the DLR, and in Hong Kong amongst many overseas sites. It uses in-cab signalling, so trackside signals are only required at boundaries, where they display red to stop or blue to proceed with in-cab signalling. Green would be an inappropriate colour since it currently means to proceed to the next signal. TBTC is transmission based via inductive loops installed between the running rails. It is effectively a moving block system, since there are no block joints or overlaps. Trains report their current position every second and are given a target destination point every three seconds, ensuring a safe separation distance. Train performance can increase with higher top speeds. This is an Automatic Train Operation (ATO) system. Although overseas it operates as a Remote Train Operation system with unstaffed trains, this would be impracticable in tube tunnels. Trains perform consistently, without individual driver variation, and run times can improve up to 12%.

A chart of all LU line upgrades showed how the Northern Line scheme promises a 20% peak capacity upgrade by 2014, following upon 33% for the Jubilee Line and 21% for the Victoria Line. The Sub-Surface Railway upgrade will stretch to 2018, whilst the other deep tube line upgrades are still under development.

SELTRAC40 AND MOVING BLOCK

Under Seltrac40 train speeds are constantly monitored and supervised. Any breach will result in an emergency brake application. Under the current trip-cock supervised signalling system, speeds are not easily monitored and trains are only stopped if they attempt to pass a red signal.

Every train has a Vehicle On Board Controller (VOBC) in each cab, either of which can control its train. A diagram showed how the VOBC of train A would automatically report its location by message to the track loop every second. At Highgate the Vehicle Control Centre (VCC), which can be supervised by the System Management Centre (SMC), receives the location message, calculates a target point for train B, reserves and locks points on this route, and passes a message via the track loop. The VOBC on train B receives this target point, and calculates a braking curve to that location. The safety zone between trains varies depending upon gradient, cant, conditions, etc, but is generally some 80 metres. However, the system does not allow two trains to occupy a platform at the same time, so the departing train must be clear before the next train enters.

COMMISSIONING SEQUENCE

The Jubilee Line upgrade had been planned with four commissioning stages, but as the project ran late the first two were merged to recover time, and then the third so that eventually it was necessary to commission three-quarters of the line over a weekend. This will not be allowed to happen on the Northern Line.

Tube Lines were looking to commission the Morden branch first since it is the busiest section of the Northern Line. The current approach is to commission the Barnet branch first since it is the least busy section! So the first area to migrate to the new signalling will be from West Finchley northbound to West Finchley southbound. This will be used as a training area for drivers for perhaps six months before the second area is commissioned from Highgate northbound to Highgate southbound. The third area will encompass the complications of the Camden Town junctions, from Euston Charing Cross branch and Old Street through to Chalk Farm and Highgate. From there both central branches will be converted north of Oval, and finally down to Morden. This leaves the Edgware branch which will be commissioned last because it includes the most complex area on the line at Golders Green. The actual timing for these stages has still to be determined, but completion by late 2014 is envisaged, and since no disruption is allowed during the Olympics summer, it is likely that the changeover will not commence before late 2012/early 2013.

VEHICLE CONTROL CENTRE AREAS

VCC1 Morden – Stockwell	VCC5 Woodside Park – High Barnet
VCC2 Stockwell – Old Street	VCC6 Old Street / Mornington Crescent – Archway
VCC3 Waterloo – Euston (CX branch)	VCC7 Chalk Farm – Hendon Central
VCC4 Highgate – West Finchley	VCC8 Hendon Central – Edgware

Provision is being made for the upgrade to incorporate a Battersea extension from Kennington by 2017 at the earliest, if private funding is obtained.

SELTRAC40 HARDWARE FOR THE NORTHERN LINE

Trackside there are Station Controller Sub-Systems (SCS) which ensure routes and points are secure, the number at each location depending upon the complexity of the area. Protection key switches also link with the SCS, as do axle counter boxes.

The inductive loops laid between the running rails of each track can be up to 1km long, but crossover every 25 metres. These 25 metre sections are divided into four positions, each 6.25 metres long. The train knows its position to within 1.2 cm, but can relocate itself at the loop crossovers after wheel slide or spin. Each inductive loop is connected to the VCC via a loop box trackside feed-in device.

Axle counters are located in pairs at each loop boundary, being able to detect the direction of train movement, and counting the passage of train wheel-sets. Their count is displayed on the SMC screen, but during normal operation train separation is controlled by TBTC, so more than one train

could be in an axle counter block. They are also used either side of points in connection with point locking. If a train fails to communicate with the inductive loop, then train separation reverts to human intervention and procedures severely reducing capacity to a handful of trains an hour. m

Concern that track renewals will take longer were answered that anticipated track renewals will be done before the new system is installed. It will, of course, be necessary to get used to renewing track with the extra complications of TBTC. A radio based system is on trial for Paris, avoiding the need for track loops, but being unproven technology it would have introduce additional risks.

Since station staff will no longer have a starter signal to show them when a train should depart, most platforms is equipped with a Ready to Depart Indicator which usually lights up eleven seconds before the train can depart as the trains' target point is advanced. These are an LU innovation to TBTC.

On the Jubilee Line new trackside signage has been fitted on 300mm x 300mm hexagonal reflective plates, e.g. "RM Hold" is a limit of movement board for trains running in restricted manual at 17.5 kph, where they must seek authority to proceed. Northern Line tunnels are smaller and their plates will only be 200 mm wide by 300mm high, with an improved reflective capability.

1995 TUBE STOCK MODIFICATIONS

Each train cab requires a Train Operators Display (TOD) as well as a VOBC. A VOBC reset button allows the driver to reset the failed controller(s) if it should fail, but this can be done remotely from the SMC, and will soon be done automatically by the VOBC. An Auto-Door Control Switch allows the doors to open automatically the train berths in a platform. A Programmable Alarm Unit (PAU) is fitted to the offside bulkhead. An ATP/Tripcock switch is operated at the TBTC boundary to change between the old and new signalling systems.

Under the train are fitted antennae to communicate with the track loops, a tachometer to count wheel turns, and an accelerometer to detect movement, whilst there is an E-Head on the auto-coupler between units to allow additional electrical connections between the two three car units. The two VOBC do not communicate with each other, except to determine which is in control of the train. The TOD indicates when VOBC are ready or communicating with the track loop. To ensure that both VOBC are regularly used, the system will automatically change from one to the other at a terminus.

The TOD has an upper system information area, a central signalling information section, and a lower system/alarm messages area. System information includes the current time, VOBC status, destination and train number, train mode (ATO, or Protected Manual, or Restricted Manual), last and next station, distance to go or dwell time. Signalling information will include the actual speed, the maximum permitted speed and the distance to the next lower target speed. The TOD LCD screen can show colours, fonts and icons, unlike the earlier LED screen. An amusing demonstration of audible tones from the PAU in connection with the TOD showed how logical alarms drew attention to changes on the TOD. A start-up test pass or fail tone only occurs when a cab is opened up. A rising tone announces a rising target speed or advanced target point, and a falling tone shows a lowering target speed, whilst an alarm tone warns of an imminent over-speed. An attention getting tone is linked to receipt of a text message from the SMC.

DIFFERENCES BETWEEN NORTHERN LINE AND JUBILEE LINE

On the Northern Line, protection key switches (PKS) are fitted in Line Clear (tunnel) sections only to hold trains at a safe distance from points where staff may be securing up. On the Jubilee Line they are fitted at all locations. They are operated by a local supervisor, with permission from the Signal Control Centre, for safe access to the track and cannot be overridden. They are another LU innovation to TBTC (though LU uses PKS elsewhere).

Degraded Mode Control (DMC), which allows direct control of a SCS in the event of VCC failure, will not be fitted on the Northern Line. Each VCC is actually three computers running in parallel, and two must agree or they shut down causing all trains in the area to stop. Trains can then only proceed in Restricted Manual mode, limited to 17.5kph until they reach the next VCC area, so an eighth of the Northern Line would be affected. This is expected to occur only once in eight years, and DMC has not been used on the Jubilee Line to date.

On the Northern Line no track circuit interrupters will be fitted in terminus platforms beyond the red lights, since trains will be supervised until fully berthed. For the same reason, no yellow warning lights will be required in tunnel sidings.

No Signal Post Telephones (SPT) will be installed on the Northern Line since secure cab radio communication is now available. This was a late change on the Jubilee Line where the SPTs are redundant.

No passenger emergency stop plungers are to be installed on the Northern Line. They were never commissioned on the Jubilee Line, since a risk based approach showed that they had not contributed to safety where fitted. They will also not be part of the sub-surface railway resignalling.

SYSTEM MANAGEMENT CENTRE (SMC) FEATURES

The SMC can implement permanent and temporary speed restrictions vitally from the Control Centre. There is no need for trackside signage, since TBTC enforces speed limits. Seven service brake rates are used between 0.4 – 1.1 m/sec^2 with defaults for open and tunnel sections, but a guaranteed emergency brake rate for safety purposes. Open section rail conditions vary with weather, and brake rates are controlled from the SMC. The SMC can enforce station non-stopping with a right click on the SMC mouse over the platform required. It can also enforce Code Red (immediate stop) and Code Amber (remain at next station) safety alerts.

For train service regulation, platform dwell times can be varied (between a minimum and maximum time), and journey times can be varied (through setting the maximum velocity between stations in 5kph increments). TBTC will normally do this automatically to maintain the scheduled timetable and work junctions efficiently.

The SMC is able to remotely reset and auto-restart VOBCs. Track, platform-edge doors and train door status are all shown at the SMC. It can track each train by set number, duty number and crew ID. Train loadings are shown on Trackernet, based upon each train which weighs itself for braking and performance purposes every time the doors close which is sent via the TMS and VCC into the LU data warehouse into trackernet and onto LU Intranet PCs.

OPERATIONAL READINESS

The existing rule books will apply but there are some minor differences that need to be applied with TBTC. An appendix to the rule books covers all procedures associated with the Jubilee and Northern Line TBTC system.

In all, 551 Train Operators need to be trained for the Northern Line, two weeks per person. 7 Service Managers and 32 Service Controllers will train for six weeks per person (assuming they are already multi-skilled). 458 Customer Service Assistants are to receive a briefing. 271 Station Supervisors need two days training. This amounts to 1,319 staff in total, plus Duty Managers, Operating Officials, etc. The cab simulators have been replaced, two at Edgware and one at Morden.

GOVERNANCE

Our speaker acts as User Acceptance Manager for the LU Human Factors standard for both the operational concept and the acceptance criteria.

Trial Operations are held before revenue service, but after hand-over by the engineers. Our speaker is responsible for their concept, planning and delivery. He is also responsible for the Chief Operations Officer safety submissions: the Operational Safety and Assurance Plans (OSP and OAP), and the report to the Director Review Change Control Assurance Team (DRACCT).

John Hawkins