

INFRASTRUCTURE Signalling

Sub-Surface ATO on trial



Testing of the Thales SelTrac IS Radio CBTC to be deployed on four London Underground routes is now underway. **Chris Jackson** reports from Old Dalby.

systems. There is also some inter-working with National Rail services on the outer parts of the Metropolitan and District lines, which he adds 'is new territory for us'.

The Sub-Surface Upgrade is an essential part of Transport for London's efforts to cope with increased ridership as the capital's population grows by a projected 1.2 million over the next 15 years. The four lines are currently carrying 1.3 million passengers a day, and the introduction of longer trains operating under attended ATO (GoA2) is expected to increase peak capacity by 33%, as well as shortening journey times.

Harvey says the aim is to operate 32 trains/h each way on core sections of the Circle Line, against 24 today. LU hopes more frequent and faster trains will cut overcrowding, while better management of dwell times should allow more trains to be squeezed through the central area despite the complexity of pathing them through the many flat junctions.

Collaborative partnership

The £760m contract with Thales is in fact LU's third attempt at resignalling the Sub-Surface Lines. Former infrastructure consortium Metronet originally allocated the work to Westinghouse Rail Systems (later Invensys Rail) under the aborted Public-Private Partnership, but the deal was cancelled by LU, which

The sight of a seven-car London Underground trainset jogging through rural Leicestershire may seem incongruous, but it has become common over the past decade. Since 2007 Bombardier has been using a 5 km section of the former British Rail test track at Old Dalby to commission almost 1500 metro cars it is supplying for LU's Victoria Line and Sub-Surface network.

Now known as the Rail Innovation & Development Centre (Melton) and operated for Network Rail by Serco, the facility is still commissioning the last of 192 S Stock trains for the Circle, District, Hammersmith & City and Metropolitan lines. So far, LU has 95 seven and eight-car sets in service; the rest are on course to be delivered by the end of this year, including an extra eight-car S8 unit ordered for the extension of the Metropolitan Line to Watford Junction (RG 1.16 p13).

However, one S7 trainset is clearly different. Identifiable by the temporary radio antennae attached to the driving cabs and the mass of electronics spread out inside the cars, this is V1, the first of two trains being used to test the SelTrac IS moving-block CBTC that Thales is to install across all four Sub-Surface Lines.

'This is probably the most complex metro resignalling project in the world', believes Stuart Harvey, Systems Programme Director at LU's Capital Programmes Directorate. Coming from Tubelines, where he worked alongside

Test train V1 stands at Old Dalby on March 11 with the temporary radio aerials attached to the driving car.

Thales on the Northern Line resignalling, he is now responsible for all systems aspects of the 'four-lines modernisation'.

Serving 102 stations and with a total of 314 km of track, the four interconnected lines account for around 40% of the Underground network. Some sections are more than 150 years old, while the complex junctions are controlled by a mix of ageing legacy signalling



The temporary layout of the onboard equipment provides easy access for the test team. A monitor shows the ATO speed and distance indications which will appear on the driver's display.



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in 2011 awarded a £374m contract for Bombardier to install its Interflo 650 technology. That in turn collapsed in December 2013, forcing another rethink. Restructuring of the SSL upgrade programme saw completion pushed back to 2023 and the total cost increase by an estimated £886m, according to a highly critical report published by the Greater London Assembly last month.

Despite the earlier problems, Harvey says the various organisations have now established a 'genuine collaborative partnership', in which Bombardier still plays 'a pivotal part' as manufacturer of the trains. Other partners include Balfour Beatty, which is working on the track layout changes; Harvey says seven of the eight major schemes have been completed, including installation of a new scissors crossover west of the Circle Line platforms at King's Cross.

LU is managing the enabling works and has built two new signal equipment rooms at Hammersmith and Baker Street; a third is 'well advanced'. More than 22 km of new cable supports have been installed, while remodelling and extension works have been undertaken at Neasden, Ealing Common, Upminster and Ruislip depots. Still to come is a planned stabling facility at Farringdon which will help accommodate the enlarged fleet and enable LU to start some services in the city centre.

More power will be needed to support the more frequent air-conditioned trains, and LU is planning to increase the traction supply voltage on the four lines from 630 to 750 V DC. This would allow the S Stock to run at its designed maximum speed of 100 km/h in 'full performance mode' — today the trains are limited to 72 km/h in manual operation.

Automatic Train Operation

Barely six months after the award of the signalling contract to Thales, V1 is already operating in ATO mode at RIDC, where Thales has established an

operations control centre and a signalling equipment room containing a full set of lineside systems for testing.

Unlike the SelTrac IS installed on the Jubilee and Northern lines, which has inductive loops for track-train communication, the Sub-Surface Lines will use an IP-based radio link. Thales' Test Manager Richard Kirby says surveying is underway in the central area tunnels, using two trollies to investigate signal propagation distances and ensure adequate radio coverage.

All four lines will be controlled from a new centre in west London, which was built under the Bombardier contract. There will be 21 workstations in the control room, similar to those that Thales has supplied for other SelTrac applications around the world. A flexible configuration will allow the control room staff to rebalance their workload as necessary, helping to relieve a busy controller during the recovery from any incident, for example. The control centre will also manage the CCTV and customer information at stations, as well as emergency alarms and help points.

At the heart of the Thales control system is the System Management Centre, providing the Automatic Train Supervision functions. This manages the entire four-line network based on predetermined timetables developed by LU; these can include special service patterns for public holidays and major events, as well as weekday and weekend schedules. Routes are set for each train, based on the train number entered by the driver.

LU puts a high priority on keeping to timetable, and Thales has developed its control system to recover as quickly as possible following any failure, by running to minimum headways. The service controllers can intervene if necessary to modify the traffic pattern, regulate trains to even out the service or turn some back before their destination. The SMC will also command a train to run slower if it predicts it would arrive at the next

Absolute train positioning for moving-block operation is provided by RFID tags in the track at approximately 25m intervals.



23 days

LENGTH OF TIME EACH S STOCK TRAIN WILL BE OUT OF SERVICE WHILE BEING MODIFIED WITH CBTC EQUIPMENT

platform too early, saving energy and avoiding long dwell times. Passenger information displays at each station are driven from the SMC using the predicted arrivals up to 30 min ahead, to ensure any disruption is reflected correctly.

Train running commands from the SMC are passed to the 14 Vehicle Control Centres which each oversee part of the network. These vital interlockings use two-out-of-three voting to establish and lock the necessary routes, communicating with local Station Controllers installed in a mix of new and repurposed equipment rooms. In moving-block operation, the VCC ensures safe separation, preventing the SMC from issuing unsafe commands. The margin between successive trains is based on their reported positions, the braking distance from the currently permitted speed and a Safety Distance of at least 50 m.

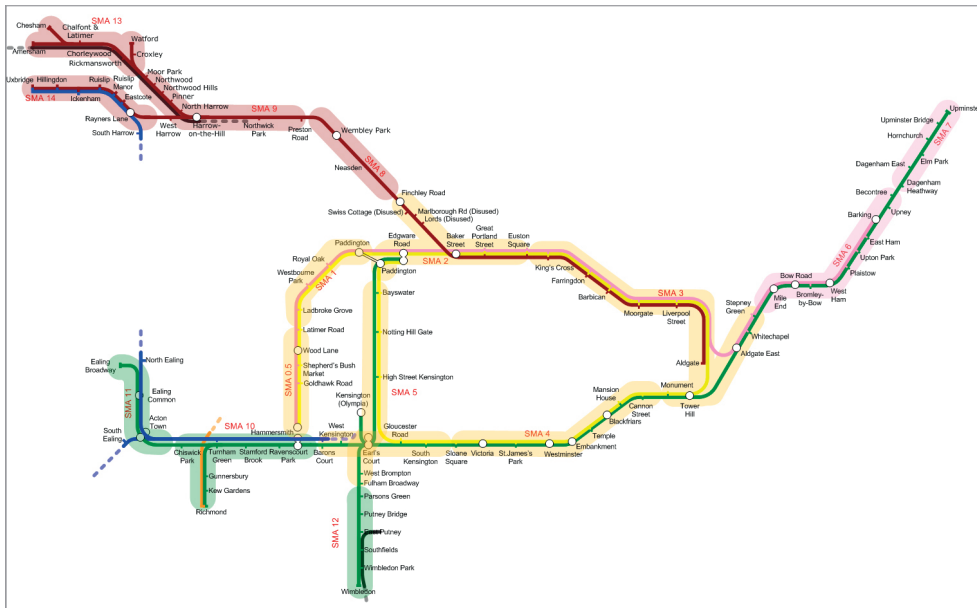
Primary train location is achieved using passive RFID transponders from Tagmaster, which are positioned in the track at approximately 25 m intervals, or more frequently in station areas. These provide the train with information about its absolute location and the position of the following tag. Each train reports its position back to the VCC, allowing the SMC to update its



A temporary control centre at Old Dalby (left) is linked to a signal equipment room housing the System Management Centre and the Vehicle Control Centre which provides the core interlocking functions (right).



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scheduling decisions accordingly. As well as the tag readers, the trains will each have four tachometers and an accelerometer.

Axle-counters are being installed for secondary train detection, particularly to protect junction areas and at each end of all station platforms. On those sections shared with National Rail services, the axle-counters and lineside signals will permit a limited degree of fixed-block operation for what LU describes as 'non-communicating trains'. These will follow the normal signal aspects, while an extra blue aspect will authorise multiple CBTC-equipped trains to enter a single axle-counter section using moving block.

Both driving cars of each seven or eight-car train will have a Vehicle On-Board Controller, and the train will be able to operate using either. This gives 100% redundancy, unlike other systems which only use the leading computer. There are numerous connections between the two VOBCs, providing continuous monitoring of train integrity.

Following an initial pilot section at Hammersmith, migration of the four Sub-Surface Lines to CBTC is set to take place in 14 phases coinciding with the VCC areas. The work is currently planned to start in 2019.

Although the onboard equipment is not the same as originally envisaged, it will fit in the same space on the vehicles, according to Bombardier commissioning engineer Mark Taylor. He says a lot of the cable looms are already in place but not connected. Nevertheless, he estimates that up to 2,000 wiring changes will be needed on each train.

In what Thales describes as 'a reversible fit', the CBTC and ATO equipment racks on V1 have been spread around the train to minimise interference until the concepts have been proven. Once the final locations have been agreed, a second test train will have the equipment correctly fitted. Train V2 is expected to begin running this later this year. Whereas V1 is solely intended for engineering development, V2 will be used for the formal testing.

Aggressive migration

Retrofitting the trains is 'on the critical path', for the entire programme, according to Harvey. The 14-stage

migration from legacy signalling is now planned to begin in mid-2019, although the team is hoping to bring this forward. Work will start at Hammersmith, with the first phases covering the Hammersmith & City and Circle lines, followed by the District, and finally the Metropolitan. Converting the central area early on, notably Baker Street – Aldgate, is expected to bring performance improvements, but will require all of the S Stock to be modified by the time it goes live. The 'aggressive' retrofit programme therefore requires 53 trains to be ready by February 2018, 59 by July of that year and 80 by September.

Each unit will be taken back to Derby, where Bombardier will fit the onboard equipment and do the post-installation checks under LU oversight. Thales will undertake its own testing, with all trains running in ATO on the Bombardier test track. Once the programme is up and running, LU anticipates that each train will be out of service for around 23 days, including preparations for their transfer by rail (such as removing the third and fourth rail collector shoes and reinstating them on return). Given that more trains have been built to operate the enhanced service than are required for today's operations, LU says there is enough 'float' to cover their absence.

The current target is to complete the entire migration by 2023. Given the earlier delays to this high-profile upgrade and the very public criticism at political level, Harvey admits 'there is a huge amount of pressure to do it quicker', although he points out that LU is also under pressure to keep the costs 'as low as possible'. Earlier delivery would improve capacity and customer service, while allowing LU to earn more revenue, he accepts. However, he insists that 'we are not committing to an earlier deployment date' until the project has progressed further and the partners have gained more confidence. ■



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