REMOTE CONDITION MONITORING ON THE VICTORIA LINE

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A recent innovation on the Victoria Line, although not provided as part of the line upgrade, is remote condition monitoring (RCM). This allows the new jointless track circuits to be inspected in real time from remote locations, improving reliability and allowing faults to be prevented before they occur. Since the signalling upgrade, track circuit failures have caused a calculated "passenger disbenefit" of £1.5 million.

The system works by monitoring the voltage in each track circuit using a small piece of electronic hardware installed in the signalling equipment rooms (SERs). A touchscreen in each SER allows a technician to see detailed technical information about each track circuit (such as voltage and frequency). In addition, all of the data are passed back to a central server. From here they are stored and can be viewed by other signalling and control staff. Each circuit reports its voltage 10 times per second – with 385 track circuits on the line, the volume of data being stored is thus very large. Fourteen locations along the length of the line report the data back to the main server using a dedicated fibre-optic cable.

The main screen shows a section of the Victoria Line, centred on a station chosen by touching a station abbreviation (across the top of the screen). Both tracks are shown, divided into the track circuits, with the circuit number shown adjacent. The location of trains is depicted rather like in the illuminated signal cabin diagrams, with track circuits changing colour as they are occupied and then left by trains moving along.

Touching a track circuit on the diagram brings up a graph across the bottom of the screen which shows the voltage in the circuit (vertically) and time (horizontally). The touchscreen allows the horizontal scale to be stretched out, and also the graph to be slid along, so that the user can see the working of the track circuit at previous points in time. These actions are performed in a similar way to zooming into and out of pictures on a smartphone or tablet computer. An unoccupied circuit should show about 6 volts – with a train present this drops to around 1 volt. As trains pass along the tracks, each circuit should ideally show a square waveform, dropping from 6 to 1 volt as the train enters the circuit, and jumping back up to 6 volts when it leaves.

Circuits that are working properly are good, but not particularly interesting. When the RCM was being demonstrated in March, one circuit had a good waveform shape, but after the passage of each train it returned to a slightly different voltage. This was indicative of a poor connection between the wire and the rail, because the passage of the train would shake the rail and thereby change the resistance at the connection. After the train had passed the rail would be still, and so the resistance would remain constant. With the passing of each train this would vary, and so the voltage in the unoccupied circuit would vary too. By noticing this, the line controller had already sent a technician to the nearest station so that he would be on hand if the connection broke. If it remained intact, as soon as the morning peak service thinned out, the technician would take advantage of the larger gaps between trains and go onto the tracks to check the connection and hopefully fix it.

The central server can monitor all of the data being received from the track circuits and send alerts to line technicians if something untoward is detected, such as a circuit failing to restore properly behind a train.

The data on the touchscreen is displayed using web technologies, and data can be streamed to it using a 4G mobile connection. Technicians can also get access from smartphones and tablet computers. The RCM system is read-only (i.e., it is only possible to get data **from** the track circuits), and hence it cannot be used to affect their operation. It would not be possible, for example, for a user (authorized or unauthorized) to cause a track circuit to 'fail', thus disrupting service, or to fool the signalling into hiding a train so that a collision might occur. A special module has been custom-designed to meet the high levels of security required, and ensure that RCM is isolated from the signalling. This ensures that the system is strictly one for monitoring only, and does not affect the inherent fail-safe nature of the signalling.

RCM was developed by LU in conjunction with National Instruments and Simplicity AI, and took less than a year to go from concept to completion. Prior to its implementation track circuits had to be checked by hand using digital multi-meters, which was a time-consuming task and not conducive to finding faults before they occurred. The new RCM is anticipated to reduce the lost customer hours metric by 39,000 annually.