



Signalling and Testing on the Elizabeth line

Our plan to complete the outstanding works and bring the Elizabeth line into passenger service continues to make progress but we are in the most challenging phase of the project, with software development and systems integration to be completed.

The Elizabeth line will increase central London's rail capacity by ten per cent and will carry more than 200 million passengers per year. It also represents the first-time national rail lines to the east and west of London have been connected through an underground metro system.

SIGNALLING

The Elizabeth line route consists of three sections – the new build central section, and the existing east and west surface sections. All of these operate different signalling systems that need to successfully work together to ensure the safe and reliable running of the Elizabeth line.

Signalling Systems



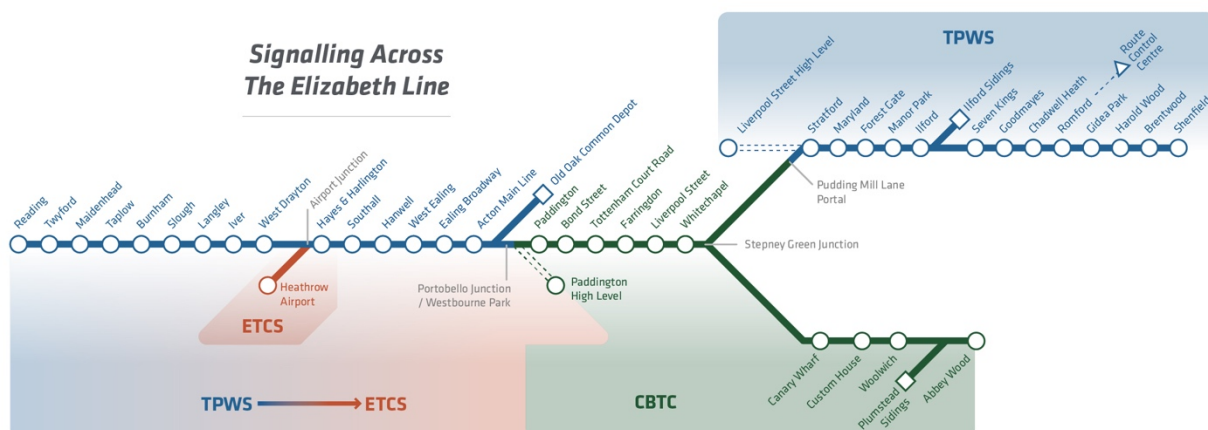
Crossrail has adopted a Communications Based Train Control (CBTC) signalling system for the central section that has successfully been used by many metro systems around the world. Trains in the central section will operate under Automatic Train Control, overseen by the Elizabeth line Route Control Centre in Romford.

The western section, which runs from Reading to Paddington (high level), forms part of the Great Western Main Line (GWML) - one of Britain's oldest and busiest railways. On this inner part of this section east of Airport Junction to Heathrow, Elizabeth line trains will operate under the European Train Control System (ETCS). For trains continuing along the GWML to Maidenhead / Reading, conventional signalling with Automatic Warning System / Train Protection & Warning System (TPWS) will be used west of Airport Junction. There are plans for Network Rail to upgrade this section to ETCS in the coming years.

The eastern section, which runs from Liverpool Street (high level) to Shenfield, forms part of the Great Eastern Main Line – originally built in the Victorian period. On this section of the existing railway, Elizabeth line trains will operate under the Automatic Warning System / Train Protection & Warning System (TPWS) only.

The challenge faced by Crossrail when designing the signalling system was which Train Control Management System (TCMS) should be in ultimate control of the system.

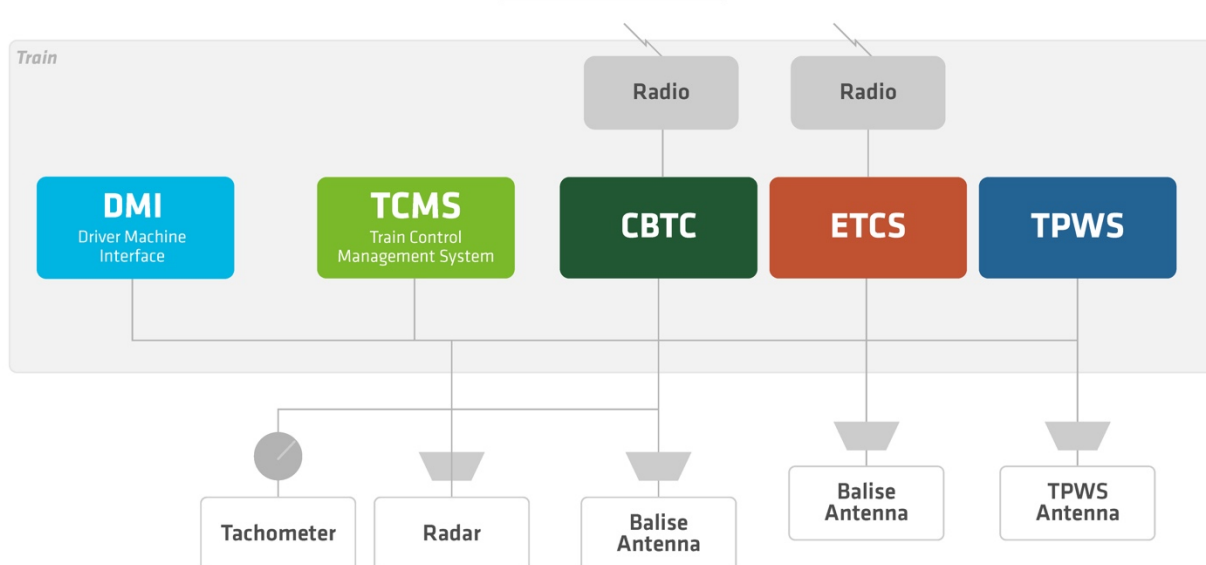
The decision was taken that European Rail Traffic Management System (ERTMS), of which ETCS is the signalling and control component, would be the overall supervising system augmented by CBTC and TPWS (AWS systems).



SYSTEMS INTEGRATION AND TESTING

Bombardier Transportation and Siemens are working closely to increase the reliability of the train and signalling software and have committed some of their most experienced team members from around the world, so that Crossrail Ltd can complete testing of the technical railway systems (known as Dynamic Testing) before intensive trials to simulate the full railway service (known as Trial Running) can begin.

Signalling & Control Systems On-Board Train Architecture



The purpose of Dynamic Testing is to identify and fix any software bugs in the train control system and to make sure everything works as planned. Test results are captured, analysed and verified to build the evidence required to prove the system is safe and meets an acceptable level of performance.

The Crossrail Integration Facility in Chippenham provides an 'off-site' environment for the integration testing of these critical systems. The tests enable signalling software and data from Bombardier and Siemens to be integrated together and to mitigate any errors or defects early, before being tested on the railway.

Each new version of the train and signalling software increases functionality and the range of Dynamic Testing that can be undertaken.

The outcome of testing conducted at the Crossrail Integration Facility provides confidence of the functionality and behaviour of the software.

Once the software has been proven 'off site', a software update is then delivered to the central section to be tested again during Dynamic Testing.

Dynamic Testing of the trains in the central section continues using four class 345 trains, the key purpose of testing is to identify and gather evidence of any software bugs in the train control system.

Main Dynamic Testing commenced in January 2019 with a single train. This then moved to testing two trains, one in each tunnel, and then to close-headway multi-train testing in 'integrated' mode which involves testing of the full signalling system in the central section, running at line speed and at minimum separation.

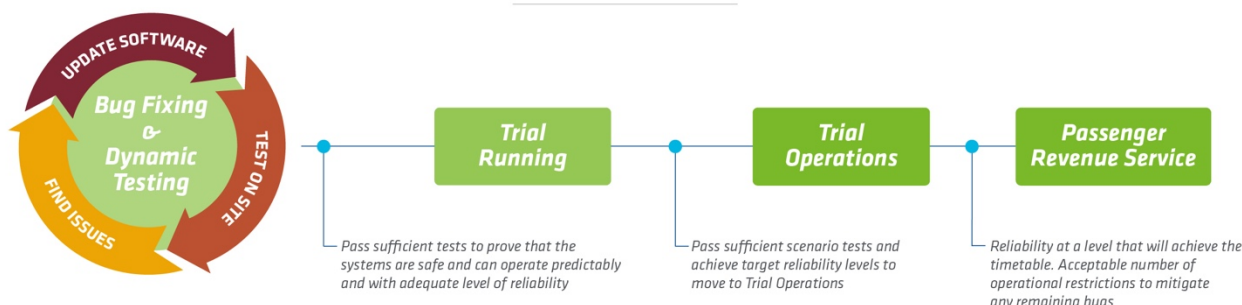
Dynamic Testing takes place four days a week and forms a vital part of the integration of the train fleet and the existing infrastructure on the national rail network, as well as in the central section, which needs to be completed before the Trial Running phase can begin.

Crossrail needs to fully integrate and test the whole system – a series of increasingly complex tests are carried out to prove functionality, safety, operation and reliability which result in a statement of safety from Siemens and Bombardier Transportation. 136 test cases must be completed and validated to enter Trial Running.

CURRENT TESTING

Crossrail is now in its critical and most challenging final phase due to the integration and testing work that must be completed.

Reliability Growth



The latest Siemens software configuration, P_D+10, was installed in the central section in early October. P_D+10, was planned to be the first version capable of supporting entry into Trial Running.

However, testing in Germany identified some missing functionality and defects. As a consequence, the next software configuration, P_D+11, is expected to be the candidate for the start of Trial Running. The nature of software development means uncertainty will remain until we have fully tested each version.

A key priority for the programme is the completion of Dynamic Testing which will allow Trial Running to commence and the operational railway to be fully tested.

Trial Running will involve integrated testing with 22 trains to demonstrate that the operating railway system performs as required. Tests will include trials to demonstrate headways, journey times and capacity. During the Trial Running phase, the railway will be operated under defined railway rules, as opposed to construction rules which apply during Dynamic Testing.

GLOSSARY OF TERMS

- **CBTC** is the fully digital 'Moving Block' signalling technology used within the central section. The system also provides for Automatic Train Control (ATC) and a similar system is currently used on the Jubilee, Victoria, and Northern lines and DLR. 'Moving Block' allows high frequency metro services to be operated.
- **ETCS** is the EU standardised digital 'Moving Block' signalling technology which is being rolled out across the national rail network. Cab signalling provides communication between train and trackside. The driver has a cab display to advise how far the train can go - the distance is based on the worst-case braking performance of the train.
- **AWS / TWPS** is the national standard legacy 'Fixed Block' train protection system used throughout the UK and provides train drivers with a cab warning of the indication of the next signal and applies the brakes if signals are passed at danger.