
Section :

SIGNALLING

TRAIN CONTROL

ETCS or CBTC on cross-city links?

CHOICES Promoters and operators of cross-city rail links must choose between metro and main line train control technologies. IRSE'S international Technical Committee has been reviewing the factors influencing current projects, such as the operating pattern and the interaction with other train services, explains Ian Mitchell*

Towards the end of last year, Transport for London subsidiary Crossrail Ltd awarded a £50m contract to Siemens and Invensys Rail for the supply of CBTC technology to equip the core section of its cross-London rail link, now under construction for opening in 2018-19 (RG 12.12 p16).

Although the east-west route has been designated as part of the TEN-T network, the project promoter obtained a derogation from the requirement to install the European Rail Traffic Management System in favour of a proprietary off-the-shelf system which could be delivered as an integrated package.

This decision was made despite the fact that ERTMS is to be rolled out on other parts of the UK network which will be used by Crossrail services, notably the Great Western Main Line which is due to be equipped by 2018. In some ways it mirrors the choice by Banedanmark in selecting a similar Siemens CBTC package to resignal the København S-bane routes, even though its Signalling Programme will see ETCS Level 2 provided across the rest of the country. However, the København S-bane network is essentially segregated from the main lines by a different electrification system.

Crossrails choice of CBTC contrasts sharply with Network Rail's decision to introduce ERTMS on the core section of London's north-south corridor as part of the Thameslink Programme. IRSE's International Technical Committee therefore decided to look more closely at the signaling choices for similar cross-city railways around Europe, to try to ascertain whether there were any common factors influencing the decision.

Generically, of course, the term Communications-Based Train Control covers any form of onboard signalling and automatic train protection system based on the transmission of safety-critical data between track and train, which would also include the higher levels of the ETCS architecture. But in practice, CBTC tends to be used as a term for an integrated signalling system including ATO, inter-lockings and control centre functionality, often optimised for high-density metro operations. The scope of ETCS is more limited, as ERTMS simply provides a standard specification for the provision of interoperable cab signalling functionality, including ATP, and its related interfaces.

Capacity and throughput

What distinguishes the development of cross-city rail links is the need to select a signalling system that can support intensive operations with a very high degree of reliability. Both Thameslink and Crossrail are aiming to provide a peak-hour service of 24 trains/h on their respective core sections, with trains running through from existing suburban routes on each side of the city.

So it is particularly noteworthy that the two project teams have taken such radically different decisions. Whereas Crossrail has opted for non-interoperable CBTC proven in a metro application, NR has specified interoperable ETCS Level 2 for Thameslink. In this application, the ETCS will have to be integrated not only with conventional elements such as interlockings, lineside signals and automatic route setting, but will also be overlaid with some form of automatic train operation, which is considered essential to avoid any loss of capacity due to the variability of manual driving techniques.

By choosing off-the shelf CBTC, Crossrail Ltd hopes to avoid these integration problems. The suppliers will provide a complete package designed from the start for moving block principles with integrated ATO, unconstrained by the need for any backward compatibility with conventional fixed-block lineside signalling or interoperability with other suppliers' equipment.

As part of its derogation from using ERTMS, Crossrail Ltd has been asked to develop proposals to retrofit the core section with interoperable signalling technology, once the moving-block functionality envisaged for ETCS Level 3 has been developed to a suitable degree of reliability for intensive operation. However, this is clearly still some way off.

Madrid suburban

ETCS Level 2 with an ATO overlay has also been specified for the latest cross-city rail link in Madrid. Whilst there has been a tunnel carrying suburban trains between Chamartin in the north and Atocha in the south for many years, two more tunnels have been built in recent years. One of these is dedicated to standard-gauge high speed trains, but the second was intended to enhance the capacity of the Spanish capital's growing suburban network.

The tunnel opened in 2008 with conventional lineside signalling and the national ASFA train protection system, but it is currently being upgraded with ETCS to boost capacity. This forms part of a wider programme to roll out ERTMS throughout the Madrid suburban network. ADIF selected Invensys Rail Dimetronic to install Level 2 in the city centre and Level 1 to provide a simpler ATP overlay in the outer areas.

This project is perhaps the furthest advanced of those described here. Level 1 is now in use on some sections of the network, and the first test trains began running under Level 2 in March 2012. However, development of the ATO overlay has been put on hold as a result of the difficult financial situation in Spain.

Marmaray

Another interesting example is the Marmaray tunnel being constructed under the Bosporus in Istanbul. This is primarily intended to carry a high-capacity commuter link across the city, joining up the existing suburban services on either side of the strait, but the tunnel will also be available for long distance passenger and freight trains as the first physical link between the European and Asian parts of the Turkish rail network.

Under a €932.8m contact for upgrading and equipping the whole route, awarded in 2011 to a 70:30 joint venture of Spanish civil engineering company OHL and Invensys Rail Dimetronic, the tunnel is to be dual-fitted with CBTC for the suburban trains, and ETCS Level 1 for the long-distance trains (RG 12.11 p8).

RER Line E

The five RER lines in Paris are a classic example of high-capacity cross-city suburban operations. The pioneering Line A linking suburban routes east and west of the French capital uses the SACEM system developed by Alstom and RATP in the 1980s and subsequently adopted for the metro in Hong Kong. This fixed block system uses sub-divided track circuits to give shorter headways in station areas, helping to boost capacity on the city's busiest route.

At present Line E only runs from the eastern suburbs through a tunnel to a terminus at Haussmann-St Lazare in the city centre, but RFF is pushing ahead with plans to extend the tunnel out to the western suburbs via La Defense, to connect with suburban lines out of St Lazare. This will create a second east-west cross-city route to relieve the increasingly overcrowded Line A. The project was launched in 2010, with construction expected to begin in 2014 for a target opening date of 2020.

As with Line A, the services on Line E are expected to continue for some distance on each side of the cross-city core. However, unlike the multiplicity of terminal pairings found on Line A, the Line E service would run from a single western terminus to two destinations in the east, providing a more intensive frequency on the central section. RFF has decided to adopt CBTC, but with lineside signals and the existing national KVB train protection system as a fallback.

Similarities and differences

So whereas Thameslink and Madrid have chosen ETCS, Crossrail, Marmaray and Line E have all opted for CBTC. What were the decision-making processes that resulted in the different approaches for these superficially similar projects? Table I compares key aspects of each scheme, including those requirements that may have influenced the choice of signalling technology.

Comparing the different characteristics, the theme that emerges most strongly is the relative weighting of the core section in the city centre and the outer suburban areas. It is apparent that the projects choosing ETCS are perceived by their major stakeholders as links between existing wide-ranging suburban or even inter-urban networks, whilst those that have chosen CBTC are seen more as urban railways where trains happen to operate onto parts of the wider network.

This differentiation can also be seen in other decisions, not just technical but organisational. For example, Crossrail will have platform screen doors, whereas Thameslink will not. Crossrail and Marmaray will have their own dedicated control centres, but Thameslink and Madrid will be managed by the respective infrastructure managers as an integral part of their national networks.

Crossrail will be the responsibility of the local transport authority, with the operating contract awarded by TfL as the infrastructure owner, and although RFF will build and own Paris Line E it will be run on behalf of the Ile-de-France transport authority STIF. ADIF's cross-city tunnel in Madrid forms an integral part of the whole RENFE suburban network, as will be the case with Thameslink, where the infrastructure is run by Network Rail and the operating franchise will be awarded by the national, rather than local, government.

In terms of operations, Thames-link is an existing cross-city business, which has been running for 25 years through tunnels dating back to the 1860s. The additional train services will be introduced progressively as the signalling enhancements and new rolling stock are ready. Line E is also an existing route, albeit much more recent, where services can be extended as and when the second stage of the infrastructure is completed.

By contrast, Crossrails commissioning strategy is to begin operations initially as a self-contained shuttle within the core section, and extend services out onto the national network at a later date.

Marmaray will see the complete replacement of the existing suburban service by a whole package of new infrastructure, trains and signalling; the two lines have been closed for a two-year blockade allowing complete remodelling and the sweeping away of any legacy constraints.

Where are the risks?

Once the stakeholder perspective is recognised, the reason behind the choice of signalling becomes clear. An essentially urban project will typically choose a CBTC solution which is proven in high capacity applications, whilst a scheme with a wider network focus will adopt ETCS for interoperability with the wider network, albeit with an optimised application to deliver the required capacity in the core section. Essentially, it comes down to a choice of where to take the risk.

For Thameslink and Madrid, the biggest risk is that ERTMS is not yet proven to deliver very high capacity, and integration with the ATO overlay still needs to be achieved. The worst case consequence of failure would be an inability to deliver the full timetable reliably, although it is not clear whether the Thameslink service of 24 trains/h would be needed from the outset.

Crossrail's key risk is the unproven transition between the different types of signalling along the corridor. As well as CBTC on the core section, the trains will be using ETCS Level 2 to the west of London and conventional lineside signalling with the existing AWS and TPWS train protection systems to the east. Here the worst case would see Crossrail services having to be restricted to the core section.

Marmaray, too, needs to interface between CBTC and ETCS, but on the track rather than the trains. Here the risk is being minimised by the provision of a separate third track for the ETCS-fitted long-distance trains over the bulk of the two suburban routes, minimising the length of the core section through the tunnel where the two train types have to share tracks.

Longer-term convergence

Of course, the ideal solution would be a signalling system that has the proven capacity benefits already being achieved by existing CBTC systems in the urban environment but which is also compliant with ERTMS standards. Meanwhile, as the technology evolves, we can expect to see more and more commonality between the 'building blocks' used within CBTC packages which can be adopted to support the required ETCS functionality.

The key factor preventing full convergence at present is the speed and capacity limitations of the GSM-R circuit-switched data link that ETCS uses to communicate between onboard and trackside elements. It has been recognised for many years that this is the weak link in the ERTMS concept, and work is underway to develop a GPRS packet-switching option for busy areas; Banedanmark is taking the lead, as it is likely to be needed for the main line operations through København at a later stage of its Signalling Programme.

The European Railway Agency is now looking to produce a revised ERTMS specification based on modern IP data communications. Once this is in place, a convergence of ETCS and CBTC technology will become possible, and the major suppliers are already planning for this. In many cases they are already using the same hardware platform to support both types of system. Further work on this convergence is one of the topics that has been proposed for the next round of European Commission research funding.

In the meantime, we will continue to see choices between different technologies being made as result of stakeholder expectations and perceptions of project risk. Taking into account all these factors, the decisions made by the various projects seem perfectly logical. However in another 10 years the picture may be quite different, and a truly universal signalling concept able to meet all the aspirations for interoperability and capacity could be available off the shelf.

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Table I. Project characteristics influencing the choice of signalling technology for selected cross-city routes

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A: London Thameslink
B: London Crossrail
C: Madrid suburban
D: Istanbul Marmaray
E: Paris RER Line E
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   Project description
A: Upgrade of north-south route between St Pancras and Blackfriars
B: New east-west route in tunnel between Paddington and Liverpool
   Street
C: New north-south tunnel between Atocha and Chamartin for
   lines C-3 and C-4
D: New tunnel link under Bosporus connecting European and Asian
   parts of city
E: Western extension of RER Line E in tunnel from St Lazare to
   Nanterre-la-Folie

   Infrastructure manager
A: National (Network Rail)
B: Local (TfL)
C: National (ADIF)
D: National (DLH)
E: National (RFF)

   Entry into service of signalling system
A: 2018
B: 2018
C: 2012
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D: 2015
E: 2020

Requirements

Peak timetable, trains/h
A: 24
B: 24
C: 17
D: 12[1]
E: 28

Rolling stock
A: New
B: New
C: Existing
D: New
E: New/existing

Characteristics of core section
A: Existing 4 km 4 stations
B: New 10 km 6 stations
C: New (2008) 8 km 4 stations
D: New 14 km 4 stations
E: 4.5 km existing 10 km new 6 stations

Characteristics of wider network

Destinations
A: 16
B: 4
C: 4
D: 2
E: 3

Route length
A: Several hundred km
B: 118 km
C: 82 km
D: 77 km
E: 120 km

Range from city
A: Up to 120 km
B: Up to 40 km
C: Up to 60 km
D: Up to 50 km
E: Up to 60 km

Access to core section
A: Dedicated trains only
B: Dedicated trains only
C: Dedicated trains only
D: Dedicated and long-distance trains
E: Mainly dedicated trains[2]

Signalling choice

Level of automation
A: ATO
B: ATO
C: Manual (ATO planned)
D: ATO (CBTC) Manual (ETCS)
E: ATO

Primary signalling system for core
A: ETCS Level 2
B: CBTC
C: ETCS Level 2
D: CBTC
E: CBTC

Design capacity of primary signalling system, trains/h
A: 27
B: 30
C: 24

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D: 28
E: 30

   Fallback for core section
A: Lineside signals AWS/TPWS
B: None
C: Lineside signals ETCS Level 1 ASFA
D: Lineside signals ETCS Level 1
E: Lineside signals KVB

   Onboard systems fitted to dedicated trains
A: ETCS AWS/TPWS
B: CBTC ETCS AWS/TPWS
C: ETCS ASFA
D: CBTC
E: CBTC ETCS KVB
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1. Plus long-distance passenger and freight trains, using ETCS Level 1 as primary signalling system

2. Some non-CBTC fitted trains can access the route. Parts of the core section may also be used by other traffic in degraded mode (eg access to Paris Est)

DIAGRAM: Fig 1. Whereas Crossrail will require trains to switch between ETCS and CBTC, Marmaray will allow mixed operation of both systems.

PHOTO (COLOR): Tunnelling work is now forging ahead on London's Crossrail project; this is the shaft for the future junction at Stepney Green.

PHOTO (COLOR): The upgraded Thameslink corridor will be controlled from one of Network Rail's 14 planned regional operating centres that will gradually take over responsibility for the entire national network.

PHOTO (COLOR): These Eurobalises support the ETCS Level 1 which is now in use on outer sections of the Madrid suburban network.

PHOTO (COLOR): Invensys Rail Dimetronic is currently testing the interlocking in Madrid (above).

PHOTO (COLOR): Fitting out of the Marmaray tunnel is progressing rapidly to enable operation to begin in October;

PHOTO (COLOR): Already serving the eastern suburbs of Paris, RER Line E will be extended west to form a cross-city route by 2020.

PHOTO (COLOR)
