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Abstract

The new St Pancras CTRL (Channel Tunnel Rail Link) station consists of nine platforms, six for international Eurostar trains and three for regional domestic services from Kent (there are four platforms for the Midland Main Line but there is no through running between the CTRL and Network Rail parts of the station). Trains approaching St Pancras leave the single bore London Tunnels approximately one kilometre from the platform ends. In this last kilometre there are connections to the nearby Network Rail main lines (Midland Main Line, North London Line (NLL) /West Coast Main Line & East Coast Main Line (ECML)) and three approaches into the station (UP, DOWN & RELIEF). All lines are fully bi-directional.

On leaving the London Tunnels, the cab signalling system TVM 430 switches over to conventional UK lineside colour light signalling with the KVB intermittent ATP system. Colour light signalling is necessary in this last kilometre due to the Network Rail interfaces, the need for routing information and because short block sections are required to meet the specified operational headway/journey time (which cannot be achieved within the low speed codes available to the TVM system due to the speed profile of the layout).

Dependability approach

Eurostar has to compete against the low cost airlines. To do that, the passenger perception should not be that of a typical train service, with late, crowded trains, frequent failures and constant excuses. For the service to succeed, we must destroy this perception. Where we as engineers can help is in the reliability of the infrastructure and in particular the signalling. To achieve the challenging RAMS targets (Reliability, Availability, Maintainability and Safety), the integrated Rail Link Engineering (RLE) team focused on three areas,

(1) Designing the station layout and associated infrastructure to minimise the impact of failures on the operation of the train service

(2) Using proven equipment and system configurations and devising methods to mitigate against their known failure modes

(3) Looking at the maintenance response to those failures and designing maintainability, fault tolerance and failure response into the system.

These three areas will now be examined in more detail, but will focus on the signalling, as this paper is written from the signal engineer's perspective.
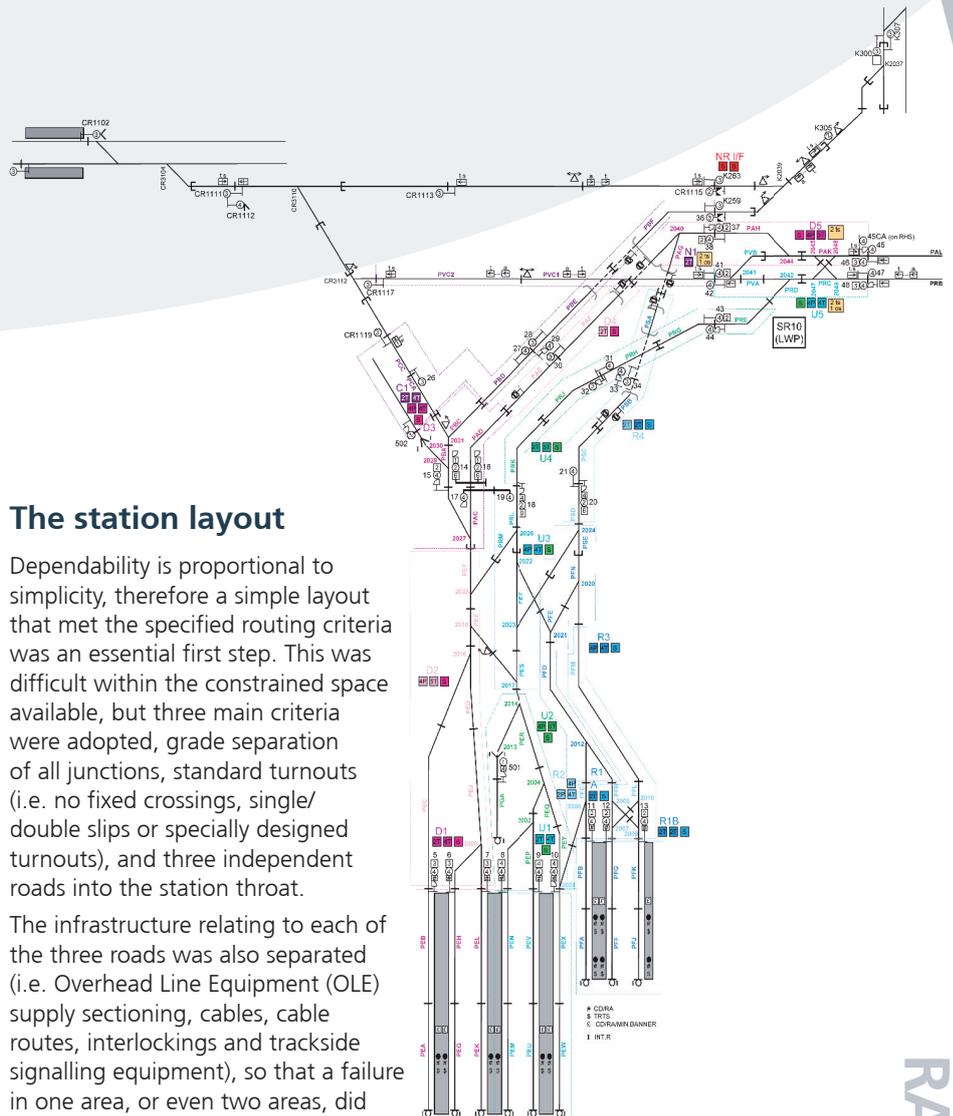
The station layout

Dependability is proportional to simplicity, therefore a simple layout that met the specified routing criteria was an essential first step. This was difficult within the constrained space available, but three main criteria were adopted, grade separation of all junctions, standard turnouts (i.e. no fixed crossings, single/ double slips or specially designed turnouts), and three independent roads into the station throat.

The infrastructure relating to each of the three roads was also separated (i.e. Overhead Line Equipment (OLE) supply sectioning, cables, cable routes, interlockings and trackside signalling equipment), so that a failure in one area, or even two areas, did not close down the station and still allowed signalled moves to continue.

Figure 1 - Schematic signalling layout sketch

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Figure 2 - Aerial view of St Pancras station

The signalling equipment and configuration

UK colour light signalling has been around for some time and the problems and failure characteristics are well known.

To overcome these common faults and increase the reliability of the signalling at St Pancras, the following enhancements were provided:

System architecture

A number of interlocking options and system configurations were considered for St Pancras, including the Interlocking & Train Control System (ITCS) with the latest trackside modules developed by the CSEE Company for the Spanish ERTMS High Speed Line project (similar to SSI architecture). However, the simplest and cheapest option was using the existing ITCS with a simple relay interface to drive trackside equipment, as this had already been proven on CTRL Section 1, including the control of the small number of colour light signals on the Ashford Chords and Waterloo Connection. Using long tail cables simplified the relay interface circuits for the signals and meant the majority of equipment could be driven directly from the Signalling Equipment Room (SER). However, as UK point machines were used, they needed a nearby location case due to the volt drop problem. The High Voltage Impulse (HVI) track circuits used also needed a location case, as the maximum feeding distance was 500m.

Location cases

To simplify the design, 4 types of location case were identified;

- Points: A single case feeding four point machines
- Track circuit (no power): A single case feeding 4 HVI tracks with power from adjacent point or 2 track circuit case
- Track circuit (with power): A single case feeding 2 HVI tracks with buffer stop & interrupter feeds
- Disconnection: A single case providing a termination point for main cables before feeding individual Engineering Zone of Protection (EZP), Local Release Switch (LR) and Manual Operation of points Devices (MOD) units.

All of the location cases used in St Pancras was from one of these basic designs, with only the function name and sometimes cable allocation changing for each case type.

Points

The latest High Performance Switch System (HPSS) point machine has been used at St Pancras, which has a number of in-built reliability features, including condition monitoring. Permanent-way faults can cause detection failures, so integration between the point machine and the permanent-way layout has been the main goal of RLE permanent-way and signal engineers. Consequently, design meetings between RLE, the permanent-way and the point machine manufacturer have taken place to ensure an optimum design.

Track circuits

The more reliable and simple single rail HVI track circuit has been used in St Pancras, with duplicated tail cables and protected routes for each track circuit.

Signals

Fibre optic signal technology has been chosen for St Pancras. Auxiliary bulbs are provided for all signals (including route indicators, banners and subsidiary signals) due to the double bulb arrangement built into the new fibre optic units. A changeover EKR relay switches in the auxiliary bulb if the primary one fails. A more reliable halogen bulb has been selected but the ability to change over to the LED bulbs being developed is something RLE have been looking at. All signal units are also fitted with a Lamp Proving Relay (ECR) relay, even where there is no requirement to prove a route indication or subsidiary.

Figure 3 - St Pancras Station extension and throat (under construction)

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Figure 4 - Engineering Zone of Protection (EZP) Module

All ECR and EKR inputs are input to the Local Maintenance Equipment system. In addition, the signal will step down to a lower aspect when the back-up bulb also fails (i.e. G -> YY, YY -> Y, Y -> R). The signal in rear will only go to red when the back-up red lamp fails. As the bulbs are located at the bottom of the signal in a dedicated light box, maintenance access is simplified.

A modular design approach was also used for the design of the fibre optic light box, with each box being able to hold up to four modules. Three module types were developed:

- Lamp Unit: A unit capable of feeding four indications (either signal aspects, route indications or position light)
- AWS unit: A unit capable of feeding an AWS electro and suppressor magnet
- Termination Unit: A unit capable of providing through terminations for splitting of cables.

Each fibre optic signal consisted of a mixture of these units depending on the number of indications shown, the AWS requirements and the cable arrangement.

Cables

SNCF standard shielded and armoured multicore cables and armoured power cables have been used in the St Pancras area. The armouring on the cable also gives additional protection (particularly with the large number of rodents from the nearby canal). Surprisingly, the standard SNCF cables were an almost identical cost to UK multicores and the short length of the St Pancras area meant that cabling costs were not a significant part of the equipment budget.

With standard location cases and a modular arrangement in the fibre optic signals, a major part of the design effort was in the cable and cable core allocation. Standard allocation rules were used that enabled a computer macro to be developed to produce the cable core allocations.

Power supply

The power to the signalling equipment room will use two independent and separate power supply feeders, backed up by a N+1 Uninterruptible Power Supply (UPS). Each location area has a direct power feed rather than a long feeder arrangement typical in the UK. The worst case location area was used for calculating the size of the power cable, and this same size cable was then used throughout. This simplified procurement and fitted with the standard location case design philosophy.

Though this increased the amount of power cable required, there was a reduction in design costs as well as mitigating the impact of any power fault.

To reduce the size and cost of the UPS battery back-up the point movements will be staggered by 0.5 seconds when the UPS is being used. In addition, a separate transformer/ rectifier has been used for each point end (motor control and detection), to avoid common earth faults.

Local Release of signalling controls

A CTRL principle introduced from the high speed line is the Local Release (LR) switch. This is a switch located at the trackside near to the points. Each LR switch covers the track circuits over the points, and can be used to release the route locking when a track circuit failure occurs. This is because any track circuit failure will dead lock the points or maintain the route locking over them.

Therefore, the technician operates the LR switch in co-operation with the signaller. This releases the sub-route locking and allows the points to be manually moved. An auxiliary route can then be set to authorise the train to pass the signal.

Manual Operation of points Device

Manual Operation of points Devices (MOD) are basically point key units that are provided at each point location. Their function is to ensure that the train crew/technician can only move the correct point end specified by the signaller.

After withdrawing the point key, which cuts the point detection, giving added protection, the train crew/ technician uses the key to operate the points motor manually. After the points have been moved and the key replaced, movements can then take place over the point end concerned. As each key is allocated to a particular point end, the risk of miscommunication and the wrong point end being moved is reduced.

The local release, point key and auxiliary signal are all principles that have been introduced to CTRL to keep the traffic moving during signalling failures, as releases and manual operation of points can be undertaken by train crew as well as technicians. An example of these units is shown in Figure 4.

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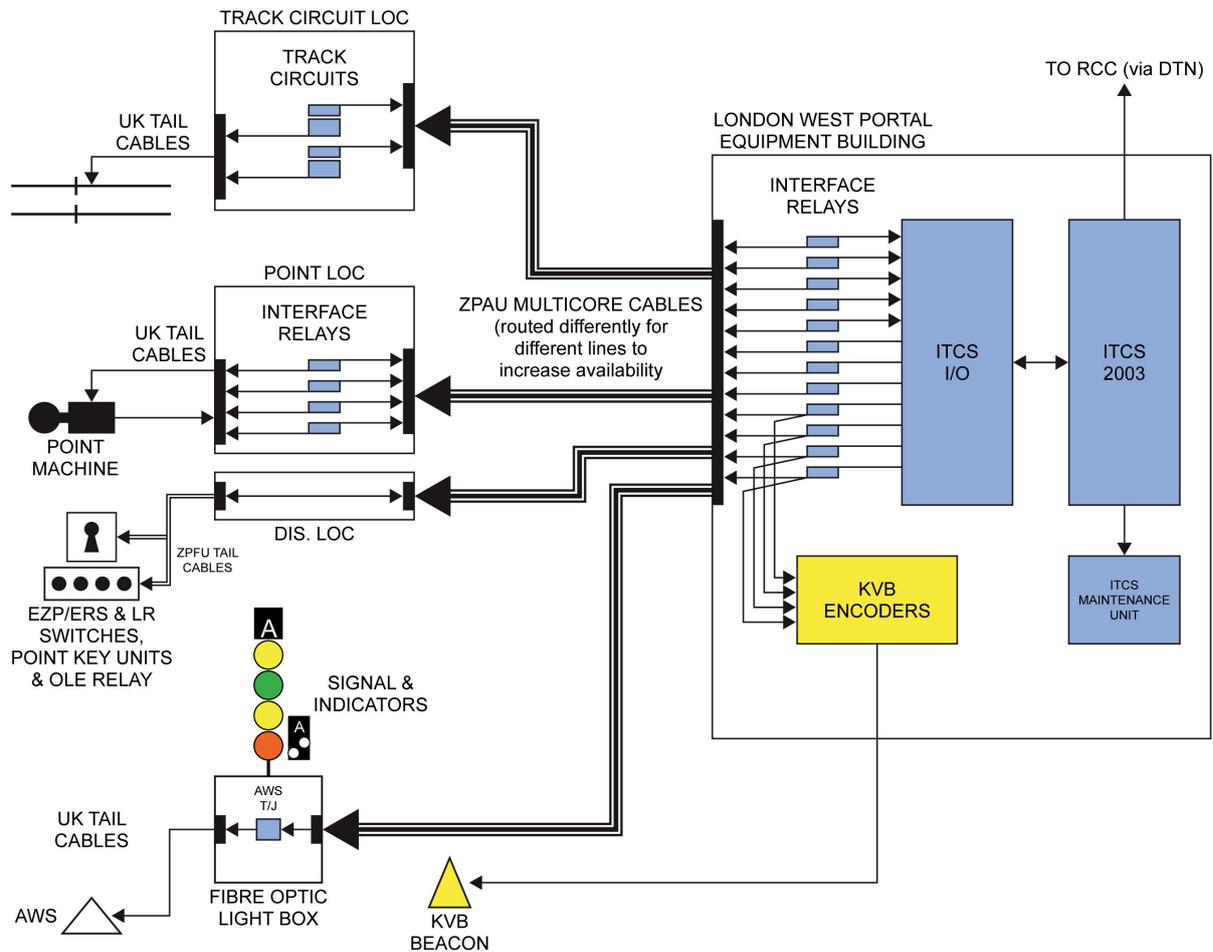
Figure 5 - ITCS Interlocking Architecture

Maintenance response

The ITCS interlocking used at St Pancras has a centralised architecture, with trackside equipment being fed via a relay interface see Figure 3. The ITCS has a dedicated maintenance terminal, which provides specific technicians controls, monitors the status of the interlocking, pinpoints specific faults, stores data logging information, etc.

Safe access and walkways have been provided to all parts of the layout, with strategically placed EZP possession switches to ensure safe access to the track if work is required during train operations. This is another principle adopted from the French high speed line. However, the EZP switches at St Pancras can also be used by staff to replace signals to danger in an emergency.

The Fibre Optic signal has been specially designed for RLE so that staff access to the signal structure is not needed.

The bulbs and equipment are housed in a small location cupboard that is integral to the signal base, and the signal tilts over to allow cleaning. However, St Pancras is closed at night, and any maintenance is planned to occur during this period (via a dedicated possession system).

A maintenance siding and strategically placed storage areas have also been provided so that signalling, OLE, permanent-way spares and point components can be stored and quickly changed when necessary.

Project management philosophy

By having a number of engineers and operations experts within the team RLE took on the role of an informed buyer as well project manager. This allowed the RLE team to develop an integrated design that met the requirements of the project client brief.

This base design could then be discussed with the chosen contractor to evaluate improvements and obtain contractor buy-in. This allowed a firm scope to be produced, which is essential for successful contract management and keeping control of costs.

The RLE set up also had the main discipline engineers and management personnel in close proximity (i.e. permanant-way, OLE, civils, operations, architects, contract management, etc), which assisted in cross discipline co-ordination, particularly when dealing with the evaluation of design changes. Also having the client located in the same building was a further advantage.

From the author's own perspective of working on other large projects, four RLE practices made a personal impression and had a major impact on the way the project was managed. These are as follows:

1. Operations and safety team

This team was lead by SNCF operators, who had a significant input into the scheme development process. This followed French practice where the scheme plan is jointly developed alongside the operations team. Various signal positions, overlaps and routing options were considered and modelled by the operations team, including the TVM interface, in order to obtain a scheme that satisfied the train service requirements (i.e. headways, journey times, train performance, timetable options, degraded mode situations, alternative routes, etc) and was safe to operate (i.e. overlaps to match the ATP system, train stopping locations where passengers could evacuate, emergency replacement facilities, etc).

This team also reviewed the OLE sectioning and permanant-way layouts to ensure train operations and safety were being considered in these disciplines. The author has come across similar teams in UK projects (i.e. like the previous Railtrack Safety and Standards managers) but none that have had such a direct project role, being involved in the design throughout the development phase and ensuring that the engineering will be fit for the train service being planned.

2. Systems integration schematics

The systems integration team produced a number of schematics that helped identify both the interfaces between systems and between contractors (i.e. telecoms, signalling, SCADA, power supply, etc). This allowed the interfaces to be logged in a database and systems interface specifications to be developed where needed. This also ensured that the relevant contractors were aware of who was responsible for what at each of the interfaces identified. Again, the author has seen similar schematics used before, but not as an integral component of identifying, allocating and tracking interface issues.

3. Virtual Reality modelling

A VR model was specifically developed by RLE to undertake preliminary signal sighting. This model also helped the positioning of trackside equipment, which proved essential in the complex and constricted environment at St Pancras.

4. Site construction packages

The St Pancras layout had to be 'shoe horned' into a very constrained site in a central London location, with much of the available spare land required for development. Consequently, the space available for equipment near the track was severely restricted, with many conflicts between the competing engineering disciplines (i.e. drainage catchpits, undertrack crossings, location areas, signal and OLE mast bases, walking routes, cable routes, maintenance storage areas and various trackside equipment). In order to avoid these conflicts and co-ordinate the site construction, RLE developed General Arrangement drawings to precisely locate all trackside equipment.

For each piece of trackside construction required, RLE then produced a site construction package, showing General Arrangement drawing extracts, cross section drawings and siting forms to ensure site construction was closely co-ordinated with the design. This is an area where the author has seen mistakes in the past, with site construction not being co-ordinated between disciplines or contractors. However, this RLE practice made sure the contractor was aware of what had to be constructed and where, and allowed close monitoring of the work. One innovation that came from this process was the development of a combined 700mm cable trough/walking route. It was recognised that the main cable routes followed the main walkways, and since most people walk on the cable route anyway, it was decided to combine the two and thus achieve savings in installation costs that were greater than the development cost of the new troughing route.

Conclusion

Of all the CTRL areas, St Pancras was one of the most involved and challenging to signal, with a complicated layout, interfaces to three Network Rail lines, a busy service and demanding RAMs targets. RLE have therefore taken the opportunity to build dependability into the system from the start. The approach taken has focused on the end product, the train service and how to keep the trains running when stopped by a fault and then keeping them running while the fault is rectified. This has been achieved by using a mixture of,

- Proven equipment and configurations from the UK and France
- Recently introduced equipment designed to overcome known deficiencies
- Introducing new signalling principles based on proven degraded mode practices.

In addition, the St Pancras area was challenging to manage due to the number and variety of contracts and contractors involved. The RLE team set up a number of processes to co-ordinate and supervise these contracts, with a particular focus on scope definition and system integration.

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