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Digital Railway – Traffic Management System Definition

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Version History

Issue	Date	Comments
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Draft 0.2	30th Jan 18	Circulated for internal peer review.
Draft 0.3	31st Jan 18	Updated to reflect comments made in workshop from Louie Lawana, Sam Lawson, Michael Lane, Vish Kalsapura and Yihan Wu.
Draft 0.4	5th Feb 18	Updated to align with SoS System definition and issued for Final Review.
Draft 0.5	15th Mar 18	Updated to incorporate comments from requirements team and issued to technical author.
Draft 0.6	23rd Mar 18	Updated to reflect comments from Technical Author and Jonathan Evans. Ready to be issued.
Draft 0.7	27th Mar 18	Updated to add section on Integration fundamental handbook. Ready for sign off.
V1.0	29th Mar 18	Document issued after updating comments from Tracey Best and Anders Moeller.
V1.1	24th Sept 18	Document updated to reflect L2 and L3 review comments and change to TMS architecture. Applied revised template. Issued for peer review.
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V1.3	02nd Nov 18	Document updated after internal review.
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V1.6	21st Nov 18	Document updated after additional SR&I review comments.
V2.0	30th Nov 18	Document updated to address DRIIATs comments. Issued
V2.1	01st Mar 19	Document updated to address L3 review comments from Ricardo
v3.0	26th Mar 19	Third formal release

Exclusions

These are items currently missing from this version of the document to be included in a later publication.

None.

Assumptions

These are items upon which the validity of this document relies, and which will be delivered by others. Non-delivery of these items will necessitate a change to this document.

None.

Dependencies

These are items upon which the validity of this document depends. Any changes to the dependencies document may require further changes to this document.

1. National Traffic Management Strategy [RD9]
2. System of Systems (SoS) System Definition [RD5]

Contents

Abbreviations

Abbreviations are explained in full on first use within this document. A comprehensive list of abbreviations and definitions is contained in the Digital Railway Programme (DRP) Glossary of Terms & Abbreviations [RI4].

References

Dependent References

An update to one of these references requires a review to identify any potential need for an update to this document.

[RD1] Digital Railway Programme – Director's Remit, Rev. 2, December 2017

[RD2] Commission Regulation (EU) 402/2013, 30th April 2013

[RD3] Commission Regulation (EU) 2015/1136, 13th July 2015

[RD4] Digital Railway – M9 Significance of Change Assessment, 147883-NWR-ASS-ESS-000001, V1.0

[RD5] DRP System of Systems (SoS) System Definition Document, 153819-REP-DRP-ESE-000002, V6.0

[RD6] TMS Generic principles and functionality 153821-NWR-PLN-ESE-000001

[RD7] Digital Railway – SoS Architecture, 153819-NWR-DRG-ESE-000003 v5.0

[RD8] Digital Railway – Integrated Concept of Operations, 000000-NWR-PLN-MPM-000005, V1.0

[RD9] National Traffic Management Strategy 159898-NWR-REP-DIR-000001 Rev. 1, 14th September 2018

[RD10] Digital Railway Programme – System Management Plan, 153819-NWR-PLN-MPM-000002, V8.0

[RD11] LINX_service_Catalogue_121997-Traffic_Management -LINX _ v7.1.1.4

[RD12] Digital Railway – GB Generic Interface Requirements Specification, 153821-NWR-SPE-ESE-000013, V3.0

Informative References

These references have no material bearing on the content of this document but are referenced within it. Unless otherwise specified, the latest version should be used.

[RI1] Digital Railway Programme – System of System Hazard Record Report, 153830-NWR-LOG-PRK-000001

[RI2] DR System Safety Plan, 147883-NWR-PLN-MPM-000008

[RI3] DR Tech – System of Systems (SoS) RAID Log, 153821-NWR-REG-ESE-000001

[RI4] Digital Railway – Glossary of Terms & Abbreviations, 153819-NWR-SPE-ESE-000001

[RI5] Digital Railway – SoS_SAF_Security Accreditation Plan, V1.0, 19th April 2018

[RI6] Digital Railway – GB Generic Customer Requirements Specification for Traffic Management Systems (TMS), 153821-NWR-SPE-ESE-000011

[RI7] DR Tech – Traffic Management RAID Log, 153821-NWR-LOG-MPM-000001

1 Introduction

1.1 Background

Digital Railway is a rail industry-wide programme designed to benefit Great Britain's economy through more effective train operation and improved customer experience and industry adaptability, enabled by accelerating the application of digital technologies to the railway (as defined in [RD1]). The benefits of the Digital Railway are expressed as:

- More trains
- Better connections
- Improved reliability

These are to be realised by the Digital Railway Programme (DRP) to GB Rail through the application of modern train control technology. The vision, purpose and objectives have been summarised in the System of Systems (SoS) System Definition Document [RD5] as:

- Increased capacity
- Safer, more secure & environmentally friendly railway
- Improved train performance (reliability and availability)
- Improved whole-life cost and sustainable commercial model
- Wider socio-economic benefits (e.g. skills, productivity, housing, exports)

This is an industry-wide programme involving Network Rail (as Infrastructure Manager and maintainer), Train and Freight Operating Companies (as Railway Undertakings, or RUs), the Rail Safety & Standards Board (RSSB), and the supply chain. It will also engage with the Regulator and the Department for Transport (DfT), as necessary, to secure the required improvements to safety, customer provision, funding, and approvals.

A Traffic Management System (TMS) is an operational planning, management and control system, capable of providing real-time information to operational staff and to other operational information systems. Service provision can be continuously planned as the system allows prediction and resolution of conflicts and enables real-time timetabling and re-planning as required. A TMS allows the control of traffic at a strategic route level as well as at the tactical level in day to day operations.

1.2 The Digital Railway Programme (DRP)

The Digital Railway Programme has several intended principal outcomes, which are defined in the System Management Plan [RD10].

In the context of the DR Programme, the term 'System' refers to the various digital technologies to be deployed (i.e. European Train Control System (ETCS) Level 2, TMS and other sub-systems and enablers).

System of Systems (SoS) refers to the integration and deployment of the various 'Systems' to reap the full benefits of the Digital Railway Programme. Both terms include more than just the products themselves, but also the people, processes and data required to operate them.

Whilst the concept is to deploy all four systems simultaneously, each system may be contracted separately, and the sequence of deployment may vary, reflecting the needs of the business for a particular application.

1.3 Context and Purpose of this Document

An EU Regulation on the adoption of a Common Safety Method (CSM) on Risk Evaluation and Assessment (CSM RA) came into full effect through Regulation 402/2013 [RD2] and was amended by Regulation 2015/1136 [RD3] in August 2015. The CSM RA applies when any technical, operational or organisational change is being proposed to an operational railway. The DRP, considered as a whole, will bring complex technical changes to the rail infrastructure resulting in a significant impact on the operation and organisation of GB Rail. A formal assessment of the significance of the change has been undertaken [RD4]. It concluded that the change is significant with 'high uncertainty' and 'high consequence'.

A key component of the hazard identification and risk assessment process defined in the CSM RA is the preparation of a System Definition, i.e. this document. The purpose of the System Definition document under the CSM RA is to complement the hazard record by bounding the scope of the hazard identification and risk assessment process and provide sufficient context to facilitate an assessment of the correct application of the process by an independent body (the Assessment Body, or AsBo).

The System Definition defines the key details of the TMS. This includes its purpose, functions, and interfaces, and the existing safety measures that apply to it. It provides a generic application design in support of subsequent development and deployment (i.e. application-specific design and implementation).

The System Definition also allows the generic application specification and design for the TMS to be assessed in accordance with the CSM-RA in order to provide a basis for a safety case and the associated business change, operational rules, and processes to be developed to support it.

This document has been written to promote a high-level understanding of the TMS; it is also intended to support the early stages of impact and hazard analysis of the proposed solution.

1.4 Scope

This document applies to the TMS only.

This definition only considers deployment of the core System within the SoS, it does not consider how a particular section of the railway might operate if only this system is deployed. Any variation from a full deployment of the SoS will need to be addressed by the particular Route (i.e. Infrastructure Manager (IM) and RU) concerned.

This document does not apply to a specific deployment of the core System; it deals with the generic system design and its associated interfaces (both physical and non-physical).

This document describes the three main configurations possible for the TMS: Integrated, Interfaced and Operational Decision Support Tools (previously called Isolated TMS) but focusses on Integrated TMS only.

This document does not describe the SoS within which it sits, as this has its own System Definition [RD5].

1.5 Background of the Generic System of Systems (SoS)

The System Requirements and Integration (SR&I) team will present a set of GB rail specifications for system development and integration purposes using a common baseline architecture referred to as the System of Systems (SoS). The TMS is one of the core systems within this architecture.

The SoS provides a modern integrated railway signalling command and control system based on:

- ETCS Level 2 No Signals
- TMS
- Connected-Driver Advisory System (C-DAS)
- Modern interlocking technologies

The SoS will be supported by:

- a fixed data network, e.g. the Fixed Telecoms Network (FTN) or the FTN – Next generation (FTNx);
- a voice and data communications network;
- data services, systems and protocols, Key Management and EULYNX (European Union initiative for the standardisation of signalling architecture and components); and
- Operational Readiness to support the people and process change required

The SoS configuration ensures that the systems within it, e.g. C-DAS, ETCS, and TMS can be developed by the supply chain with the majority of the interfaces built in to minimise future integration and migration costs for deployment programmes.

1.6 Document Maintenance

This System Definition Document (SDD) is owned by the TMS Lead Architect. It will be subject to technical review to ensure its ongoing adequacy for progressing to the next stage gate. Other updates may be instigated, as necessary, when directed by the Head of System Requirements & Integration (SR&I).

This document has presumed a particular technical solution, as outlined in the SoS System Definition Document [RD5]. However, if during execution of this plan, a different technical solution emerges that would also achieve the Digital Railway primary objectives (see section 2), then this will be considered. An update to this document may then be necessary.

This SDD will be updated during this programme to reflect the evolving stages of development in order that it forms an accurate and final representation of the System.

The application of individual DR Systems to a specific section of railway is outside the scope of this SDD. Specific applications will be addressed through a deployment-specific SDD.

2 System Purpose and Objectives

The TMS supports high levels of automation during normal working, disruptions and around Conflict resolution – It is used in various roles across the route to:

- validate and de-conflict the day's plan prior to start of service;
- resolve conflicts and considerations as they occur;
- plan / re-plan the train service during times of perturbation;
- request and cancel routes;
- request the moving of points (either individually or as part of a route); and
- set signals to their most restrictive aspect (for example establishing a protection area for a worksite) and observe the occupation / de-occupation of train detection areas, typically track-circuits, axle counters or track-circuit interrupters.

To ensure that any future deployment is successful, business change activities (e.g. people and process change) will also be required to support optimal operation of the system and to maximise benefits. Manipulation of the train service within the TMS, either automatically or manually, results in the route setting sub-systems carrying out their respective required actions.

This SDD (and architecture) is deployment- and solution-agnostic; however, it is based around current and emerging technology solutions. The system architecture shown in Figure 1 highlights the TMS element and its interfaces within the DR SoS architecture [RD7] in blue.

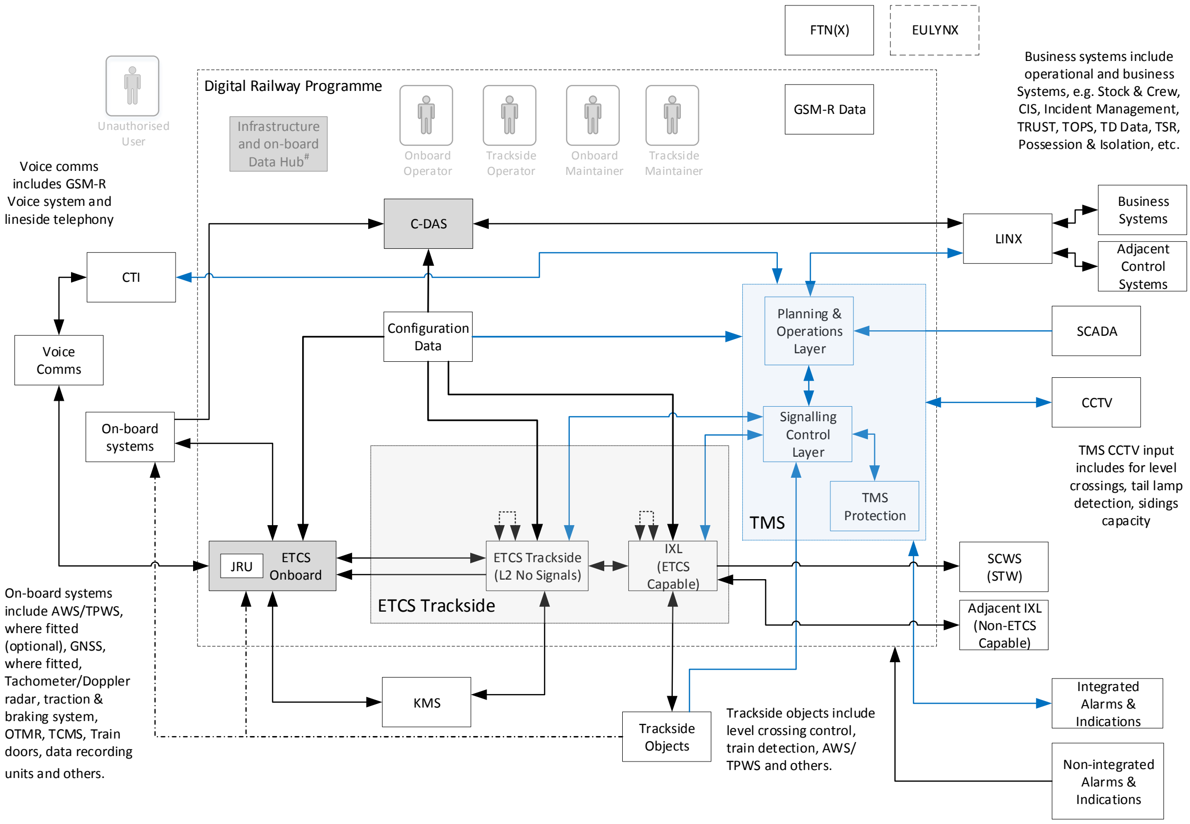

Figure 1. SoS Architecture

The TMS comprises hardware and software elements. The majority of the hardware will be housed in Rail Operating Centres (ROCs). The system architecture shown in Figure 2 represents the Digital Railway Integrated TMS architecture and associated systems.

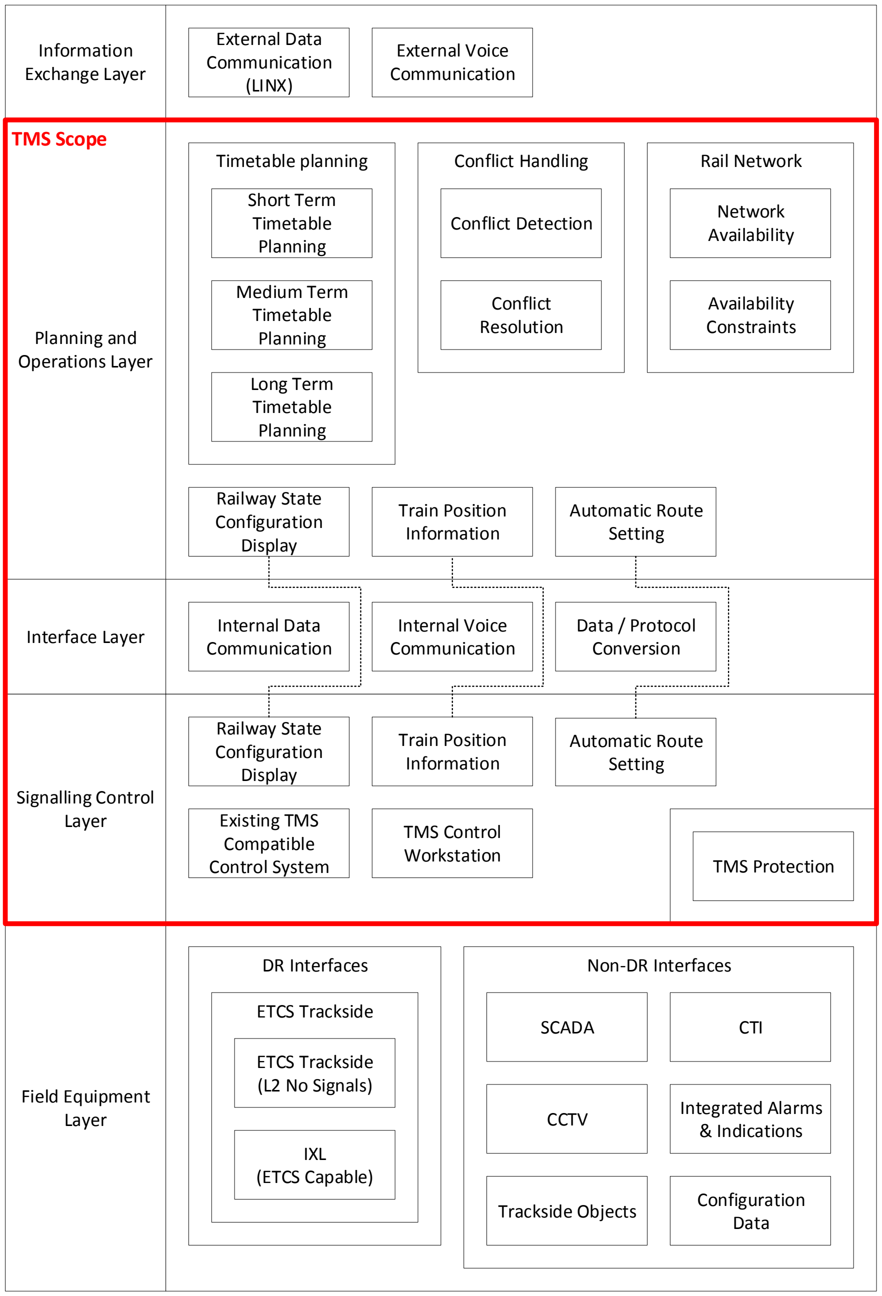

Figure 2. TMS Architecture

The Information Exchange layer takes care of the external communication of the TMS. Except for the voice communications, this is all carried out by LINX (Layered Information Exchange). Refer to section 6.2.1 for further information on LINX.

The Planning & Operations layer, Interface layer, and Signalling Control layer form the core of the TMS and they connect to the Trackside through the Field Equipment layer. ETCS Trackside and ETCS-capable interlockings are again part of the SoS and are shown in the architecture for completeness.

Users at the Signalling Control Layer are presented with a single integrated interface to the system, allowing both automatic and manual control of the railway. The interface with the ETCS Trackside is used to communicate with different types of field equipment in order to provide abstraction, and the ability to transfer Areas of Control (AoCs) between workstations and, potentially, even ROCs, subject to configuration.

Functions in the Non-DR Interfaces block in the Field Equipment layer in Figure 2 are out of scope for the purposes of the SoS, but their interfaces with TMS are in scope. This includes non-ETCS interlockings which are part of the 'Trackside objects' mentioned in the figure. [RD6] details TMS functionality in greater detail.

2.1 TMS Mission and Objectives

Management of rail traffic will be largely automated, with the computer system performing repetitive day-to-day tasks and controlling trains in accordance with a set of rules. Regulating decisions will be made based on predicted train movements, and the system will be operated by a small team of skilled personnel. The technology will optimise the use of the existing infrastructure and enable better capacity utilisation without impacting performance.

In fully, integrated mode, amendments to train services are achieved by the TMS through manipulation of the train plan using the system's 'Plan and Re-plan' functionality. The TMS will provide real-time train running information and allow easy manipulation of the daily plan, which can assist during periods of disruption and following incidents. This real-time train running information can then be easily shared with other applications.

The TMS is interfaced to the ETCS Trackside so that it has an immediate view of each train's location and can request routes, as required, for each train. The ETCS Trackside interface ensures that details of speed restrictions, modes of degraded working, and other operational commands are passed over to the TMS. It also allows functionality, such as flexibility in AoCs, to be implemented as part of the TMS Plan / Re-plan solution. This enables TMS operators to adjust workload to suit current conditions. There are a number of decision support tools that form part of the TMS: some of these are core to the functionality of the system, and some of them are optional interfaces to additional (non-core-TMS) functionality.

2.1.1 Business Benefits of TMS

The core business benefits of a TMS are that it enables:

- de-confliction of a planned timetable ahead of implementation;
- a greater level of automation;
- reduction of everyday workload, allowing more efficient response to scenarios;
- recovery of the timetable more quickly during perturbation;
- more efficient management of capacity within the network;
- regulating decisions to be made based upon predicted train movements;
- the sharing of real-time information between stakeholders to allow more informed decision-making;
- provision of an intuitive interface to allow the optimal resolution approach, which considers the impact of optional solutions;
- assistance to be provided to the Business Change process within Network Rail with respect to the introduction of near to real-time train planning;
- the use of other automated functions such as Conflict Detection and real-time timetabling and re-planning;
- swift and pro-active resolution of disruption, through improved decision support, reducing the potential for operational safety issues, e.g. delegation of control;
- service delivery to be planned as a continuous process; thereby improving the quality of information; and
- dissemination of the implemented plan to the industry, customers and passengers, and to other parts of Network Rail for post-event analysis.

2.1.2 Business Change Consideration

The introduction of a TMS will affect a number of business processes, and all staff engaged in the operation and management of trains and the Control Centre. A strategic approach to the deployment of DR TMSs in the UK is provided in [RD9].

Processes affected include:

- Definition of signalling projects
- Design of signalling systems
- Installation of trackside equipment
- Testing, commissioning and authorisation of systems
- Maintenance and repair of systems
- Management of compatibility and versions
- Renewal and disposal of systems

Personnel affected include:

- Signallers
- Train Running Controllers
- Possession staff
- Train managers/guards
- Trackside maintenance staff
- Incident investigators
- Operational managers
- Service and timetable planners

3 System Functions and Elements

3.1 TMS Functionality Overview

Part of the GB railway is controlled from ROCs or from other, modernised control locations. With the introduction of an ETCS railway, operations within the area controlled by each ROC / control location will be automated to a high degree. Operational activities also include day-to-day supporting activities required to run train services.

Rail Operating Centre

ROC / control location personnel are fully trained to supervise and, where necessary, control service delivery with the support of the Railway Control System. Planned services are run with minimal intervention by the real-time Operations organisation. All parts of the industry are organised and equipped to operate services, or support service delivery and to undertake asset maintenance on the upgraded railway.

The ROC / control location is a secure location that can provide accommodation for all personnel and activities associated with the operational control of the railway. This includes the IMs, RUs, and maintenance organisations. The railway operates to a single train plan and with consistent information that is accessible to all authorised personnel. The railway is equipped such that the potential for human error is reduced, and it is organised in a manner that allows consistent behaviour and performance by personnel involved in running train services and carrying out maintenance activities.

Current Plan

Prior to the start of each ‘Traffic Day’, the TMS receives an automatic transmission of the Daily Plan from the train planning systems; it cross checks the received data with other data sources for conflicts and other data issues. Following this, the TMS supports the application of changes to the Plan during the Traffic Day via the TMS’s Plan/Re-Plan functionality. The TMS provides comprehensive control functionality to authorised users in the ROC and in other control locations.

The TMS recognises all current restrictions (including Temporary and Emergency Speed Restrictions) that affect the operation of planned services, and controls and protects each train on the network. It interprets the plan and sets a route to allow each planned movement to be executed safely. It operates the service with the use of Calculated Running Times rather than Sectional Running Times, enabling greater flexibility and highly accurate, train specific planning.

Forecast

TMS monitoring and reporting service delivery performance occurs automatically in conjunction with the ETCS; the system detects divergences from the Plan and determines the most effective strategy for recovery. At the same time, the system monitors the status, usage, and performance of connected assets.

The TMS Plan / Re-Plan function of enables TMS operators to apply rules which will lead to the automatic regulation of services. Also, pre-configured regulation rules can be applied, enabling the system to regulate services automatically.

Predictive elements within the TMS continually forecast the operation of the Plan to a defined time horizon and predict where delivery may be adversely impacted given the current and known future states of the railway. The system also continually predicts the time at which a train will arrive at the boundary with adjacent control areas. It provides advanced notification to the control system in adjacent areas of the time at which the train will arrive at the boundary.

Signalling Field equipment

The interface with ETCS trackside subsystem allows the signaller to set and cancel routes, request movement of points (either individually or as part of a route), release routes, set signals to their most restrictive aspect (for example establishing a protection area for a worksite) and observe the occupation of train detection areas, typically track-circuits, axle counters or track-circuit interrupters. Provision of manual control of automatic level crossing operation is also incorporated in this layer.

Safe working

The TMS, in conjunction with ETCS, supports the planning and creation of safe working areas for activity on or near the line and provides signalling-based protection for personnel in safe working areas, including the capability for remote activation of signalling protection. Permissive working and bi-directional operation are also facilitated by the TMS and ETCS.

TMS Protection

This function of the TMS prevent trains entering the protected area during possession. It also enables control of points to be transferred to the terminal that implemented the 'Blockage of the Line'. Functionality used for granting and taking back possessions and line blockages. TMS Protection is an internal system to the TMS and does not therefore have any interfaces

The TMS also makes service movement and service alteration information available, via the LINX interface, to Customer Information Systems and personnel located on trains and at stations.

3.2 TMS Layers

The TMS can be functionally split into three layers namely

- The Planning & Operations layer
- Interface layer and
- Signalling Control layer.

These form the core of the TMS and they connect to the ETCS Trackside through the Field Equipment layer (see Figure 2). The ETCS Trackside and ETCS capable interlockings are again part of the SoS and are shown in the architecture for completeness.

The Planning & Operations layer of the TMS is connected to the Business Systems, which provide the operational and business input, through the Layered Information Exchange (LINX). LINX is Network Rail's strategic solution for providing the single source of NR planning and operational information required to operate the GB train and rail services. Refer to RD[11] for details on LINX

Users at the Signalling Control Layer are presented with a single integrated interface to the system allowing both automatic and manual control of the railway. The interface with the ETCS Trackside is used to communicate with different types of field equipment in order to provide abstraction, and the ability to transfer AoCs between workstations, and potentially even ROCs, subject to configuration.

3.3 TMS Configurations

Within the context of Traffic Management there are three possible generic system configurations. These are shown in Figure 3 and are detailed in this section.

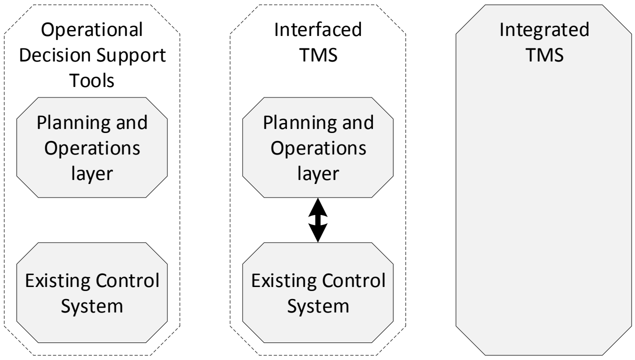

Figure 3. TMS Configurations

3.3.1 Operational Decision Support Tools (ODSTs)

This option was also previously called 'Isolated TM' and it provides just the planning functionality with no automatic control of infrastructure. Information is simply made available to operators (signallers and operations staff) and the responsibility for implementing the solution remains with the operator. With ODSTs, the functionality from the TMS Planning and Operations Layer is provided by the system and all aspects from the Signalling Control Layer are provided by the existing arrangements. This effectively supplies the operators, both planners and signallers, with sophisticated decision support tools. Refer to Figure 4 for an overview of the ODSTs (shown in blue). In this figure, the planner is indicated with a '1' and the signaller is indicated with a '2' to signify that these are usually different persons in this configuration. It is however possible for one person to carry out both these roles.

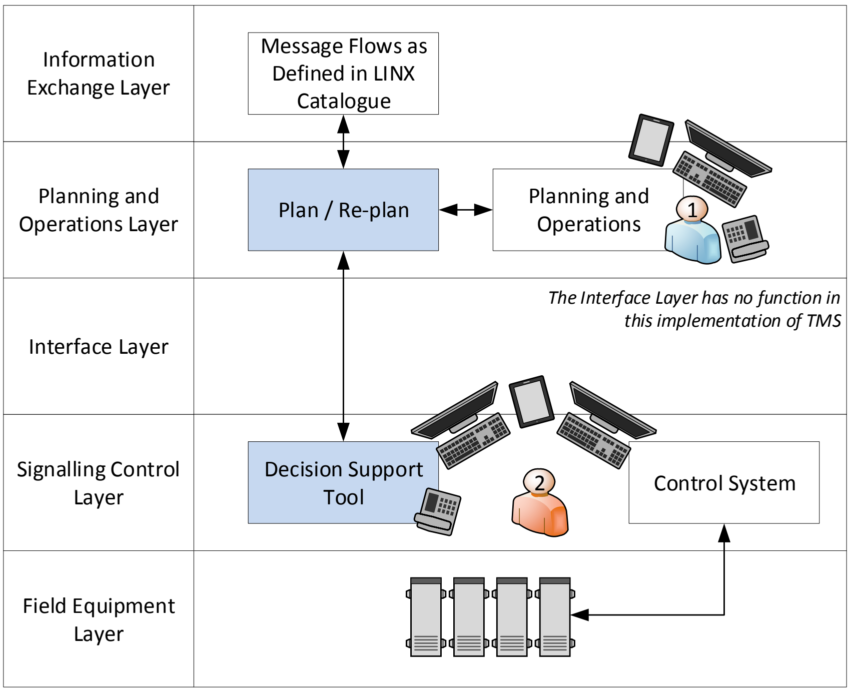

Figure 4. Operational Decision Support Tools (ODSTs)

The signaller receives additional information via the ODST display which could be used to assist in creating the optimum routing for the area.

Should the existing control system contain an Automatic Route Setting (ARS) system it would fall to the signaller to determine if this is to remain enabled to set routes. It is possible that the existing ARS system may make decisions that are contrary to those proposed by the ODST system, potentially reducing the benefit of the system as a whole.

3.3.2 Interfaced TMS

This configuration provides the planning functionality via the new TMS but takes advantage of an automatic interface to the control system. Information is made available to operators (signallers and operations staff) and routes can be automatically requested via the existing control system. The key advantage of this solution over the ODST option (detailed above) is the ability for the system to request automatically that routes be set which conform to the planning system's suggested conflict resolution. Refer to Figure 5 for an overview of Interfaced TMS (shown in blue). In this figure, the planner is indicated with a '1' and the signaller is indicated with a '2' to signify that these are usually different persons in this configuration.

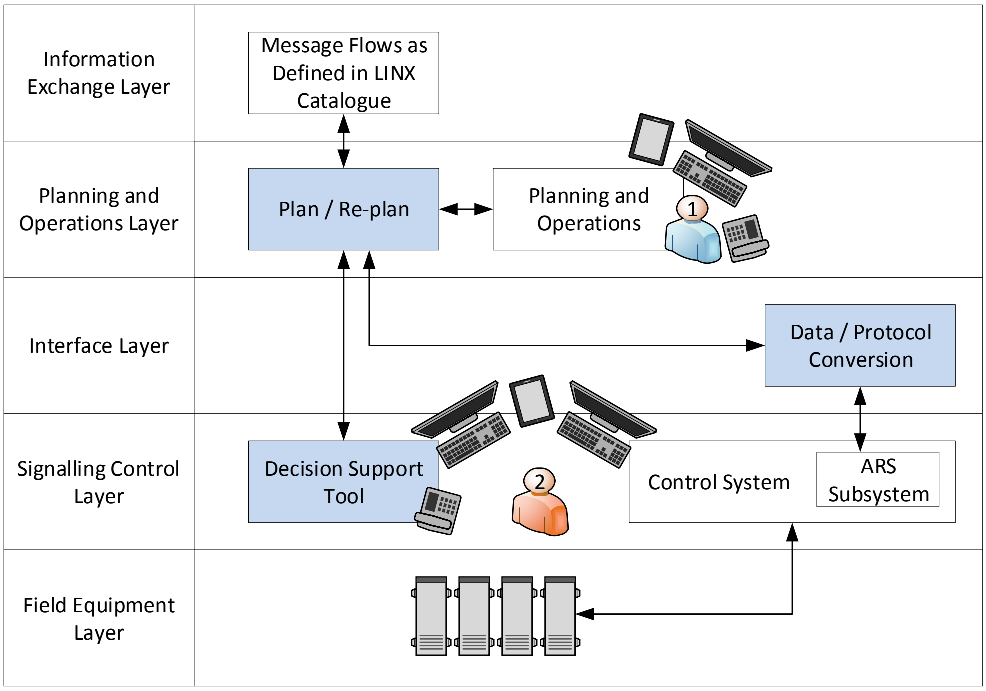

Figure 5. Interfaced TMS

As can be seen from Fig 5, the planning and operations layer can communicate directly with the signalling control system. Exchange of information is bi-directional. The signalling control layer provides the planning and operations layer with details relating to the current state of the railway supplied by the interlocking this enables the planning layer to provide the automated route requests to the control system. This two-way flow of information allows the TMS planning and operations layer to offer significantly better-informed conflict resolution decisions. In this configuration, the interface layer allows for the Plan / Re-plan and the ARS Subsystem to communicate by translating the data flow between the two systems.

3.3.3 Integrated TMS

In the Integrated TMS arrangement, users at the Signalling Control Layer are presented with a single integrated interface to the system, allowing both automatic and manual control of the railway. The TMS can communicate with different types of field equipment and facilitates the transfer of AoC between workstations, and even between ROCs (subject to configuration). Refer to Figure 6 for an overview of Integrated TMS (shown in blue). In this figure, the planner and signaller are both indicated with a ‘1’ to signify that these roles are usually carried out by the same person in this configuration.

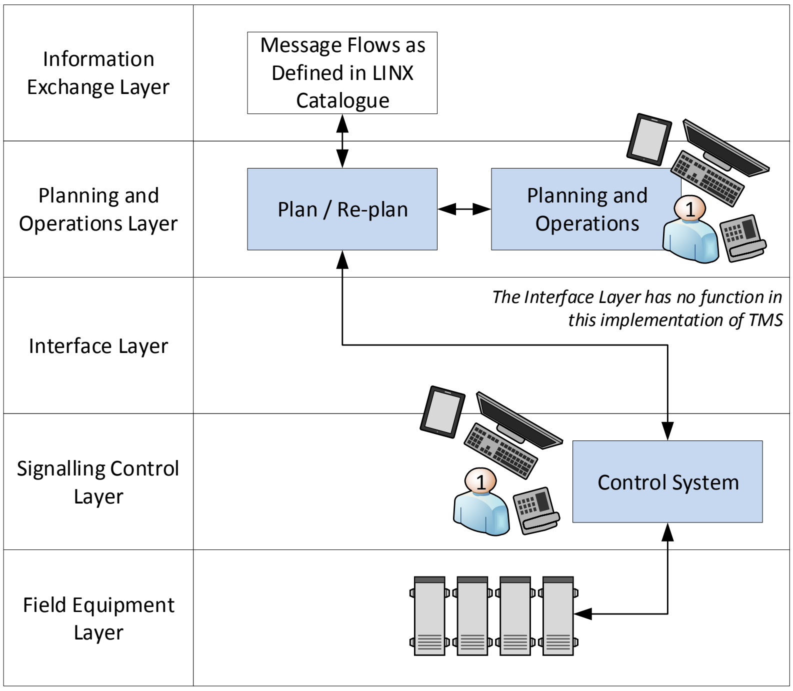

Figure 6. Integrated TMS

Integrated TM allows the control of traffic at a strategic route level as well as at the tactical level in day to day operations, as and when they arise. In full automatic mode, amendments to train services are achieved by TM through the manipulation of the train plan using the Plan and Re-plan system and implemented automatically through ETCS trackside (shown as lineside equipment in the diagram above). TM will provide real time train running information and allows easy manipulation of the daily plan at times of disruption which can then be shared with other systems via LINX, e.g. CIS and C-DAS.

3.4 TMS Operation

The DR Integrated Concept of Operations [RD8] and TMS Generic principles and functionality [RD6] provide greater detail on desired System operation. However, this section is included to provide a brief summary of how a TMS typically operates in order to aid understanding of other sections of this document. The TMS will support operation in normal, degraded, and emergency modes of operation.

A TMS will enable the control of larger areas of the network from fewer locations, help increase capacity, and improve reliability. The new system and processes will automate many repetitive tasks and bring a number of operational benefits, such as real-time planning / prediction and resolution of conflicts. It will be easy to reconfigure AoC when operational needs dictate. A single operational information system (LINX) will provide real-time information to passenger and freight customers, which is particularly useful during times of perturbation or disruption.

The key functions supported by the TMS are described below:

- **Provision of information to the signaller**: The TMS continuously provides the signaller with the latest operational network information and the current plan. This allows the signaller either to supervise effectively or initiate the 'Operate the Network to the Current Plan' function.

- **Optimisation of current plan:** When the current plan is no longer achievable within the agreed tolerances, the system performs a re-plan activity based on the latest available information. This activity optimises the proposed plan to achieve the desired outcome (e.g. maximum capacity, recover to the original timetable, etc.). Once optimised, the proposed plan is then agreed by relevant parties and published as the new 'current plan'.
- **Operation of the network to the current plan**: The TMS requests that routes be set in the correct order, and at the correct time, to allow trains to move across the network safely in order to fulfil the current plan.
- **Monitoring of train movements against the current plan**: Using available information, the system aids monitoring train movements across the rail network against the current plan.
- **Interfacing with mainline entrance / exit:** Once the need for co-ordination with depots, sidings or other third-party infrastructure has been identified, the signaller ensures that arrangements are made and agreed before updating the current plan with any resulting changes.
- **Managing Possession**: The TMS supports the taking control/ surrendering of an area or zone to enable access and working for a specified time. The TMS also supports multiple parallel possessions and handback of possessions in stages. Persons in Charge of Possessions (PICOPS) are responsible for possessions.
- **Taking/ surrendering of short notice possessions**: The TMS supports such possessions where an unplanned event has occurred, and an immediate response is required involving short-notice works.
- **TMS Protection**: The TMS will support the granting and taking back of possessions remotely. TMS protection will interact with elements of the DR Systems, as appropriate, and allow the signaller to grant and take control of an area or zone.

3.4.1 Normal operation

Under normal operation, the TMS will provide frontline operators with better tools to create and manage the current plan for the train service. The technology will provide real-time forecasting of train movements, considering the following:

- current service performance;
- specific train and rolling stock performance;
- infrastructure or rolling stock restrictions; and
- disruptive events.

Any conflicts, such as two trains being forecast to arrive at the same point on the infrastructure at the same time, will be highlighted to the operator. The technology will support operators in resolving conflicts by proposing resolution options and displaying the resultant impact of those decisions prior to any change being committed to the plan. Conflicts can be highlighted and resolved, or, if intentional, flagged as 'Accepted'. Any planning alterations will be incorporated into the current plan along with any imposed restrictions on rolling stock, crew and / or infrastructure.

The TMS will then use the agreed or updated plan to request routes automatically, and in a timely manner, for all trains in its AoC. These requests will be sent to the ETCS Trackside. The ETCS Trackside will then set routes for those requests that can be actioned, rejecting those that would create conflicting train movements.

The TMS will support the imposition of speed restrictions and the granting and taking back of possessions. In both cases, the TMS will interact with the operator and other elements of the

DR Systems, as appropriate. Speed restrictions are communicated through LINX and TMS will disseminate that information to the ETCS Trackside.

3.4.2 Degraded mode operation

The TMS will receive changes from operational systems as they occur, and will support management of events that disrupt train service running in real-time. Thus, the initial plan for the day's service will be updated with changes to ensure continued train running, wherever possible, despite service-affecting events.

The TMS will support the safe management of trains in the event of failures and incidents disrupting the railway. This includes:

- Managing the Very Short-term Timetable (VSTP) process
- Implementing a service recovery framework
- Taking mitigating action
- Applying infrastructure restriction/s
- Applying infrastructure speed restriction/s
- Applying train speed restriction/s
- Managing Incident timescale average

The scenarios relating to how the TMS will operate in degraded mode will be defined in the Route Operating Model (ROM), which will be produced by the Routes.

3.4.3 Emergency mode operation

The TMS will support emergency mode operation. Details regarding emergency scenarios are yet to be defined.

3.5 Enabling Systems

These are systems that are deemed to be outside of the TMS, but which are critical dependencies for its operation

- LINX
- ETCS Trackside/ existing Legacy systems
- Trackside Objects
- Configuration Data
- Temporary Speed Profile Change management (via LINX)
- TRUST (via LINX)
- TOPS (via LINX)
- Timetable (via LINX)

4 System Boundary

This SDD describes a generic system with no specific application in mind. Consequently, there is no geographical boundary that can be discussed in this section. Geographical boundaries will be considered in the SDDs for specific DR deployment schemes as and when they occur.

4.1 Trackside Configuration

TMS equipment will be deployed in a ROC and its configuration along with the boundary and fringes will be defined in the ROM, which will be published by the Routes. Currently the TMS boundary is dictated by the existing interlocking boundary.

Different TMS configurations are described in section 3 and the decision to implement ODST, Interfaced or Integrated TMS will be driven by respective business cases.

4.2 Interfacing Systems

These are systems that are deemed to be outside of the TMS. In some cases, the DR SR&I team will be specifying interface requirements for these systems to ensure that they will integrate with the TMS. For more detail on the interfaces, see section 5 for the physical interfaces and section 6 for the functional interfaces.

- Staff
- ETCS Trackside
- LINX
- CCTV
- Trackside Objects
- Configuration Data
- Computer Telephony Interface (CTI)
- Supervisory Control and Data acquisition (SCADA)
- Integrated Alarms & Indications

5 Physical interfaces

When deployed in the railway environment, the TMS will also interface to other physical systems, as shown in Figure 1 and described in terms of their functionality in section 6.

There is no formal TMS Reference Architecture and most of the physical interfaces within the TMS are driven by existing legacy systems. This section will set out the physical interfaces and any protocols used on an interface which are known at this point. More detailed information on the physical interfaces is provided in the Generic Interface Requirements Specification [RD12]. Final physical interfaces are defined by the deployment project / supplier / integrator:

- LINX (5.3)
- ETCS Trackside (including ETCS Capable interlocking (IXL) (5.4)
- Computer Telephony Interface (CTI) (5.5)
- Voice Communications (5.5.2)
- Trackside Objects (5.6)
- Closed-circuit television (CCTV) (5.7)
- Supervisory Control and Data Acquisition (SCADA) (5.8)
- Configuration Data System (5.9)
- Integrated Alarms & Indications (5.11)

5.1 Rail Operating Centre

5.2 Building Interior

The principal systems that comprise the DR infrastructure hardware (TMS, ETCS Trackside and C-DAS) will be housed within a ROC building. The building provides space in a secure, temperature-stable environment where equipment can be easily accessed by operational and maintenance staff.

5.2.1 Power Supply

Within each ROC, the systems that comprise the DR SoS are expected to interface to the existing diverse and secure power supplies which are provided within most ROCs. Appropriate survey activities will need to be undertaken to determine available spare capacity and changes to support deployment, as necessary.

5.3 Layered Information Exchange

The Layered Information Exchange is not part of the DR SoS but is a vital interface which connects the TMS with the Business Systems (including the Temporary Speed Restriction tool) and is responsible for providing operational and business input to the planning layer of the TMS. LINX is implemented using a Service Bus messaging technology which supports a catalogue of message flows and a reliable message delivery system that requires any message consuming and/or producing system to only have a simple, single network connection to the disparate master source conventional systems. Refer to Figure 7 for a schematic overview of LINX.

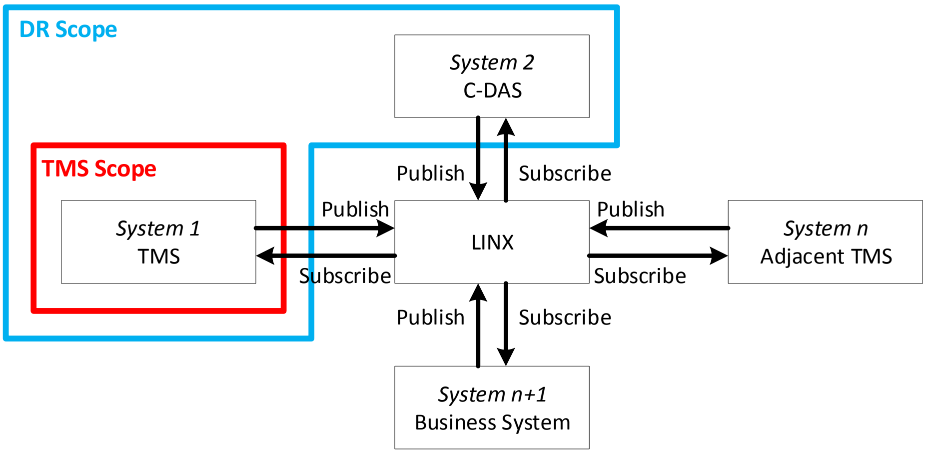

Figure 7. Overview of the LINX publish-subscribe mechanism.

Systems can publish information to LINX, and other systems can subscribe to that information flow independently. LINX also provides facilities for consuming systems that require automated recovery of reference and planning data for example, translating STANOX (Station Numbers) locations used in mainframe operational systems such as TOPS (Total Operations Processing System) and TRUST (Train Running Under System TOPS) into TIPLOC (Timing Point Locations) and UIC (International Union of Railways) location codes. Messages are also transformed into a standard message structure based upon the European Railway Agency (ERA) Telematic Application Freight (TAF) Telematic Application Passenger (TAP) Technical standard for Interoperability (TSI) as adapted for GB Traffic Management. This GB TAF TAP TSI message standard has the necessary changes to support the unique characteristics of NR's business practices and existing planning and operational technology systems. The preferred protocols are MQ (Message Queue), FTP (File Transfer Protocol) and SOAP (Simple Object Access Protocol) MQ.

5.4 ETCS Trackside (including ETCS capable IXL)

The TMS will be connected to the ETCS Trackside systems to supply requests/commands for both automated and manual routes setting, and to receive signalling and positioning information.

The interface protocol to the ETCS trackside is currently not defined but the aspiration is to migrate to IP-based connections utilising EULYNX protocols. The connection will be a standard physical communications protocol (to be defined) that will utilise a common, open source message structure. This will enable products from different suppliers to be connected.

5.5 Computer Telephony Interface (CTI)

5.5.1 Local Area Network (LAN)

The DR SoS elements within the ROC (TMS, ETCS, C-DAS, IXL, Data centre, Safe Track Worker (STW) System) will communicate with each other via LANs.

Where safety critical or safety related information is communicated over these networks the information will be secured against loss or corruption. The redundancy and resilience of the network will take account of the safety risks and business criticality of the information flows

5.5.2 Voice Comms

The TMS will have an interface to the Operational Telecommunications systems via CTI such that a subset of the Human Machine Interface (HMI) functions can, for convenience, be provided to the operator within the DR System.

5.5.3 Fixed Telecommunications Network (FTN) / Next Generation FTN (FTN-X)

The DR Systems will interface to remote equipment that equipment has a functional interface via the Network Rail Fixed Telecommunications Network (FTN / FTN-X). This will include communications between adjacent TMSs. Safety critical or safety-related communications over "open" systems, such as the FTN, will be suitably protected through addressing, authentication or encryption

5.6 Trackside Objects

This interface is for receiving train status information from trackside devices such as Wheel Impact Load Detection (WILD), level crossing controls, AWS, TPWS, Hot Axle Box Detection (HABD), and Pantograph Checking. The connection between TMS and trackside objects is currently supplier specific. The intention is to move to an IP based connection utilising EULYNX protocols.

5.7 CCTV

TMS receives Level Crossing CCTV images and control the CCTV camera (Tilt/Pan/Zoom) and operation of the wiper blades. The interface is detailed in Railway Group Standard GK/RT0192. It is assumed that Manually Controlled Barrier (MCB) CCTV will continue to be handled by a dedicated CCTV desk / operator.

5.8 SCADA

The TMS receives the energisation status of the traction sections from the SCADA. Details of this interface are currently not available and are being developed. The intention is to move to an IP based connection using open source protocols

5.9 Configuration Data System

The TMS will need to be configured with the necessary data that describes the physical railway in such a manner that it can successfully monitor and control the movement of trains. This data will be sourced externally; the protocol and procedures required to ensure correct configuration are to be defined.

It is essential that the Configuration Data is prepared and downloaded into the systems in a controlled manner. The types of data and the controls required need to consider:

- Data sources
- Data consumption
- Derivation of resolution and accuracy requirements
- Derivation of safety integrity requirements
- Assurance of Data for Safety Integrity Level (SIL) processes
- Security classification of data and derived information
- Storage and management of data throughout the life cycle

5.10 TMS Protection

This is fundamentally to provide remote possession management functionality, coupled with the necessary process change. This functionality is already fully integrated within the TMS and has been listed here separately for clarity purposes only. The Interfaces for TMS protection will be operated by the Signalling Control Layer.

5.11 Integrated Alarms and Indications

Currently, multiple systems which are not a part of the control system (e.g. tunnel ventilation, flood alarm etc) provide alarms and indications for the TMS user. This interface receives alarms and alerts from such systems and displays them to the TMS user. There is no common definition for this interface and it is still being driven by legacy systems to which TMS interfaces. The intention is to move to an IP based connection using open source and EULYNX (for safety critical alarms) protocols

6 Functional Interfaces

Digital Railway technology interfaces to the high-level functional systems as described in the DR SoS System Definition [RD5]. These interfaces will be implemented taking into account the required service level, presentation, capacity, Quality of Service, availability, integrity, security, etc. appropriate to each one. Some interfaces may also entail some provision for confidentiality where commercially sensitive data is being exchanged between systems. As shown in Figure 1, the TMS will interact with people (i.e. users), and the systems listed below:

- ETCS Trackside (including ETCS capable IXL)
- LINX
- CCTV
- CTI
- SCADA
- Voice Communications
- Trackside Objects
- Integrated Alarms & Indications
- Configuration Data System

For the purposes of the TMS, the afore mentioned systems and the people defined in section 6.1 sit within the system boundary and, as such, appropriate operational readiness activities will be needed to enable the successful deployment and operation of the TMS. The operational readiness activities should also generate appropriate supporting procedures to allow staff to operate the System in a safe and efficient manner. Interfaces to the system will be procedural or technical. Details for specific groups of staff are described in the following sections.

6.1 People

Discussion of staff within this document is limited to only those staff that will interact directly with the TMS, that is

- Operational staff,
- Electrical Control Room Operator (ECRO)
- Maintenance staff,
- Installation staff,
- RU staff,
- Staff engaged in the design and configuration of the TMS,
- Testing and authorisation personnel,
- Accident / incident investigation staff.

6.1.1 Operations Staff

DR Operational staff are defined as any individuals who are authorised, competent and responsible for the movement of trains and who interface with the DR System as part of their duties e.g. signaller. This includes staff who, through their role, contribute to the safe movement of trains, e.g. RU platform staff undertaking train dispatch duties.

It is anticipated that the roles listed below (indicative only) will require direct routine interaction with a TMS implementation:

- Signallers
- IM and RU Controllers
- IM Data Preparers
- Performance Analysts and Capacity planning roles
- Level Crossing Operator

People in these roles will need to be appropriately trained in how to engage with the system, and continuing competence management regimes, as appropriate, will need to be in place.

6.1.2 Maintenance staff

TMS Maintenance staff are defined as individuals who are responsible for undertaking engineering activities on the TMS and its associated systems. These activities need to include maintenance management and involvement of back room support staff. The key interface for Maintenance Management is through the staff undertaking the work. To discharge their duties effectively, they need to have a knowledge of the TMS and its interfaces to other systems, especially LINX as this is a key interface.

A lesson learnt from other deployments is that, if management and support staff do not understand the principles of the system, there can be a breakdown in communication and support.

6.1.3 Installation staff

A key requirement is for installation staff to understand the criticality of positioning the Visual Display Units (VDU) as per the design and ergonomic assessments.

6.1.4 Non-authorised User

All interfaces are required to be designed such that a non-authorised user or system is unable to access the TMS. Users must therefore login to use the TMS.

6.1.5 Remote Users, Railway Undertakings

The TMS may also be required to supply information for information-only displays to other remote users at various locations. Where this is the case, this will be achieved through LINX, usually accessed via users' own existing computing environment. RU Management and Operational staff will need to co-operate with IM staff in the management of incidents and their investigation. The Delay Attribution process will need to be amended to reflect new causes of delay. Both parties (RU and IM) will need to co-operate to identify failure trends and to resolve issues as part of a DRACAS (Defect Recording, Analysis and Corrective Action System) process.

6.1.6 Testing and authorisation personnel

It is essential that the System be tested as individual components, and then as an integrated system (with adjacent systems, conventional control systems and the ETCS Trackside). The majority of testing will be undertaken in a laboratory environment and the risks of using simulated products needs to be understood particularly at boundaries and interfaces. Testing and authorisation personnel need to have demonstrated their competence.

6.1.7 Accident / Incident Investigators

Investigations into serious railway safety incidents are carried out by the Rail Accident Investigation Branch (RAIB). Examples of such incidents include: train over-speed, exceedance of Movement Authority, derailment, collision and passenger / workforce fatality. Evidence for such an investigation will include voice or data logs from the DR System, which will be stored in a tamper-proof memory. TMS will include sufficient data recording (with replay facilities) with time stamping linked to a defined source. This will support maintenance and incident investigations.

Others involved in incident investigations include (but are not limited to) British Transport Police, the Centre for Protection of National Infrastructure, and the Health and Safety Executive (HSE), all of whom could require access to the infrastructure and control system data records in the event of an incident. Although they sit outside the boundary of the System, interface provision for them is crucial; to facilitate incident investigation, data will have to be shared openly and efficiently across the industry within defined regulations and law.

6.2 Command, Control and Signalling Systems

6.2.1 LINX

The TMS will need to interface to adjacent systems (including other TMSs), existing legacy control systems or depot control systems. This will be done via LINX. These TMSs are integrated with conventional systems using LINX in order to provide a powerful plan and re-plan functionality that improves operational efficiency in the use of the rail network. This is especially so in times of unplanned incidents such as broken-down trains, derailments, storm damage, flooding, and other events.

Source systems – including Conventional Systems and TM Systems – that publish messages or files, are responsible for timely delivery to LINX and the content of the information they send to LINX. LINX is responsible for validation (to the extent defined in the LINX Catalogue [RD11]), translation (where applicable) and making the information received from the source systems available in a timely manner to the appropriate subscriber(s), as described in the LINX Catalogue.

The details regarding message flows and its functionality which have been developed so far are detailed in the LINX service catalogue [RD11]. Functional interfaces with LINX are summarised in Table 1, below.

Table 1 LINX / TMS interfaces

Type	Description	Functionality
Input to TMS from LINX	CIF (Common Interface File) from CIF Manager	Publish CIF File
	VSTP from Train Service Information Access System (TSIA)	Publish VSTP
	Crew Allocations from Genius	Publish Crew Allocations
	Passenger Train Consist from Web Gemini	Publish Passenger Train Consist
	Freight Train Consist from TOPS	Publish Freight Train Consist

Type	Description	Functionality
	Publish TD Messages from Smart Aggregator	Publish TD Message
	TRUST Message	Publish TRUST Message
	Asset from BPlan	Publish Asset
	Temporary Speed Restriction from PPS	Publish TSR
	Planned Possessions from PPS	Publish Planned Possessions
	BPlan	Publish Reference Data
	CORPUS	Publish Reference Data
Output from TMS to LINX	VSTP	Publish VSTP
	Current Plan	Publish Current Plan
	Train Delay Reason	Publish Train Delay Reason
	Train Running Forecast	Publish Train Running Forecast
	Train Running Interrupted	Publish Train Running Interrupted
	Change of Track/Platform	Publish Change of Track/Platform
	Train Journey Modified	Publish Train Journey Modified
	Change of Train Identity	Publish Change of Train Identity
	Train Running Information	Publish Train Running Information
	Train Consist (Request & Response)	Request/Response Train Consist
	Asset Status	Publish Asset Status
	Speed Restriction	Publish Speed Restriction

Type	Description	Functionality
	Emergency Possession	Publish Emergency Possession
	Possession Actuals	Publish Possession Actuals

6.2.2 ETCS Trackside (including ETCS Capable IXL)

There is an aspiration that the interface between the TMS and the ETCS Trackside will be implemented using EULYNX Interface Specifications. The functional interfaces with the TMS are summarised in Table 2 below.

Table 2 ETCS Trackside (including ETCS Capable IXL) / TMS Interfaces

Type	Description	Functionality
Input to TMS from ETCS Trackside (including ETCS Capable IXL)	Position Reports	The ETCS Trackside will share position reports received from trains with the TMS. This enables the TMS to display more information on train location and speed to signaller, on request, and can be used to improve the optimisation of the plan.
	Level crossing status	Status of level crossings (including failure status)
	Train Running Number (TRN)	The ETCS Trackside will share the TRN received from trains (referenced by the NID_ENGINE of the communicating Onboard) with the TMS.
	Validated Train Data	The ETCS Trackside will share the validated train data for each communicating train. This may be used for display to signaller on request, to enable the selection of temporary speed profiles or to support optimisation of the plan.
	Train Detection Status	The status of track circuits and axle counters
	Point Detection	Position and status of points
	Signal Aspects	Status of lineside signals (when fitted)
	Lineside controls	Status of lineside controls such as lockouts, Train Ready To Start (TRTS), Close Doors/ Right Away (CD/RA) controls

Type	Description	Functionality
	Moveable infrastructure	Status of swing bridges, airport/avalanche trip wires
	Movement Authority Request	A request from a train approaching the on-board calculated Perturbation Point may be used to trigger route setting or to request the start of a level crossing sequence.
Output from TMS to ETCS Trackside (including ETCS Capable IXL)	Route Request	The signaller or the automated planning system requests that a route is set from an origin to a destination including, where relevant, the class of route. The ETCS Trackside will confirm that the route is available and action the request on receipt. If the request cannot be actioned it will be rejected.
	Route cancellation	The signaller will be able to request that any Movement Authorities for a route are withdrawn and, when safe, the route is cancelled, and the infrastructure locking released. The cancellation may include a request that the impact on the train's current movement be assessed before the MA is updated and the route cancelled. The signaller will also be able to implement cooperative shortening.
	Temporary speed profiles	The TMS will instruct the ETCS Trackside to modify the speed profile sent to all or specific trains passing through sections of the railway.
	Shunting Area authorisation	The signaller will be able to authorise pre-defined shunting areas where the ETCS Trackside will authorise trains to enter SH. The ETCS Trackside will confirm that the conditions for the shunting area have been met and apply relevant controls including the setting of trapping protection. The ETCS Trackside will respond to requests for Shunt from trains with a location within the shunt area authorising the mode change.
	Shunt Area cancellation	The signaller will be able to cancel a pre-defined shunting area. The ETCS Trackside will not authorise

Type	Description	Functionality
		any further requests for Shunt from trains within the area. The ETCS Trackside will release locking when safe to do so.
	Point commands	Request Command to the points equipment.

6.2.3 Computer Telephony Interface (CTI)

The TMS will have an interface to the Operational communications systems through a Computer Telephony Interface (CTI), so that a subset of the HMI functions can, for convenience, be provided to the operator within the DR System to the operator. Refer to Table 3 for an overview of the interfaces.

Table 3 CTI / TMS Interfaces

Type	Description	Functionality
Input to TMS from CTI	Replicate a subset of the functionality available on the telecommunications HMI	Provides the controllers with complete command and control interface to the Unified Operational Telecommunications System (UOTS). Identify any trains or traction units which are not registered with the Global System for Mobile Communications- Railway (GSM-R) network
Output from TMS to CTI	Update signalling AoCs and telecommunication areas	Notify and dynamically update the telecoms system with information on Areas of Control (AoC) assigned to user log on
	Zone control	Access to the correct outgoing voice communications services for each user. After a CTI link failure, the TMS should when requested update the CTI with any changes that occurred during the failure period

6.2.4 Trackside Objects

The DR System will be required to interface to existing legacy command and control systems at the boundary of the DR deployment area to enable the handover of operational services. Regularly staffed signal boxes that are adjacent to the lines they control provide the capability for lineside observation of passing trains and the detection of emerging faults with them, such as hot axle boxes. Where projects will be closing signal boxes of this type they will need to assess, as part of their CSM-RA activities, whether there is a need to provide additional vehicle monitoring systems to mitigate the risk of an incident arising from an undetected vehicle defect. The volume and type of traffic using the line in question will be a key consideration in this assessment. Refer to Table 4 for an overview of the interfaces.

Table 4 Trackside Objects / TMS Interfaces

Type	Description	Functionality
Input to TMS from Trackside Objects	Static (Intelligent) Infrastructure	Input from HABD, Tunnel Ventilation and flood alarms Input from WILDs
Output from TMS to Trackside	Indicators	Request / command what to be shown on CD/RA indicators and other lineside displays

6.2.5 CCTV

DR deployment schemes requiring interfacing to Level Crossings will need to address issues such as Human Factors, updating of existing Level Crossing control systems, and assimilation of control and indication functions. Refer to Table 5 for an overview of the interfaces.

Table 5 CCTV / TMS Interfaces

Type	Description	Functionality
Input to TMS from CCTV	Live stream	Currently the MCB CCTV crossing clear function is handled by a dedicated desk but the aspiration is to receive CCTV live streams from level crossings. Incorporation of these live streams into the TMS rather than as stand-alone displays will reduce the number of display monitors at the user's desk.
Output from TMS to CCTV	Control CCTV wipers	Control CCTV wipers from the signallers' desk

6.2.6 SCADA

Table 6 SCADA / TMS Interfaces

Type	Description	Functionality
Input to TMS from SCADA	Availability Status	Traction section 'live' and 'dead' states, along with traction supply status information, are to be acquired and used / displayed.

Type	Description	Functionality
Output from TMS to SCADA		*This table will be updated in further issues of this document.*

6.2.7 Integrated Alarms & Indications

Table 7 Integrated Alarms & Indications / TMS Interfaces

Type	Description	Functionality
Input to TMS from Integrated Alarms & Indications	Alarms, Alerts and Indications	*Further development and definition of this interface by the application projects is needed.* *An example of such a system would be the monitoring of signalling power supplies by a system called the Signalling Power Alarm System (SPAS), which reports states to the maintainer. The TMS will interface with such systems to acquire the operationally relevant alarms.*
Output from TMS to Integrated Alarms & Indications		*Further development and definition of this interface by the application projects is needed.*

6.2.8 Configuration Data System

Table 8 Configuration Data System / TMS Interfaces

Type	Description	Functionality
Input to TMS from Configuration Data System		*This interface is covered in section 5.*
Output from TMS to Configuration Data System		*This interface is covered in section 5.*

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6.3 Support Tools

A series of optional Support Tools will provide an interface to the TMS to support operators with the day-to-day running of the railway in both normal and degraded operating modes. These tools are outside the system boundary of TMS and interface through LINX. They are described here for completeness as they are dependent on data generated by TMS for optimal performance.

6.3.1 Crew and Stock

The Crew and Stock module refers to the system(s) and processes utilised to manage events that affect the running of train services regarding specific crew and stock route and utilisation issues. The Crew and Stock module will either replace or interface with existing RU Crew and Stock systems.

The Crew and Stock module combines activities currently undertaken separately by RU controllers and brings this part of the decision-making within the DST, adding to the data quality and providing the information necessary for managing crew and stock allocations during perturbation. This has the potential to provide accurate and consistent information of the location of train crew and rolling stock and their subsequent availability, which does not exist at present; it also allows operators greater focus on the management of an incident or event.

With the use of a single, integrated system and decision support supplied to controllers, management of perturbation/disruption is expected to be quicker and more appropriate, resulting in a reduction in reactionary delay. Similarly, the use of a Crew and Stock module, and its connection to downstream systems, will increase the availability of information for distribution to stakeholders, including the need to comply with Passenger Information During Disruption (PIDD) requirements.

6.3.2 Incident Management

The Incident Management module refers to the system(s) and processes utilised to manage and resolve disruptive events that affect the running of train services.

6.3.3 Customer Information System

The Customer information (CIS) has two distinct elements:

i. Information supplied by Network Rail to its customers
ii. Information displayed by RUs to their customers

The customer information module will provide historical, real-time, planned and forecasted information in a ‘read only’ format to all internal and external customers. This will be presented via a selection of interfaces in both graphical and tabular formats, maintaining information integrity in line with the ‘one version of the truth’ vision.

The customer information module will also provide information to existing downstream RU systems to support PIDD and prioritised plan information distribution. An integrated customer information module combines activities currently undertaken separately by controllers from Network Rail and RUs, and brings these together to provide a logical and consistent process, by which operators can disseminate consistent information. This will provide nationwide consistency and much more accurate customer information.

6.3.4 C-DAS

Within a TMS context, Driver Advisory Systems (DASs) are designed to provide drivers with information derived from the status of the current plan (e.g. relating to progress updates of the train concerned) and indicate the required driving speed.

A Connected DAS (C-DAS) is a driver advisory system with a communications link (via LINX) to the TMS in each controlled area in which the train operates. This enables the provision of schedule, routing and speed restriction updates to trains continuously and also receipt of information from trains to the TMS to improve regulation decisions. Realisation of the potential benefits offered requires data to be exchanged between the C-DAS on-board units and the DST modules in response to changes to current status.

TMS continuously publishes the messages to LINX and C-DAS subscribes to the information when required.

7 System Environment

The system environment will be different for each deployment. Therefore, the DR SoS Operating Model will need to be defined and implemented for each specific deployment. The Operating Model is a high-level representation of how IMs and RUs can best execute the DRP Strategy. Moreover, it provides a common understanding of how to operate and maintain the DR System by allowing people across the industry to visualise it from a variety of perspectives as every significant element of business activity should be represented. The development of this Operating Model will require a detailed analysis of roles, responsibilities and accountabilities in using the deployed DR SoS. The DR SoS Operating Model will potentially result in changes to, and the splitting of, roles and responsibilities within the industry.

7.1 Procedures and Rules

The majority of DR deployments will be into existing mature operating environments and will provide new functions, facilities and shared information sources. They will need to:

- Define competence requirements;
- Draw up training and development framework;
- Conduct a training needs analysis;
- Formulate a training and assessment plan;
- Run training events;
- Develop a resource plan; and
- Introduce competency profiling

Impact assessments on existing operational processes, procedures and instructions should be carried out for all applicable roles that have been identified in the Operating Model and all operational processes, procedures and instructions should be reviewed and updated taking into account those impact assessments.

TMS deployment will cause changes to operational publications including, but not be limited to: the Rule Book, Operations Manual, Local and National Operating Instructions, and Sectional Appendix.

Particular areas of operation affected are:

- Reconfigurable AoC
- Possessions management and remote access
- Management of incidents
- Implementation of plan
- Management of train and infrastructure failures
- Management of restricted routes
- Line Control
- Operational Rules

7.2 Staff Competence and Assessment

In addition, training in normal, degraded and emergency modes of operation with a realistic portrayal of the AoC and the traffic (both trains and communications) within it will be provided for those who will be impacted by introduction of DR SoS.

Particular areas to be addressed include:

- Routine monitoring of data logging systems to identify potential issues and signs of system degradation;
- Investigation and rectification of failures; and
- Management of safety critical or safety related failures including preservation of evidence.

7.3 Security

Appropriate physical and cyber security requirements and arrangements will need to be implemented for the TMS. This will be done in the context of the wider Network Rail Telecoms and railway industry security and cyber security policies, procedures and provisions.

All TMSs will be housed in secure buildings with physical security and restricted access in place. Consideration will be given to the availability and security of support systems such as:

- Power supplies;
- Communication systems to the ETCS trackside, CTI and other systems within the same building;
- Communication systems to trackside objects;
- Communication with LINX; and
- Remote access and remote monitoring systems.

Cyber security for Network Rail and Digital Railway is overseen by the DfT (Security – Transport (Rail) division) as the Regulator and implemented by the Security Assurance Framework process. Further information is provided in the DR Security Accreditation Plan [RI5].

7.4 Maintenance

Deployment of a TMS will require new maintenance requirements. Appropriate maintenance support – both tools and local and remote facilities – for the DR system will be provided to assist the maintainer in monitoring, understanding, and repairing the system. Where possible, common maintenance procedures will be adopted; however, it is recognised that it may not be possible to apply these procedures to all products.

Prior to Entry into Service, a fully documented maintenance regime will be authorised by the relevant duty holder(s) including:

- Routine maintenance tasks and frequencies;
- Component replacement instructions;
- Interrogation of, and extraction of data from, data recording systems;
- Management of safety related or critical failures;
- Reset and restart procedures; and
- Proactive maintenance techniques such as data logger analysis.

The procedures for working on the TMS and managing operational incidents for use by all railway disciplines and parties will be updated and authorised in accordance with industry practices (e.g. Rule Book, incident investigation processes, delay attribution).

Applications will consider the whole life maintenance of the asset, including requirements for routine renewal of assets, upgrades and management of obsolescence. Projects should put in place arrangements for software and other updates to address identified defects or cyber threats. These are project- and product-specific.

7.5 Local Environment and Conditions

The TMS comprises equipment which will be housed in control centres in controlled environments.

The central system will interface with LINX and both conventional and ETCS-related equipment e.g interlockings. The equipment external to the control centre will be contained in suitable trackside housings. The current environmental, vibration and Electro Magnetic Compatibility (EMC) requirements for signalling equipment will apply to new or modified equipment.

7.6 EMC

It is reasonable to assume that the EMC environment for the system should be compliant with the latest standards and this assumption will be validated as part of the TMS deployment validation activities.

7.7 Human Factors

For the TMS, there is likely to be a significant change to the HMI for operators and maintainers. Therefore, ergonomics assessment work will be required to ensure that HF requirements are captured in the DR specifications.

The TMS Reference Design process has involved consultation with users of the system and been supported by HF experts at all stages to enable understanding of the required processes and facilities. HF was identified as a core competency within the development process and remains thus for the change control process.

In addition, all new and revised operational and maintenance process, procedures and instruction should be subject to a Human Factors-assessment.

7.8 RU Staff

The RU staff co-located with Network Rail staff to operate parts of the DR System will have TMS display screens as well as their own employer's proprietary systems and equipment.

8 Existing Safety Measures

The CSM RA process will be applied to the system. Therefore, all safety measures and associated requirements will be listed in the hazard record and associated safety requirements specifications.

Within the current (conventional) railway command and control system, the interlocking contains the safety-critical functionality that ensures route integrity and provides Movement Authority.

The TMS (in isolation) respects the existing long-standing principle that the control system is safety-related and that the safety-critical functions are contained within the underlying signalling or train control systems (e.g. the interlocking or ETCS).

In operational terms, the existing safety measures include the applied maintenance regime, RU operating practices, Railway Rule Book, and compliance with Group and Network Rail Standards, all of which will require review, update and implementation as part of the DR System deployment.

The Safety Requirements that emerge from the hazard identification and risk assessment process from TM First deployments in Cardiff, Romford, Three Bridges and Didcot have been cross-referenced to the DR SoS Generic Hazard Record [RI1] and the DR Systems Generic Hazard Records for each DR System (where applicable).

Existing safety measures identified by the risk assessment process will be captured in the DR Generic Hazard Record and will be assessed to determine their effectiveness based on the engineering change and whether special arrangements / additional procedures and standards, etc. may be required during the implementation period of the change.

Further information with respect to Safety Measures and Requirements is contained in the DR System Safety Plan [RI2].

9 Safety Requirements

Safety Requirements are contained within the specifications which are contained in the configuration-managed DOORS database and included in the TMS CRS [RI6]. Safety requirements are tagged as such within the DOORS database and with the word ‘Safety’ in the CRS.

Safety Requirements that emerge from the hazard identification and risk assessment process will be cross-referenced to the source of the requirement e.g. DR SoS Generic Hazard Record [RI1] and System Safety Plan [RI2].

10 Assumptions

The assumptions listed here are additionally captured in the Technical RAID Logs for the TMS [RI7] and for the SoS [RI3] in case the assumption relates to multiple DR systems. The RAID Log is used only to manage the assumption and track it until it is closed and not as the master record of the assumptions. The master record of the assumptions remains here in this document and set out in the following sections.

10.1 Technical

1. Functional SIL allocation will be undertaken as part of the development.
2. Power requirements for TMS subsystems are undertaken as part of detailed design.
3. The EMC environment for the system should be compliant with the latest standards.
4. LINX has been assessed for safety including message flows.

10.2 Environmental

None.

10.3 Operational

1. All operational and maintenance staff interfacing to the TMS will work to a common set of national standards.
2. The operational readiness activities generate appropriate supporting procedures to allow staff to operate the System in a safe and efficient manner.
3. Deployment of a Traffic Management System will cause changes to the Rule Book and other longstanding practices. Operational procedures will be modified to reflect the new processes, roles and responsibilities.
4. It is expected that maintenance staff will need to be trained and retrained to be able to maintain and find faults in any new equipment appropriately and safely, and their competence will require ongoing assessment.

10.4 System Integration

1. The TMS will interface to operational telecommunications systems for the purposes of routing calls / text messages to and from the TMS workstations, and instigating Railway Emergency Calls (RECs)
2. The TMS will not contain, nor interface directly to, any national Defect Reporting and Corrective Action System (DRACAS), Fault Management System (FMS), or Failure Reporting and Corrective Action System (FRACAS). However, TMS may have its own reporting systems and this will need updating to include additional fault codes and data fields.
3. A master timetable for each operating day is available to the TMS from the appropriate national systems.
4. Data Communications: Adequate communications capacity will be available in the ROC to meet the needs of the installed TMS.
5. All controls and indications for CCTV crossings that are to be controlled from the TMS are provided within their respective interlockings / Time Division Multiplexers (TDMs). This only includes control of the CCTV wipers at level crossings and indications.
6. All TMS to TMS interfaces will be via LINX.
7. LINX message flows have been developed and tested elsewhere.
8. Currently the MCB CCTV crossing clear function is handled by a dedicated desk but the aspiration is to receive CCTV live streams from level crossings within the TMS. This will reduce the number of display monitors at the user’s desk. For the foreseeable future it is assumed that MCB CCTV will continue to be handled by a dedicated CCTV desk / operator.

10.5 Maintenance

None.

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