Digital Railway

Digital Railway – Joint Development Group
Common Interface Dataset – Report

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Document Control

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1 Executive Summary

Traffic Management (TM) is a Digital Railway (DR) technology that offers significant improvements in train service reliability through better daily planning and regulation. TM can deliver benefits in isolation ('Isolated TM') from traditional signalling control and automatic route setting systems (generically referred to herein as 'Route Setting Systems'). However, greater benefits are possible where TM interfaces directly to these Route Setting Systems ('Interfaced TM').

Bespoke TM to Route Setting System interfaces have been developed for each of the three Interfaced TM solutions current deployed (Wales & Anglia, Thameslink and Western). Standardisation of this interface to provide a 'common interface' was perceived to be necessary to encourage consistency, allow competition and innovation. Working within the DR Joint Delivery Group (JDG), a team of subject matter experts from Network Rail (NR) and various suppliers were set a problem statement to develop this common interface.

The JDG team began by challenging whether the problem statement that they were set was fit for purpose (section 3). They identified that, given the low number of TM to Route Setting interfaces likely to be deployed, the case for a common interface was not as clear as originally assumed, hence there was need to assess this case in more detail. Development of a complete interface specification, agreed by all respective parties, was also believed to be unrealistic with the time and resources available. The team therefore descoped the problem statement to production of an outline definition of the interface plus a plan for developing it in greater detail.

The delivery team formulated assumptions concerning the TM to Route Setting Systems interface (section 4) and considered the case for a common interface (section 5) before developing an outline definition of that interface.

The first step in producing an outline interface definition was to review the existing ARS+ specification (section 6, Ref. 3) to identify which clauses applied to TM, which the Route Setting Systems and which to both. As part of this exercise the delivery team identified areas that would need to be specified for a common interface, but which were not currently defined in the ARS+ specification. The next step was to propose an outline optimum TM to Route Setting System interface (section 7) and practical steps for developing it (section 8).

The key conclusions of this work (detailed in section 9) were as follows.

- The commercial case for developing a common interface for TM to Route Setting Systems is unclear given the small number of TM to Route Setting System interfaces likely to be encountered in practice in the UK.
- Even if a complete interface specification is not worthwhile to develop and implement, more cost effective steps can still be taken to facilitate Interfaced TM deployment and maximise the benefits that can be realised from it:
    - adaptation of the CIF format for communicating timetables to make it more suitable for the needs of Interfaced TM;

- improving the quality of geographic data available to Interfaced TM and other systems through a common infrastructure data model;
- update of ARS+ specification to support addition of functionality to make new / upgraded ARS deployments 'TM ready;'
- provision of a commercial framework to enable collaborative working between TM and Route Setting System suppliers for specific deployments so that success is less dependent on compliance to a common interface specification.

- Until the future path for Safety Integrity Level (SIL) apportionment can be determined for an Integrated TM future, Interfaced TM projects must adhere to SIL functionality remaining in the Signalling Control / ARS layer.

Based on these conclusions recorded, the JDG team makes the following recommendations (detailed in section 10).

- The commercial issues associated with developing and implementing a common TM – Route Setting System should be assessed.
- A TM migration strategy should be developed to enable the full potential of Interfaced TM to be realised through successive, achievable steps from current TM and Route Setting System technologies to future technologies that support a more functionally rich interface.
- A further working group should be set up to identify how current restrictions in the CIF format that prevent Interfaced TM achieving its full potential, when using CIF to communicate current plans, can be overcome.
- The (existing) ARS working group should review the proposed additions to the ARS+ specification described in this document with a view to incorporating them into future versions of the specification.
- The future safety functions of TM Integrated in combination with the JDG Common Interface Dataset review should be assessed for the best fit location (system wise). This analysis also take into account the general trend of migrating safety functionality into the Signalling Control Layer from the Interlocking layer.
- A study should be conducted assuming TM were to remain at an Interfaced status, asking whether functionality intended to be introduced from a Interfaced TM perspective.

2 Introduction

2.1 Joint Development Group

Building on the lessons learned from the previous Early Contractor Involvement (ECI) work streams combined with an industry specific benchmarking exercise, the Digital Railway Programme (DRP) developed the concept of a Joint Development Group (JDG). The JDG seeks to leverage the breadth and depth of technical competencies that exist in the supply chain to inform a diverse industry opinion and respond to novel and ambiguous problem statements that emerge within the DRP. The core concept behind the JDG is to bring together a community of suppliers with a wide range of skills and capabilities, each able to be called upon / invited to support the DRP's development activities. This new way of working allows the DRP to utilise the diversity of thinking from the supply chain on a variety of problem statements. For the remainder of CP5, the JDG will be in its interim phase (IJDG) during which the concept and operating model will be validated prior to a solution being locked in CP6.

A combination of ECI led to the JDG end to end process being developed. Figure 1 shows each step with descriptions

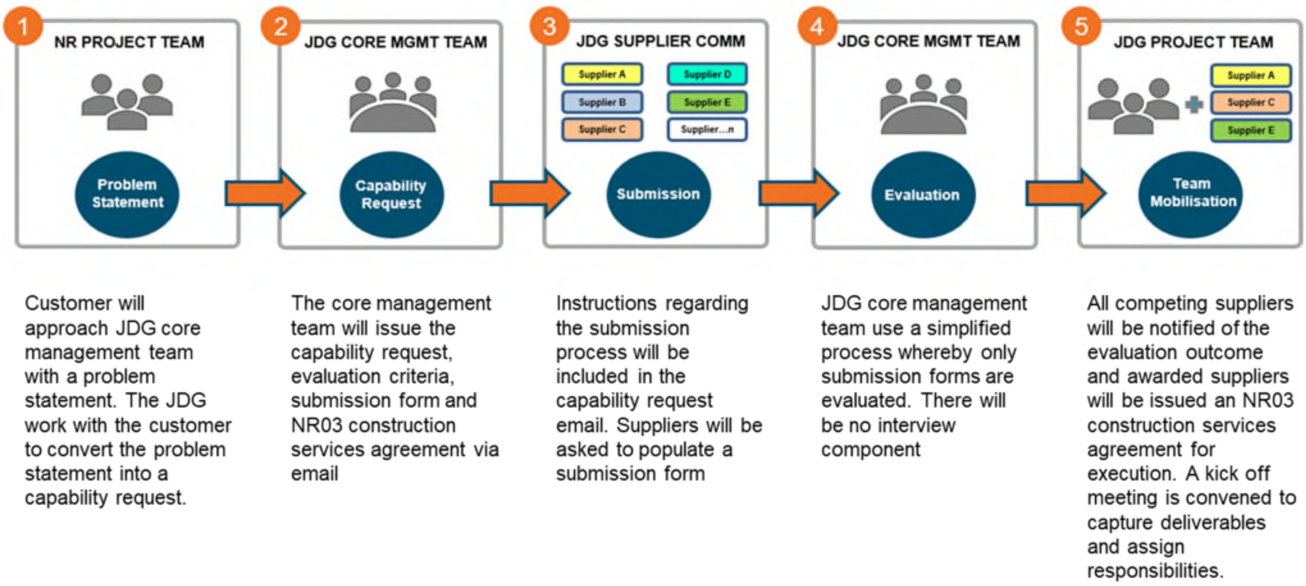

Figure 1 – JDG commissioning process

2.2 Project background

The UK railway is undergoing a significant growth in demand which is expected to significantly exceed the levels that existing capacity can accommodate. At the same time there is a need to improve performance by reducing delay.

Traditional ways to meet increasing demand such as building new infrastructure might not be the most cost-effective solutions to address this challenge. This is leading to the seeking of lower cost alternatives enabled by new technology focusing on a better optimisation of the current available infrastructure.

In this regard, Digital Railway (DR) has evolved a 'toolkit' of technology and associated business change to offer increased capacity and improved performance to contribute towards meeting future rail demand. A key component of DR is Traffic Management (TM) as it can offer significant benefits on the daily planning and regulation of train services. This improves train performance (reduced delay minutes) across the network through the reduction of some primary, but particularly secondary delays and through the provision of better operational information to staff and customers.

Traffic Management projects undertaken so far have concentrated on the verification of the expected capabilities required from a TM, along with gaining understanding on how they would safely interface with Network Rail (NR) systems and architecture, to create a useful and dynamic plan / re-plan tool for front line operational control in service of route performance improvements. This has meant all three projects (Wales & Anglia, Thameslink and Western) have to a varying degree done the above, but in accordance with their own proprietary solutions and the options for interfacing with existing signalling control equipment available to them.

The agreement of a standard solution by which TM interfaces to signalling control equipment on future projects is perceived as benefitting NR and the Industry generally in the following ways:

- reduction in the development risk for each new deployment (once a steady state has been reached whereby products have been developed to comply with the common interface);
- reduction in the amount of change needed if either TM or Signal Control system changes in the future.

This proposed common interface for an "Interfaced TM [1]" is the subject of this report.

[1] For definition of Interfaced TM, see section **Error! Reference source not found.** and Ref. 1.

2.3 Delivery Team

Name	Organisation	Role
Ali Aziz Alsamawi	Arcadis	Problem Statement Project Manager
Andy Bourne	Arcadis	Senior Technical Director
Johnathan Moss	Network Rail	Operations Support
Simon Price	Network Rail	Operations Support
Stefano Saccomani	Network Rail	Engineering Support
Nick Thorley	Network Rail	Operations Support
Matt Alway	Thales	Technical SME
Alastair Hayden	SNC Lavalin	Technical SME
Jon Hayes	SYSTRA	Technical SME
Dominic Taylor	SYSTRA	Technical SME + Report Author
Keith Thomas	Resonate	Technical SME

2.4 Problem Statement

The delivery team were set the following problem statement.

> *'The TM delivery strategy as part of its development has considered the need for commonality of interfaces between the different levels of equipment interfacing into Traffic Management. Particularly in the "Interfaced" version of TM. To this end it has identified that the layer between the Signalling Control / Automatic Route Setting (ARS) and the Traffic Management layer on all current three deployments is proprietary; a scenario which will be potentially repeated on further TM deployments, locking NR into a single supplier's architecture once deployed or necessitating interface development with every change in TM or ARS / Signalling Control.*
>
> *To avoid the scenario described above and to encourage consistency, allow competition and innovation (on the other side of the common interface), NR intends to define the Common / minimum Dataset necessary to allow the deployment of a Traffic Management System with whichever Signalling Control / ARS system is already deployed.'*

No assumptions were stated about the interface or how it might be implemented in new / existing equipment.

2.5 Expected output

The delivery team were initially expected to provide the following outputs.

‘

i) Develop an Interface development plan based on the scope below – End Jan 2019.

ii) Conduct the following activities, for completion by March 2019.

a. Set-up separate working and review groups, including the following stakeholders in both: Industry partners (sourced from the JDG partners), Operational Interface Managers currently working within the TM programme, Business Analysts and subject Matter experts from within NR.

b. Utilising the working and review groups define the

i. common interface dataset,

ii. timing sequences and functionality needed to allow a TM to work with a Signalling Control system / ARS system, ensuring that no safety functionality is bled across the interface to the TM.

c. Ensure that this common dataset allows a level of functionality commensurate with the so-called ARS & ARS+ level of functionality.

d. Propose any further work needed to realise the data set for use on TM future deployments.

e. As a final output, review the current NR ARS specification and suggest modifications to align it with the developed common dataset.

The suppliers will assist in the work scope above by

- *offering system interface experts for ARS and Signalling Control Systems,*
- *participating in the working and review groups and*
- *assisting in the re-writing of the current ARS specification, building on the identified common datasets.’*

3 Review and challenge of the problem statement

The JDG reviewed the problem statement as set and raised the following challenges.

- **Appropriateness of interface**
  The problem statement pre-supposes a common interface between TM and deployed Signalling Control Layer / ARS solutions on the basis that it would encourage consistency, allow competition and innovation. This rationale was challenged on the basis of the low numbers of interface permutations and instances of those permutations likely to be encountered [2].

  Significant investment would be required to agree a common interface specification, develop supplier products to meet that specification and adapt / replace installed systems to do likewise in order to support the required 'plug and play' interchangeability between products. Whilst such investment can often be justified for high volume consumer products as it can be amortised over a large number of deployments. The case is less clear for a TM where a common interface would only apply to a small number of deployments [2] giving little opportunity to recover development costs.

- **Detail of expected outputs**
  The definition of developed datasets and timing sequence was not believed to be achievable given the limited time and resources available. Furthermore, having developed such datasets and time sequences, the process of consulting and agreeing them with all affected stakeholders would require considerably more time than available to the JDG.

To address these challenges, the problem statement was re-formulated as follows.

> *'The JDG delivery team will assess the pros and cons of a common TM to signalling control layer / ARS interface. Having done so, they will take the following steps to define that interface.*
>
> - *Review the existing ARS+ specification to determine its suitability as the basis for the interface, identifying any additional areas that need to be specified.*
> - *Propose an outline definition of an optimal TM to Route Setting System interface.*
> - *Identify practical steps for developing that interface.'*

[2] There are expected to be no more than 12 TMs in the UK with direct interfaces to the Signalling Control Layer, each unlikely to interface to more than ten signalling control / ARS systems.
Given the limited number of suppliers producing TMs and signalling control / ARS systems for the UK market, the total number of interface permutations is likely to be in the region of six (three incumbent TM suppliers x 2 incumbent control system suppliers) to 15 (allowing for two more TM and two more control system suppliers), of which three permutations are already being deployed as bespoke interfaces.

4 Assumptions and terminology

4.1 The Interfaced TM

The term ‘Interfaced TM’ is used in this document to refer to a TM that provides ‘TM Planning and Operations Layer’ functionality (as described in Ref. 1) and interfaces to a separate system – the ‘Route Setting System’ – that provides ‘Signalling Control Layer’ functionality (as described in Ref. 1). The subject of this report is the interface between these two systems.

The TM is assumed to generate and maintain the current plan, the continuously updated timetable for train services within the TM’s area of control, which it passes to the Route Setting System for implementation. The current plan is based on planned timetables that the TM receives from the timetable server, continually modified in light of TM regulation / perturbation management decisions and inputs from TM operators.

4.2 Route Setting System

The term 'Route Setting System' is used in this document to refer to a signalling control system that provides traditional UK railway control centre functionality, as described in Ref. 2, as well as functionality to set routes automatically in accordance with the current plan received from the TM. The latter could be sophisticated route setting functionality that includes complex regulation and perturbation management algorithms, such as provided by traditional ARS – Ref. 3. It could instead be more basic functionality that only sets routes in accordance with the current plan issued to it when trigger conditions are met, such as provided by Immediate Route Setting (IRS) – Ref. 5.

For the purposes of this report, the Route Setting System is assumed to provide functionality that has an assigned Safety Integrity Level (SIL) as described in section 10.2 of Ref. 2 and section 10.1 of Ref. 3. It is however, noted that many railway administrations outside the UK do not mandate a SIL for similar systems. See also Ref. 4.

4.3 Mapping of Interfaced TM to Route Setting Systems

The following assumptions are made about mapping of an Interfaced TM to Route Setting Systems and are illustrated in Figure 2.

- Each Interfaced TM interfaces to one or more Route Setting Systems.

  Rationale: by definition, an Interfaced TM needs to interface to at least one Route Setting System. Given that TM control areas are substantially larger than the control areas of (current) Route Setting Systems, an Interfaced TM is likely to interface to multiple Route Setting Systems.

- A Route Setting System will never directly interface to more than one TM at the same time.

  Rationale: to avoid ambiguities and the risk of inconsistencies at TM boundaries, each Route Setting Systems should only receive plans from (and so interface to) no more than one TM.

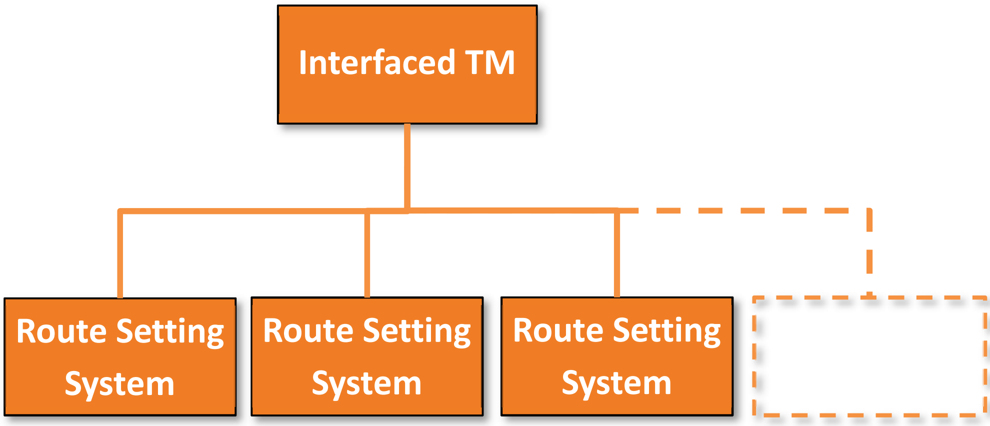

Figure 2 – Interfaced TM – Route Setting System Mapping

4.4 Operator roles

There are assumed to be two primary actors who interact with the TM and Route Setting System in an operational capacity: the signaller and the Train Running Control (TRC). See Table 1.

Role	Interacts with TM	Interacts with Route Setting Systems
Signaller	✓	✓
TRC	✓	

Table 1 – Operator roles

Responsibilities of the signaller that relate to traffic management.

- Ensure that Train Services are safely routed within the signaller's area of control.
- Manually route train services in the Route Setting System where they are not (intentionally or otherwise) routed automatically.
- Manipulate the plan and timings in the TM as necessary and appropriate for the delivery of changes to the regulation of train services. [Typically based on a 15 – 20 minute look ahead view provided by the TM.]
- Supervise, and where necessary intervene to correct, the automatic routing of train services.

  Note: as with traditional ARS, this is only feasible where the signaller has sufficient visibility of future automatic routing to have time to intervene. When automatic routing decisions are changed at the last minute, as can occur with ARS, it is not reasonable to expect the signaller to intervene if the new decision is contrary to the signaller's intention (see Ref.: 6).
- Make time critical regulating decisions where these have not been, or cannot be made, automatically or by the TRC.
- Override planning decisions being implemented by Route Setting System functionality, whether resulting from automatic decision making or made by a TRC / equivalent role, where appropriate to ensure the safe and efficient operation of the railway in the signaller's area of control.

Responsibilities of the TRC that relate to traffic management.

- Manipulate the plan and timings within the TM as necessary to deliver the train services conformant with the business rules within the TRC's area of responsibility. This could include approval of re-planning decisions submitted by Train Operation Companies (TOCs) and Freight Operating Companies (FOCs), including Very Short Term Planning (VSTP) proposals.

  Note: the TRC's area of control is likely to cover multiple signallers' areas of control. TRCs generally plan and update services over a wider geographical area than the area controlled by a signaller.

- Request amendments to train schedules by modifying the current plan, in the medium term, to resolve conflicts (such as providing for a fixed train sequence).

- Make re-platforming requests for passenger services and Empty Coaching Stock (ECS) by modifying the current plan, in the medium term, where such a decision may be validated by rules within both the TM and interfaced Route Setting System.

- Make significant service re-planning decisions, guided by and implement through TM, to manage major disruption.

- Contingency planning for cases of severe disruption.

4.5 Functional split

Table 2 shows the assumed split of functionality between Interfaced TM and Route Setting Systems.

Interfaced TM	Route Setting Systems
In charge of regulation and perturbation management decisions	Depending on specific implementation, may make regulation / perturbation management decisions where permitted by the TM or if communications with the TM are lost. The decision made won't necessarily be the same as the one TM would have made.
Resolves inconsistencies / ambiguities in timetable received from timetable server in accordance with pre-defined criteria.	Resolves inconsistencies / ambiguities in current plan received from TM in accordance with pre-defined criteria.
Generates current plan for Route Setting System to implement.	Able to reject current plan if it contains ambiguities / inconsistencies that cannot be resolved or if implementing it would lead to an unsafe event or an event that would cause significant operational disruption.
	Implements current plan. Routes are set when trigger conditions are met.
	Optimises route setting in view of overlap constraints: • selecting between main and warner routes; • selecting which route to set first where the overlaps of two routes conflict.
Enables signaller to implement special timing patterns	Provides facility for signaller to enable / disable automatic setting in specific areas ('ARS sub areas').
	Provides facility for signaller to enable / disable automatic setting for specific trains.
Generates timetable simplifiers.	Enables signaller to set routes manually.
Provides alerts and information to TRC and signaller.	Provides alerts and information to signaller.
Does not have any specific safety function.	Has a specific safety functions with an assigned SIL.

Table 2 – Functional split between Interfaced TM and Route Setting System

5 The case for a common interface

Open interfaces provide an opportunity to support multi-vendor 'mixing and matching' with the associated attraction of increased flexibility, technical compatibility and commercial competition. In order to unlock these benefits, it is first necessary to create the appropriate commercial / technical environment so that market forces encourage the desired outcomes. Economic theory suggests that the value of common interfaces is greatest when introduced before the emergence of product solutions, in markets where there are potentially very large numbers of suppliers, with products that are easy to adapt, the standards are adopted widely (internationally) and where the market opportunity is large.

In the case of the proposed open interface (common dataset) between the Traffic Management System and *whichever Signalling Control / ARS system is already deployed*, this brings some specific challenges.

- **Market maturity:** there are already paired product solutions that have been delivered into, are being delivered or are designed for the UK market. These necessarily pre-date the common interface and these either would persist alongside any emerging common standard or would need to be re-engineered in response to it.
- **Market size (volume and commitment):** the cost of re-engineering (or for new entrants, creating) product interfaces to match the common dataset interface would need to be absorbed by suppliers and amortised across anticipated / committed future UK sales or funded by some other means. The anticipated volume of committed sales, therefore, becomes a critical factor.
- **Market size (likely number of suppliers)**: the 'mix and match' competition-based benefits achieved are likely to be higher if the number of likely (or potential) suppliers on each side of the interface is large. However, with a fixed market opportunity, the amortisation cost of meeting the interface is larger per supplier when there are a large number of suppliers.
- **Market specialisation:** the introduction of a UK-specific interface requirement, that does not get adopted more widely, may have the effect of raising a barrier to entry for international suppliers and have the effect of reducing commercial competition rather than increasing it.
- **Interface precision:** in order to gain the sought commercial and technical 'mix and match' benefits, the residual requirement for development for systems once engineered to comply with the interface would need to be extremely low. This means that the interface specification would need to be extremely precise to achieve this (else significant market cost could be achieved with little net benefit as the need for application specific development and divergence at the interface would continue).
- **Asymmetric development:** the stated intent of this common Dataset interface is to make a quick impact on railway industry performance by exploiting the existing installed systems. This means that, in order to gain those benefits, the modification to existing systems should be minimised, at least in the first instance, and focused on meeting this common interface rather than on functional extension.

Table 3 lists the specific pros and cons of developing and implementing a common TM to Route Setting System interface.

Pros	Cons
Can facilitate open supply market as TM supplier does not require proprietary knowledge of existing Route Setting Systems to interface to them.	Could act as a market entry barrier to new suppliers with a non-compliant interface trying to complete with incumbents that have implemented a common interface.
Can enable greater operational potential to be realised from Integrated TM as its interface to Route Setting Systems can be optimised to deliver a richer level of functionality unconstrained by existing protocols and standards.	Requires upfront investment to develop specification and supplier products to meet that specification.
	Requires upfront investment to adapt / replace existing Route Setting Systems so that they comply with the common interface.
	Ongoing commitment to manage and update products to comply with an evolving common interface specification.
Enables integration risk reduction and efficiencies if rolled out across multiple projects.	Limited capacity of supply chain to support changes needed to realise a common interface.

Table 3 – Pros and cons of a common TM to Route Setting System interface

It can be seen that the decision whether to progress with a common interface depends on NR business priorities. If the benefits of an open supply market, realising the full potential of Interfaced TM and reduction of integration risk / cost over a large deployment programme outweigh the cost of the initial investment to realise the interface then it is advantages to develop and enforce it; otherwise, it is not.

6 ARS+ specification

6.1 Overview

The first step in defining the TM to Route Setting System interface was to review the existing ARS+ specification (Ref. 3) in the context of this interface. This began with a clause by clause of the specification and was followed by identification of the additional areas that would need to be specified to adequately define the TM to Route Setting System interface.

It should be noted that the ARS+ specification is not currently mandatory. Furthermore, a working group is currently reviewing the specification with a view to modifying it where deemed appropriate.

6.2 Applicability of existing clauses

A full clause by clause analysis of the ARS+ specification, in the context of the assumed functional split between Interfaced TM and Route Setting Systems described in section 4.5, is provided in Appendix C. This identifies which clauses apply to Interfaced TM, which to an IRS type Route Setting System and which to a full ARS Route Setting System. The key findings of this analysis are summarised in Table 4.

Area	Details
Specified functionality that applies to Interfaced TM & full ARS, but not IRS.	• Receipt of timetable from the timetable server. • Insertion of Special Timing Patterns. • Insertion of speed restriction information. • Regulation of services at conflict points. • Perturbation planning. • Operator's workbench simulation. • Generation of timetable simplifiers. • Provision of performance statistics. • Automatic Code Insertion (ACI) functionality pertaining to determination of train sequence at specific locations.
Specified functionality that applies to IRS and ARS, but not Interfaced TM.	• Request routes in interlocking when trigger conditions are met. • Allow signaller to select between timetabled and first come, first served operation for specific junctions. • Indicate and allow signaller to select which trains are routed automatically. • Indicate and allow signaller to select which areas automatic routing is enabled in ('ARS sub-areas'). • Manage selection of main / warner class routes. • Event logging. • ACI functionality pertaining to the execution of changes in the Train Describer or equivalent system.
Specified functionality that is split between Interfaced TM and Route Setting Systems (IRS & ARS).	• Explain routing actions to signaller when interrogated. • Diagnostics.
Requirements that apply to Route Setting Systems for which TM equivalents are also needed.	• Signaller interface. • Technician's interface. • System support interface. • Reporting failures and alarms. • Reliability, Availability, Maintainability and Safety (RAMS). • Ergonomics. • Geographic data. • Configuration management. • Training. • Installation, testing and commissioning. • Whole-life management.

Table 4 – Summary of ARS+ analysis

6.3 Additional areas to be specified

6.3.1 Proposed additions to current ARS+ specification

The ARS+ specification is predicated on the functionality described therein being performed by a single 'black box' system, rather than split between a TM and Route Setting Systems. This split, and the fact that the TM does not have a SIL like the Route Setting System, introduces a need for the following new functionality to be specified in order for an ARS+ system to provide a subset of basic TM functionality when acting as a Route Setting System.

- **Constraints of regulation and perturbation management functionality**
  Recommended for all TM – Route Setting System interfaces.

  Some Route Setting Systems, such as ARS, are capable of making regulation and perturbation management decisions in their own right (as specified in the ARS+ specification). To avoid the TM and Route Setting System conflicting with each other, the TM needs to be in overall charge of regulation and perturbation management decisions with equivalent functionality in the Route Setting System constrained. This is to avoid the situation whereby a signaller / TRC modifies the current plan in the TM, this is then passed to the Route Setting System, but the Route Setting System implements something different and inappropriate without prior warning. This a known frustration that operators experience with existing ARS systems (see Ref. 6).

  There are, however, situations in which it would be desirable to allow the Route Setting System some freedom in making its own regulation and perturbation management decisions based on the intended current plan received from the TM. Typically this would be the case where the current plan cannot be communicated sufficiently frequently to manage the required service headway in real time, e.g. due to bandwidth / processing constraints and / or very short service headways. It would also be the case where the TM proposes a current plan with conflicting train paths (e.g. due to insufficient visibility of interlocking constraints) or ambiguities (e.g. due to the limitations of the Common Interface File (CIF) format) that the Route Setting System could resolve.

  The constraints on the Route Setting System regulation and perturbation management functionality (where provided) should be selected to meet site specific needs. It would also be desirable, though not essential, for the TM to be able to specify these constraints so as to retain a greater level of control over all regulation and perturbation management functionality.

- **Behaviour in the event of loss of connection to TM**
  Recommended for all TM – Route Setting System interfaces.

  Should communications with the TM be lost, the Route Setting System should continue working to the most recent plan received from the TM. If the Route Setting System is capable of its own regulation and perturbation management functionality then this should be automatically re-enabled.

- **Resolution of inconsistencies / ambiguities in current plan**
  Desirable in an optimum TM – Route Setting System interface.

  It is desirable that the Route Setting System resolve inconsistencies / ambiguities in each current plan received from TM in accordance with pre-defined criteria to avoid situations where plans are not implemented. Inconsistencies / ambiguities in TM plans could arise, amongst other reasons, due to the limitations of the CIF format or the TM having incomplete information on interlocking constraints. Inconsistencies / ambiguities that cannot be resolved should be alerted to the signaller and the plan not be executed automatically. Where supported by the interface to the TM, the TM should also be notified to trigger a re-plan.

- **Verification of safety constraints**
  Desirable in an optimum TM – Route Setting System interface.

  It is not reasonable to expect a signaller to manually check every routing decision made by the TM, which has no assigned SIL. It is therefore desirable for the Route Setting System to conduct an independent check of each plan received from the TM to ensure it does not violate any of the following safety constraints:

  - *loading gauge compatibility;*
  - *axle load compatibility;*
  - *signalling system compatibility;*
  - *planned / current engineering possessions;*
  - *suitability of lines for passenger trains;*
  - *pathing constraints on specific hazardous / sensitive trains (e.g. nuclear flask trains / royal train).*

  The Route Setting System should not automatically execute a plan for which a safety verification check fails and should alert the signaller.

  Practically, however, such verification checks would require improvements in the quality of train consist data available to the Route Setting System as well as development of products to support this functionality. The quality of data (format, provenance, accuracy, completeness, timeliness, etc.) reaching the Route Setting System would need to be demonstrated to be sufficient for safety related decision making. Pragmatically, the use of head-codes to designate specific trains as requiring manual routing (as is currently done) may prove the preferred solution for the immediate future.

- **Verification of performance constraints**
  Desirable in an optimum TM – Route Setting System interface.

  It is not reasonable to expect a signaller to manually check every routing decision made by the TM. It may therefore be desirable for the Route Setting System to conduct an independent check of plans received from the TM to ensure they do not violate any of the following performance constraints:

  - *trains sent to correct destinations;*
  - *achievable stock and crew associations;*
  - *avoidance of deadlock situations;*
  - *electrification compatibility;*
  - *platform length;*
  - *operational length available in occupied platforms.*

  The Route Setting System should not automatically execute a plan for which a performance verification check fails and should alert the signaller.

  Practically, however, such verification checks would require improvements in the quality of train consist data available to the Route Setting System as well as development of products to support this functionality so may not be achievable in the near future.

6.3.2 Information sent from TM to Route Setting Systems

As the ARS+ specification does not envisage a split between a TM and Route Setting Systems, it does not define information that should be sent from a TM to Route Setting Systems. This information needs to be specified as part of TM to Route Setting System interface and should include the following.

- **Link monitoring**
  Recommended for all TM – Route Setting System interfaces.

  Protocol by which the TM to determine whether it is communicating with the Route Setting System. E.g. a heartbeat signal or maximum time between successive messages.

- **Current plan**
  Recommended for all TM – Route Setting System interfaces.

  An equivalent of section 7.6 in the ARS+ specification to describe how the Route Setting System receives current plans from TM. Key differences from the way ARS receives timetables from a Timetable Server, using CIFs, are as follows:

  - *the Route Setting System must accept new path or timing information at a frequency and with sufficient speed to permit near real time changes to the current plan for all paths within its area of control;*
  - *to avoid excessive data flows, the current plan should be updated by communicating significant changes rather than re-issuing the whole plan and configuration parameters defined for determining when changes are significant;*
  - *where a TM interfaces to multiple Route Setting Systems, updates of the current plan need to be synchronised across all Route Setting Systems to ensure that they work to a consistent version;*
  - *the duration for which the current plan remains valid after loss of TM - Route Setting System communications is lost needs to be specified;*
  - *whereas ARS can tolerate missing / incorrect stock and crew associations, some Route Setting Systems are likely to be more dependent on them being correctly specified in the current plan to ensure that they are implemented correctly, application rules to enforce this are therefore needed;*
  - *to realise the full potential of Interfaced TM, the current plan it transmits should be more geographically precise, particularly around junctions, than timetables currently*

provided through CIF (signal to signal [3] rather than TIPLOC to TIPLOC) so as to avoid pathing and regulation ambiguities [4];

- o *the current plan should be more granular in terms of time (to the nearest second rather the nearest ½ minute) to allow effective regulation of densely operated areas;*
- o *future work should assess the appropriateness of the CIF format as a medium for the delivery of a current plan.*

The option of the TM issuing detailed route setting commands to the Route Setting System was considered, but dismissed on the basis that it transfers safety functionality from the Route Setting System to the TM.

- **Constraint of regulation and perturbation management functionality**
  Desirable in an optimum TM – Route Setting System interface.

  As described in section 6.3.1, regulation and perturbation management functionality needs to be constrained in the Route Setting System when it is communicating with a TM [5]. At a basic level, this could be achieved by the Route Setting System monitoring its link with the TM and applying pre-configured constraints as long as the TM is present. It would, however, be desirable for TM to specify the constraints that the Route Setting System should apply as these are likely to change depending on location and service type. For example, constraining sequencing may be unnecessary at diverging junctions or converging junctions approached by trains with identical stopping patterns. It would be more important when both a stopping and non-stopping service approach a junction. Applying such dynamic constraints would require additional information to be passed from the TM.

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3 Or 'route setting position to route setting position' to make provision for future moving block operation / sub-division of conventional signalling block sections into shorter ETCS block sections.

4 This especially important where Automatic Train Supervision (ATS) functionality is provided via the Route Setting System (as is done on the Thameslink project) as the exact path taken by the train needs to be specified.

5 These constraints only applicable where a Route Setting System has regulation and perturbation management functionality (e.g. ARS). Route Setting Systems that don't, such as IRS, have no need of suppression.

6.3.3 Information sent from Route Setting Systems to TM

In addition to information sent from a TM to Route Setting Systems, information sent in the opposite direction – from Route Setting Systems to TM – is also a desirable part of an optimal TM to Route Setting System interface. This information should include the following.

- **Link monitoring**
  Desirable in an optimum TM – Route Setting System interface.

  Protocol by which the TM to determine whether it is communicating with the Route Setting System. E.g. a heartbeat signal or maximum time between successive messages.

- **Whether current plan has been accepted**
  Desirable in an optimum TM – Route Setting System interface.

  As described in section 6.3.1, it is desirable for the Route Setting System to identify inconsistencies / ambiguities in plans received from TM as well as perform independent safety / performance verification checks on these plans. Where such functionality is implemented in the Route Setting System, it would be similarly desirable for the Route Setting System to inform the TM whether its latest plan has been accepted, triggering the TM to re-plan if not.

- **Train describer information**
  Desirable in an optimum TM – Route Setting System interface.

  The Route Setting System interfaces to train describers identifying the locations, to the nearest signal berth, and identities of train services. This information is needed by the TM to monitor the service in order to make regulation and perturbation management decisions.

  Whilst train describer information can be fed directly to the TM as well as the Route Setting System, providing it via the Route Setting System ensures that the TM always receives a view of the railway that is consistent with that of the Route Setting System (albeit slightly later).

  As a minimum, the TM will require train describer information for its control area, which needs to be supplied by the relevant Route Setting System(s) within that area. The TM is responsible for maintaining a coherent view of train describer information within this area.

- **State of railway information**
  Desirable in an optimum TM – Route Setting System interface.

  The Route Setting System receives state of railway information from interlocking(s) that it controls. This information includes

  - *train detection occupancies,*
  - *Train Ready To Start (TRTS) plunger states,*
  - *signal states, etc..*

Relaying this information to the TM, provides the TM with more accurate train location information (through train detection section occupancies) than can be determined from train describer data. It also informs the TM when trains are ready to depart from platforms (by means of TRTS plungers) and restrictive signal aspects that might impede their progress. This information enables the TM to make better regulation and perturbation management decisions.

Where a TM interfaces to multiple Route Setting Systems, state of railway information updates provided to the TM need to be synchronised across all Route Setting Systems to ensure consistency across the whole TM control area.

- **European Train Control System (ETCS) position reports and validated train data (if available)**
  Desirable in an optimum TM – Route Setting System interface.

  On lines signalled with ETCS Level 2, a Route Setting System may receive ETCS position reports and validated train data reports from an ETCS Radio Block Centre (RBC). Where available, ETCS position reports provide more precise information on train speed and location than can be determined from train detection occupancies in 'State of railway information.' Relaying this information to the TM enables it to make better regulation and perturbation management decisions. Relayed validated ETCS train data provides the TM with the information it needs to conduct safety and performance verification checks.

- **Routes available to be set automatically**
  Desirable in an optimum TM – Route Setting System interface.

  It is desirable for the signaller and the Train Running Controller (TRC) to be informed where routes are not available to be set automatically to make them aware that manual intervention and decision making is required in these areas. This can occur when ARS sub-areas are disabled and when signaller reminder devices prevent routes being set automatically, for example to manage an operational incident of which the TM is unformed / incapable of managing [6]*.*

- **Trains that cannot be routed automatically**
  Desirable in an optimum TM – Route Setting System interface.

  It is desirable for the signaller and the TRC to be informed of specific trains that cannot be routed automatically so that they are aware that manual decision making is required for these trains. This can occur where a train has been assigned a specific head code indicating that it should not be routed automatically [7]*.*

[6] For example an infrastructure defect / report of trespassers on the line, which requires the signaller to talk to drivers before they are authorised to proceed into the affected section.

[7] For example, trains that have specific routing constraints due to axle load / loading gauge of which the TM / Route Setting System has insufficient information to manage or trains with highly politically sensitive routing requirements such as the Royal Train or trains carrying nuclear flasks.

6.3.4 Other interface requirements

As well as the information exchanged over it, the following aspects of the TM – Route Setting System interface need to be specified.

- **RAMS**
  Recommended for all TM – Route Setting System interfaces.

  The introduction of a TM to Route Setting System interface has the potential to adversely affect the RAMS of the Route Setting System. Measures need to be put in place to ensure that this does not happen.

- **Security**
  Desirable in an optimum TM – Route Setting System interface.

  The introduction of a TM to Route Setting System interface creates system access points through which a cyber attack could potentially damage safety related equipment (the Route Setting System) or cause disruption across a wider area (by disrupting the operation of a TM). Physical and cyber security requirements should be specified for the interface to ensure that both sides are adequately protected from cyber attack. Examples of such requirements includes isolated circuits, firewall protection and data diodes.

6.3.5 Other information flows related to interface

For an optimum TM – Route Setting System interface, it is desirable that both sides of the interface have to the following information.

- **Train consist data**

  Desirable in an optimum TM – Route Setting System interface.

  In order to conduct detailed safety / performance checks, the TM and Route Setting System would need access to good quality information concerning train consists: length, loading gauge, maximum axle load, traction type(s), on-board signalling system(s). Where such information is not provided by ETCS validated train data (fed to the Route Setting System and thence to TM), it will need to come from third party stock and crew management systems.

  As noted in section 6.3.1, such verification checks would require improvements in the quality of train consist data available to the Route Setting System, especially where safety related decisions are to be made using it.

6.3.6 Data and configuration management

For the TM – Route Setting System interface to behave as required, it is essential that both sides of the interface have a consistent pre-configured view of the railway that they are controlling. Specifically, the following need to be specified.

- **Interface Specification**
  Recommended for all TM – Route Setting System interfaces.

  A detailed interface specification defining message formats, protocols and interface specific configuration is needed to ensure messages sent across the interface are correctly interpreted.

- **Common infrastructure data model**
  Recommended for all TM – Route Setting System interfaces.

  Both TM and the Route Setting System need an accurate and up-to-date model of the railway that they are controlling in order to correctly communicate information to that railway between each other. To ensure this data model is consistent between TM and the Route Setting Systems (as well as other DR technologies that have need of such a model), it should be sourced from a common infrastructure data model that acts as the single source of truth for geographic data. Requirements for the common infrastructure model need to be specified as do processes for its generation, management and configuration into TM and the Route Setting System.

- **Interlocking constraints**
  Desirable in an optimum TM – Route Setting System interface.

  The TM, Route Setting System(s) and interlockings need to be configured with equivalent signalling interlocking constraints and topology:

  - *within the TM so that it doesn't generate unachievable plans;*
  - *within the Route Setting System so that if doesn't stress the interlocking by requesting routes that interlocking constraints prevent from being set (see section 10.2 of Ref. 3).*

  These constraints need to be consistent between TM and the Route Setting System and, crucially, with the signalling interlockings that implement them.

7 Optimal TM to Route Setting System interface

7.1 Functionality

Based on the analysis in section 6, an optimal TM to Route Setting System interface would support the functionality described below. It is recognised that the constraints of existing products, commissioned systems and funding will limit the extent to which this functionality can be comprehensively achieved in the near future. Nonetheless, this optimal interface functionality provides a proposed 'end goal' to guide future product and project development.

- **Link monitoring**
  It is recommended that a protocol / functionality be developed by which the TM and Route Setting System can determine when communications with the other have been lost. This enables the TM to identify when the Route Setting System is no longer providing it with up to date information. It also enables the Route Setting System to identify when TM is no longer communicating regulation / perturbation management decisions to it and hence its own regulation / perturbation management (if applicable) needs to be re-enabled.

- **Communicate current plan to Route Setting System**
  A fundamental part of the TM to Route Setting System interface is the ability for the TM to communicate a current plan to the Route Setting System that the latter then implements. Whilst this can be achieved using CIFs, as used by ARS to receive timetables from a timetable server, CIF is sub-optimal for realising the regulation and perturbation management benefits of TM:

  - it is unable to provide sufficient geographic precision to unambiguously specify all paths to be taken by trains or which specific signals trains should be held at to allow conflicting services to pass in front;
  - it has insufficient temporal granularity to effectively manage densely operated services.

  To realise an optimal interface, an alternative electronic timetable format should be developed better suited to the needs of Interfaced TM and the modern Digital Railway.

  Aside from the limitation of the CIF format itself, the way it (or an alternative format) would need to be used in a TM to Route Setting System has some important differences compared to its current use:

  - updates need to be much more frequent (every few minutes / fraction of a minute versus every 12 hours) and, to avoid excessive data flows, targeted to specific areas / service changes;
  - the duration for which a plan communicated from TM to a Route Setting System remains valid needs to be clearly defined;
  - updates need to be synchronised across all Route Setting Systems interfaced to the same TM;
  - the quality and completeness of stock information needs to be ensured.

- **Accept current plan**
  As described in section 6.3.1 and 6.3.3, it is desirable for the Route Setting System to communicate to the TM whether a current plan has been accepted having been checked for inconsistencies / ambiguities and compliance with constraints.

- **Constrain regulation and perturbation management in Route Setting System**
  To avoid the Route Setting System and TM planning or executing disparate plans, the TM needs to be in overall charge of regulation and perturbation management decisions. It is therefore desirable that the TM be able to constraint the extent to which the Route Setting System makes its own regulation and perturbation management decisions where such functionality exists. The extent of such constraints will vary according to specific geographies, frequency of communication between TM and Route Settings systems as well as the characteristics of the TM and Route Setting System products themselves.

  - Where status information provided to the TM and plan updates delivered by the TM are both sufficiently frequent, in relation to service headway, for the TM to promptly respond to changing operational circumstances then a high degree of constraint may be appropriate. For example, constraining the Route Setting System to only setting routes when certain trigger conditions are met. This is, however, subject to the TM providing consistent, unambiguous plans that accurate reflect the current state of the railway.

  - Where status exchange of information is less frequent and / or the plans provided by the TM are liable to contain inconsistencies / ambiguities then a lower level of constraint is appropriate. Inconsistencies / ambiguities in TM plans could arise, amongst other reasons, due to the limitations of the CIF format or the TM having incomplete information on interlocking constraints. In such scenarios, it is appropriate to grant the Route Setting System some freedom to make its own regulation / perturbation management decisions based on the intended plan received from the TM.

  - Intermediate situations also exist where Route Setting Systems do need to make their own regulation / perturbation management descriptions, but these must adhere to well defined constraints. For example: not changing the sequence in which trains pass over a specific conflict point.

- **Provide information to TM**
  To enable the TM to plan effectively, it is recommended that the Route Setting System provides the following information to it via the interface.
  - Train describer data with approximately equivalent functionality to the 'C' class data described in Ref. 7.
  - State of railway information received from signalling interlocking(s) (train detection occupancies, TRTS plunger states, signal states, etc.) with approximately equivalent functionality to the interlocking state data supplied using Ref. 8. Updates to be synchronised with other Route Setting Systems interfaced to the same TM.

  To optimise TM functionality, it is desirable that the Route Setting System provides the following status information to it via the interface:
  - ETCS position reports and validated train data (if available);
  - routes available to be set automatically;
  - trains that cannot be routed automatically.

7.2 Information flows

Figure 3 illustrated the information flows needed to realise the functionality described in section 7.1.

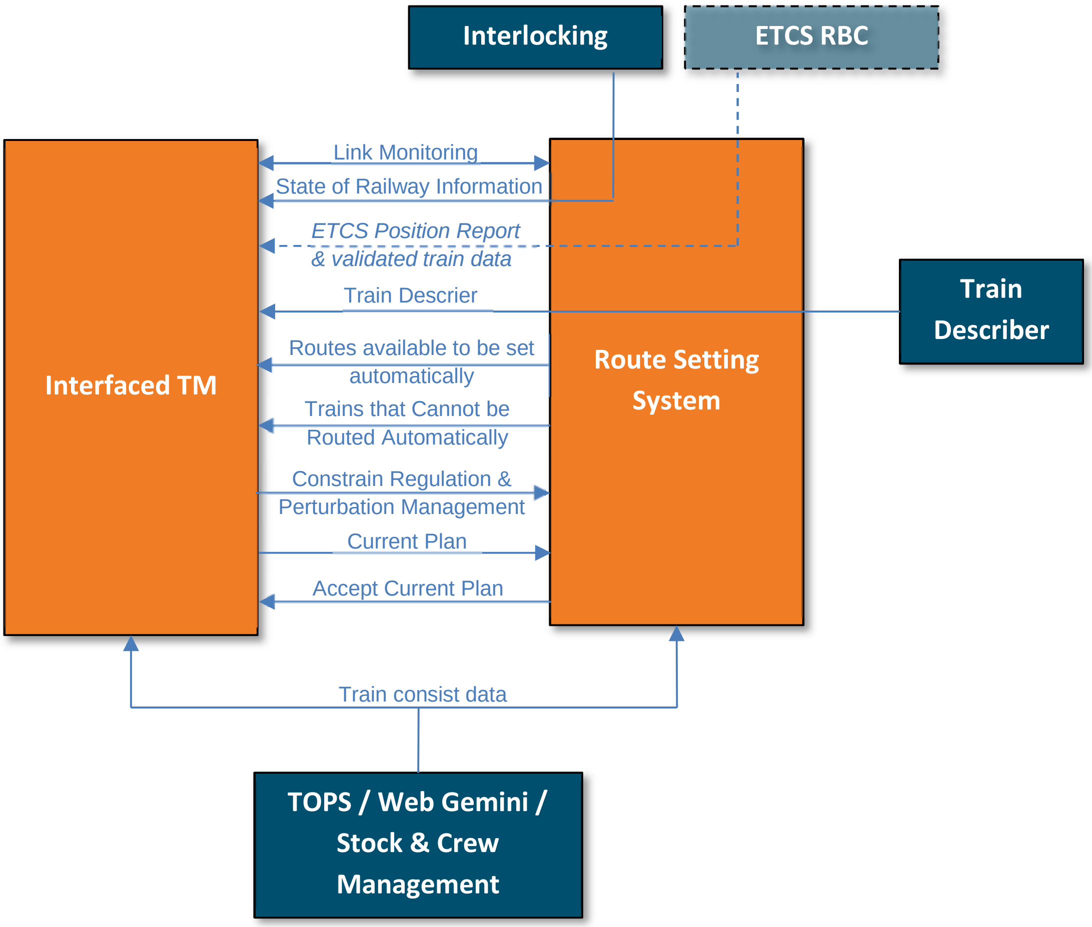

Figure 3 – Information flows

7.3 Configuration data

In order for the information flowing across the interface to be interpreted correctly on both sides, it is essential that configuration data is consistent between the TM and Route Setting System. Specifically, as illustrated in Figure 4, the following configuration data needs to be generated from common sources:

- interface specification defining message formats, protocols and interface specific configuration used;
- accurate and up-to-date map of the railway infrastructure, derived from a common data model;
- interlocking constraints on when routes can be set / which train paths are possible.

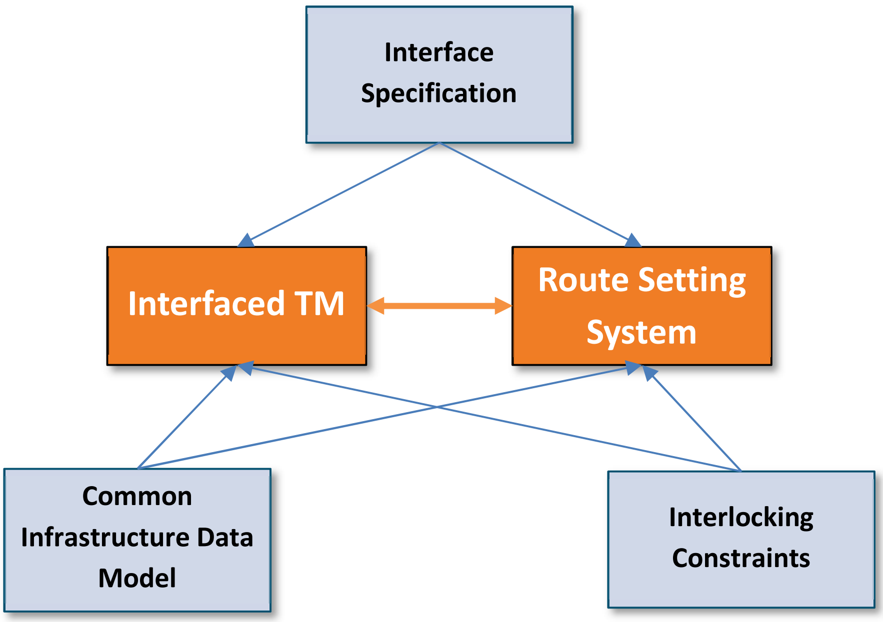

Figure 4 - Configuration

8 Practical steps for developing interface

Rather than attempting to develop a complete interface at once, potentially with little business case to do so, it is proposed that development be broken down into the following work packages in order of decreasing priority.

- **Conduct commercial assessment of the common interface**
  Digital Railway should conduct an activity to assess the commercial viability of achieving the objectives of the common interface dataset as a mandatory development activity. This is without prejudice to any of the additional actions below, but reflects repeated concerns arising throughout the course of this project.

  Compatibility between different suppliers is a good engineering practice and is endorsed by the JDG delivery team. However, it may be more commercially viable to seek other ways of ensuring this compatibility than mandating a 'plug and play' common TM to Route Setting System interface. A commercial assessment of the different methods for achieving compatibility could be realised as a cost benefit analysis that may inform what activities to take forward from the recommendations of this JDG.

- **Develop a TM migration strategy**
  Achieving the full potential of Interfaced TM, as envisaged by the optimal interfaced proposed herein, would require significant time and investment. There is, however, an urgent need for TM to deliver benefits in the immediate future. A migration strategy is needed to enable these immediate benefits to be delivered without adopting solutions that compromise the potential for greater benefits in future. This migration strategy should consider the extent to which a common interface is mandated or incentivised in each of the following cases:
  - new TM / Route Setting System deployments;
  - planned upgrades to existing TM / Route Setting System equipment;
  - existing TM / Route Setting System equipment for which no upgrades are otherwise planned.

- **Improve quality and precision of electronic timetable information**
  Electronic timetable information, currently in the form of CIFs, is used by many different systems. The benefits of improving the quality and precision of this information would therefore extend beyond those of the TM to Route System interface and hence investment in this work package would be easier to justify.

  As an initial step, the work package should focus on improving the information within existing CIFs as this would not require development to existing products:
  - *enabling more frequent, synchronised and targeted updates using CIF including definition of requirements for*
    - *acceptable update frequency per service,*

        - *acceptable update frequency for total updates and*
        - *maximum processing time;*
    - *developing processes to address missing / incorrect data, notably concerning stock / service associations;*
    - *resolving ambiguities over the location of 'TIPLOC' timing locations;*
    - *proposing additional TIPLOCs to provide greater granularity where possible within the constraints of the CIF format.*

  As a further step, the work package should develop a proposed successor to the CIF format that addresses the latter's shortcomings in terms of geographical precision and temporal granularity. Support for this new format could be built into future / upgraded products, providing a richer level of Interfaced TM functionality, whilst existing products could continue to operate using the existing CIF format.

- **Common infrastructure data model**
  Developing and maintaining an accurate and up to date geographic model of the railway infrastructure is essential, not only for the efficient deployment of TM and Route Setting Systems, but also for a whole host of other DR technologies: ETCS, Connected Driver Advisory System (CDAS), Automatic Train Operation, etc. The business benefits of developing it are therefore far wider than purely the TM to Route Setting System interface. Furthermore, it would not require changes to existing products.

  As an initial step, the work package should focus on defining the geographic data requirements for TM and Route Setting Systems (and other DR technologies where required): assets and track centre lines to record, attributes, spatial coordinate systems, location accuracy, time for which data is valid, quality requirements, processes to keep data up to date, etc. The work package should then identify synergies with other initiatives, such as Building Information Modelling (BIM) and ORBIS, and how they might be adapted to support DR data requirements. Finally, the work package should propose a strategy for resolving gaps in the data, whether that be on a project by project basis, as a national initiative or a combination of the two.

- **Interlocking constraints**
  Development of a comprehensive standard for specifying interlocking constraints, as applied to both the TM and Route Setting System, can mitigate the risk of the former generating unachievable plans and the latter stressing the interlocking with frequent, unsafe requests. As this information is already needed by TM and Route Setting Systems, no product development is envisaged to implement the findings of this work package.

- **Route Setting System to TM information flow**
  Standardised of information flows between Route Setting System and TM would require significant product development and alterations to existing products with benefits constrained to Interfaced TM. It is therefore a low priority activity, best targeted toward future upgrades / deployments of Route Setting Systems and TMs.

  If undertaken, the work package should develop data structures and protocols to communicate the following information:

  - train describer data [8];
  - state of railway information and how this is synchronised when provided by multiple Route Setting Systems [9];
  - ETCS position reports;
  - routes available to be set automatically;
  - trains that cannot be routed automatically.

  As part of this work, link monitoring functionality should be developed so that a TM can quickly identify when it is no longer receiving information updates from a Route Setting System.

- **Verification of current plans received from TM**
  Verification of current plans received from TM would require significant product development of Route Setting Systems and of the systems / processes that provide train consist data with benefits constrained to Interfaced TM. It is therefore the lowest priority activity, best combined with ETCS deployments that provide the necessary train consist information [10].

  If undertaken, the work package should specify the following:

  - functional requirement for checks carried out by the Route Setting System and analysis of the safety implications of such checks;
  - functional requirements for data validation requirements to be carried out by the TM;
  - protocol by which a Route Setting System accepts / rejects plans received from TM;
  - processes / technical interfaces via which the Route Setting Systems / TM are provided with sufficient, accurate train consist data with which to conduct the checks;
  - additional common infrastructure data model requirements to support the checks.

[8] A TM could potentially source train describer data via a number of methods. However, where other information is provided by the Route Setting System, it is desirable that train describer data also be provided with this information to ensure consistency and synchronisation. This may be achievable using Ref. 7.
[9] This may be achievable using Ref. 8.
[10] The dependency that ETCS places on correct train data for its safety critical braking calculations means that data quality issues would need to be addressed irrespective of the TM solution.

9 Conclusions

- The commercial case for developing a common interface for TM to Route Setting Systems is unclear given the small number of TM to Route Setting System interfaces likely to be encountered in practice in the UK. This is compounded by the facts that many Route Setting Systems, as well as several TMs, are already in service and hard to adapt to any new standard. It is also questionable whether the perceived benefits (encouraging consistency, allowing competition and innovation) justify the cost of developing and implementing an interface.
- Even if a complete interface specification is not worthwhile to develop and implement, more cost effective steps can still be taken to facilitate Interfaced TM deployment and maximise the benefits that can be realised from it:
  - adaptation of the CIF format for communicating timetables to make it more suitable for the needs of Interfaced TM;
  - improving the quality of geographic data available to Interfaced TM and other systems through a common infrastructure data model;
  - update of ARS+ specification to support addition of functionality to make new / upgraded ARS deployments 'TM ready;'
  - provision of the appropriate commercial framework to enable collaborative working between TM and Route Setting System suppliers for specific deployments so that success is less dependent on compliance to a common interface specification.
- Until the future path for SIL apportionment can be determined for an Integrated TM future, Interfaced TM projects must adhere to SIL functionality remaining in the Signalling Control / ARS layer, e.g. train consist data being checked within the Route Setting System to determine appropriate train path.

10 Recommendations

- The commercial issues associated with developing and implementing a common TM – Route Setting System should be assessed. This should be done from the perspective of establishing the validity of the approach, the way in which a common specification might be used (particularly to support procurement) and the consequential impact on the nature and content of such a specification.

- A TM migration strategy should be developed to enable the full potential of Interfaced TM to be realised through successive, achievable steps from current TM and Route Setting System technologies to future technologies that support a more functionally rich interface. This should included determining where, and the extent to which, a common interface is mandated / incentivised.

- A further working group should be set up to identify how current restrictions in the CIF format that prevent Interfaced TM achieving its full potential, when using CIF to communicate current plans, can be overcome.

- The (existing) ARS working group should review the proposed additions to the ARS+ specification described in this document with a view to incorporating them into future versions of the specification:

    - constraints of regulation and perturbation management functionality;
    - behaviour in the event of loss of connection to TM;
    - resolution of inconsistencies / ambiguities in current plan;
    - verification of safety constraints;
    - verification of performance constraints.

- The future safety functions of TM Integrated in combination with the JDG Common Interface Dataset review should be assessed for the best fit location (system wise). This should be mapped and then compared to potential European models where TM and signalling control / route setting solutions do not contain safety functionality, but rely on data integrity feeding these systems.

  Rationale: *to identify whether the shift from Interfaced TM to Integrated TM is only possible on the back of a potential future shift from current unreliable / coarse data (timetable, data model) in NR to high integrity data.*

- The above analysis should also take into account the general trend of migrating safety functionality into the Signalling Control Layer from the Interlocking layer. This may need some sub-analysis on the types of interlockings employed. This may also include a review of the safety case for the SIL4 interlockings to identify whether they contain any assumptions about the integrity of the control system.

- In addition, a study should be conducted assuming TM were to remain at an Interfaced status, asking whether functionality intended to be introduced from a Interfaced TM perspective, e.g. train consist data assisting in the verification of safety / performance constraints, could be done safely with the current data / systems.

  Rationale: *so that any updating of the ARS+ specification by the ARS working group (based on this report's recommendations) does not create a future blockage for the ability to migrate between Interfaced TM and Integrated TM.*

APPENDIX A: GLOSSARY

Abbreviation	Definition
ACI	Automatic Code Insertion
ARS	Automatic Route Setting
ATO	Automatic Train Operation
BIM	Building Information Modelling
CDAS	Connected Driver Advisory System
CIF	Common Interface File
DR	Digital Railway
DRP	Digital Railway Programme
ECI	Early Contractor Involvement
ECS	Empty Coaching Stock
ETCS	European Train Control System
FOC	Freight Operating Company
IJDG	Interim Joint Development Group
IRS	Immediate Route Setting
JDG	Joint Development Group
NR	Network Rail
RAMS	Reliability, Availability, Maintainability and Safety
RBC	Radio Block Centre
SIL	Safety Integrity Level
TM	Traffic Management
TOC	Train Operating Company

Abbreviation	Definition
TRC	Train Running Controller
TRTS	Train Ready To Start
VSTP	Very Short Term Planning

APPENDIX B: REFERENCES

Ref. No.	Title	Document No.	Issue / Version	Date
1.	Traffic Management System Definition	153821-NWR-REP-ESE-000004	1.0	29/03/2018
2.	VDU Based Signalling Control System	RT/E/S/10067	2	August, 2003
3.	Automatic Route Setting Specification	NR/L3/SIG/10120	1	1st Sep. 2008
4.	Understanding SIL	IRSE International Technical Committee Topic 38	N/A	October 2015
5.	Siemens WESTCAD-DCR Marketing Brochure	N/A	N/A	Downloaded Jan 2019
6.	**Human Factors Challenges of Automation in Railway Control** *by Michael Carey C.ErgHF FIEHF, Head of Ergonomics, Network Rail* European Rail Human and Organisational Factors Seminar	N/A	N/A	November, 2018
7.	Message Handling and Data Transmission between Processor Based Systems	RT/E/PS/00009	2	May 2004
8.	IECC Internal Subsystems Communications requirements	NR/SP/SIG/17503	1	June 1999

APPENDIX C: ANALYSIS OF ARS+ SPECIFICATION

Provided as a separate Excel spreadsheet.

Digital Railway

Working together for a better railway: