Reference	153819-NWR-PLN-ESE-000006
Issue/Ver:	2.0
Date:	26th March 2019

Digital Railway – Requirements Management Plan

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MB-26032019 Date: 26th March 2019

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DJN-28032019-0098 Date: 28th March 2019

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RNG-280319-0090 Date: 28th March 2019

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Electronic file reference: https://digitalrailway.ipss-hdms.co.uk/DigitalRail/Framework/default.aspx

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Version History

Issue	Date	Comments
0.1	17/01/2018	Initial Draft
0.2	30/01/2018	Updated to new requirement structure and new requirement governance
0.3	07/02/2018	Updated from peer review input from: Anders Moeller, Jonathan Evans, Arvind Bali, Thulasi Karunakaran and David Nicholson
0.4	12/02/2018	Updated from Tracey Best & David Nicholson input
1.0	13/02/2018	First Issue
1.1	22/10/2018	Updated to new requirement structure and hierarchy, and to include a new Section covering Timetabling Development Work
1.2	12/11/2018	Retitled DR RMP, updated to DJN comments, and changed adopt to the requirement structure.
1.3	21/12/2018	Updated to DRIIAT Level 2 Assurance comments
1.4	15/02/2019	Update to Ricardo Level 3 Assurance comments
1.5	15/02/2019	Update to RICMWG comments
2.0	26/03/2019	Updated Issue

Exclusions

These are no items currently missing from this version of the document that should be included in a later publication.

Assumptions

These are items upon which the validity of this document relies, and which will be delivered by others. However, it is assumed that NR's Requirements Management Database will hold all requirements and requirement sources to enable traceability.

Dependencies

There are documents upon which the validity of this document depends, and these have been identified with the 'RD' reference – *see* the References Section below. Any changes to a referenced document may require further changes to this document.

Content

Abbreviations and Definitions

Abbreviations are explained in full on first use within this document. A comprehensive list of abbreviations and definitions is contained in the Glossary [RI1].

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] System Management Plan, 153819-NWR-PLN-MPM-000002, Issue 8.0
[RD2] Outcome-based Generic Business Requirements for Digital Railway Technologies, 000000-NWR-PRG-MAN-000002, Issue 1.0
[RD3] DR System of Systems Integrated Concept of Operations, EB 000000-NWR-PLN-MPM- 000005, Issue 1.0 dated 15th May 2018
[RD4] System of Systems Architecture, 153819-NWR-DRG-ESE-000003, v5.0
[RD5] Basis of Design, 153819-NWR-REP-ESE-000002, v2.3

Informative References

These references have no material bearing on the content of this document, but are referenced in the processes. Unless otherwise stated, reference should be made to the most recent authorised version of the document.

[RI1] DR Glossary, 153819-NWR-SPE-ESE-000001, 153819-NWR-SPE-ESE-000001
[RI2] System of Systems (SoS) Requirements Specification, 153819-NWR-SPE-ESE-000003
[RI3] Digital Railway – GB Generic Customer Requirements Specification for ETCS Trackside, 153821-NWR-REP-ESE-000007
[RI4] Digital Railway – GB Generic Customer Requirements Specification for ETCS Onboard, 153821-NWR-REP-ESE-000008
[RI5] Digital Railway – GB Generic Customer Requirements Specification for Traffic Management Systems (TMS), 153821-NWR-REP-ESE-000011
[RI6] Digital Railway – GB Generic Customer Requirements Specification for Connected Driver Advisory System (C-DAS), 153821-NWR-SPE-ESE-000010
[RI7] Digital Railway – GB Generic Interface Requirements Specification, 153821-NWR-REP-ESE-000013
[RI8] Digital Railway – GB Generic Customer Requirements Specification for Operations & Maintenance, 153819-NWR-PLN-000014
[RI9] Digital Railway – System of Systems System Definition Document,153819--REP-DRP-ESE-000002
[RI10] No longer used.
[RI11] TMS System Definition Document, 153821-NWR-REP-ESE-000004
[RI12] C-DAS System Definition Document, 153821-NWR-REP-ESE-000005
[RI13] ETCS Onboard System Definition Document, 153821-NWR-REP-ESE-000006
[RI14] ETCS Trackside System Definition Document, 153821-NWR-REP-ESE-000007
[RI15] ERTMS/ETCS Baseline 3 Onboard Subsystem Requirements: Retrofit, RIS-0797-CCS
[RI16] ERTMS/ETCS Baseline 3 Onboard Subsystem Requirements: New Trains, RIS-0798-CCS
[RI17] ETCS - Baseline 3 – GB System Requirements Specification NEPT/ERTMS/REQ/0005
[RI18] ETCS - Baseline 3 – GB Trackside Sub-system Requirements Specification NEPT/ERTMS/REQ/0006
[RI19] ETCS - Baseline 3 – GB Onboard Retrofit Sub-System Requirements Specification NEPT/ERTMS/REQ/0007

[RI20] ETCS - Baseline 3 – GB Onboard New Trains Sub-System Requirements Specification NEPT/ERTMS/REQ/0038
[RI21] ETCS - Baseline 3 – GB Telecoms Sub-system Requirements Specification NEPT/ERTMS/REQ/0008
[RI22] ETCS - Baseline 3 – GB Operations Sub-system Requirements Specification NEPT/ERTMS/REQ/0009
[RI23] Traffic Management Requirements Specification, DR/TM/REQ/0003
[RI24] Interim System Requirements for Connected Driver Advisory System (C-DAS), C-DAS Requirements 153821-NWR-REQ-ESG-000001
[RI25] Interim Railway Undertaking (RU) Subsystem Requirements for Connected Driver Advisory System (C-DAS), C-DAS Requirements 153821-NWR-REQ-ESG-000007
[RI26] Interim Infrastructure Manager (IM) Subsystem Requirements for Connected Driver Advisory System (C-DAS), C-DAS Requirements 153821-NWR-REQ-ESG-000008
[RI27] Interim Exported Subsystem Requirements for Connected Driver Advisory System (C-DAS), C-DAS Requirements 153821-NWR-REP-ESE-000003
[RI28] DR Level B & C Requirements Management Plan, 153819-NWR-PLN-ESE-000001
[RI29] DR Customer System of Systems Requirements Specification Template, 153819-NWR-PRG-ESE-000001
[RI30] DR Customer System Requirements Specification Template, 153819-NWR-SPE-MAN-000001
[RI31] DR Customer Interface Requirements Specification Template, 153819-NWR-PRG-ESE-000002
[RI32] DR System of Systems Hazard Record, 147883-NWR-LOG-ESS-000001
[RI33] Commission Implementing Regulation (EU) No 402/2013 of 30 April 2013 on the common safety method for risk evaluation and assessment as amended by Regulation (EU) N°2015/1136
[RI34] DR Hazard Management Plan, 147883-NWR-PLN-000005
[RI35] DR Issues Log, TBD
[RI36] DR System Assurance Plan, 147883-NWR-PLN-ESS-000004
[RI37] System of Systems Acceptance Plan, 147883-NWR-PLN-ESS-000004 P01
[RI38] Systems and Software Engineering – System Life Cycle processes, BS ISO/IEC/IEEE 15288:2015
[RI39] The Digital Railway Strategy, April 2018
[RI40] ETCS Reference Design Topic A, Continuing Movement, CCMS No: 64363474 Version 3.0 dated 21st September 2016
[RI41] ETCS Reference Design Topic B, Operation in Possession, CCMS No: 64406798 Version 6.0 dated 22nd September 2016
[RI42] ETCS Reference Design Topic C, End of Mission, CCMS No: 64344605 Version 2.0 dated 27th September 2016
[RI43] ETCS Reference Design Topic D, Train Dispatch, CCMS No: 64344606 Version 2.0 dated 21st September 2016
[RI44] ETCS Reference Design Topic E, Stopping at an End of Authority (EOA), CCMS No: 64381686 Version 3.0 dated 29th September 2016
[RI45] ETCS Reference Design Topic F, Applying Speed Restrictions, CCMS No: 64406799 Version 3.0 dated 21st September 2016
[RI46] ETCS Reference Design Topic G, Starting, CCMS No: 64344608 Version 3.1 dated 25th October 2016
[RI47] ETCS Reference Design Topic H, Permissive Moves, CCMS No: 64344610 Version 3.0 dated 27th September 2016
[RI48] ETCS Reference Design Topic I, Attaching and Detaching, CCMS No: 64401416 Version 3.0 dated 27th September 2016
[RI49] ETCS Reference Design Topic J, Stopping Trains, CCMS No: 64401417 Version 3.0 dated 27th September 2016
[RI50] ETCS Reference Design Topic K, Changing Driver ID and TRN mid-journey, CCMS No: 64424605 Version 3.0 dated 27th September 2016
[RI51] ETCS Reference Design Topic L, ETCS Route Release, CCMS No: 64401418 Version 3.0 dated 28th September 2016

[RI52] ETCS Reference Design Topic M, Neutral Sections, Traction Changeover and Pantograph Management, CCMS No: 64401420 Version 5.0 dated 28th September 2016

[RI53] ETCS Reference Design Topic N, Entering ETCS, CCMS No: 64375796 Version 3.0 dated 29th September 2016

[RI54] ETCS Reference Design Topic O, Exiting ETCS (Leaving Level 2 and 3), CCMS No: 64381687 Version 3.0 dated 21st September 2016

[RI55] ETCS Reference Design Topic R, Boundaries, CCMS No: 64547689 Version 4.0 dated 21st September 2016

[RI56] ETCS Reference Design Topic S5**,** Degraded or Abnormal Working, Route Not Proved, CCMS No: 64528341 Version 5.0 dated 5th October 2016

[RI57] ETCS Reference Design Topic T, Inhibition of Transition to Levels 1-3 where driver not authorised to drive in those levels, CCMS No: 64375797 Version 5.0 dated 28th September 2016

[RI58] ETCS Reference Design Topic U, System Controls for Issue of Movement Authorities, CCMS No: 65030841 Version 4.0 dated 21st September 2016

[RI59] ETCS Reference Design Topic V, Provision of Routing Information, CCMS No: 64401415 Version 5.0 dated 21st September 2016

[RI60] ETCS Reference Design Topic Y, Miscellaneous, CCMS No: 64531861 Version 4.0 dated 21st September 2016

[RI61] ETCS Reference Design Topic Z, Non-trackside, CCMS No: 64444893 Version 2.0 dated 28th September 2016

[RI62] ETCS Reference Design Topic AA**,** Consistent Provision of Lineside Signage, CCMS No: 65029860 Version 4.0 dated 21st September 2016

[RI63] ETCS Reference Design Topic CC**,** Utilisation of Packet 44 in ETCS Areas, CCMS No: 64734109 Version 3.0 dated 21st September 2016

[RI64] ETCS Reference Design Topic EE**,** Key Management, CCMS No: 64623191 Version 2.7 dated 30th September 2016

[RI65] ETCS Reference Design Topic HH**,** Train Maintenance and Testing, CCMS No: 64609520 Version 4.0 dated 27th September 2016

[RI66] ETCS Reference Design Topic II**,** Balise Configuration Rules, CCMS No: 64609521 Version 4.0 dated 21st September 2016

[RI67] ETCS Reference Design Topic JJ**,** Level Crossing Operation and Protection, CCMS No: 64609522 Version 5.0 dated 28th September 2016

[RI68] ETCS Reference Design Topic KK**,** Transmission of National Values, CCMS No: 64724970 Version 3.0 dated 21st September 2016

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[RI71] TMS Reference Design Topic 2: Planning Functions, CCMS No: 66267720, Version 1.0, dated 03/11/2017

[RI72] TMS Reference Design Topic 03: ATO & C-DAS Interface to TMS, CCMS No: 66268338, Version 1.0, dated 17/11/2017

[RI73] TMS Reference Design Topic 04: Communications Capabilities, CCMS No: 66268280, Version 1.0, dated 07/11/2017

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[RI76] TMS Reference Design Topic 7: Alarms and Alerts Management, CCMS No: 66267684, Version 1.0, dated 22/11/2017

[RI77] TMS Reference Design Topic 8: Stock and Crew Interface, CCMS No: 66267704, Version 1.0, dated 10/11/2017

[RI78] TMS Reference Design Topic 09: Incident Management System Interfaces, CCMS No: 66268334, Version 1.1, dated 18/12/2017
[RI79] TMS Reference Design Topic 10: Customer and Business Information Systems Interface, CCMS No: 66268227, Version 1.0, dated 03/11/2017
[RI80] TMS Reference Design Topic 11: Conflict Identification and Resolution, CCMS No: 66268259, Version 1.0, dated 09/11/2017
[RI81] TMS Reference Design Topic 12: Forecasting, Simulation and Replay, CCMS No: 66268383, Version 1.0, dated 03/11/2017
[RI82] TMS Reference Design Topic 13: TM Systems Management (Performance and Administration), CCMS No: 66268324, Version 1.1, dated 05/01/2018
[RI83] TMS Reference Design Topic 14: HMI Configuration, CCMS No: 66267680, Version 1.0, dated 12/11/2017
[RI84] TMS Reference Design Topic 15: Lineside Asset Identification, CCMS No: 66268261, Version 1.0, dated 09/11/2017
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[RI86] TMS Specification Early Contractor Involvement Report, 148628-NWR-REP-MPM-000002, Issue 1 dated December 2017
[RI87] Early Contractor Involvement (ECI) 1.10 C-DAS Findings Report, Version 1.0 dated November 2017
[RI88] No longer used.
[RI89] Interface Management Plan, 153819-NWR-PLN-MPM-000004
[RI90] Security Management Plan & Framework, 000000-NWR-PLN-MAN-000009
[RI91] DR System Safety Plan,147883-NWR-PLN-MPM-000008
[RI92] DR Configuration Management Plan, 153819-NWR-PLN-ESE-000005
[RI93] DR Configured Item Change Management Process, 153819-NWR-PRO-ESE-000001
[RI94] Safety & Security Plan, 147883-NWR-PLN-MPM-000008
[RI95] Interoperability Compliance Plan, 147883-NWR-PLN-ESE-000001
[RI96] Systems Integration Plan, 153819-NWR-PLN-MPM-000005
[RI97] Security Strategy & Action Plan, TBD
[RI98] EMC Control Plan,147883-NWR-PLN-ESS-000002
[RI99] Human Factors & Ergonomics Plan, Ergonomics Integration Plan 148628-NWR-REP-EHF-000001
[RI100] Reliability, Availability and Maintainability Plan, 147883-NWR-PLN-ESS-000001
[RI101] System HSQE Plan, 153819-NWR-PLN-ESE-000008
[RI102] System Test Plan, TBD
[RI103] Operations & Maintenance Plan, 158875-NWR-PLN-OPP-000001
[RI104] Data Management Plan, 153819-NWR-PLN-EMG-000001
[RI105] Timetabling Requirements Specification, 153868-NWR-SPE-OPP-000001
[RI106] Digital Railway Requirements - Traffic Management System, 153821-NWR-SPE-ESE-000014
[RI107] Digital Railway Requirements - C-DAS Railway Undertaking Subsystem, 153821-NWR-SPE-ESE-000015-1
[RI108] Digital Railway Requirements - C-DAS Infrastructure Manager Subsystem, 153821-NWR-SPE-ESE-000015-2
[RI109] Digital Railway Requirements - ETCS Trackside, 153821-NWR-SPE-ESE-000016
[RI110] Digital Railway Requirements - ETCS Onboard, 153821-NWR-SPE-ESE-000017
[RI111] Digital Railway – Alignment of GB Generic Customer Requirements Specifications to Integrated Concept of Operations, 153821-NWR-REP-ESE-000010

1 INTRODUCTION

1.1 Purpose

Requirements are an expression of need, demand or obligation that are defined in unambiguous, clear, unique, consistent, atomic, and verifiable terms and which are necessary for stakeholder acceptability. Effective management of requirements increases the probability of a programme's success.

This Requirements Management Plan (RMP) describes the plan, processes, roles and responsibilities associated with the creation, development and ongoing management of Customer Requirements Specifications (CRSs) and Digital Railway Requirements (DRRs) within the Digital Railway Programme, where:

1. CRSs contain the 'Normative' and 'Application-Specific' 'What' requirements that can be tailored by Deployment Project Teams to enable the business benefits to be realised by Digital Railway (DR) technologies. These Customer Requirements must provide scope for innovation and creativity whilst meeting the overall needs.
2. DRRs define the 'Normative', 'Application-Specific', 'Preferred', and 'Generic Product' 'How' requirements that provide the constraints against which the CRS requirements may be validated.

Notes: 'Why', 'What' and 'How' are more fully explained in Section 3.1. 'Normative', 'Application-Specific', 'Preferred', and 'Generic Product' are more fully explained in Section 7.1.4.

Requirements Management provides the following benefits:

1. Completion of the linkage and traceability from the DR objectives and vision to the detailed outcomes and requirements.
2. Development of the right system(s) to meet the business demand and need. Systems Engineering follows the 'V' model system development and incorrect requirements could cause significant costs and delays.
3. A coherent 'whole' view that can be used to derive functional entities or elements and gain consensus on the requirements.
4. Co-ordinated 'Top-Down', 'Bottom-Up', and 'Horizontal' design.
5. Derivation of new systems architectures and validation of existing ones.
6. Facilitation of impact assessment when undertaking requirement change management.
7. Requirement configuration management.
8. Establishment of the qualification and acceptance process for each requirement.
9. Agreement of the key requirements.

1.2 Scope

The scope of this RMP covers the process for the creation, development and management of the Suite of Requirements that is described more fully in Section 2, but which comprises the System of Systems (SoS) Customer Requirements Specification [RI2] and the following Systems and Operations & Maintenance Customer Requirements Specifications:

- European Traffic Control System (ETCS) – Trackside [RI3] and Onboard [RI4]
- Traffic Management System (TMS) [RI5]
- Connected Driver Advisory System (C-DAS) [RI6]
- Interfaces [RI7]
- Operations and Maintenance [R18]

It also covers generation of the following Digital Railway Requirements:

- ETCS – Trackside [RI109] and Onboard [RI110]
- TMS [RI106]
- C-DAS – Railway Undertaking (RU) [RI107] and Infrastructure Manager (IM) [RI108]

The Interface Requirements document will cover the interfaces between linked projects both within the system boundary (e.g. TMS to ETCS Trackside) and across the system boundary (e.g. interfaced alarms and indications) (*see Figure 1*, below).

In addition, this RMP encompasses the process for the creation, development and management of other requirements developed under the Digital Railway Programme (DRP), such as Timetabling. It does not, however, cover the governance of these requirements; they will be owned and assured by others outside the remit of this RMP. Also, where the process undergoes changes from that described for the generic suite, these changes are identified in a separate section (e.g. Appendix: B for Timetabling Development Work).

The requirements suites will include functional, non-functional, process, data, and interface requirements.

This RMP supports the overarching systems engineering process defined within the DR Systems Management Plan (SMP) [RD1]. It includes the requirements activities that will be completed at DRP level.

The scope of this RMP covers:

- the requirements strategy and requirements structure;
- the processes for capturing, analysing and managing requirements;
- identification of the roles and responsibilities required to perform the various activities described within this plan;
- a definition of the tools to be used in supporting the requirements management process;
- an outline plan of when the requirements management activities must be performed within the context of the programme and project life cycles; and
- an outline of the work that will be required subsequently to develop the supporting project-specific DR Requirements, Standards and Policies.

1.3 Aim

The objective is to produce a set of generic CRSs and DRRs that constitute a suitable basis for inclusion within ‘Invitation to Tender’ and Contract documentation, yet which allows scope for innovation and creativity whilst meeting the overall needs. The CRS suite of documents comprises the SoS CRS as the parent, and child documents (both System CRS and DRR) that exist to allow independent procurement of the ETCS Onboard, ETCS Trackside, TMS, and C-DAS, along with Interface, and Operations & Maintenance specifications.

Functional and data requirements will to have their origin within a wide range of sources including: the Outcome-based Generic Business Requirements; the Concept of Operations; the Enterprise Architecture; existing Level B and C ETCS Onboard, ETCS Trackside, TMS, and C-DAS Requirement; and the ETCS and TMS Reference Design work. The requirements derived from these sources must be linked to their originating documents, with linking achieved within the requirements database.

Non-functional requirements (safety, security, etc.) and process requirements will have their origin within a wide range of sources including: the Plans being developed under SMP [RD1] governance; hazards, dependencies, caveats and issues; and the existing ETCS Onboard, ETCS Trackside, TMS, and C-DAS requirements. Again, the requirements derived from these

sources must be linked to their originating documents, with linking achieved within the requirements database.

The CRSs must be suitable for use by the supplier in developing their systems requirements specifications and delivering the resulting systems.

1.4 Exclusions

This RMP only sets the process for the creation, development and management of CRSs and DRRs. It does not cover the application-specific processes and procedures necessary for implementation of these requirements in support of a deployment, nor does it cover the creation and issue of the Generic Outcome-based Business Requirements [RD2].

1.5 Update Policy

This plan is to be reviewed regularly and updated, where required, as the programme progresses. In particular, the document may need to be updated:

- to incorporate any changes following review and consultation;
- to incorporate any changes to the requirements governance structure;
- to provide further detail on the requirements structure and process for deployments;
- prior to any stage gate review;
- prior to development of the DR Requirements, Standards and Policies;
- as required, when the parent document (SMP) is re-issued; and
- as required by the Head of System Requirements & Integration.

This document will be submitted for review and consultation in accordance with the process outlined in the SMP [RD1].

1.6 Governance

The DR systems engineering governance structure is defined in the SMP [RD1], which covers the systems engineering activities within DR. This RMP is subordinate to the SMP.

A cross-Industry Requirements, Issues and Configuration Management Working Group (RICMWG) has been established and, for Requirements, will:

a. make recommendations to the DR System Authority Chief Systems Engineer in the deployment and operation of the Requirements, Issues and Configuration Management functions to achieve its output;

b. provide cross-industry support for Verification and Validation (V&V) activities for DR System Requirements;

c. provide input, feedback and review evidence to the Rail Safety and Standards Board (RSSB) Standards Board on recommendations for DR Requirements to become standards;

d. support the validation of DR System Requirements by providing input, feedback and review of evidence on their suitability both prior to and throughout implementation; and

e. review, provide support for, and make recommendations on, the content of change requests.

A cross-Industry DR System Authority Systems Review Board (SRB) provides a peer-review group, established on the model of the System Review Panels, that will be used across the Industry for accepting new and novel products. The purpose of the SRB is to review and

recommend acceptance to the Duty Holders of the generic products produced by the DRP, and to review and recommend acceptance to proposers of proposed significant specific implementation variations to generic products produced by the DRP.

Thus, the Requirement suites will be created and continuously developed under SMP governance through adherence to the principles contained within this RMP. The output will be accepted by the RICMWG and the process by the SRB.

Note: None of this absolves the Deployment Duty Holder of their responsibilities.

2 CUSTOMER REQUIREMENTS ARCHITECTURE

2.1 System Scope

The Customer Requirements governed by this RMP are limited to the individual systems contained within the architecture diagram shown in *Figure 1* overleaf and the interfaces to linked systems both within and outside the boundary.

Notes:

1. This diagram presents the DRP's functional architecture. It shows the Infrastructure Fit & Rolling Stock Fit systems (as outlined in the DR System Definition Document [RI9]) and their functional inter-relationships; it is not intended to be read as a physical relationship diagram. Some other systems associated with this state's Enhancing Facilities and Required Enablers are shown where these directly enable or interface to the principal systems. It is supported by a Design Log, 153819-NWR-LOG-ESE-000002.
2. This diagram corresponds to a full deployment of DR systems, which, in practice, are deployed in accordance with the convention set out in the DR System Definition [R19].
3. Deleted
4. The need for each interface is supported by the Basis of Design [RD5].
5. The DRP is responsible for delivering requirements for those systems shown within the boundary only.
6. The relationships shown with a dotted line represent a system interfacing with the same system of a different area, which may be operated by a different IM.
7. The KMS, GSM-R Data, FTN(X), EULYNX, and LINX are Required Enabler systems which facilitate communications between other systems. LINX is principally a message broker system used to pass messages between Business Systems and TMS/C-DAS and between TMS and C-DAS. EULYNX and KMS are driven by open standards. EULYNX is a communication protocol as opposed to a system and is differentiated with a dashed border.
8. Deleted
9. The generic Trackside/Onboard Operator/Maintainer roles are integral to operations, but are currently shown in grey. This is because the interfaces between these roles and the systems are not presented, and the details of these interfaces are yet to be defined.
10. The interfaces of the Infrastructure and on-board Data Hub have been omitted. This system is expected to facilitate the distribution of configuration information, such as speed restrictions, to those systems which require it. It is shown in grey and marked with (#) as it is awaiting review by Subject Matter Experts.
11. The ETCS version assumed is BL3 R2 (Control, Command and Signalling Technical Specification for Interoperability (CCS TSI) set of requirements #3). This does not support interfacing to ATO. The inclusion of ATO will require an update to the ETCS version.

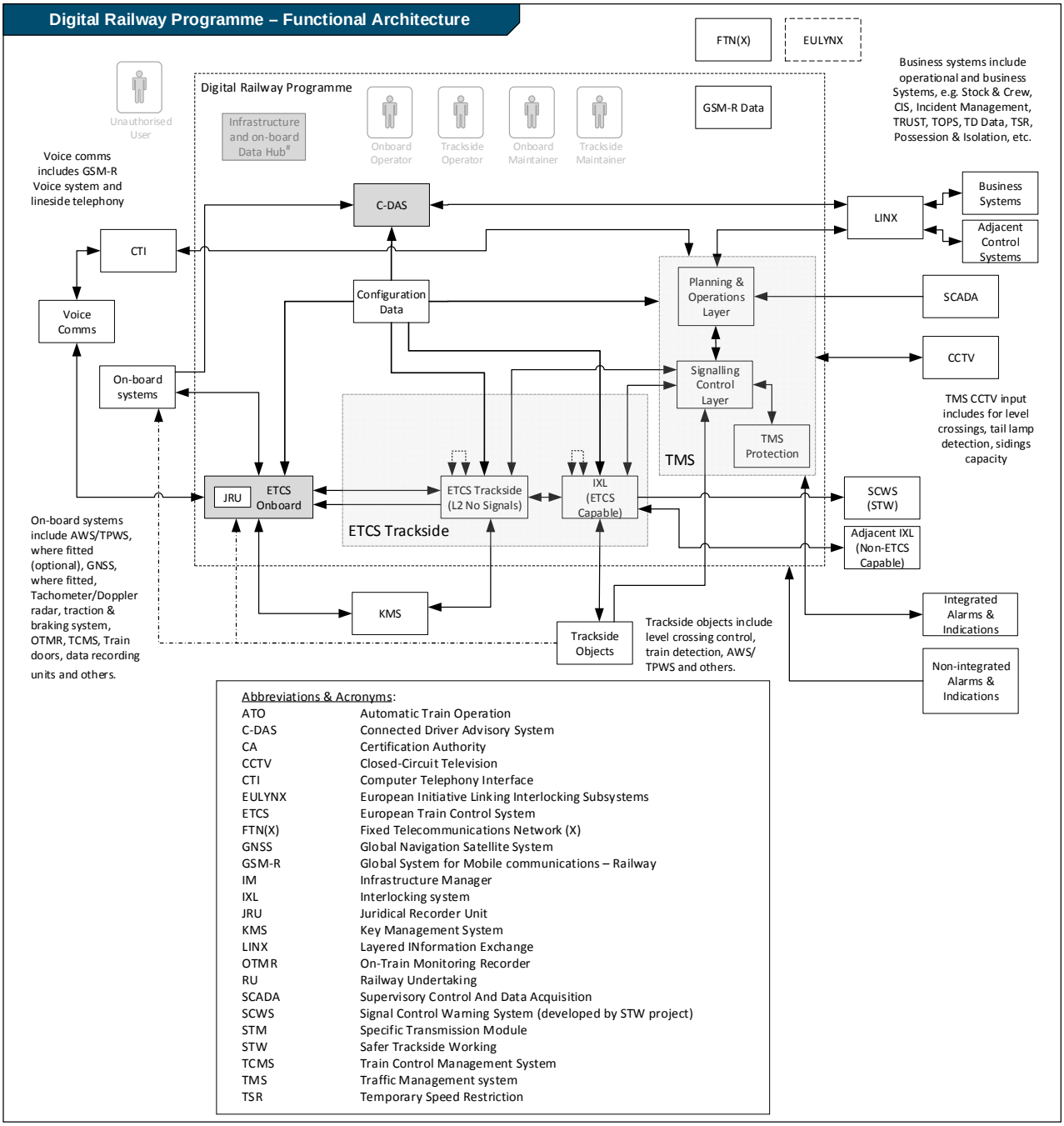

Figure 1 - Functional Architecture

Notes (continued…):

12. Deleted
13. The TSR Tool (part of Business Systems) is a required Enabler System which delivers essential functionality for the digital railway.
14. ETCS Trackside incorporates the functions of ETCS Trackside Level 2 (L2) No Signals and IXL.
15. The ETCS Onboard must continue to operate when the train is operating outside the boundary of a DR-fitted network. The interface from Trackside Objects is intended to

show Class B Systems which, optionally, go directly into an STM, a relationship already shown from on-board systems to ETCS Onboard.

16. Alarms & Indications interfaces can consist of those that are integrated into the DR Systems, or those that are supplied within buildings or on board the train for users to see and act upon, as required. Both types can result in a change to the workload for the user (e.g. train driver, signaller). Examples include Hot Axle Box Detector (HABD) (non-integrated).
17. ETCS Trackside (L2 No Signals) has two interfaces to the ETCS Onboard. The double-headed arrow represents two-way radio-based communications. The single-headed arrow represents balise transmissions.
18. There are three possible TMS configurations: Operational Decision Support Tool (ODST), consisting of the Planning & Operations Layer only; Interfaced, consisting of the Planning & Operations Layer with an interface to elements of the existing, conventional Signalling Control Layer, and Integrated, consisting of both the Planning & Operations and Signalling Control Layers. The integration of Alarms & Indications, CCTV, Configuration Data, and CTI with TMS will depend on the choice of possible configurations.
19. For the control/interface of the Automatic Warning System (AWS)/Train Protection & Warning System (TPWS) in Level NTC, the interface is either from trackside objects directly into the ETCS Onboard, or via on-board systems into the ETCS Onboard; this is determined by the Deployment Projects concerned and shown as a dotted interface.

Further details of the boundaries, including people and processes, can be found in the System of Systems Definition Document [RI9], supported by the individual System Definition Documents [RI11], [RI12], [RI13] and [RI14].

3 OVERALL REQUIREMENTS STRUCTURE

3.1 Basic Structure

DR Requirements are structured from the Generic Outcome-based Business Requirements using a ‘Why?’ ‘What? And ‘How?’ approach, as indicated in *Figure 2* below.

‘The three levels of requirements are:

- **Why? - Outcome-based Business Requirements**. These form the foundation of a Deployment Project Customer Requirements Document (CRD).
    - ‘Why?’ requirements describe the purpose behind the proposed change (why the digital technology upgrades are wanted).
- **What? - Customer Requirements for the SoS and individual Systems**. ‘What?’ Requirements are governed by this RMP.
    - ‘What?’ requirements describe the capabilities the industry wants from the deployment of Digital Railway technologies, and any constraints that may apply at the whole-railway level.
    - They describe the functional, non-functional and process requirements.
    - They fulfil the needs expressed in the ‘Why?’ requirements (i.e. that the benefits required will be achieved).

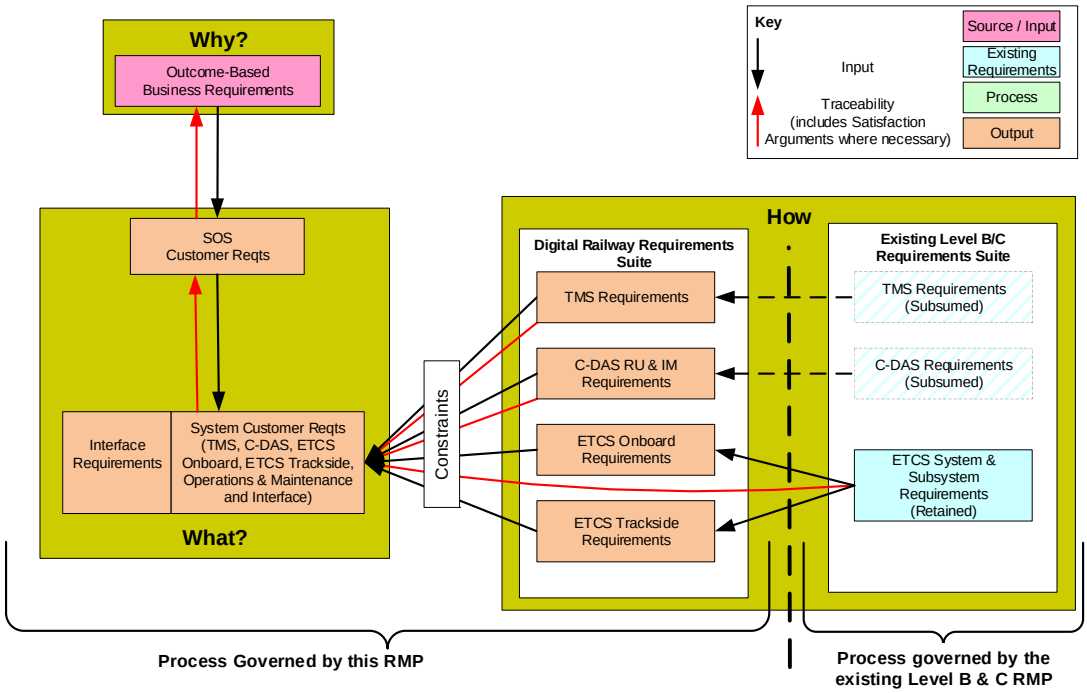

Figure 2 - DRP Basic Requirements Structure

- **How? - DR Requirements for the individual DR Systems**. 'How?' requirements have been developed from the DR Level B and C Requirements ([RI17] to [RI27]) that are governed by the DR Level B / C RMP [RI28][1].
  - 'How?' requirements specify constraints on the realisation and/or implementation under consideration.
  - They provide opportunities for business benefits to be realised.
  - They do not describe the full functionality of the sub-systems but are sufficient for integration / intra-operability. In other words, they do not prevent a supplier from providing an innovative solution, provided that it can be successfully integrated into the wider railway context in accordance with these constraints.'

Note: Deployment Guides covering the Customer Requirements and DR Requirements, including SoS and Operational & Maintenance Requirements, will be provided, as necessary, for Deployment Project Teams to implement their development, delivery and assurance activities.

[1] As explained in the DR Level B / C RMP [RI28], the lower-level requirements have been structured into three levels:

- Level A – 'System of Systems' (not produced)
- Level B – equates to system level (e.g. the complete ETCS [RI17])
- Level C – equates to sub-system level (e.g. ETCS Onboard [RI19] or [RI20])

3.2 Requirement Structure

The requirements management work is aimed at producing an SoS CRS document [RI2], supported by the following System documentation:

- ETCS Trackside [RI3]
- ETCS Onboard [RI4]
- TMS [RI5]
- C-DAS [RI6]
- Interfaces [RI7]
- Operations and Maintenance [RI8]

Note: The Interface Requirements document will cover the interfaces between linked projects both within and across the system boundary.

It also covers generation of the following Digital Railway Requirements:

- ETCS – Trackside [RI109] and Onboard [RI110]
- TMS [RI106]
- C-DAS – Railway Undertaking (RU) [RI107] and Infrastructure Manager (IM) [RI108]

Data requirements will be spread, as appropriate, across all requirements specifications. Those included within the Interface Requirements Specification will be in line with the interface details provided in the SoS Architecture [RD4].

System-specific People and Process requirements will be incorporated, as appropriate, within the appropriate CRS, but core requirements which apply to two or more Systems will be provided within an Operations and Maintenance Requirements Specification [RI8].

3.3 Relationship of the CRSs with the Business Requirements, Concept of Operations, DR System Architecture, and Basis of Design

The complete suite of CSRs has been derived from the Business Requirements [RD2], Concept of Operations [RD3], System Architecture [RD4], and Basis of Design [RD5], as indicated in *Figure 3* below.

3.3.1 Relationship with the Business Requirements

The Generic Outcome-Based Business Requirements DR Technologies [RD2] document is an all-embracing, structured expression of the highest-level Customer Requirements for the implementation of DR technologies on infrastructure and rolling stock across GB's rail network. It forms the baseline for DRP project development and has been used as the parent for the CRSs.

The Business Requirements determine the scenarios and use cases necessary to meet those aspects of the Business Requirements that can be addressed.

The scenarios and use cases derived from the Business Requirements, along with the output from the data model, are modelled within the Enterprise Architecture model to determine the Functional and Data requirements, as explained in the BoD document [RD5].

The aim will be to align every requirement within the CRS with a statement in the Business Requirements, noting that the Business Requirements contain very high-level statements that exceed the scope of the DR technology input.

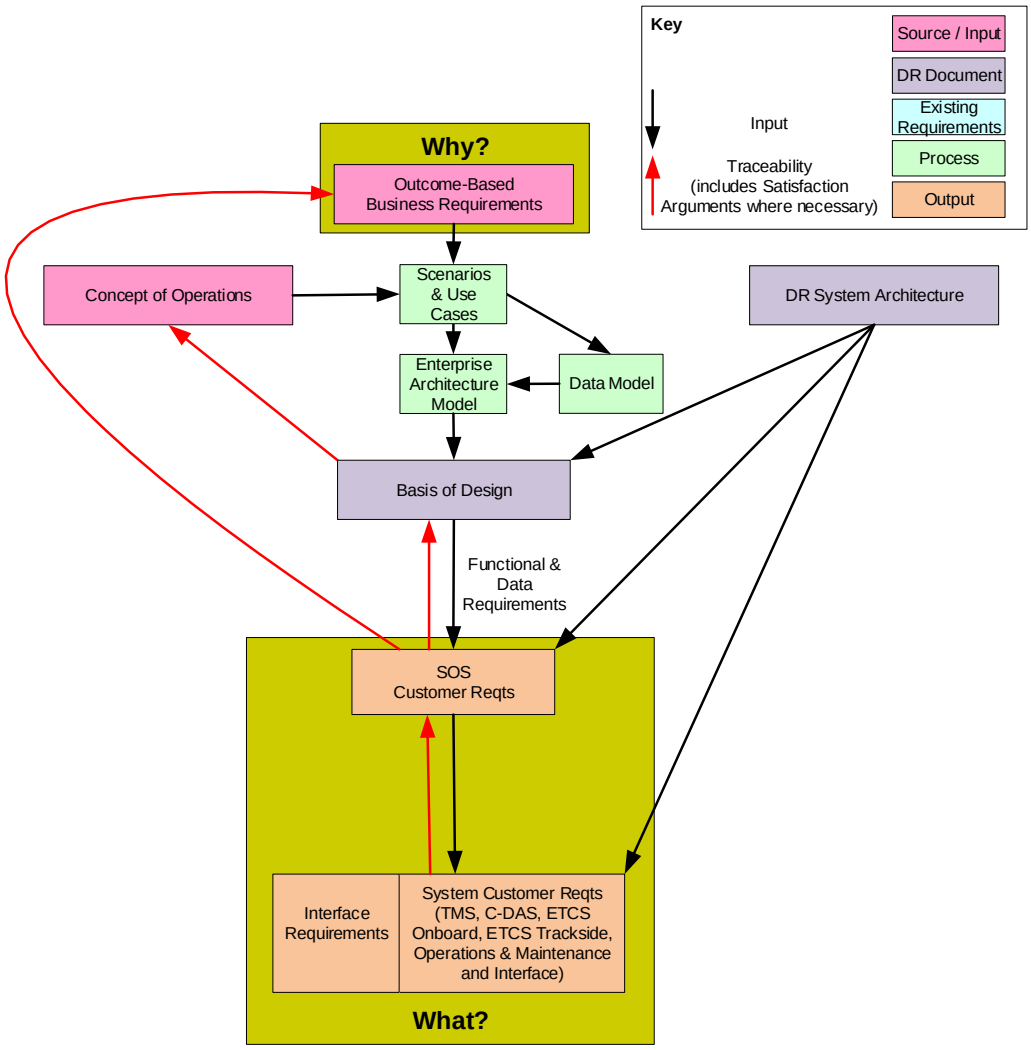

Figure 3 - Requirements Structure – Business Requirements to CRSs

3.3.2 Relationship with the Concept of Operations

The DR System of Systems Concept of Operations (ConOps) [RD3] describes the future state of the GB Railway following the introduction of the processes, technologies and organisational structures that fall within the scope of the DRP.

As with the Business Requirements, the scenarios and use cases derived from the ConOps, along with the output from the data model, are modelled within the Enterprise Architecture model to determine the Functional and Data requirements, as explained in the BoD [RD5].

The aim will be to align every functional requirement within the CRS with a statement in the ConOps documents through the BoD, noting that the ConOps documents contain operational statements that exceed the scope of the DR technology architecture. The alignment of the CRSs to the ConOps is contained within an alignment report [[RI111]].

3.3.3 Relationship with the System Architecture

The System Architecture document [RD4] provides the functional relationships between the constituent systems of Digital Railway Systems, as shown in *Figure 1* and described in the SoS

Systems System Definition Document [RI9]. This architecture bounds the scope of the CRS requirements.

3.3.4 Relationship with the Basis of Design

The BoD [RD5] aims to demonstrate how the SoS operates by taking the output from the scenarios developed in the Enterprise Architecture (EA) model, and thereby supporting the creation of the SoS Customer Requirements Specifications (CRSs). It also allows the apportionment of functionality to the different Systems, as expressed in the SoS Architecture [RD4].

The BoD generates the System functional and data CRS requirements.

Every functional requirement within the CRS will be linked with a section within the BoD.

3.4 Overall CRS & DRR Structure

The DR Requirements aim to provide a holistic and complete approach across the whole DRP, above any technology, organisation or implementation.

Figure 4, below, shows the overall CRS and DRR requirements structure and relationships.

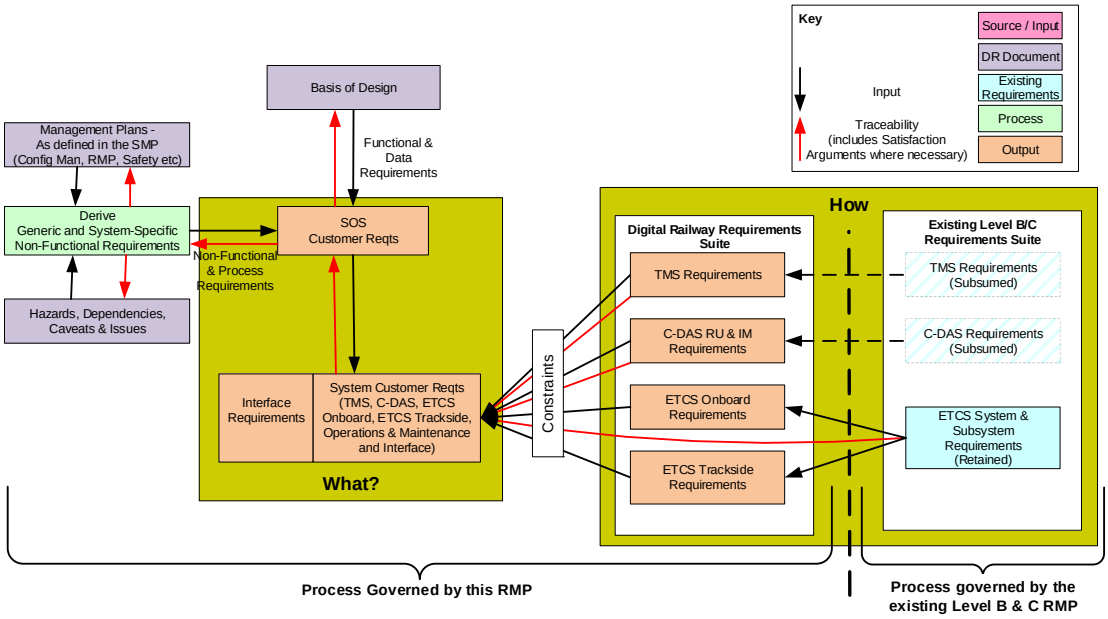

Figure 4 - Requirements Structure – CRSs to DRRs

3.4.1 SoS Customer Requirements Specification

Functional and data requirements are derived from the BoD [RD5] and linked back to sections within it.

The non-functional requirements will be derived from the plans being developed under the governance of the SMP [RD1], and from hazard, dependency, caveat, and issue work. In all cases, generic requirements will be apportioned to the SoS requirements, and System-specific requirements will be apportioned to the appropriate System requirements.

All requirements will be managed in the Dynamic Object-Oriented Requirements System (DOORS) database and will be linked upward to the BoD and the Business Requirements [RD2], and downward to the System CRSs to reduce the risk of duplication or omission.

The SoS CRS [RI2] will be created and published using the SoS CRS Template [RI29].

3.4.2 System Customer Requirements Specifications

The System CRSs [RI3] to [RI9] have been derived from work previously undertaken during the generation of the existing Level B & C requirements, as explained below.

All requirements will be managed in the DOORS database and will be linked upward to the SoS CRS and downward to the System DRRs to reduce the risk of duplication or omission.

The System CRSs will be created and published using the System CRS Template [RI30].

3.4.2.1 TMS

The TMS CRS [RI5] has been derived from the TMS Level B Requirements, version 1.7.1 [RI23] and the statements of need contained within Reference Design Topics [RI70] to [RI84].

3.4.2.2 C-DAS

The C-DAS CRS [RI6] has been derived from the Interim C-DAS Level B & C Requirements [RI24] to [RI27].

3.4.2.3 ETCS Onboard

The ETCS Onboard CRS [RI4] has been derived from the ETCS Onboard Level B & C Requirements [RI17], [RI19] and [RI20].

3.4.2.4 ETCS Trackside

The ETCS Trackside CRS [RI3] has been derived from the ETCS Level B & C Requirements, [RI17] and [RI18], and the statements of need contained within Reference Design Topics [RI40] to [RI69].

3.4.2.5 Operations & Maintenance

The O&M CRS [RI8] has been derived from workshops where the operations aspects of the C-DAS, TMS and ETCS Operations Level C Specifications [RI22] were considered.

3.4.3 System Digital Railway Requirements

The System DRR Specifications have been derived from work previously undertaken during the generation of the existing Level B & C requirements, as explained below.

All requirements will be managed in the DOORS database and will be linked upward to the relevant System CRS and downward, where applicable, to the Level B & C requirements to reduce the risk of duplication or omission.

The System CRSs will be created and published using the System DRR Template [RI30].

3.4.3.1 TMS

The TMS DRR Specification [RI106] has been derived from the TMS Level B Requirements, version 1.7.1 [RI23] but excluding requirements already incorporated within the TMS CRS.

3.4.3.2 C-DAS

The C-DAS DRR Specifications [RI107] and [RI108] have been derived from the Interim C-DAS Level B & C Requirements [RI24] to [RI27] but excluding requirements already incorporated within the C-DAS CRS. In addition, the existing four Interim Level B & C Specifications have been amalgamated into two: one for Railway Undertakings [RI107] and one for Infrastructure Managers [RI108].

3.4.3.3 ETCS Onboard

The ETCS Onboard Level C Requirements have been incorporated into two Railway Industry Standards (RISs): one for Retrofit [RI15] and one for New Trains [RI16]. The decision has been made to retain these Standards and use the ETCS Onboard DRR as a signpost only.

3.4.3.4 ETCS Trackside

The ETCS Level B & C Specifications covering the ETCS System [RI17], Trackside [RI18], and Telecoms [RI21] have been Industry-approved and the decision has been made to retain these Specifications and use the ETCS Trackside DRR as a signpost only.

3.5 Satisfaction Arguments

Where a linked requirement is satisfied by a number of lower-level requirements, but the identification of the contribution of each lower-level requirement is complex or unclear, then satisfaction arguments will be considered. Such arguments present, where appropriate, evidence that the DR Requirements, Standards and Policies satisfy the project CRS requirements, which then satisfy the SoS CRS requirements. Satisfaction Arguments may also be needed to show that the suite of requirements satisfies the originating documentation.

Satisfaction Arguments have been created for the SoS CRS in support of the Business Requirements. The Satisfaction Arguments for the other levels are being created and will be finalised when the overall requirements suite is sufficiently stable.

3.6 Hazards

Hazards will be identified at Hazard workshops (HazIDs). They will then be analysed and Hazard Reports raised. The overall output from this Hazard work will be a Hazard Record [RI32] that meets the needs of the Common Safety Method on Risk Evaluation and Assessment (CSM RA) [RI33]. The Hazard Record will be uploaded into a module within the Requirements Database.

The Hazard Record will then be used to identify safety measures, some of which will be addressed by emergent safety-related requirements. Traceability will be provided from the emergent safety requirements back to the Hazard Record within the Requirements Database.

The CRS is a Safety Requirements Specification as it contains safety-related requirements. However, it is the responsibility of subsequent Deployment Projects Teams to satisfy these requirements and ensure their own continued risk evaluation and assessment is undertaken.

Full details of the Hazard Management process are contained in the Hazard Management Plan [RI34].

3.7 Assumptions, Dependencies & Caveats

Assumptions, Dependencies and Caveats (technical and operational) will need to be identified, recorded and maintained throughout the project. Dependencies and Caveats may give rise to

requirements and these will be added to the CRS suite. Assumptions will not generate requirements, but must be recorded in order that the CRS has validity.

3.8 Issues

A log of issues (technical and operational) and associated 'working assumptions' [RI35] will be kept and maintained throughout the DRP.

As with Assumptions, 'working assumptions' will be validated by requirement satisfaction and the evidence used to resolve the Issue. As before, where a requirement that has been raised against a 'working assumption' does not confirm the 'working assumption', then the Issue will need to be re-assessed and either the 'working assumption' or the requirement may need to be amended.

4 PROGRAMME OVERVIEW

An integrated programme has been developed to plan for generation of the Requirement Specifications. This has adopted a staged approach, as shown in Figure 3, below:

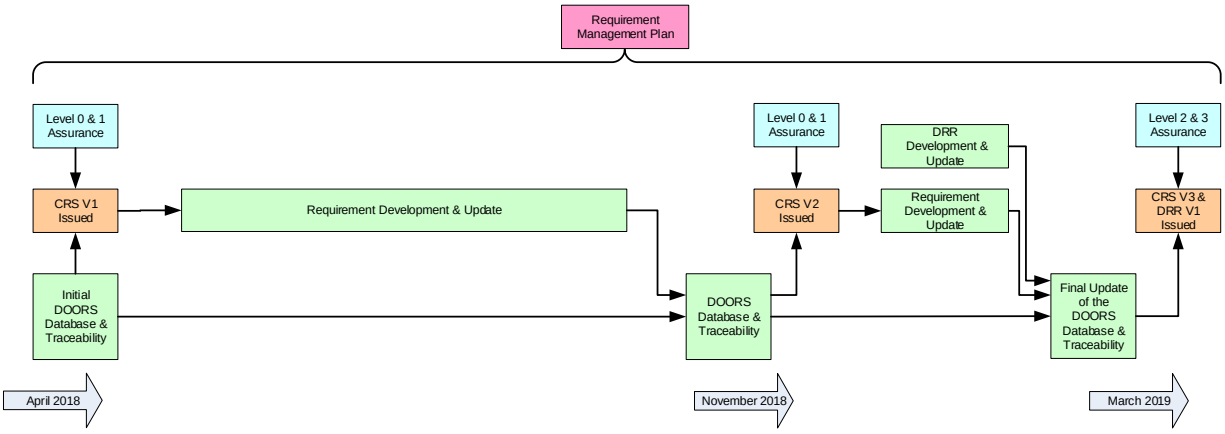

Figure 5 – Requirement Specification Delivery Plan

As explained in the SMP [RD1], assurance will be satisfied through the adherence to 'Levels', where:

Level 0 –	Dependent	Members of the SR&I team will provide self-assurance of individual Requirement Specifications.
Level 1 -	Dependent	The SR&I team will provide first-level day-to-day assurance, which will be indicated by the Approver signature on the Requirements Specifications.
Level 2 -	Independent	A separate DR team, independent of the SR&I team, will review the Requirement Specifications on behalf of the DRP.
Level 3 -	Independent	An external person or team, independent of DR, will review the Requirement Specifications.

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5 ROLES AND RESPONSIBILITIES

The generic roles and responsibilities for the implementation of this Plan are identified in the SMP [RD1] and shown in *Figure 6* below.

This section covers the specific Requirements Management roles.

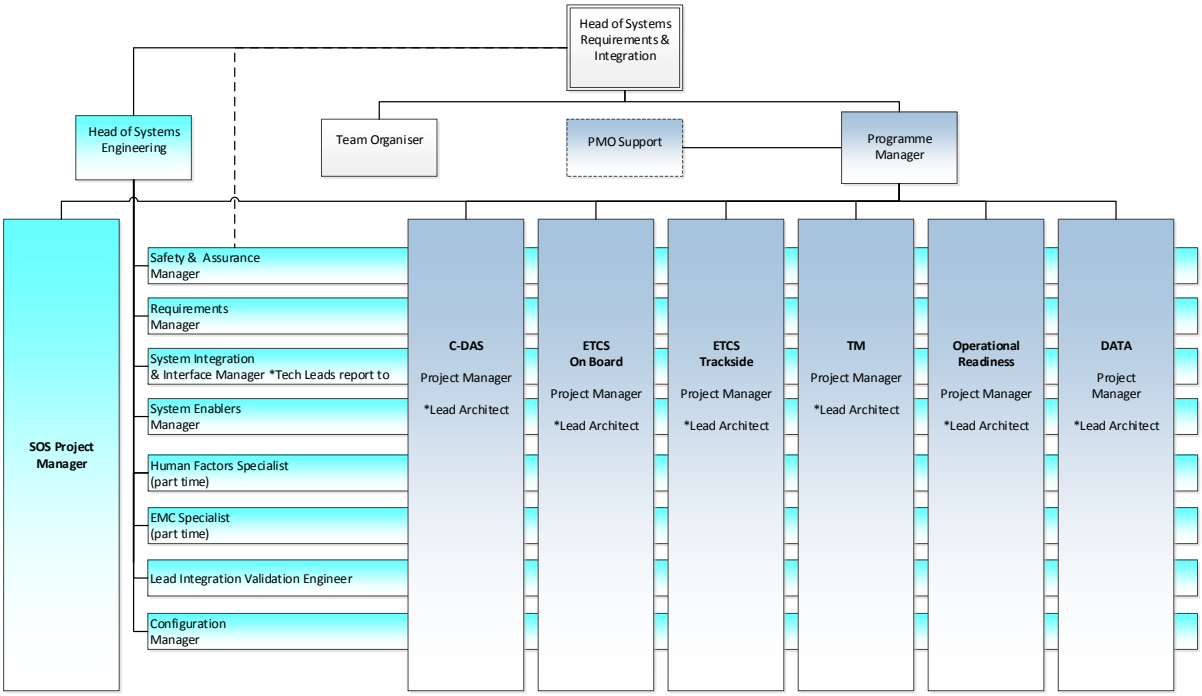

Figure 6 – SR&I Roles and Responsibilities

5.1 SR&I Requirement Management Roles

5.1.1 Requirements Manager

The Requirements Manager will be responsible for ensuring that all CRS requirements activities within the scope of this RMP are performed in accordance with this RMP, including:

- managing the requirements activities performed by the Requirements Team;
- producing and maintaining this RMP;
- managing DRP requirements on behalf of the project teams;
- ensuring requirements are managed within the governance structure;
- managing the DRP requirements management database (DOORS);
- assuring requirements to Assurance Level 0; and
- maintaining the schedule and priorities for Requirements Management activities.

5.1.2 Requirements Engineers

Requirements Engineers will be responsible for performing requirements engineering activities in accordance with the processes contained within this plan, and as directed by the Requirements Manager.

5.1.3 Database Manager

The Database Manager will be responsible for administering the requirements repository and providing support to the Requirements Manager and other database users. The Database Manager will be a competent database user with sufficient database access rights to control access for the repository users. The periodic archiving of modules within the requirements repository and creation of baseline sets is also the responsibility of the Database Manager.

5.2 Competence and Training

All personnel identified above will need to demonstrate competence in their area of involvement, in accordance with an appropriate Systems Engineering competency framework.

Before work is undertaken by a contractor, they will have to be assessed as having an appropriate level of competence, most probably, by the Requirements Manager, but possibly by another means. Evidence for compliance will be stored in accordance with the System Assurance Plan [RI36].

The Requirements Manager will be responsible for determining all competency and overcoming any shortfall through appropriate training.

6 GENERIC REQUIREMENTS MANAGEMENT PRINCIPLES

6.1 Requirements Management (RM) Basic Principles

Nine basic principles govern this RM process:

1. The capture of requirements is a unified process which successively refines and structures the requirements in a hierarchical fashion until an agreed specification of the output is reached.
2. A top-down approach means that projects can achieve integrity of design whilst making use of existing materials at the detailed level.
3. Requirements can be traced back to source documents and supporting information.
4. Requirements, Assumptions, Dependencies, and Caveats are recorded.
5. Conflicts between requirements are managed to achieve appropriate resolution.
6. A requirements database is used as the master source for the requirements and caveats, to manage change control and provide a detailed audit trail of changes.
7. Requirements documents are generated from the repository as the master source of the information.
8. Requirements are allocated specific attributes to allow subsets of the requirements to be extracted according to specific viewpoints (e.g. specific stakeholder views) and/or engineering disciplines (e.g. safety, performance).
9. Where possible, requirements are reused to minimise duplication of information.

Requirements Management is an iterative process in which emerging design and experience lead to better and more detailed requirements being developed.

The RM process must also make sure that:

1. the requirements in all areas are properly addressed, aligned, accurate, and complete;

2. any changes proposed by one workstream are properly assessed as part of the overall requirements development, and the implications for other aspects of the system are fully considered and communicated;
3. justification for requirements can be provided through the production of Satisfaction Arguments which can be traced back to source documents, where necessary; and
4. rationale or guidance does not contain wording that implies a hidden requirement and avoids use of the word 'ensure'.

6.2 CRS& DRR Principles

In addition to the standard principles, there are further principles that should be considered with each CR or DRR r such that they:

1. are a statement of a customer need or a constraint.
2. are generic.
3. can be integrated into the environment.
4. provide clear contractual obligations for suppliers.
5. provide essential process requirements to ensure a consistent national approach.
6. are worded in consistent and concise requirement language and nomenclature.
7. are structured to provide a requirement statement with appropriate cross-referencing to source material, along with a suitable rationale and guidance.
8. use appropriate cross-referencing to limit their extent (ideally, no more than one page per requirement).
9. incorporate a rationale that identifies: 'Why?', 'Who?', 'What for?', and constraints & essential detail.
10. relate to the clearly-defined system boundaries.
11. provide the context within which the requirement is set.
12. identify acceptance criteria that allow the requirement to be validated.
13. are either 'Normative', 'Application-Specific', 'Preferred', or 'Generic Product'.
14. are consistent in level with all other requirements throughout the requirement suite.
15. are consolidated to ensure that all requirements 'look and feel' the same.
16. specify any 'knowns' and identified 'unknowns'.

In addition to the standard principles, there are further principles to apply specifically to each requirement such that they should NOT:

1 be 'nice to have' – if it is NOT going to be missed, leave it out.

2 contain detailed and/or specific 'solutional' or supplier-specific product requirements – this inhibits any opportunity for innovation or creativity.

3 include bespoke requirements related to an Application's specific needs.

4 include requirements detailing methods of testing.

5 include requirements that a supplier would provide in their response to the CRS (i.e. within their System Requirements Specification).

6 include requirements covered by existing standards or processes as these would be covered within the contract statement.

6.3 Requirement Governance

The Head of System Requirements & Integration (SR&I) is responsible for approving the formal release of baselined CRS documents. Once approved, the requirements will only be changed through the Requirement Change Control Process described in Section 10.3.

The Head of Route Engineering & Integration will be responsible for working with the Deployment Project Teams in the use and application of the CRS documents.

The Head of SR&I will be responsible for the ongoing maintenance and update of CRS documents, including ensuring that deployment feedback on the requirements suites is actioned.

6.4 Requirement Assurance

As part of requirements assurance, requirements will be managed through adherence to process throughout their life, from creation to provision of evidence that shows that the acceptance criteria have been met, thereby satisfying the requirement and also confirming that the right system has been built (validation).

Assurance must be incremental and commence when the process itself. Full records must also be kept throughout. Progressive assurance evidence will be collated and presented at gate reviews – details of the evidence and quality of the evidence for such reviews will be defined in the System of Systems Acceptance Plan [RI37].

Requirements will be assured at four different levels, as explained in Section 4.

6.5 Quality Assurance

As part of the quality assurance of the requirements suite, an independent review by a specialist in both the English language and technical authorship is recommended. This will provide an opportunity for input on the following:

1 correct use of English – particularly useful in a multi-national team.
2 clarity of English – does it say what it means / is it in any way ambiguous?
3 consistent use of terminology – abbreviations and expressions.
4 commonality across the requirements suite – style and content.
5 consistent level across the requirements suite – to omit low-level requirements.

The initial input could be considered during the creation of the requirements (*see* Section 8.4), but is particularly valuable during Verification and Validation (V&V) of the requirement wording (*see* Section 8.8).

A document review, following the process described in the SMP [RD1], is recommended before the requirements are sent out for review. This will enable efficient use of external reviewers' time as they will not have to spend time correcting the English or trying to understand exactly what each requirement is saying/intended to cover. This process will also incorporate a check for the correct document template, document number, version, adherence to the document management process, etc. prior to issue.

A document review is also recommended as part of the final review before the requirements suite is issued.

It is also recommended that every Change Request (CR) raised that results in an amendment to the requirements or supporting information be reviewed before the CR is authorised.

6.6 Requirements Management (RM) and Common Safety Method (CSM)

There is a close relationship between the RM and hazard management processes, undertaken to support the requirements raised, through application of the Common Safety Method on Risk Evaluation and Assessment (CSM RA) [RI33]. The Hazard Record [RI32], containing Hazards and their mitigation, will be stored in a separate module within the Requirements database. Holding the Hazard Record module and CRS modules within the same database enables

traceability of linking. Additionally, all requirements have been created within the scope of their respective Systems Definition Document [RI9], [RI11], [RI12], [RI13] and [RI14].

7 REQUIREMENTS STRUCTURE

All requirements will be written to a common structure, as explained below.

7.1 Basic Requirement Form

All requirements are in the following form:

Safety

Requirement text.

Unique-Identifier

Source: Identifies where the requirement originated.

Status: Normative/Application-Specific/Preferred/Generic Product. (*See* Section 7.1.4 belo*w).*

Rationale: Shows applicability of the requirement, including why the requirement exists, who it is for, what industry benefit could be achieved, what the constraints are, and any other essential detail. Note: Cross-referencing should be used to avoid over-lengthy rationales.

Guidance: Supplementary information to support Requirement interpretation and satisfaction.

Topics: Reference Design Topics (if applicable). (*See* Section 7.1.5 below).

7.1.1 Safety Requirement

Where a requirement has been associated with a Safety Measure, this is identified and referenced to the hazard record number. (Note, the requirements marked as *Safety* in this document arise from the work on the Reference Design, hazard identification for the SoS is outstanding. For this reason, hazard identities are not included in this version)

7.1.2 Provisional Requirement (Level B / C only)

Where a requirement has been derived from a source that has not yet been fully authorised (e.g. ETCS Reference Design Topic that has not been issued as a Release Version), or where Industry discussion is still required (e.g. Tilt Authorisation and Speed Supervision (TASS)), then the requirement is identified at the start as '[Provisional]'.

7.1.3 Unique Requirement-Identifier

Each requirement will be identified uniquely. The requirement numbers will be generated when the requirement is entered into the Requirements database, which means that the requirement numbering may be neither sequential nor gap-free due to requirements having been moved or deleted.

7.1.4 Normative / Application-Specific / Preferred / Generic Product status

Each requirement will be identified as one of: normative, application-specific, preferred, or if applicable, generic product. These are defined as follows:

- Normative (applies to all CRSs and DRRs)
    - Necessary to achieve compatibility or optimisation of the system in relation to the GB rail network, or
    - A system feature that is deemed to be cost-effective and universally beneficial.

    Satisfaction of normative requirements in compliance with this document is expected to be a requirement of individual delivery contracts.
- Application-Specific (applies to all CRSs and DRRs)
    - A requirement which may not be relevant or applicable to every implementation of the system. It is expected that, where a requirement is applicable, it will be applied.

    Satisfaction of application-specific requirements in compliance with this document is expected to be a requirement of individual delivery contracts, as appropriate to the implementation being considered.
- Preferred (applies to some DRRs only)
    - A requirement of lower importance which, whilst not essential, the industry would prefer were satisfied. It is expected that, where a requirement is applicable, it will be applied.

    Satisfaction of preferred requirements in compliance with this document is not expected to be a requirement of individual delivery contracts unless explicitly specified within the relevant contract.
- Generic Product (applies to some DRRs only)
    - A feature required to enable all the Reference Design topics to be satisfied, and
    - Necessary to minimise future development of the product for other projects.

    Satisfaction of preferred requirements in compliance with this document is not expected to be a requirement of individual delivery contracts unless explicitly specified within the relevant contract.

7.1.5 Topics (Only where applicable, e.g. ETCS and TMS)

Some Level B & C Requirements suites have been derived from a Reference Design process. This process has broken down the overall system functionality into Topic areas to enable understanding of the principles involved and to obtain Industry agreement on the concepts. The Reference Design process has also been used to derive functional requirements.

Where functional requirements have been derived from the Reference Design process, the Reference Design Topic will be identified below the requirement. This also aids understanding of the requirement context.

The Topic references will be broken down further, where applicable, into Options and Variants, e.g. Topic N1-2 refers to Topic N, Option 1, Variant 2.

Where the Reference Design Topic has not yet achieved Release Version status, the requirements will be marked [Provisional] (*see* Section 7.1.2).

8 REQUIREMENTS ENGINEERING PROCESS

A Systems Engineering (SE) approach will be taken for requirements engineering in terms of functional, non-functional, performance, capacity, quality, usability, supportability, safety, and environmental requirements. This section describes the methods to be used to develop the CRS requirements suite.

8.1 Overview

Requirements development for the Digital Railway is based on the generic principles and processes defined within ISO 15288 System and Software Engineering – System Life Cycle Processes [RI38] but tailored to the DRP. Where the Digital Railway process directly maps to ISO 15288, only a summary is provided within this document. Where additional processes have been identified, these are described in more detail.

Requirements development is iterative; at each life cycle stage, the products of the previous stages need to be reviewed and any changes incorporated under change control.

Digital Railway is a complete business change programme covering Process, Organisation, Technology, and Information. Successful delivery of the capability is about more than just delivery of new technology and assets; it is about ensuring the coherence of all the elements that go together to create the DR capability.

The DR requirements process and artefacts, therefore, include all these elements:

- Process – Generation of new, or modification of existing, rules and guidelines for operating and maintaining the railway [Commercial practices];
- Organisation/People – Provision, within a suitable organisational structure, of sufficiently competent, trained people to operate and maintain the railway [Industrial relations, culture change, and behaviour];
- Technology – Provision of new or modified technology to achieve the required function and performance;
- Information Management and Configuration – Generation and configuration of data to support the deployment of the generic capability on different rolling stock and routes; and
- Toolset for managing requirements and processes.

The generic attributes to be used when capturing and managing requirements at all levels are defined in Section 7.1. Specific attributes appropriate to specific levels of requirements are detailed in the relevant Appendix.

8.2 Requirement Functionality

There will be two categories of requirement:

- Functional Requirements – These define what a system needs to accomplish, i.e. how suppliers' equipment will be applied, what it needs to do, and what processes, procedures and rules need to be in place to achieve that. These will also include:
    - Data Requirements – These define the information that needs to be received from other systems, and information that could be made available if required by other systems
- Non-Functional Requirements – These express constraints on the design or implementation, such as performance, security, competence, training, and reliability requirements. These will also include:

- Process Requirements – These define processes that will need to be implemented by the application projects, or their suppliers, in order to determine target values and / or establish the environment within which the system applied will need to work optimally.

8.3 Requirement Flow Diagram

*Figure 7**Error! Reference source not found.*** below illustrates the process for creating requirements.

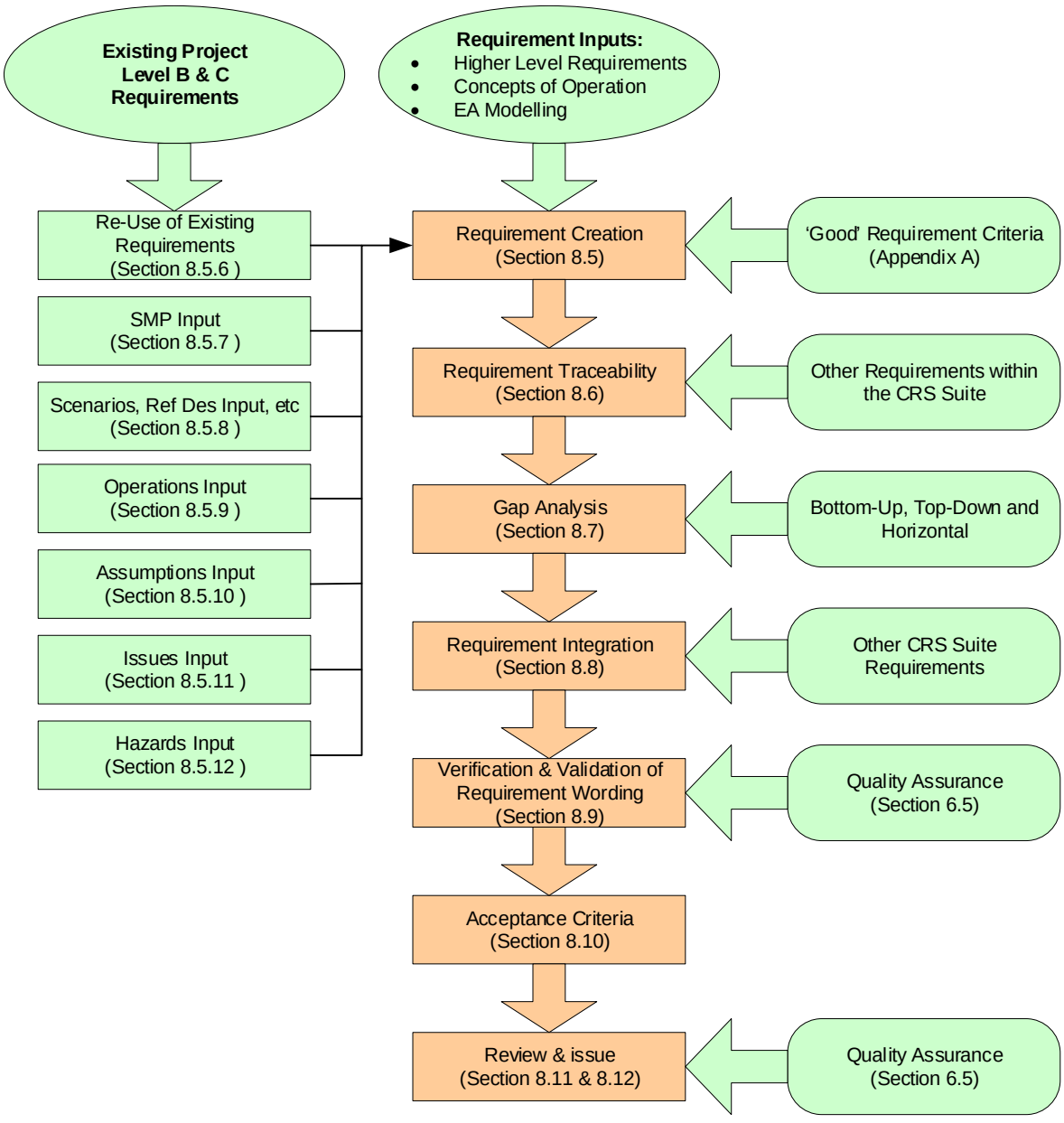

Figure 7 - Digital Railway Requirements Process Flow Diagram

8.4 Requirement Creation

Requirements will be elicited using a variety of techniques, including workshops, interviews, capability modelling, and from the document sources identified above.

As a result of successful implementation of the requirement creation process:

1 the requirements can be defined.
2 the constraints on a system solution can be defined.
3 traceability can be achieved.
4 validation needs can be identified.
5 assurance can be declared.

8.4.1 Input

Requirements will be derived from the following documents:

1 System Management Plan [RD1]
2 System Definition Documents [RI9] to [RI14]
3 Concept of Operations [RD3]
4 ETCS - Baseline 3 - GB Requirements Specifications [RI17] to [RI22]
5 ETCS Reference Design Topics [RI40] to [RI69]
6 TMS Requirements [RI23]
7 TMS Reference Design Topics [RI70] to [RI84]
8 C-DAS Requirements [RI24] to [RI27]
9 ECI Reports – ETCS, TMS & C-DAS [RI85] to [RI87]
10 SoS Architecture Document [RD4]
11 System Assurance Plan [RI36]
12 System of Systems Acceptance Plan [RI37]
13 Interface Management Plan [RI89]
14 Security Management Plan & Framework [RI90]
15 System Safety Plan [RI91]
16 Configuration Management Plan [RI92]
17 Safety & Security Plan [RI94]
18 Interoperability Compliance Plan [RI95]
19 Systems Integration Plan [RI96]
20 Security Strategy & Action Plan [RI97]
21 EMC Control Plan [RI98]
22 Human Factors Integration Plan [RI99]
23 Reliability, Availability and Maintainability Plan [RI100]
24 System HSQE Plan [RI101]
25 System Test Plan [RI102]
26 Operations and Maintenance Plan [RI103]
27 Data Management Plan [RI104]

8.4.2 Amend Requirement

The input item is unlikely to be written as a requirement (unless it has been derived from the Level B or C requirement suites) and is also unlikely to have the full complement of attributes

defined in the CRS Template documents [RI29], [RI30] and [RI31]. Therefore, work must be undertaken, as a minimum, to create the following:

1. Requirement Text – see Appendix: A – What Makes a Good Requirement?
2. Source
3. Rationale
4. Guidance

Note: The unique identity will be provided by the Requirements Management Team when the data is entered into the requirement database.

8.4.3 System of Systems, System or DR Requirement?

The aim must be to develop generic requirements that can be contained within the generic SoS set.

If a functional, non-functional, process or data requirement is specific to a particular system or group of systems, but not to all systems, then it will need to be included within the System Requirements set for that/those system(s).

8.4.4 Which System?

The identification of whether a requirement is generic or system-specific should also enable the identification of the particular set within which it should reside.

8.4.5 Reuse of Existing Requirements

Where possible, current assured requirements from existing sources should be used as the foundation upon which the new suite will be built.

The advantages of this are:

1. Reduction in overall workload by amending requirements rather than creating them; and
2. The possibility of Inherited assurance if the previously used requirement had already been assured and is intended to be used for the same purpose.

8.4.5.1 Reduction in Overall Workload

The requirements will already have been created and entered into the requirements database. All that is needed is to replicate them in a new module ready for amendment and / or update.

Amendment and update will be needed, but that involves less work than that needed for requirement creation.

8.4.5.2 Inherited Assurance

Requirements that have been developed through an authorised process and validated by an application have a level of assurance that could be transferred, although the implications of new standards or practices will need to be considered along with the impact of any change to the requirement wording or intent.

8.4.6 SMP Plans

Plans are to be developed to determine the non-functional and process requirements needed in some disciplines, e.g. configuration management, security, etc. These Plans are being developed through the governance of the SMP [RD1].

8.4.7 Reference Design Input

Some Level B & C Requirements suites have been derived from a Reference Design process. This process broke down the overall system functionality into Topic areas to enable understanding of the principles involved and to obtain Industry agreement on the concepts. The Reference Design process has also been used to derive functional requirements.

The principles used to derive the Level B & C functional requirements and the safety measures arising from the HazIDs, as contained within the Topic documents, may be pertinent to the creation of SoS, ETCS, or TMS System requirements and should be considered.

8.4.8 Operational Input

Operational input is essential to creating and capturing requirements and will be achieved via industry engagement and inclusion; this will give operational validity.

Requirements generated can be identified and then categorised into three distinct groups:

1. Requirements for the Rule Book and other Standards;
2. Training Requirements (for all operators); and
3. Functional requirements to be met.

8.4.9 Dependencies & Caveats Input

Dependencies and Caveats (technical and operational) may give rise to requirements and these will need to be added to the requirements suite.

8.4.10 Issues Input

Engineering issues (technical and operational) may also give rise to requirements and these will need to be added to the requirements suite.

8.4.11 Hazards Input

Hazards identified at HazID workshops may give rise to safety measures which result in requirements; these will need to be identified as safety requirements added to the requirements suite. *See* System Safety Plan [RI91].

8.5 Requirements Traceability

The requirements structure enables relationships to be established between requirements and other items, such as other requirements, safety measures, etc. These relationships make it possible to demonstrate why any requirement at any level is necessary by linking it back to a top-level requirement or a source document, noting that some processes may be bypassed, e.g. the Enterprise Architecture Model.

Traceability also enables impact analysis of changes anywhere within the requirements structure by identifying related requirements and allowing the impact of any change to be assessed.

8.6 Gap Analysis

'Bottom-up', 'top-down', and 'horizontal' analyses will be required to identify gaps and divergence. Any gaps identified will then be analysed to assess their impact and how they can be closed.

'Bottom-up', and 'top-down' analyses will also help to eliminate unnecessary lower-level requirements.

'Horizontal' analysis will help identify problems with interface requirements.

8.7 Requirements Integration

There is a danger that requirements could be developed in isolation without an understanding of the 'overall system' perspective. Consequently, it will be important to co-ordinate requirements development work.

Requirements integration work will be achieved by applying traceability linking (*see* Section 8.5 and contributing to the gap analysis (*see* Section 8.6). It will also prevent 'gold-plating', i.e. creating a requirement without a traceable justification.

8.8 Verification and Validation of Requirement Wording

Requirement wording V&V provides the 'quality control'. Although it is a step that must be undertaken on the final requirements document at each level within the requirements hierarchy, it should also be considered at interim stages in order to build confidence. This may form part of a quality assurance review (*see* Section 6.5).

8.8.1 Requirement Wording Verification

Requirement wording verification checks that:

- each higher-level requirement is addressed in more detail at the next level (decomposition); and
- each requirement at the lower level links to, and contributes to, full satisfaction of a requirement at the higher level.

Where requirements have been introduced at the lower level, this may be an indication of 'scope creep' or 'gold-plating', or an indication that the higher-level requirements are incomplete.

8.8.2 Requirement Wording Validation

Requirement wording validation involves review of the requirements set, taking account of aspects such as: completeness, consistency, meaningfulness, traceability, relevancy, viability, and acceptability. It will be achieved by issuing the requirements documents to a review group that has the expertise and competence to review the requirements at the given level. This review may involve a number of stages and may lead to further interaction with other steps in the requirements process.

8.9 Acceptance Criteria

Acceptance criteria for each requirement will be defined, comprising a statement of what the organisation responsible for delivering the necessary functionality (the delivery team) is expected to supply as evidence that the requirement has been satisfied.

The acceptance criteria to be used for validation (*see* section 10.4 below) will be stored in the requirements management database against each Requirement.

Usually, the acceptance criteria inspection, demonstration, test, and analysis should be sufficient, but experience may add to this list.

8.10 Requirement Review and Endorsement

Requirements need to be reviewed and endorsed before they can be issued; this process is covered within the SMP [RD1].

The Head of SR&I will approve the Requirements Suite for Industry use.

8.11 Issue

Customer Requirement Specifications can be prepared for issue once endorsement has been given by the Head of SR&I. They must contain an extract of the requirements from the requirements database as evidence that the specification contains the correct version of the requirements.

Once the document has been signed, it will be placed under formal configuration control, along with all the requirements in the requirements database.

9 REQUIREMENTS REPOSITORY

9.1 Overview

All requirements and associated source documentation will be captured and managed using a dedicated requirements management tool. The use of a dedicated tool means that there is a single repository for all requirements and that the repository is the 'single source of truth'. Requirements management tools enable relationships to be established between requirements at different levels and with differing original source documentation. These relationships provide traceability of requirements throughout the programme and enable impact and gap analyses to be performed.

9.2 Requirements Database (DOORS)

IBM's Rational Dynamic Object-Oriented Requirements System (DOORS) has been selected as the requirements management tool for the DRP. DOORS is designed to capture, link, trace, analyse, and manage changes to information to ensure a project's compliance with specified requirements and standards.

The Requirements Database will hold the following Modules:

- SoS CRS Requirements
- System CRS Requirements (separate ETCS Trackside, ETCS Onboard, TMS, C-DAS, Interface, and Operations and Maintenance)
- Links (to contain relationships between the Requirements within different Modules)
- Satisfaction Arguments
- Hazard Records
- Supporting Documentation

9.3 Generic CRS Requirement Module DOORS Attributes

The attributes to be contained within the repository are specific to each of the systems being deployed, but the generic database attributes are described below:

1. **Requirement ID** – A unique Identity (ID) allowing individual identification of the requirement within a document, and the document within the CRS hierarchy.

2. **Requirement Text** – The actual requirement text. This may be preceded with 'Safety' if there are associated Safety Measures.
3. **Requirements Source** – Where the requirement has originated. This may be clients' documents, Standards, etc.
4. **Requirement Status** – One of: Normative or Application-Specific
5. **Rationale** – Justification for the existence of the requirement and for any parameters specified within the requirement text. Also used to identify associated Safety Measures.
6. **Guidance** – Any additional information which provides clarification, context or indicative solutions.
7. **Acceptance Criteria** – The criteria against which the evidence will be assessed.
8. **Validation Method** – monitoring, client statement, supplier statement, etc.
9. **Analysis Notes** – Informal notes on any further work required in developing the requirement. Once the requirement is agreed, this field must have no outstanding entries.
10. **Audit Trail** – Captures the reasons behind any changes to the requirement.
11. **Requirement Maturity** – The status of the requirement in terms of maturity and approval for inclusion within the requirements set (Draft, Candidate, Confirmed, Traded, Cancelled, or Transferred).

Further attributes may be added, as required.

9.4 Export to Microsoft Office

DOORS supports the export of requirements sets to other formats, such as Microsoft Word and Excel, to enable the production of requirements specifications and reports. Where there is no access to DOORS, the requirements set may be exported to Microsoft Excel and viewed / updated offline. The data held within DOORS remains the master set and any changes are to be updated from the spreadsheet at the earliest opportunity.

9.5 Supply Chain

Where requirements are managed within the supply chain, use of a common toolset provides significant advantages in terms of information management and transfer.

DOORS web access will be considered for enabling organisations outside the DRP to view and update requirements and associated V&V attributes.

10 SUPPORTING PROCESSES

10.1 Requirement Configuration Management

This DR RMP complies with the Configuration Management Plan [RI92].

10.2 Requirement Baselines

Configuration management is essential in supporting controlled development of the requirements and enabling activities to progress against defined sets of requirements.

Configuration management of the requirements sets will be implemented through the use of baselines, which is supported by the DOORS requirements database. Baselines are a configured record of the requirements set at a defined point in time.

As a minimum, baselines will be generated:

- prior to any workshop or stakeholder review; and
- on formal issue of a requirements set.

Additional baselines may be generated at any suitable point, as determined by the programme or individual projects. Baselines can be produced for individual requirements sets or for groups of requirements.

10.3 Requirement Change Management

Requirements can, and do, change during the course of a project. All changes to a requirements set must be made in a controlled manner. Until the requirements have been baselined, a less formal process can be used since formal change control incurs a considerable administration overhead and should, therefore, be invoked only when a requirements set has reached a sufficient level of maturity.

Once a requirement set has reached a sufficient level of maturity and has been agreed and baselined, all requirements within the set will be subject to a formal change control procedure if a change is deemed necessary. This will enable impact analysis of any changes across the programme and ensure that formal requirement suites only contain approved requirements and that each party is working to the correct set of requirements.

All baselined requirements will be controlled according to the Requirement Change Control Process [RI93].

10.4 Requirement Verification and Validation

The application of V&V within the Digital Railway Programme is described within the System of Systems Acceptance Plan [RI37].

11 REQUIREMENT OUTPUT

The requirements management work aims to produce the following CRS and DRR Specifications, having undergone Industry review through the RICMWG and been assured to Level 3 Independent Assurance:

- System of Systems [RI2]
- ETCS Onboard [RI4] & [RI110]
- ETCS Trackside [RI3] & [RI109]
- C-DAS [RI6], [RI107] & [RI108]
- TMS [RI5] & [RI106]
- Operations and Maintenance [RI8]
- Interfaces [RI7]

These Specifications will contain functional and non-functional requirements, including those related to processes and data.

The following will also be produced:

- Hazard Record [RI32]

- Level 1 Assurance, evidenced through Approval signatures on the front page of the Specifications
- Verification Report

Appendix: A What Makes a Good Requirement

A 'Good' Requirement is generally in the form:

(Restricting clause,) Subject / shall / Verb / Object (* where appropriate)

e.g. ***Where required by the Business Case, the infrastructure / shall / support / bi-directional movements.***

Good requirements will have the following characteristics:

Table 1 - Requirement Characteristics

Non-Solutional	The requirement states the need and not how it will be satisfied.
Singular	The requirement addresses only one thing. If the requirement contains an 'and', then that is either because it has subordinate singular requirements or it should be two separate requirements.
Entire	The requirement has no missing information.
Complete	The complete set of lower-level requirements must fully meet the parent requirement. The requirements set is complete and no areas have been overlooked: functional, performance, operational, interface, environment, training, competence, availability, reliability, maintainability, safety, security, appearance, physical, and design.
Stand-alone	The requirement stands alone. The requirement may require repetition where reference is made to several sub-functions individually.
Consistent	Requirements must be mutually consistent, both in content and terminology. The requirement does not contradict any other requirement and is fully consistent with all authoritative external documentation.
Traceable	The requirement is clearly linked to a parent requirement or client need.
Identifiable	The requirement is uniquely numbered, including showing the level of the requirement in the hierarchy.
Current	The requirement has not become obsolete.
Feasible	The requirement can be implemented. Considering the environment and likely products, it must be possible to deliver to the requirements set.
Unambiguous	The requirement has one, and only one, interpretation.
Clear	The requirement avoids use of technical jargon, abbreviations and acronyms (unless well-defined and understood), ambiguous terms (e.g. minimise, as appropriate, etc., and/or, but not limited to), or other esoteric verbiage.
Factual	It expresses facts and not subjective opinions. Vague subjects, adjectives, prepositions, verbs, and subjective phrases should be avoided.
Positive	Negative statements should be avoided unless there is no alternative to retain the meaning of the requirement (e.g. 'The new equipment shall not interfere with existing equipment').
Well-Written	The requirement is grammatically correct and is consistent in use of terms.

Note: The requirements set should be just sufficient to meet the client's objectives, and no more, as every requirement has a resource overhead: drafting, reviewing, issuing, verifying, specifying, changing, satisfying, validating, and closing. Each individual requirement adds to the overall project cost, so reduce if possible.

Appendix: B Timetabling Development Work

B.1 Introduction

The timetabling requirements are being developed by Digital Railway and Capacity Planning to address the necessary changes to the timetable development process resulting from the introduction of Digital Railway technologies (TMS, C-DAS and ETCS).

Functional and business requirements are being developed to accommodate the changes needed to create a timetable fit for the operation of a digital railway, thereby complementing the System Operator capacity planning strategy.

The documented requirements will then be embedded into Capacity Planning's strategy for change throughout CP6, and within proposed schemes planning to implement a Digital Railway. This will include creation of a Business as Usual (BAU) process and governance structure by which these requirements become mandatory for future schemes that are not in development when the Timetable Development Project closes.

B.2 Requirements Management Process

Timetabling requirements creation and management will follow the generic processes identified within this RMP, with the exception of the following:

1 The timetabling requirements will be spread, as appropriate, across all requirements specifications (SoS, Systems and Interfaces), but the core requirements will be provided as separate output in the form of a Timetabling Requirements Specification [RI106]

2 The Timetabling Requirements Specification will undergo a separate approval and acceptance process to that outlined in section 6.3. The Head of SR&I will, however, approve the requirements for integration within the DR technologies systems (e.g. TMS, C-DAS and ETCS).

B.2.1 Scope of the timetabling requirements

Timetabling requirements will encompass data requirements and process requirements as follows:

Traffic Management

- Provision of a clear statement of TMS requirements for an operational timetable and the undertaking of a gap analysis on these requirements against the 'as-is' state, as well as production of a proposed delivery plan to close the gap at industry level. This is expected to include, but will not be limited to: a review of the contents, completeness, and format of data supplied in the Common Interface file (CIF) and how this compares to the data required to operate the TMS.
- Definition of the TMS requirement for train association data and the undertaking of a gap analysis against the Capacity Planning existing capabilities and the Station Working project specification for train associations. The DR Requirements, Issues and Configuration Management Working Group (RICMWG) will review this prior to its inclusion in the Digital Railway requirements suite. Once reviewed, the group will provide the output specification to TMS suppliers to ensure that the TMS can exploit the same association data that is available from the output of the planning process.
- A clear and consistent definition of a 'conflict' for Digital Railway systems. The undertaking of a feasibility study on the identification and resolution of these conflicts in timetabling and operations when operating under digital railway technologies. This

will include an assessment of the level of conflict that the TMS can accept within the timetable before it fails to fulfil its function.

- Undertaking of a feasibility study to resolve how the TMS can feed real-time train running information back into the timetable planning life cycle in order to improve the timetable plan. This will include an assessment of the benefits available and articulation and quantification of risks, such as timetable resilience.

ETCS

- Development of a modelled understanding of how the railway will operate under ETCS, for example, data required to calculate braking curves. This will allow Capacity Planning to develop concept timetables and test whether the Routes' digitally-enabled train service aspirations are achievable.

TMS & ETCS

- Alignment of timetable data changes with the ConOps. Undertaking of an impact assessment against all identified gaps between DR and Current Plan data requirements to articulate the impact if the gap cannot be resolved. The group will provide recommendations on ways to resolve any gaps.

B.2.2 Process

TMS & ETCS

- Identification of the required changes to the timetable planning process in order to enable realisation of the benefits of a digital railway. These changes will be assessed against the Digital Railway ConOps for timetabling. It is anticipated that data requirements captured in the proposed work package will drive most of these process changes.
- Documentation of the impact of the changes to, or input within, the timetable process (including process and data) on the performance process and systems.
- DRP support of close industry working in order to ensure necessary contract changes are defined, consulted and implemented.
- Documentation of the implication of proposed changes to timetable processes by the DRP, outlining the effect of these in the context of frameworks/Network code.

Traffic Management

- Feasibility study to be conducted on improving timetable precision using Traffic Management, including the assessment required in accordance with the Code of Practice for the Management and Development of Railway Code Systems of the impact of this precision on upstream and downstream legacy systems such as TRUST, ARS and TOPS, etc.
- Confirmation of assumptions as to how TMS dynamic timetable optimisation, prior to the day of operation, can gain industry agreement and stay within Part D of the Network Code.

Digital Railway

Working together for a better railway:

Department for Transport

Rail Delivery Group

National Rail

NetworkRail

RFG Rail Freight Group

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