Interim Infrastructure Manager (IM) Subsystem Requirements Specification for Connected Driver Advisory System (C-DAS)

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Date: 06/06/17

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Date: 13/06/17

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Scope Identification

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1 Introduction

1.1 Overview

1.1.1 Background

A Driver Advisory System (DAS) is a tool to help improve the information available to the driver so as to aid efficient operation of the train. Its use originated in the heavy haul freight sector where long heavy trains, travelling long distances between recessing opportunities or passing loops, could gain significant benefits by optimising arrival times and running speeds. More recently its use has spread to passenger fleets.

Three variants of DAS are being considered on the GB railway:

- Standalone DAS (S-DAS) is a driver advisory system which has all data downloaded to trains at or prior to journey start. Product support for S-DAS is already established and examples are in use on the GB railway as part of passenger operations.

- Networked DAS (N-DAS) is a driver advisory system which can communicate with an RU facility capable of providing updates to train schedule and/or routing information and (in certain cases) to speed restriction data. Product support for N-DAS is emerging, and examples are in use on the GB railway as part of passenger operations.

- Connected DAS (C-DAS) is a driver advisory system with a communications link to and from each area’s Traffic Management System. This variant supports Traffic Management’s train regulation activities through the provision of schedule, routing and speed restriction updates to trains, and also receipt of information from trains. In an area not controlled by a Traffic Management system, C-DAS will operate with initial data (as per S-DAS), or with the most recent updates received from a Traffic Management or from an RU facility (i.e. as per N-DAS). Products for C-DAS are beginning to be developed and are expected to be rolled out on the GB railway over the next few years.

1.1.2 Benefits of DAS

Any DAS implementation (S-DAS, N-DAS, or C-DAS) would be expected to deliver benefits in the quality, cost and efficiency of train operation, while still meeting all times specified in the schedule.

With S-DAS the expected benefits are:

- Improved Safety
  - Train regulated to the working timetable encountering fewer restrictive signals
  - Overall lower sectional running speeds
  - Advance warning of locations where speed restrictions change
  - Lower approach speeds to PSRs / stations / known conflict points with extended coasting
  - Reminder of next station calling point, thus reducing missed stations / overruns

- Improved fuel efficiency (up to 15% reduction on diesel trains)
- Improved capture of delay attribution data
- Reduction in wear and tear
  - Reduced braking / lower speed
  - Lower running speeds.

However benefits are not realised unless trains are on schedule (or nearly so), i.e. typically ~75% of passenger journeys on major routes.

With C-DAS the expected benefits are all of those anticipated for S-DAS and in addition:

- Improved recovery from disruption (due to ease of communicating revised schedule to trains)
- Train regulation to revised schedule
- Support for regulation to optimise for network capacity or performance (based on fewer delays due to red signals)
- Support for improved conflict resolution (based on trains’ predicted running)
• Fuel savings potentially on nearly 100% of journeys
In addition, both S-DAS and C-DAS variants will potentially support future anticipated requirements to optimise energy consumption based on locally available electrical power or power tariffs.

1.2 Purpose
The purpose of this document is to capture the Interim subsystem requirements allocated to the Infrastructure Manager (IM) subsystem of a Connected Driver Advisory System (C-DAS) so as to inform C-DAS procurement for forthcoming franchises.

1.3 Scope
This document is the Interim IM Subsystem Requirements Specification for a Connected Driver Advisory System (C-DAS) which is capable of operating in cooperation with the Traffic Management system being developed for the GB Digital Railway. It forms part of a set of requirements and supporting documents:

1. C-DAS System Requirements
2. C-DAS RU Subsystem Requirements (RU Trackside + Onboard elements)
3. C-DAS IM Subsystem Requirements (IM Trackside element) - this document
4. C-DAS External Interface Requirements [RD22]
5. C-DAS IM-RU Interface Specification [RD11]
7. C-DAS Assumptions Register [RD26]
8. C-DAS Hazard Record [RD24]

The C-DAS requirements set has been developed in accordance with the process laid out in the C-DAS Requirements Management Plan [RD23]. Every effort has been made to ensure that the requirements are supplier and product agnostic, to allow for the maximum flexibility in how requirements are met.

This version of the document is limited to C-DAS operations involving multiple unit train sets which are not-ETCS fitted; a later version will include also requirements relevant to C-DAS operation on ETCS fitted trains, and to variable formation trains both ETCS fitted and not ETCS fitted.

1.4 Exclusions and Requirements Status
This Interim version of the document is limited to C-DAS operations involving multiple unit train sets. C-DAS operation on ETCS-fitted trains is not precluded, but issues associated with integrating C-DAS on ETCS-fitted trains are not addressed.

A later version of the document will address C-DAS integration on ETCS-fitted trains, and will also include requirements to support C-DAS operation on:

• Variable formation trains (whether ETCS-fitted or not ETCS-fitted)
• Bi- or multi-modal trains.

The following Open Points await input from external sources:

• CDX.01 RAM targets for C-DAS
• CDX.02 System response time requirements.

The requirements are informed by a number of Assumptions (see [RD26]), and the Working Assumptions for a set of unresolved Issues (see [RD25]), which have been agreed with Digital Railway but are not yet fully validated.

The document reflects input from a wide range of stakeholders including DAS product suppliers and customers, but has not yet been reviewed by Digital Railway stakeholders.
1.5 References
Where no version is stated, the most recent version should be used unless otherwise stated.

[RD1] GRIP Stage 1: Development Remit: Operational and Technical Requirements for Driver Advisory System for DAS Project, CCMS2: 62518215 Issue 1.1, 28-Jan-2011

[RD2] C-DAS Project: Data Requirements for Driver Advisory Systems

[RD3] Reference removed

[RD4] Reference removed

[RD5] Traffic Management Outline Solution Design (OSD 121993), CCMS/61984427 v3.0, 02 Nov 2011


[RD8] Network Rail Common Interface File: User Guidance Notes, latest version

[RD9] Reference removed

[RD10] Reference removed


[RD12] Reference removed

[RD13] Reference removed

[RD14] Reference removed

[RD15] Reference removed


[RD18] Service Catalogue for LINX National Deployment, SVC-140708-LINX_Service_Catalogue-v7_01_01_03


[RD20] Reference removed

[RD21] Digital Railway System Migration States Definition & Scope, DRD/00000/DRP2/SPE/100033 v1.0

[RD22] External Interface Requirements for Connected Driver Advisory System (C-DAS), NOS/CDAS/REQ/0018 latest version.

[RD23] C-DAS Requirements Management Plan NOS/CDAS/SYS/0014

[RD24] C-DAS Hazard Record NOS/CDAS/SYS/0019 latest version

[RD25] C-DAS issues Log, NOS/CDAS/REQ/0024 latest version

[RD26] C-DAS Assumptions Register, NOS/CDAS/REQ/0027 latest version.

1.6 Abbreviations and Terminology
Abbreviations and terminology are defined in the Glossary in section 5.

1.7 Requirements Format
Requirements are presented in this document in the following form:

<table>
<thead>
<tr>
<th>Requirement Text</th>
<th>Unique Requirement Identifier</th>
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</table>
Status: Normative/Application-Specific/Preferred (See below).
Rationale: The justification for a requirement.
HF Measure: Identifies a requirement that is managing a human factors/ergonomics risk.
Safety Measures: Identifies a requirement which is managing safety risk and identifies the associated hazards (C-HXX). Hazards are captured and maintained in the Hazard Record [RD24].
Guidance: Supplementary information to support requirement interpretation and application.

References of the form CA-xx are to entries in the C-DAS Assumptions Register [RD26], and references of the form CD2.yy are to entries in the C-DAS Issues Log [RD25].

Each requirement within this document is identified as one of: normative, preferred, or application-specific. These are defined as follows:

- **Normative**
  - Necessary to achieve 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**
  - A requirement which may not be relevant or applicable to every C-DAS application. It is expected that where a requirement is applicable, it will be supported.

  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**
  - A requirement of lower importance which, whilst not essential, the industry would prefer were satisfied.

  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.
2 System Architecture and Interfaces

This section summarises the primary functions of the C-DAS, lists the functionality of its constituent subsystems, and outlines the C-DAS external and internal interfaces by functional purpose. These interfaces are shown on Figure 2-1 below.

2.1 System Overview

The section is intended to help the user understand the boundary and scope of the system and its constituent subsystems.

2.1.1 Purpose

The overall purposes of the C-DAS are (in order of priority): to assist in delivery of the Working Timetable, to support traffic regulation and to aid energy efficiency.

The primary functions of the C-DAS are:

- To calculate recommended energy-efficient speed profiles which allow trains to meet scheduled Timing Points and which are consistent with Infrastructure Geography, Line Speeds (including speed restrictions) for the given train, and the train characteristics and capabilities.
- To monitor train progress towards the next Timing Point, changing the recommended speed profile as required.
- To display advisory information to the driver.
- To provide trains’ location and speeds to Traffic Management.
- To notify Traffic Management when a train cannot meet its schedule.
- To provide changes to Train Specific Data to Traffic Management.
- To generate data for rail network performance analysis.
- To notify Traffic Management of changes in the operating state of C-DAS on individual trains.

2.1.2 System architecture

The C-DAS system architecture comprises two subsystems:

- The C-DAS IM Subsystem, which comprises a single off-train element (C-DAS IM Trackside) operated by Network Rail as Infrastructure Manager (IM);
- The C-DAS RU Subsystem, which comprises:
  - An off-train element (the C-DAS RU Trackside) operated on behalf of a Passenger or Freight operator, referred to as a Railway Undertaking (RU);
  - An on-train element (the C-DAS Onboard) on each C-DAS fitted train in an RU’s fleet.

The C-DAS RU Trackside communicates with its C-DAS Onboards via mobile telecommunications, the details of which fall outside the scope of this specification and are agreed between the RU and the C-DAS product supplier. Figure 2-1 below shows the C-DAS reference architecture.

The apportionment of the functionality between the C-DAS RU Subsystem and the C-DAS IM Subsystem is outlined in the following subsections.
2.1.3 C-DAS RU Subsystem

The C-DAS Onboard element of the C-DAS RU subsystem will be responsible for:

1. All interactions with the driver
2. Managing on-train C-DAS set-up
3. Calculation and display of advisory information
4. Exporting current Train Specific Data at set-up and in the event of change
5. Monitoring current running line, train location and speed
6. Exporting run-time train location and speed, and forecasts
7. Journey records (logging)
8. Synchronising time with the selected trusted local time source.

The C-DAS RU Trackside element of the C-DAS RU subsystem will be responsible for:

1. Managing run-time communications with a set of C-DAS Onboards, including message acknowledgements and keep-alive functionality.
2. Checking that versions of data used for the calculation of advisory information are current
3. Acquiring speed restriction data relevant to the trains it manages.
4. Providing data to the C-DAS Onboards of the trains it manages.
5. Backhauling journey logs from individual C-DAS fitted trains.
6. Synchronising time with the trusted local time source.
7. Supporting the C-DAS IM-RU Interface Specification defined in [RD11] by:
   a. Establishing and maintaining communications with the C-DAS IM Trackside;
b. Run-time data transfer between each C-DAS Onboard and the C-DAS IM Trackside in both directions, including re-formatting between any proprietary format and the messages specified in the IM-RU Interface Specification;

c. Maintaining data alignment between itself and the C-DAS IM Trackside in respect of data relevant to the trains it manages;

d. Obtaining Infrastructure Geography and Static Speed Profile and published TSR data from the IM’s data systems;

e. Supporting set-up of individual trains by
   ▪ Providing data, including an initial schedule to the C-DAS Onboard
   ▪ Conveying data from the C-DAS Onboard to the C-DAS IM Trackside.

2.1.4 C-DAS IM Subsystem

The C-DAS IM Subsystem will be responsible for:

1. Supporting the C-DAS IM-RU Interface Specification defined in [RD11], including:
   a. Managing all aspects of the interface between each of the C-DAS RU Subsystem and LINX/ Traffic Management;
   b. Run-time data transfer between LINX and C-DAS RU Subsystems in both directions, including re-formatting between LINX service formats and the messages specified in the IM-RU Interface Specification;
   c. Maintaining data alignment between an individual C-DAS RU Subsystem and LINX / Traffic Management in respect of speed restriction data, and of schedule and Train Specific Data for individual trains;
   d. Obtaining schedule updates for each C-DAS Onboard and dispatching them to the corresponding RU Subsystem;
   e. Obtaining TSRs and ESRs from LINX and dispatching them to C-DAS RU Subsystems;
   f. Supporting C-DAS set-up of individual trains by exchanging relevant data with LINX / Traffic Management;

2. Synchronising time with the selected trusted local time source.

2.2 External Interfaces

The following sections outline the C-DAS external interfaces. Refer to the C-DAS External Interface Requirements Specification [RD22] for requirements on external systems. Note that no requirement has been identified for input to the C-DAS IM Subsystem by the Infrastructure Manager’s staff.

2.2.1 Driver interface

This interface is shown as 2.2 on Figure 2-1. It is expected to support the following functionality.

2.2.1.1 Set-up

1. To enable the driver to enter / confirm Set-up data.

2.2.1.2 Run-time

1. To display information to the driver.
2. To enable the driver to enter / select / confirm input (e.g. running line, delay attribution).
3. To enable the driver to enter C-DAS controls (e.g. manual suppression of display).

2.2.2 Interfaces with LINX / Traffic Management

These interfaces are shown as 2.4 on Figure 2-1.
2.2.2.1 Set-up interfaces

2.2.2.1.1 LINX/Traffic Management to C-DAS IM Subsystem

Interfaces between C-DAS and LINX/Traffic Management consistent with [RD5] are required for the following to allow C-DAS customisation data to be provided by the C-DAS IM Subsystem to C-DAS fitted trains.

The data required includes:
1. Planned schedule for all relevant trains.
2. Train Specific Data for non-ETCS fitted trains.

2.2.2.1.2 C-DAS IM Subsystem to LINX/Traffic Management

An interface consistent with [RD5] is required in order that C-DAS can provide Traffic Management with current data.

The data content of this interface are the items listed in section 2.3.1.2.

2.2.2.2 Run-time interfaces

Interfaces between C-DAS and LINX/Traffic Management consistent with [RD5] are required for the following to support run-time information exchange:

2.2.2.2.1 LINX/Traffic Management to C-DAS IM Subsystem

1. Schedule and routing updates for all relevant trains.
2. Non-published TSRs and ESRs.
3. Train location requests.

2.2.2.2.2 C-DAS IM Subsystem to LINX/Traffic Management

1. Train location and speed.
2. Changes to Train Specific Data (e.g. arising from defects).
3. Predicted arrival / passing times for Timing Point locations.
5. Train confirming receipt of schedule update.
6. Delay attribution code.

2.2.3 Interfaces with Train Data Systems

These interfaces are shown as 2.7a and 2.7b on Figure 2-1. They are required in order to provide fixed train data to C-DAS fitted trains.

2.3 C-DAS IM-RU Interface

The IM-RU interface is the interface between the C-DAS RU Subsystem and the C-DAS IM Subsystem; its purpose is to enable different suppliers to develop C-DAS products that will all integrate in the same way with Network Rail systems. The interface was initially published as [RD11], and forms the basis of an open Rail Industry Standard currently in development.

The IM-RU Interface Specification supports the data flows outlined in the following subsections.

2.3.1 Set-up interfaces

These interfaces form part of the set shown as 2.3a on Figure 2-1.

2.3.1.1 C-DAS IM Subsystem to C-DAS RU Subsystem

This interface is used for passing data intended for the C-DAS Onboard
1. Train schedule.
2. Train Specific Data (for variable formation train).
3. List of trains with given Train Running Number.

2.3.1.2 **C-DAS RU Subsystem to C-DAS IM Subsystem**

This interface is used for passing data received from the C-DAS Onboard

1. Set-up data: Driver ID, Train Running Number, Train Specific Data (multiple unit train sets).
2. Train Specific Data (including power mode if applicable).

2.3.2 **Run-time interfaces**

These interfaces form part of the set shown as 2.3a on Figure 2-1.

2.3.2.1 **C-DAS IM Subsystem to C-DAS RU Subsystem**

This interface is used for passing data intended for the C-DAS Onboard

1. Schedule data and schedule updates pertaining to an individual train, including changes to schedule times and / or stopping pattern. It may also include changes to minimum dwell time and schedule timing tolerances.
2. Routing updates pertaining to the train.
3. TSRs and ESRs pertaining to Traffic Management areas.
4. Requests for the train to report its location and speed.

2.3.2.2 **C-DAS RU Subsystem to C-DAS IM Subsystem**

This interface is used for passing data received from the C-DAS Onboard

1. Changes to Train Specific Data (e.g. arising from defects).
2. Train location and speed reports.
3. Predicted arrival / passing times at Timing Point locations.
5. Delay attribution code.

2.3.3 **Initialisation interfaces**

These interfaces are shown as 2.3b on Figure 2-1.

2.3.3.1 **Infrastructure Manager data systems to C-DAS RU Subsystem**

1. Infrastructure Geography.
2. Static Speed Profiles.
3. Published TSRs for relevant areas and routes.
4. Applicable timetable for relevant trains (optional).
3 Subsystem Requirements - Functional

3.1 Operating context

When communication between the C-DAS IM subsystem and the C-DAS RU Subsystem is resumed after loss, the C-DAS IM subsystem shall attempt to acquire and make available current data.

Status: Normative
Rationale: So that the C-DAS RU subsystems and Traffic Management acquire the most up-to-date data from each other.

3.2 Operational data

- **CSSR-497b**
  
  When communication between the C-DAS IM subsystem and the C-DAS RU Subsystem is resumed after loss, the C-DAS IM subsystem shall attempt to acquire and make available current data.

  **CSSR-271**
  
  The C-DAS IM Subsystem shall obtain from LINX and deliver to the C-DAS RU Subsystem details of all speed restrictions.

  **CSSR-265**
  
  The C-DAS IM Subsystem shall obtain from LINX and deliver to the C-DAS RU Subsystem all plans and individual train schedules which are relevant to that C-DAS RU Subsystem.

  **CSSR-277**
  
  The C-DAS IM Subsystem shall obtain from LINX and deliver to the C-DAS RU Subsystem schedule updates which are relevant to that C-DAS RU Subsystem.

Status: Normative
Rationale: To support consistency between data used by C-DAS and other systems, including Traffic Management.
Guidance: Speed restriction data will be supplied in a Traffic Management area by Traffic Management, and in a Non-Traffic Management area sourced by the appropriate Business System. If the proposed National System for speed restrictions is implemented then it will serve as a common source of all speed restrictions for all affected systems.
Guidance: A consequence of this requirement is that the C-DAS RU Subsystem will be responsible for selecting speed restrictions relevant to its operational routes and trains.

Status: Normative
Rationale: To provide the C-DAS RU Subsystem in an efficient manner with the appropriate information from which Individual train schedules can be identified.
Guidance: These may include any or all of Applicable Plan (22h00 plan), VSTPs, Current Plan and individual train schedules. The information provided used by the C-DAS RU Subsystem to obtain an initial schedule for each C-DAS journey, or to replace a previously acquired schedule for the journey.

Status: Normative
Rationale: So that the C-DAS uses the up-to-date train schedule.
Guidance: In Traffic Management areas schedule updates will be sourced from Traffic Management. In Non-traffic Management areas schedule updates will generally not be available.
The C-DAS IM Subsystem shall deliver to LINX notifications which it receives from the C-DAS RU Subsystem that a schedule update has been received by the relevant C-DAS Onboard.

**Status:** Normative

**Rationale:** So the Traffic Management system is informed that the train is operating with the updated schedule.

**Guidance:** If the Traffic Management system does not receive the notification it will not be able to determine whether the information was or was not received by the Onboard.

### 3.3 Reporting

The C-DAS IM Subsystem shall deliver to LINX, using the services defined in the LINX service description document [RD18], the following data received in accordance with the C-DAS standard interface:

- a. Train Registration Data
- b. Changes to Train Registration Data
- c. Changes to Train Specific Data
- d. Train location and speed
- e. Predicted train arrival data
- f. C-DAS operational state on individual trains
- g. Delay attribution data.

**Status:** Normative

**Rationale:** To make information reported by C-DAS available to Traffic Management or other systems which can use it to improve operations.

**Guidance:** The C-DAS standard interface is specified in [RD11].

### 3.4 Messaging and Telecommunications

The C-DAS IM subsystem shall preserve message ordering.

**Status:** Normative

**Rationale:** To ensure that each C-DAS IM subsystem processes related data messages in the order in which they were generated.

**Guidance:** The C-DAS IM subsystem must forward messages in the order in which it receives them.

The C-DAS IM subsystem shall dispatch each data message it receives as soon as allowed by the relevant communications link.

**Status:** Normative

**Rationale:** To avoid delays in making data available to user subsystems and systems.

The C-DAS IM subsystem shall have the capability to receive messages at any time.

**Status:** Normative

**Rationale:** To avoid delays in making data available to user subsystems and systems.
The C-DAS IM subsystem shall transmit and receive the data messages which comply with the C-DAS standard interface.

CSSR-385a

Status: Normative
Rationale: To support the standard interface, and hence enable development of C-DAS products independently of development of Network Rail systems.
Guidance: The C-DAS standard interface is specified in [RD11].

The C-DAS IM subsystem shall construct and de-construct the data messages specified in the C-DAS standard interface.

CSSR-386a

Status: Normative
Rationale: To support the standard interface, while also allowing C-DAS product suppliers to maintain proprietary data formats for internal processing.
Guidance: The C-DAS standard interface is specified in [RD11]. The formats of the other data messages involved are: supplier-specific format for messages to/from trains, and as specified in [RD18] for messages to/from LINX and Traffic Management.

The C-DAS IM subsystem shall construct and invoke the appropriate LINX service call for each message it receives from a C-DAS RU Subsystem.

CSSR-389

Status: Normative
Rationale: To translate between the messages defined in the C-DAS standard interface [RD11] and the specified protocol for using LINX [RD18].

The C-DAS IM subsystem shall construct and invoke the appropriate LINX service call for all data required by a C-DAS RU Subsystem.

CSSR-390

Status: Normative
Rationale: To translate between the messages defined in the C-DAS standard interface [RD11] and the specified protocol for using LINX [RD18]

The C-DAS IM subsystem shall timestamp each message it constructs.

CSSR-391a

Status: Normative
Rationale: So that the receiver of the message can determine whether or not the data contained in the message is time-expired.
Guidance: This requirement applies to messages passed (in either direction) between the C-DAS RU Subsystem and C-DAS IM Subsystem, as specified in the C-DAS standard interface [RD11].

The C-DAS IM subsystem shall include the Unique Train Identifier in each message sent to or from a C-DAS Onboard.

CSSR-392a

Status: Normative
Rationale: In order to help ensure that data is routed to and received by the correct C-DAS Onboard.
Guidance: The Unique Train Identifier is provided to C-DAS as part of the schedule data during set-up.

The C-DAS IM subsystem shall confirm receipt of messages from the C-DAS RU Subsystem as specified in the C-DAS standard interface.

CSSR-393a
Status: Normative
Rationale: To ensure that schedule data, speed restriction data and Train Specific Data used by C-DAS is aligned with the corresponding data used by the Traffic Management.
Guidance: The C-DAS standard interface is specified in [RD11]

The C-DAS shall utilise a guaranteed message delivery system between the C-DAS RU and IM Subsystems.

CSSR-394a

Status: Normative
Rationale: To ensure that no messages are lost in transit between the C-DAS RU and IM Subsystems.

3.5 Time synchronisation

The C-DAS IM Subsystem shall synchronise time on each of its constituent elements with Network Time Servers linked to a trusted local time source.

CSSR-398a

Status: Normative
Rationale: To be consistent with Network Rail's Traffic Management system
Safety Measures: C-H21

3.6 Faults and Failures

The C-DAS IM Subsystem shall have the capability to detect and report to LINX a loss of communications with a C-DAS RU Subsystem.

CSSR-403

Status: Normative
Rationale: To provide the state of the C-DAS RU Subsystem so as to enable a person or system to take the appropriate action (e.g. to compensate for trains not being capable of receiving updates to their schedules).
Guidance: The mechanism to support this requirement is documented in [RD11].

The C-DAS IM Subsystem shall, where applicable, be able to self-diagnose faults and, when faults are detected, log the faults, and output a notification to local and remote systems as required.

CSSR-436a

Status: Preferred
Rationale: To support maintainability of the system and contribute to achieving availability targets.
4 Subsystem Requirements – Non-Functional

4.1 Safety

The C-DAS IM Subsystem shall be developed and implemented to a safety integrity of SIL-1.

Status: Normative
Rationale: Determined by safety analysis (see Ref [RD16])

The C-DAS IM Subsystem shall not compromise the safe operation of any interfacing system when operating correctly or when in a degraded state of operation.

Status: Normative
Rationale: A C-DAS IM Subsystem fault or failure must not create safety issues in other systems.

4.2 Security

The C-DAS IM Subsystem shall be secure against cyber threats.

Status: Normative
Rationale: To protect the availability, integrity and confidentiality of the system.

The C-DAS IM Subsystem shall be physically secure against unauthorised physical access, damage or interference.

Status: Normative
Rationale: To prevent unauthorised physical access, damage or interference to Digital Railway premises and information.

The C-DAS IM Subsystem shall be secure against the risk presented by personnel.

Status: Normative
Rationale: To minimise the likelihood of malicious activity or human error that may harm the operational railway.

4.3 RAM

The C-DAS IM Subsystem reliability targets are TBD.

Status: Normative
Rationale: To meet the required performance targets for the subsystem
Guidance: Reliability targets will be derived from overall system availability requirements set by Digital Railway – Open Point CDX.01 refers. Until Digital Railway targets are available it is recommended that the reliability targets specified in the RAM plans supplied as part of the IM Subsystem deliverables should be used.

The C-DAS IM Subsystem availability targets are TBD.

Status: Normative
Rationale: To meet the required performance targets for the system
Guidance: Availability targets will be derived from overall system availability requirements set by Digital Railway – Open Point CDX.01 refers. Until Digital Railway targets are available it is recommended that the availability targets specified in the RAM plans supplied as part of the IM Subsystem deliverables should be used. Digital Railway availability targets will also drive Start-up requirements for the C-DAS IM subsystem.

The C-DAS IM subsystem maintainability targets are TBD

Status: Normative
Rationale: To meet the required performance targets for the system
Guidance: Maintainability targets will be derived from overall system availability requirements set by Digital Railway – Open Point CDX.01 refers. Until Digital Railway targets are available it is recommended that the maintainability targets specified in the RAM plans supplied as part of the IM Subsystem deliverables should be used.

The C-DAS IM subsystem shall be developed for minimal maintenance requirements and low Mean Time To Repair (MTTR) times.

Status: Normative
Rationale: To support effective and efficient maintenance.
Guidance: This includes but is not limited to:
- The use of Line Replaceable Units
- No or limited requirement to configure replaceable components
- No or limited preventative maintenance
- No requirement for bespoke tools for routine maintenance

4.4 Performance

The C-DAS IM subsystem shall be operational at all times when LINX is running.

Status: Normative
Rationale: To provide adequate support for on-train C-DAS operations.

The C-DAS IM Subsystem shall achieve expected one-way latencies of 2 seconds (80%) and 3 seconds (95%) for processing messages received from the C-DAS RU Subsystem and delivering the corresponding data to LINX.

Status: Normative
Rationale: To achieve operationally acceptable response times
Guidance: System response times covering Traffic Management and C-DAS will be set by Digital Railway (see Open Point CDX.02) and will be partitioned to give allocations to each of the system elements involved. In the meanwhile the requirements above are proposed for message flows initiated by the C-DAS RU Subsystem. These are based on:

a. The assumption that Traffic Management will generally perform plan / replan for a time window greater than 15 minutes ahead, and no less than 5 minutes ahead. This allows cross-system latency requirements....
to be less demanding than if Traffic Management updates were generated for a shorter interval ahead;

b. The performance of an existing C-DAS system which is in operational use;

c. Simulations which show the effect on capacity and energy consumption depending on when updates to the C-DAS Onboard subsystem are delivered.

The C-DAS IM Subsystem shall achieve expected one-way latencies of 3 seconds (80%) and 5 seconds (95%) for retrieving data from LINX and dispatching the corresponding messages to the C-DAS RU Subsystem.

**Status:** Normative

**Rationale:** To achieve operationally acceptable response times

**Guidance:** System response times covering Traffic Management and C-DAS will be set by Digital Railway (see Open Point CDX.02) and will be partitioned to give allocations to each of the system elements involved. In the meanwhile the requirements above are proposed for message flows initiated by the Traffic Management System. These are based on:

a. The assumption that Traffic Management will generally perform plan / replan for a time window greater than 15 minutes ahead, and no less than 5 minutes ahead. This allows cross-system latency requirements to be less demanding than if Traffic Management updates were generated for a shorter interval ahead;

b. The performance of an existing C-DAS system which is in operational use;

c. Simulations which show the effect on capacity and energy consumption depending on when updates to the C-DAS Onboard subsystem are delivered.

### 4.5 Design & Development

The C-DAS IM Subsystem shall be designed and implemented to be compliant with all the relevant safety standards.

**Status:** Normative

**Rationale:** To meet the requirements for the acceptance and approval of safety-related electronic systems in the railway signalling field.

**Guidance:** Standards include: BS E50129 - Railway applications — Communication, signalling and processing systems — Safety related electronic systems for signalling; BS E50128 - Railway applications — Communication, signalling and processing systems — Software for railway control and protection systems; BS EN50159: Railway applications - Communication, signalling and processing systems - Safety-related communication in transmission systems.

The C-DAS IM subsystem shall be developed in accordance with industry good practice with regard to all hardware or software development, test and release processes, including support by full configuration control of its hardware, software and document components.

**Status:** Normative

**Rationale:** To support effective operation throughout the system life.
Guidance: This includes compliance with BS E50129 - Railway applications — Communication, signalling and processing systems — Safety related electronic systems for signalling; BS E50128 - Railway applications — Communication, signalling and processing systems — Software for railway control and protection systems; BS EN50159: Railway applications - Communication, signalling and processing systems - Safety-related communication in transmission systems; BS EN 50155 Railway Applications – Electronic Equipment used on rolling stock.

The C-DAS IM Subsystem shall be designed to be extensible in the future to providing an interface between Traffic Management and other RU applications.

Status: Preferred

Rationale: To make provision for an expected future requirement to interface with RU applications that can provide information to support Traffic Management operations, or might need to acquire information from Traffic Management for consistency.

Guidance: Examples of other RU applications include:
- Automatic Train Operation systems
- Mobile Timetable Information System Application (MTISA)
- Mobile Consist Application (MCA)

It shall be possible to interrogate C-DAS IM Subsystem fault logs both remotely and locally.

Status: Normative

Rationale: To support the maintenance organisation in the provision of effective and efficient maintenance.

4.6 EMC

The C-DAS IM Subsystem shall be compliant with all relevant EMC standards.

Status: Normative

Rationale: The C-DAS and its constituent subsystems is required to operate correctly in the railway environment without undesired affects from within and outside that environment, or affecting the correct operation of other systems.

Guidance: Standards include: BS EN50121 Railway applications - Electromagnetic Compatibility.

4.7 Environmental

The C-DAS IM Subsystem shall comply with all relevant environmental standards.

Status: Normative

Rationale: The C-DAS IM Subsystem must be able to operate correctly in its intended environment

Guidance: Standards include BS EN50125 Railway applications — Environmental conditions for equipment.
5 Glossary

5.1 Abbreviations

ATO  Automatic Train Operation
ATP  Automatic Train Protection
AWS  Automatic Warning System
C-DAS Connected Driver Advisory System
CCS  Command Control and Signalling
CIF  Common Interface File
COTS Commercial Off The Shelf
DAS  Driver Advisory System
DMI  Driver Machine Interface
DRA  Driver’s Reminder Appliance
DSD  Driver’s Safety Device
EoA  End of Authority
ERTMS European Rail Traffic Management System
ETCS European Train Control System
ESR  Emergency Speed Restriction
GNSS Global Navigation Satellite System
GPS  Global Positioning System
IM  Infrastructure Manager
LINX Layered Interface Exchange
N-DAS Networked DAS
NRT  Network Rail Telecoms
PRM  People with Reduced Mobility
PSR  Permanent Speed Restriction
QoS  Quality of Service
RAMS Reliability, Availability, Maintainability and Safety
RFID Radio Frequency Identifier
ROC  Rail Operating Centre
RU  Railway Undertaking
S-DAS Standalone Driver Advisory System
SSP  Static Speed Profile
STM  Specific Transmission Module
STP  Short Term Planning
TAF  Telematics Applications for Freight
TAP  Telematics Applications for Passenger
TM  Traffic Management
TPWS  Train Protection & Warning System
TRN  Train Running Number
5.2 Terminology

**Applicable Timetable**
The Working Timetable for a set of services overlaid by Short Term Planning updates, as agreed between the IM and RU as the basis of operations for the following day.

**Application data**
Part of Customisation data (qv).

**Blanket speed restriction**
A speed restriction which is not published, but is notified to drivers by Operations Control via the signaller or by other means. Lineside signage is not provided, and stop and caution procedures do not apply. A single speed value applies, and the restriction may apply only to selected train types (i.e. not to all train types). Blanket speed restrictions will be made available to C-DAS by Traffic Management in Traffic Management areas. Assumptions and requirements for ESRs given in this document should be considered to apply also for blanket speed restrictions except where otherwise stated.

**Common Interface File**
A file whose format is described in [RD8], used for conveying train schedules and schedule revisions from Network Rail’s Integrated Train Planning Service to its customers.

**Connected DAS**
A system which provides train drivers with an advisory train speed (within and up to the linespeed profile and maximum train speed) that is informed by the real-time, measured progress of the individual train against (static) Infrastructure Geography with (dynamic) linespeed and schedule data.

**Current Schedule**
The currently planned sequence of named locations, corresponding times and path for a single train service, as per the Planned Schedule together with any Schedule Updates. The time specified will be arrivals and departures for scheduled stops, and passing times for non-stopping locations.

**Customisation Data**
The data which determines the detailed operation of the C-DAS. It comprises:
- Application data – Infrastructure Geography, Static Speed Profiles, TSRs and ESRs, Schedule
- Set-up data – Driver ID, Train Running Number (TRN), Train Specific Data

**Data partitioning**
A scheme to allow trains to carry Infrastructure Geography and Static Speed Profile datasets only for a relevant subset of the rail network. (These datasets change relatively rarely, and the aim is to provide trains with the Application data required for their routes (see definition of Customisation Data above), but without requiring them to be updated when there are changes only to parts of the national data which are irrelevant to their operations.)
Disable  Action by which the DAS Onboard is closed down, either by the
driver or automatically, in the event of a system failure, display
frozen or as instructed by the RU.

Emergency Speed Restriction  A speed restriction which is not published but which is indicated to
the driver by lineside signage, and notified to drivers by stop and
cautions procedure when the signage is not yet in place. The
speed value may vary by direction of travel. Speed values apply
as per TSRs. Changes to published TSRs are treated as ESRs.
ESRs will be made available to C-DAS by Traffic Management in
Traffic Management areas. Assumptions and requirements for
ESRs given in this document should be considered to apply also
for blanket speed restrictions except where otherwise stated.

Infrastructure Geography (data)  The data which describes the topography and topology of the
network infrastructure. It comprises three parts:
   a. Track Geography  Track centre line, altitude, curvature
   b. Rail Network Model(s)  Connectivity and Navigability
   c. Track features  Asset data (points, stations, tunnels,
      location markers e.g. mileposts, line identities etc.) and other
      parameters (e.g. C-DAS display units and ETCS National
      Values)

   It also includes linkages (mapping) between (b) and (a), and
   between Timing Point locations and Track Geography / Track
   features, and a means – based on track link id – to support
   mapping between routing data, track geography and network
   models.

Initial Schedule  The schedule obtained by a train as part of C-DAS set-up. An
Initial Schedule obtained from Traffic Management will be the
Planned Schedule (qv) with any amendments generated by
Traffic Management has generated; otherwise it will be just The
Planned Schedule.

Journey  The scheduled movement of a train between two named points,
e.g. journey between London Euston and Glasgow Central.

Journey Segment  The part of a journey that lies between two adjacent Timing
Points.

Layered Interface Exchange (LINX)  The data integration platform being developed as part of the
Network Rail Traffic Management system.

Line segment  The sequence of track links between two adjacent Timing Point
Locations on the train journey.

Linespeed  The Static Speed Profile modified by any applicable Temporary,
Emergency and Blanket Speed Restrictions for a particular
direction of travel and train type.

Linespeed Profile  The sequence of linespeeds to be observed by a particular train
along its journey or part of journey.

Multiple unit train set  A permanently or semi-permanently coupled set of rail vehicles
(i.e. a unit), which can be operated independently as a train, or
which, when coupled to one or more similar units, can operate
collectively as a train driven from the cab of the leading unit.

Network Model  A description of the track layout which specifies how it may be
traversed, i.e. permissible sequences of track links.

Networked DAS  A system which provides train drivers with an advisory train speed
(within and up to the linespeed profile and maximum train speed)
that is informed by the measured progress of the individual train against (static) Infrastructure Geography with schedule and linespeed data which may be updated dynamically by an RU facility.

Non-Traffic Management area
An area which is not controlled by a Traffic Management system. Such areas may support N-DAS operation, i.e. limited data exchange between C-DAS fitted trains in the area and an RU’s facility.

Permanent Speed Restriction
A speed restriction which is published in the Sectional Appendix and is reflected in the Permissible Speeds (qv). PSRs are indicated to the driver by lineside signage and, where the reduction in speed exceeds applicable criteria, warning signage with a permanent AWS magnet may be provided on the approach.

Permissible Speed
The speed published in the Sectional Appendix. This is the speed at which the train may operate over a particular stretch of infrastructure, and reflects infrastructure constraints, direction and the train type. The concept of Permissible Speeds is replaced in ETCS by Static Speed Profiles (qv).

Plan
The collective schedule for multiple trains.

Planned Schedule
The part of the Applicable Timetable that applies to a single train service; this would generally align to the published timetable modified by any STPs. Where a service has been introduced or amended by VSTP, the Planned Schedule is the schedule defined or amended in the VSTP.

Planning Data
Any plan or schedule.

Registration Data
The data passed by C-DAS to identify a particular train and service. It comprises Set-up data and Train Specific Data.

Routing
The route and track on which the train operates.

Schedule (1)
As Current Schedule (qv).

Schedule (2)
Any of Planned Schedule, Initial Schedule or Current Schedule (qv).

Schedule Timing Tolerance
A time window during which a train may arrive, depart or pass a given Timing Point Location without affecting the behaviour of other trains.

Schedule Updates
Any changes made to the Planned Schedule for a particular service, so as to regulate trains and/or to recover from perturbations.

Segment Profile
A data packet used for ATO (see [RD4])

Set-up
The driver-controlled sequence by which the on-train DAS subsystem is prepared for operation. This may be either Full Set-up which is generally performed when the driver first activates the cab, or Partial Set-up which must be performed whenever any of the Set-up data (qv) is changed.

Set-up data
Part of Customisation data (qv).

Speed restrictions
Infrastructure-related limitations on the maximum speed a train may travel. Speed restrictions apply to a given area or length of track and may vary with the direction of travel and the train type. A speed restriction will be one of:

- Permanent speed restriction (qv)
- Temporary speed restriction (qv)
- Emergency speed restriction (qv)
- Blanket speed restriction (qv).

**Standalone DAS**
An on-train system which provides train drivers with an advisory train speed (within and up to the linespeed profile and maximum train speeds) that is informed by the real time measured progress of an individual train against pre-defined (static) Infrastructure Geography, linespeed and schedule data.

**Static Speed Profile**
This is the speed profile at which the train may operate over a particular stretch of infrastructure, and reflects infrastructure constraints, direction and the ETCS train categories. Static Speed Profiles are the ETCS equivalent of Permissible Speeds (qv).

**Suppress**
Action by which the DAS on-train display is disabled in whole or in part. This is either done by the driver manually or automatically in circumstances defined by the RU.

**Temporary Speed Restriction**
A speed restriction which is published in the weekly operating notice. The speed value may vary by direction of travel. One speed value may apply for all types of train, or two differential speeds may apply to different types of train, colloquially termed as passenger and freight. TSRs are indicated to the driver by lineside signage and, in most cases, warning boards and permanent AWS magnets. A TSR may undergo a non-published change if its geographical limits are reduced; such changes are reflected in changes to the lineside signage and will be made available to C-DAS in Traffic Management areas.

**Timing Point**
A named location on the railway and the time associated with it on a train’s schedule. A Timing Point may correspond to an arrival time, departure time or passing time.

**Timing Point Location**
A named location for which a time is specified on the train’s schedule.

**Track link**
An individual length of track which cannot include points, a junction, or the end of a loop except as an end-point.

**Traffic Management area**
An area of the rail network controlled by a Traffic Management system. Such areas will be capable of supporting full C-DAS operation, i.e. systematic data exchange in near-real time between C-DAS-fitted trains in the area and a Traffic Management system.

**Train Consist and Capability Data**
A table of train data, containing ‘preset’ values including physical train characteristics, braking, traction and resistance parameters for a number of consists, to be used in C-DAS speed profile calculations. The use of ‘presets’ is recommended for multiple unit train sets as an efficient and effective means of data entry and may also be applicable for frequently used consists of variable formation trains.

**Train Running Number**
The identity of the train service. GB Rail currently uses a 4-character headcode, but may be expected to migrate to an identifier which is unique across the network, and not repeated within a 24-hour period.

**Train Specific Data**
Parameters which determine the behaviour of a particular train, including train length, mass, maximum speed, braking parameters, traction parameters, resistance coefficients.

**Unique Train Identifier**
An identifier which identifies a particular service uniquely across the GB rail network on a particular day.
Unsuppress  Action by which the C-DAS on-train display is re-enabled. This is either done by the driver manually or automatically in circumstances defined by the RU.

Variable formation train  A variable formation train is one for which a 'preset' has not been defined e.g. freight train, loco-hauled passenger train, or unusual combinations of units.
Appendix A  C-DAS Overview

A.1 Problem statement

The role of a Driver Advisory System is to provide information that helps the driver of each train to deliver the service specified by the Traffic Management control function in a manner which optimises the use of key resources across an area and set of trains, typically some combination of performance, capacity and energy.

Network Rail plans to facilitate the deployment of Driver Advisory Systems to operate in conjunction with the Traffic Management systems which are being developed as part of the implementation of the Digital Railway programme.

It is a key requirement for the client of this project and the end-users of the proposed Driver Advisory System that it shall improve recovery from perturbation as well as supporting scheduled operation.

A.2 Solution outline

To meet these requirements the Driver Advisory System will include a ground subsystem and an on-train subsystem. The ground subsystem receives target timing information for each train, calculated by Traffic Management’s operational forecast and planning function based on the train’s current location and the current traffic control priorities. The targets, reflecting the capabilities of the train (mass, braking characteristics etc.) and the constraints imposed by the route (permissible speeds, gradients, speed restrictions etc.), are transmitted to the train. The on-train subsystem calculates the appropriate speed profile for that train, continuously monitors the train’s location relative to its targets, displays advisory information to the driver and also informs the ground subsystem of the train’s progress to pass on to Traffic Management so that targets may be updated as appropriate. A closed-loop Driver Advisory System of this kind is known as a Connected Driver Advisory System (C-DAS)

A high level of the system architecture for the proposed Connected Driver Advisory System is shown in Figure 1.

Figure A-1: Connected Driver Advisory System overview
Appendix B  C-DAS Context Architecture

Figure B-1: C-DAS Architecture Context