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Track to Train RFID Compatibility

This document sets out requirements for RFID compatibility between train and track, including the management of application codes.

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Synopsis

This document sets out requirements for RFID compatibility between train and track, including the management of application codes.

Published by RSSB

Issue record

Issue	Date	Comments
One	05/09/2015	Sets out the technical requirements for the RFID on-board reader and track based beacon interface using the data format structure and communications protocol for Automatic Selective Door Operation (ASDO) functionality, which was originally set out in Appendix 2 of GMRT2473 issue two.
Two	02/12/2017	New application codes for ASDO and Automatic Power Change Over (APCO) added. Detailed process for requesting a new application code added.
2.1	01/02/2020	Appendix A amended with allocation of RFID application code 24. Errors in Appendix A corrected. Clause B.1.7 in Appendix B amended to provide more clarity.
2.2	04/12/2021	Appendix C amended to include new application code 14 (Automatic Power Change Over - APCO) 'Passes Information' and 'Demands Action' codes. Table 1 updated to expand 'APCO' abbreviation. Figures 2, 5 and 6 updated for legibility (no change to figure content). References to RIS-0796-CCS - Train to Infrastructure RFID Compatibility and RIS-2713-RST - System Requirements for the Introduction and Operation of Multi- Mode Rolling Stock added.
2.3	02/09/2023 [proposed]	Appendix D added to include new application code 36 for Automatic Power Mode Control (APMC).

Revisions have been marked by a vertical black line in this issue. Definitions and References may also have been updated but these are not marked by a vertical black line.

Superseded documents

The following Railway Group documents are superseded, either in whole or in part as indicated:

Superseded documents	Sections superseded	Date when sections are superseded
RIS-2795-RST issue 2.2 Rail Industry Standard for Track to Train RFID Compatibility	All	02/09/2023 [proposed]

Supply

The authoritative version of this document is available at www.rssb.co.uk/standards-catalogue. Enquiries on this document can be submitted through the RSSB Customer Self-Service Portal https://customer-portal.rssb.co.uk/

Contents

Section	Description	Page
Part 1	**Purpose and Introduction**	**8**
1.1	Purpose	8
1.2	Scope	8
1.3	Application of this document	9
1.4	Health and safety responsibilities	9
1.5	Structure of this document	9
1.6	Approval and Authorisation	10
Part 2	**Railway Undertaking - Architecture Interface**	**11**
2.1	RFID protocol	11
2.2	Data transfer	11
2.3	Speed of train	11
Part 3	**On-Board Subsystem**	**12**
3.1	Reader mounting	12
Part 4	**Trackside Subsystem**	**13**
4.1	Beacon specification	13
4.2	Beacon installation	13
4.3	Beacon installation design	14
4.4	Potential interference with other RFID systems	14
Part 5	**Management of Application Codes**	**16**
5.1	Allocated application codes	16
5.2	Data structure	16
5.3	Proposing a new application code	19
5.4	Specifying new values for variables in an existing application code	24
5.5	Decommissioning	25
Appendices		**26**
Appendix A	RFID Train to Track Allocated Application Codes	26
Appendix B	Automatic Selective Door Operation (ASDO)	28
Appendix C	Automatic Power Mode Control (APCO)	30
Appendix D	Automatic Power Mode Control (APMC)	32
Definitions		**34**

References **37**

List of Figures

Figure 1: RFID interfaces and the rail industry standards covering them 9

Figure 2: Generic RFID data format structure 18

Figure 3: New application code 21

Figure 4: Change existing application code 23

Figure 5: ASDO data structure 29

Figure 6: APCO data structure 31

Figure 7: APMC data structure 33

List of Tables

Table 1: Permitted and allocated application codes 26

Table 2: Spare values of F 30

Table 3: APMC function code table 33

Part 1 Purpose and Introduction

1.1 Purpose

1.1.1 This document is a standard on track to train RFID compatibility.

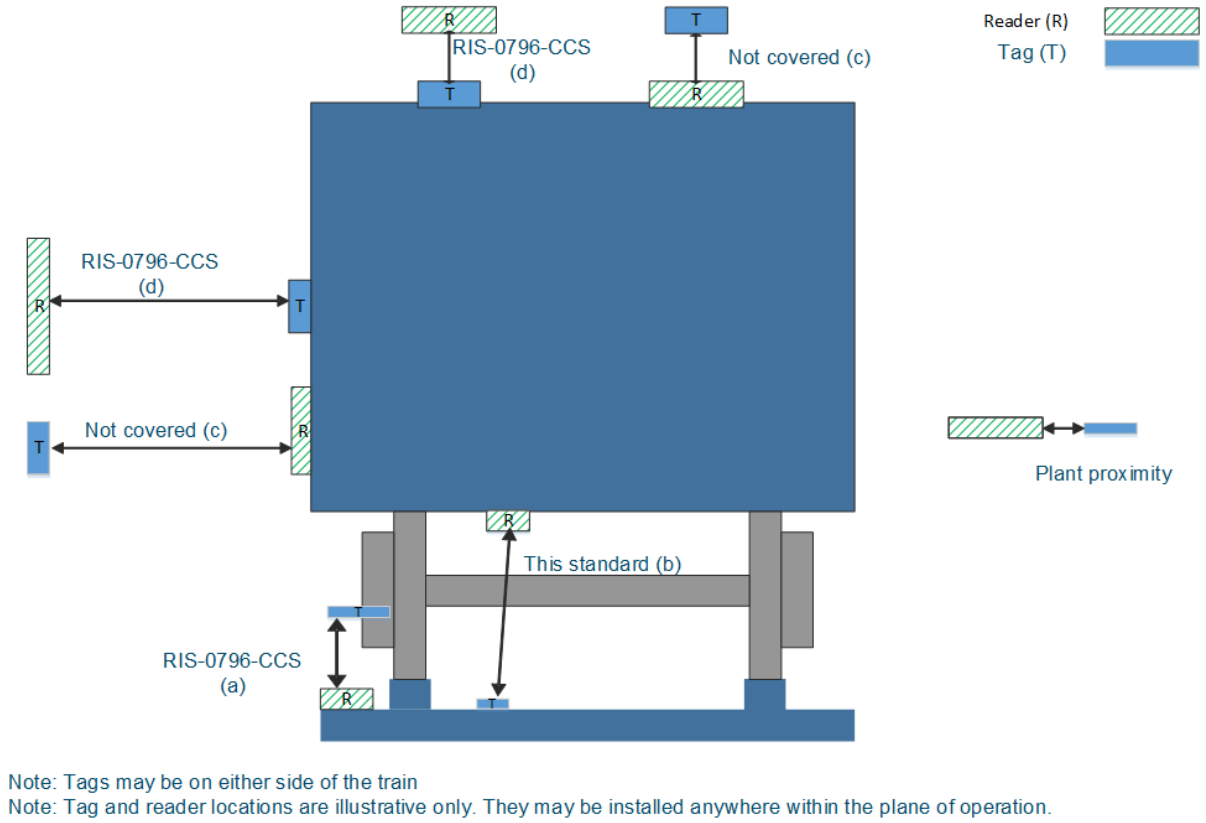
1.1.2 This document sets out the process for managing data structures for new applications and the change control process for existing applications. Industry governance for these data structures will be through the approval of the application-specific standard in which they are documented, in accordance with the Railway Group Standards Code and Manual.

1.2 Scope

1.2.1 The scope of this document is the system where the tag (transmitting part of the RFID interface) is mounted on the track on a sleeper and the reader is mounted on the underside of the train and the protocol is IP-X tag talks only (TTO).

1.2.2 The interface covered by this document is one of the four possible configurations of RFID readers and tags, as shown in *Figure 1*. The four configurations are:

a) Reader on track; tag on vehicle. Tag positioned on underside of vehicle, for example axle or underframe (covered by RIS-0796-CCS);
b) Reader on underframe; tag on track (covered by this document);
c) Reader on side or roof of train; tag trackside or on infrastructure above track (no existing applications, so not currently covered in a standard); and
d) Reader trackside or on infrastructure above track; tag on side or roof of train (covered by RIS-0796-CCS).



Note: Tags may be on either side of the train
Note: Tag and reader locations are illustrative only. They may be installed anywhere within the plane of operation.

Figure 1: RFID interfaces and the rail industry standards covering them

1.3 Application of this document

1.3.1 Compliance requirements and dates have not been specified because these are the subject of internal procedures or contract conditions.

1.3.2 If you plan to do something that does not comply with a requirement in this RIS, you can ask a Standards Committee to comment on your proposed alternative. If you want a Standards Committee to do this, please submit your deviation application form to RSSB. You can find advice and guidance on using alternative requirements on RSSB's website www.rssb.co.uk.

1.4 Health and safety responsibilities

1.4.1 Users of documents published by RSSB are reminded of the need to consider their own responsibilities to ensure health and safety at work and their own duties under health and safety legislation. RSSB does not warrant that compliance with all or any documents published by RSSB is sufficient in itself to ensure safe systems of work or operation or to satisfy such responsibilities or duties.

1.5 Structure of this document

1.5.1 This document sets out a series of requirements that are sequentially numbered. This document also sets out the rationale for the requirement, explaining why the

requirement is needed and its purpose and, where relevant, guidance to support the requirement. The rationale and the guidance are prefixed by the letter 'G'.

1.5.2 Some subjects do not have specific requirements but the subject is addressed through guidance only and, where this is the case, it is distinguished under a heading of 'Guidance' and is prefixed by the letter 'G'.

1.6 Approval and Authorisation

1.6.1 The content of this document was approved by Rolling Stock Standards Committee on 13 July 2023.

1.6.2 This document will be authorised by RSSB on 20 August 2023 [proposed].

Part 2 Railway Undertaking - Architecture Interface

2.1 RFID protocol

2.1.1 The RFID protocol shall be transmitted by the on-board reader in the radio frequency (RF) range 865.7 MHz to 867.9 MHz, with an effective radiated power (ERP) not exceeding 2 W.

Rationale

G 2.1.2 The intended emissions lie within the IR 2030/13/3 - UK Interface Requirements 2030 Licence Exempt Short Range Devices frequency band, and at the power levels regulated for the purposes of RFID by Ofcom and the Radio Equipment Directive (RED) and referenced to ETSI EN 302 208 v3.1.0 (2016-02).

Guidance

G 2.1.3 The RED came into force on 13 June 2016.

G 2.1.4 Independent channel frequency hopping technology can be incorporated to mitigate potential radio interference issues within this frequency band.

G 2.1.5 The Great Britain (GB) rail industry has successfully used an ERP of 500 mW for this RFID data transmission.

2.2 Data transfer

2.2.1 The data transfer shall occur when the onboard reader, which includes an integral antenna, and the track based beacon are at a distance of one metre.

Rationale

G 2.2.2 At the required operating frequency and ERP, at distances greater than one metre between the onboard reader and track based beacon, the data transmission is unreliable.

Guidance

G 2.2.3 Within the one metre operating distance an optimum data transfer occurs at approximately half a metre between the onboard reader and track based beacon.

G 2.2.4 *G 3.1.7* sets out options for when the beacon cannot include an integral antenna.

2.3 Speed of train

2.3.1 The RFID system shall not be used at speeds exceeding 120 km/h (75 mph).

Rationale

G 2.3.2 The GB rail industry trials have only validated and verified reliable readings for trains travelling at a maximum of 120 km/h (75 mph).

Part 3 On-Board Subsystem

3.1 Reader mounting

3.1.1 The RFID onboard readers shall be designed to be mounted on the underside of the vehicle.

3.1.2 The lateral position of the onboard readers mounted on the underside of the vehicle shall be limited to ± 30 mm of the train / vehicle centreline.

3.1.3 There shall be a clear, unobstructed line of sight between the reader and the beacon when they are within one metre of each other, to enable data transmission to occur.

Rationale

G 3.1.4 The readers are mounted to enable an unobstructed line of sight for data transmission to occur at distances less than or equal to one metre between the onboard reader and the track based beacon. Obstructions absorb and reflect varying levels of ultra-high frequencies (UHFs), depending on the composition of the material, and may prevent beacon activation or reduce the reliability of the reader receiving the pre-programmed data.

Guidance

G 3.1.5 The 30 mm limitation of the lateral position from the centreline enables the data transmission between the track based beacon and the onboard reader to occur within the one metre range, taking account of cant deficiencies and overthrow of the vehicle.

G 3.1.6 Further details on designing and mounting devices are set out in GIRT7073, GMRT2173 and GERT8073.

G 3.1.7 If space does not permit a reader with an integral antenna to be installed at a suitable location on the underframe, then a separate antenna may be mounted on the underside of the vehicle.

G 3.1.8 In positioning the reader within the train consist, all operational scenarios where the beacon is expected to transfer data are considered.

G 3.1.9 As the train consist can vary in length, due to coupling and uncoupling of vehicles and units, the position of the reader in respect to the whole train formation can also vary. This can affect whether the data transmission between the on-board reader and track based beacon distance of one metre is achieved for all applications on all routes.

G 3.1.10 The emitted UHF reader signal spreads outwards from the onboard reader, commonly referred to as the ‘cone of acceptance’.

G 3.1.11 As the UHF band signal emitted from the reader spreads out in a conical shape, part of that signal can, at approximately one metre from the beacon, start to receive data from the tag. Similarly, having passed over the beacon, the reader continues to receive consistent data until the on-board reader exceeds 1 m from the tag. While passing over the beacon, the optimum read reliability is achieved when the centre of the reader and centre of the beacon become directly aligned.

Part 4 Trackside Subsystem

4.1 Beacon specification

4.1.1 The beacon shall be:

a) A passive UHF read / write transponder; and
b) IP-X tag talks only (TTO) format; and
c) Capable of receiving the onboard reader UHF signal within an operating coverage range of less than or equal to one metre.

Rationale

G 4.1.2 A pre-programmed application identification (ID) code, and user configured data, are transmitted back to the reader by varying the levels of RF energy (signal) returned from the beacon.

G 4.1.3 The most expedient data transfer speed is achieved by a TTO method, which avoids the additional time required for a reader talks first.

G 4.1.4 The maximum ERP of the onboard emitted UHF signal regulated by Ofcom, as set out in IR 2030/13/3, limits the operating range cone of acceptance for track beacon activation to less than or equal to one metre.

Guidance

G 4.1.5 The RFID passive beacon is energised from RF energy that the onboard reader transmits, removing the need for any electrical power to be supplied to the beacons, thus making trackside installation simpler and cheaper than using a battery or dedicated electrical supply.

G 4.1.6 Active beacons, that use a power supply, are excluded due to the complexity of providing the power.

G 4.1.7 Battery operated beacons are excluded due to the increased maintenance implications and the disposal requirements, for environmental reasons.

G 4.1.8 Application of this specified format will achieve consistency across the rail network and provide benefits when developing RFID for further applications.

G 4.1.9 The generic RFID data format structure is compatible with BS ISO/IEC 18000-6:2013 Type D beacon.

4.2 Beacon installation

4.2.1 The beacon shall be installed on a sleeper between the running rails, on the centreline between them, with a tolerance of ± 5 mm.

4.2.2 The vertical position of the nominal plane of the beacon shall be between 135 mm and 170 mm below the top of the rail.

Rationale

G 4.2.3 Providing a fixed position for the beacon between the running rails enables the installation of the onboard reader on the underside of the train to be adjusted to maintain a data transmission range of less than or equal to one metre.

G 4.2.4 This represents the 140 mm (highest) to 165 mm (lowest) below top of rail distance, with a 5 mm tolerance.

Guidance

G 4.2.5 The mounting and fixing on different types of sleeper material affects the height of the beacon, relative to the top of the rail, as set out in *4.2.2*.

G 4.2.6 If the design includes an encapsulating material to protect the passive RFID device from mechanical damage, consider the effect this may have on signal penetration from the onboard reader.

4.3 Beacon installation design

4.3.1 The design shall be capable of data transmission between one metre of the onboard reader and track based beacon, under environmental conditions of rain / snow / ice / leaf build-up and other typical railway debris such as metallic powder contamination from rail grinding and friction brake systems.

Rationale

G 4.3.2 Data transmission between the onboard reader and track based beacon within a one metre range is unreliable in conditions other than typically found in the railway environment; for example, where a beacon is immersed in water, or completely covered by metal, for example foil.

Guidance

G 4.3.3 Ingress protection (IP67) provides protection against the effects of immersion in water to a depth between 15 cm and 1 m.

4.4 Potential interference with other RFID systems

4.4.1 Requirements to mitigate potential interference between the RFID system set out in this document and ISO/IEC 18000-63 RFID readers and tags is an open point in this document.

Rationale

G 4.4.2 Analysis and management of the potential interference, as stated in the guidance, provide mitigation of the potential for interference; that is, tags not being read from other RFID systems.

Guidance

G 4.4.3 Suitable requirements to manage the hazards associated with interference can be identified through application of a suitable risk assessment and management methodology.

G 4.4.4 Factors which can mitigate the potential for interference are:

a) Using different channels for the readers
b) The orientation of the tags and readers; that is, one system operating laterally and the other vertically
c) Reduced reading range.

G 4.4.5 The current recommendation is that tags used for the system set out in RIS-0796-CCS are placed at least 70 metres from the antennas for these systems. This distance is taken from the Affini report.

G 4.4.6 Research is currently being undertaken to determine suitable mitigation methods.

G 4.4.7 Testing may be used to determine whether there is an issue at each site.

Part 5 Management of Application Codes

5.1 Allocated application codes

5.1.1 Only allocated application codes, as set out in *Appendix A* and the associated protocols, shall be used.

5.1.2 The database of allocated unique RFID application codes for the rail vehicle and track technical interface shall be maintained by RSSB.

Rationale

G 5.1.3 Only using allocated application codes and associated data protocols allows potential future use of existing applications.

G 5.1.4 The re-use of existing applications provides benefits including:

a) The prevention of the proliferation of bespoke applications that provide the same functionality, which results in repeating the installation and transmission of the same data
b) The optimisation of the use of the limited available data and message capacity
c) The reduction in the time and effort required to design a bespoke application.

Guidance

G 5.1.5 The values allocated at the date of publication are set out in *Appendix A*. The specification of the application codes and variables for each application will be included in the appendices that follow *Appendix A*, one appendix for each application.

G 5.1.6 Availability of an application code for a function does not automatically permit the function to be used. Use of the function is still subject to the Route Compatibility Assessment Process.

5.2 Data structure

5.2.1 Each beacon data structure shall start with a 64-bit unique identification (UID) code, known as page 0, followed by 7 x 64-bit pages of user electrically erasable programmable read-only memory (EEPROM) pages that can be written to, read and locked with the appropriate programming tool.

5.2.2 The first four bits of each EEPROM page (pages 1-7) shall identify the page number, and contain hex values h1x to h7x.

5.2.3 Each EEPROM page has its own Consultative Committee for International Telephony and Telegraphy-Cyclic Redundancy Check (CCITT-CRC) 16-bit, which shall verify the tag data.

5.2.4 The last two bytes (6 and 7) of each page shall contain a CCITT-CRC 16-bit checksum of the data contained on each page.

5.2.5 The bits within each page shall be ordered from the most significant bit (MSB) – 63, to least significant bit (LSB) – 0 where the MSB of the page starts within Byte 0 (see Figure *Figure 2*).

5.2.6 Page 15 of each tag shall provide configuration indication of the total number of pages where the default is the maximum seven EEPROM pages and the minimum is zero EEPROM pages.

5.2.7 Information passed from the Control, Command and Signalling (CCS) trackside subsystem to the CCS on-board subsystem (data transmission) shall be as shown in *Figure 2*.

5.2.8 The Rail Industry Standard (RIS) reserved two version control bits shall use:

a) Byte 0 LSB binary digit 56; and
b) Byte 1 MSB binary digit 55.

5.2.9 The RIS reserved application code for a specific application shall be programmed using seven bits from Byte 1 MSB binary digit 54 to Byte 1 LSB binary digit 48.

Rationale

G 5.2.10 Reducing the number of different programmed pages increases the number of reads, which benefits applications operating at higher speeds.

G 5.2.11 The onboard reader is programmed to receive data in the generic format.

Guidance

G 5.2.12 A page within the beacon data structure consists of 8 bytes, where page 0 is the factory setting and contains the serial number of the tag. The whole page 0 is the UID of the tag.

G 5.2.13 Each specific application code is assigned a unique binary number, as set out in *Appendix A*.

G 5.2.14 Page 0 is programmed by the manufacturer, who sets the version control bits and adds the relevant values to each page of the tag.

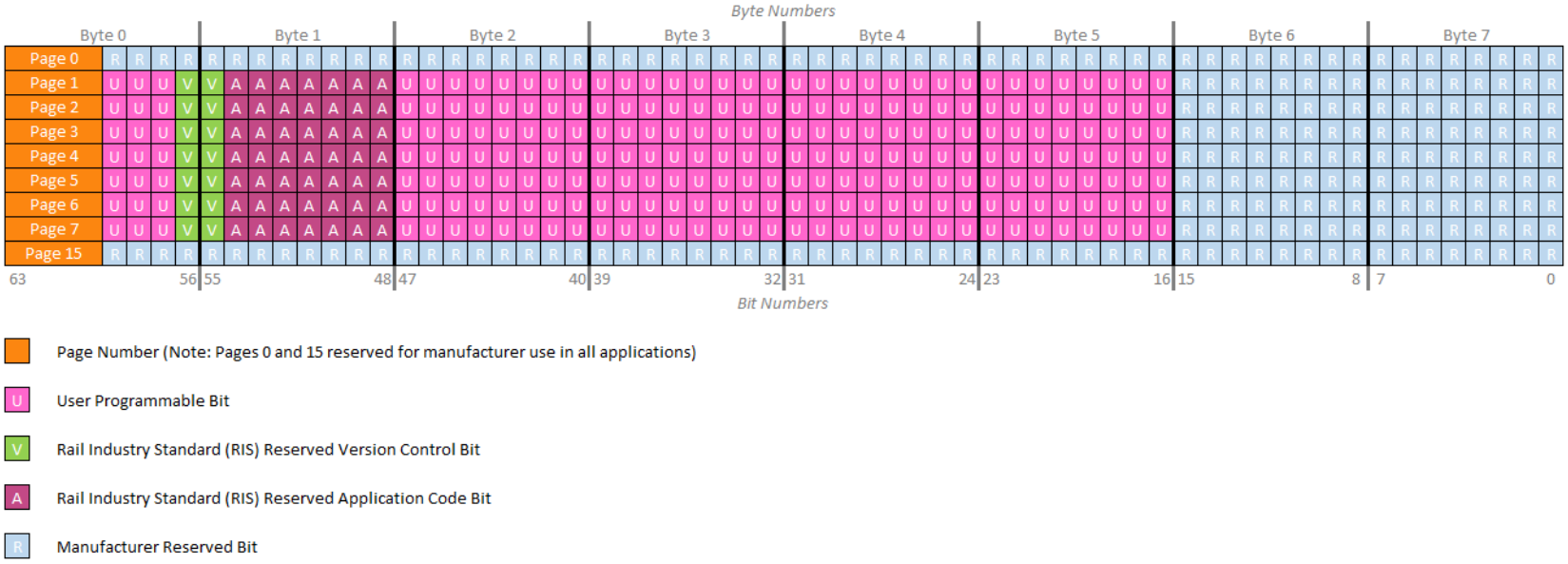


Figure 2: Generic RFID data format structure

5.3 Proposing a new application code

5.3.1 Registration of a new RFID application code shall be submitted according to the provisions for changing documents set out in the Standards Manual.

5.3.2 The new application code shall be selected from the list set out in *Table 1* that are currently unallocated.

5.3.3 The proposal shall include the following:

a) Identities of parties applying applicable train types and operating routes
b) Outline description of system functionality, including why the application is required and what the application code and its associated variables are used for
c) Justification for issue of a new application code, if an application code performing the same function exists
d) Data structure and values, which include:
    i) The application code and variables proposed to provide the functions; and
    ii) The data structures; and
    iii) A description of all the usable programmable bits.
e) Number of configured pages that are expected to be read
f) The proposal form shall set out the page number(s) of any repeated pages.

Rationale

G 5.3.4 This is a standard industry process to manage change to standards.

G 5.3.5 The limited application codes provide a Hamming distance of four between the application codes to reduce the chance of the incorrect application code being read.

G 5.3.6 The details of the application are included to support the management of RFID application codes.

G 5.3.7 Details of the application structure, variables and specific values are needed to help any potential future use of existing applications.

G 5.3.8 When an application performing the same function already exists, a new application code is only assigned where the need for a new protocol is justified.

G 5.3.9 Details of design principles and implementation rules relating to why and how the data are implemented are essential to facilitate the correct re-use of existing applications.

Guidance

G 5.3.10 Where an additional application is identified, a unique seven digit application code is required as per the data message format structure set out in Appendix A. To support a unique database application code for each additional application, an application code register is maintained by RSSB on behalf of the industry.

G 5.3.11 An additional application code can be generated that encompasses other individual application codes within the register.

Guidance on design

G 5.3.12 The full list of possible application codes which also shows the allocated application is set out in *Table 1*.

G 5.3.13 It is good practice to consider the data requirements for other similar fleets, routes or operator needs in designing a common data field length when proposing the use of a new application code.

G 5.3.14 When designing a new function, consider whether requirements for any potential future applications, for example other rolling stock types or other routes, can be met, so that the same function could be future proof.

G 5.3.15 Co-ordination and cross-industry discussions are encouraged, especially for functions that are expected to be widely applicable.

G 5.3.16 The process for proposing a new RFID application code is shown in *Figure 3* with the key steps shown in the left column. More details of how to change a standard, by submitting a Request for Help form, can be found on the RSSB website.

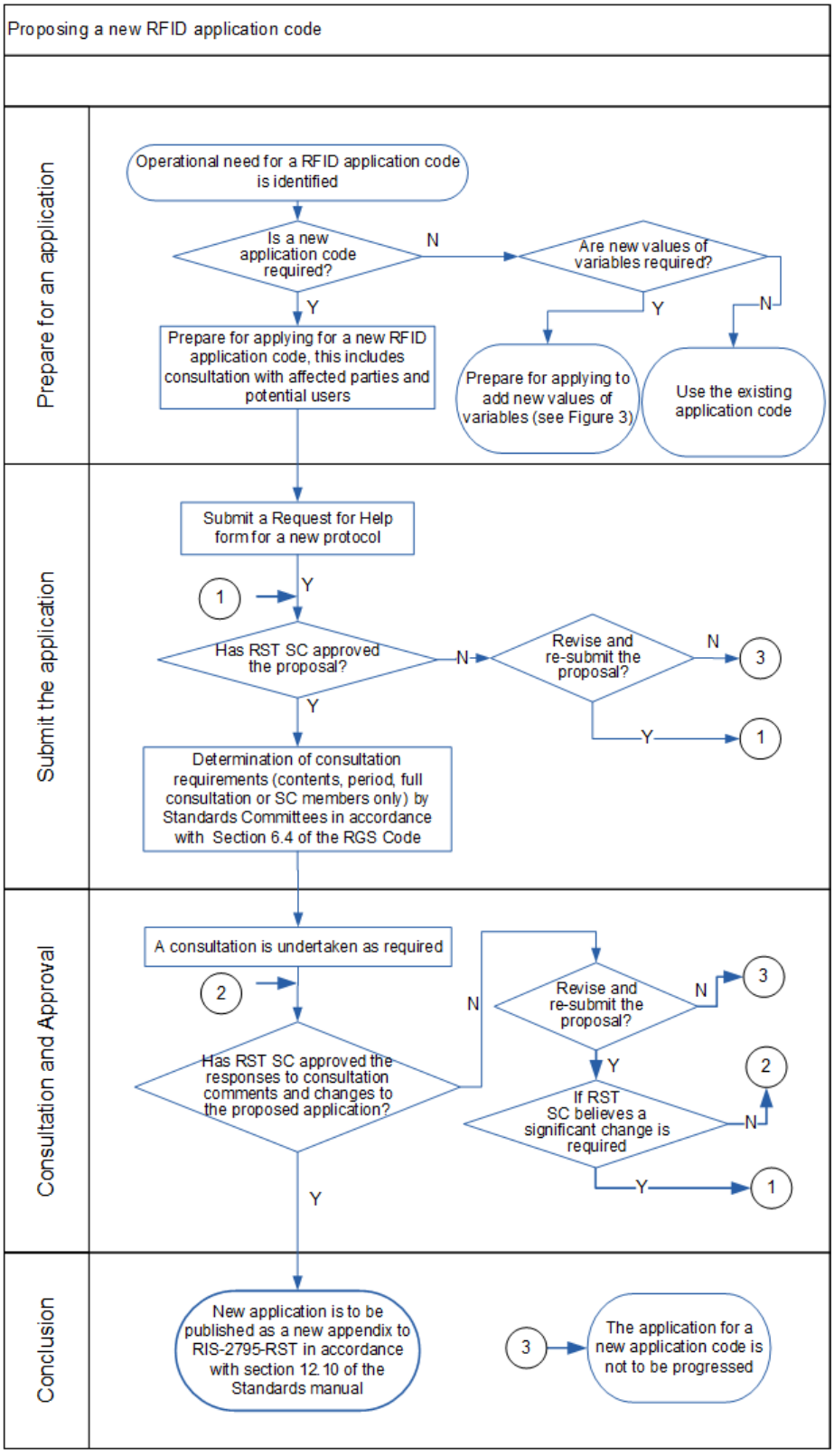


Figure 3: New application code

Guidance on how to prepare for an application

G 5.3.17 When an operational need for an RFID application code arises, the first step is to check whether it is possible to make use of an existing application code. If an existing application code can be used, follow the steps shown in *Figure 4*.

G 5.3.18 The applicant is encouraged to engage with potential stakeholders at the early stage of the development process so that any potential issues can be identified and resolved before the proposal is submitted. This could also support the applicant in identifying and considering the needs of potential future users to improve the re-usability of the application.

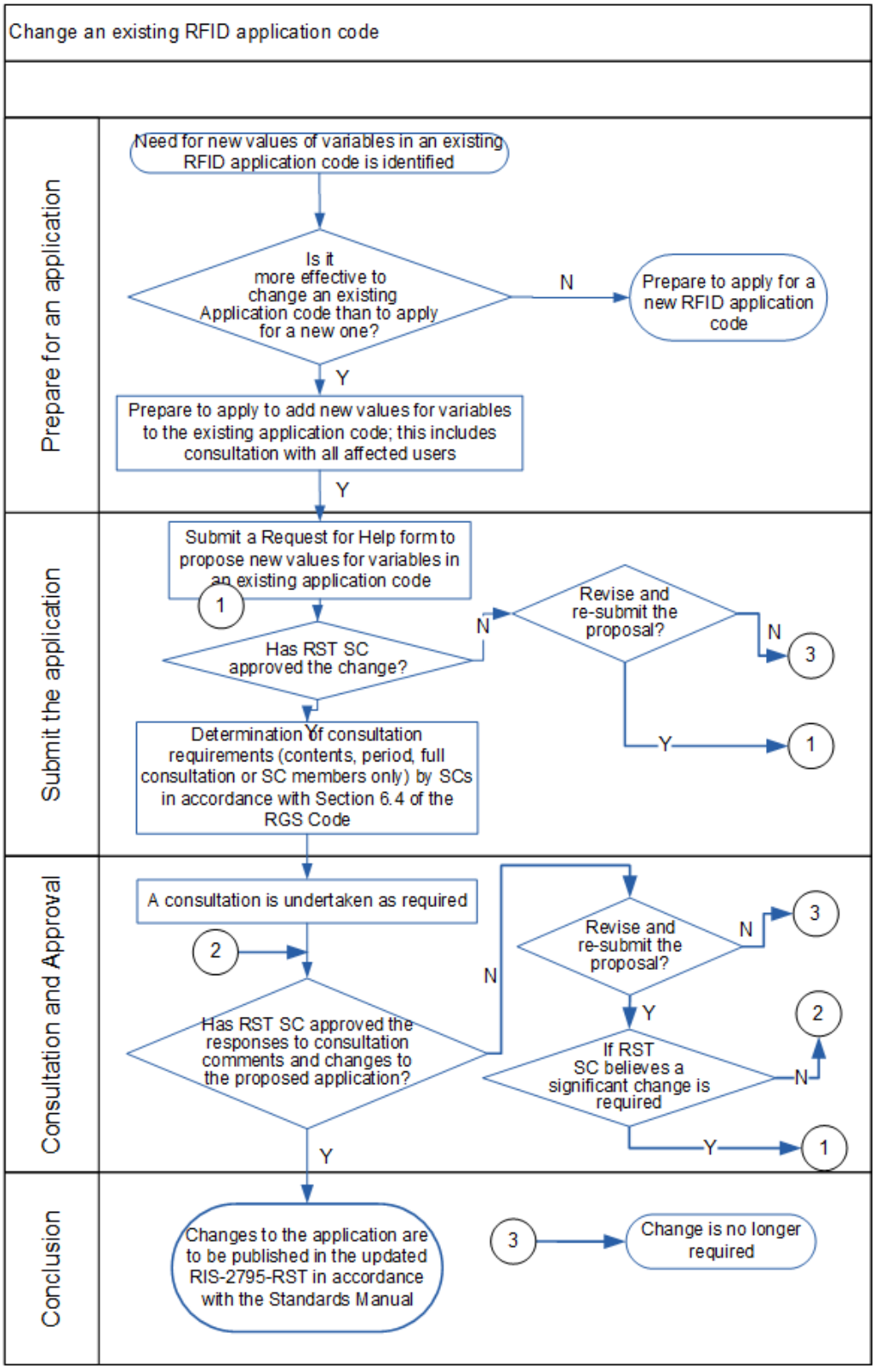


Figure 4: Change existing application code

Guidance on how to submit the application

G 5.3.19 If a new application is considered to be justified, the procedure for change to a RIS, as set out in in section 14 of the Standards Manual, needs to be applied.

G 5.3.20 The first step of this process, in accordance with the 'how to change standards' page on the RSSB website, is to complete a request for help form. A link to the application form and details of where to submit the form are provided at the web page.

G 5.3.21 The completed form is submitted to the lead Standards Committee (SC) (Rolling Stock (RST) SC), for consideration. The procedure for consultation is set out in sections 6.5 and 6.6 of the Railway Group Standards Code.

Guidance on consultation and approval

G 5.3.22 If the lead SC approves the proposal, an industry-wide consultation may be undertaken in accordance with sections 6.5 and 6.6 of the Standards Manual.

G 5.3.23 The consultation process provides the opportunity for industry to advise any commonality with existing and future RFID application codes, and whether there are safety or functional implications for the applications in use.

G 5.3.24 Any responses to consultation comments are approved by the relevant SC before being published and sent to those parties who commented on the proposed change.

Guidance on conclusion of an application

G 5.3.25 After SC approval, the new RFID application code is published as an additional appendix to this standard.

5.4 Specifying new values for variables in an existing application code

5.4.1 A proposal shall be submitted, in accordance with the Standards Manual, for changes to RFID application code variables that have an impact on existing users or potential future users.

Rationale

G 5.4.2 This is a recognised industry process for managing changes to the content of a RIS.

G 5.4.3 Changes that have an impact on existing users, or potential future use, need to be reflected in the document, to avoid incompatibility and support re-usability of the associated application.

Guidance

G 5.4.4 Some application codes may have variables with multiple values where some values of the variables were not specified in the original description of the application code. Other parties may use the spare values for additional functions within the scope of the operation of the system using the application code.

G 5.4.5 The process for change to a RIS is set out in in section 14 of the Standards Manual.

G 5.4.6 The process for proposing a change to an existing RFID application code is shown in *Figure 4*. More details of how to change a standard can be found at https://www.rssb.co.uk/standards-and-the-rail-industry/how-to-change-standards.

G 5.4.7 An assessment of the impact of change is needed to accompany the proposal. In some circumstances a new RFID application code could be needed depending on the outcome of the assessment.

G 5.4.8 Prior consultation with affected parties reduces the risk of the proposal being challenged at the industry consultation stage.

5.5 Decommissioning

5.5.1 A proposal shall be submitted for the decommissioning of a use of an RFID application code.

Rationale

G 5.5.2 This is a recognised industry process for managing changes to the content of a RIS.

G 5.5.3 This supports the whole life management of RFID application codes.

Guidance

G 5.5.4 Prior consultation with affected parties reduces the risk of the proposal being challenged at the industry consultation stage.

G 5.5.5 The table for the use of RFID application codes and associated details are updated after the proposal is approved by the relevant SCs.

Appendices

Appendix A RFID Train to Track Allocated Application Codes

A.1 Permitted and allocated application codes

Guidance

Application Code (Decimal)	Application Code (Binary)	Use	Appendix Reference
1	0000001	Automatic Selective Door Operation (ASDO) (Any installation position in accordance with RIS-2747-RST)	*Appendix B*
14	0001110	Automatic Power Change Over (APCO)	*Appendix C*
23	0010111	ASDO (Beacon positioned between 10 m and 16 m from the start of the platform)	*Appendix B*
24	0011000	ASDO (Beacon positioned between 30 m and 480 m from the signal, and after the last diverging points)	*Appendix B*
36	0100100	Automatic Power Mode Control (APMC)	*Appendix D*
43	0101011	Not yet allocated	N/A
50	0110010	Not yet allocated	N/A
61	0111101	Not yet allocated	N/A
66	1000010	Not yet allocated	N/A
77	1001101	Not yet allocated	N/A
84	1010100	Not yet allocated	N/A
91	1011011	Not yet allocated	N/A
103	1100111	Not yet allocated	N/A
104	1101000	Not yet allocated	N/A
113	1110001	Not yet allocated	N/A

Application Code (Decimal)	Application Code (Binary)	Use	Appendix Reference
126	1111110	Not yet allocated	N/A

Table 1: Permitted and allocated application codes

Note: The provision of codes for functionalities permits the functionality to be used. The bringing into use of a new functionality needs to be justified in the safety case for the system operator.

Appendix B Automatic Selective Door Operation (ASDO)

B.1 ASDO Data Format Structure

Guidance

G B.1.1 Page 1 of EEPROM data for Automatic Selective Door Operation (ASDO) is repeated over EEPROM pages 2 to 4.

G B.1.2 Page 15, the system configuration page, has noted that the seven EEPROM pages in this application are set to pages 1 to 4 only.

G B.1.3 The system configuration page is factory set and records the pre-set number of pages to be programmed, where the minimum is zero pages and the maximum seven pages.

G B.1.4 Readability reliability increases with repeatability by reducing the number of pages read in a cycle.

G B.1.5 Readability reliability also increases if a page of information is repeated in the same cycle.

G B.1.6 Appendix 2 of RIS-2795-RST issue two originally set out the data format structure and communications protocol for ASDO functionality.

G B.1.7 The different application codes for ASDO reflect the need for precise beacon positioning when per vehicle ASDO systems are used, and/or the different signal sighting requirements of each TOC/fleet. The data within each application code is specified exactly the same so other ASDO systems may read either application code as a valid beacon. So long as the operator has established relevant application code, the ASDO system will apply the correct door pattern.

G B.1.8 Further details on different ASDO systems are provided in RIS-2747-RST.

G B.1.9 The format of the structure is set out in *Figure 5* .

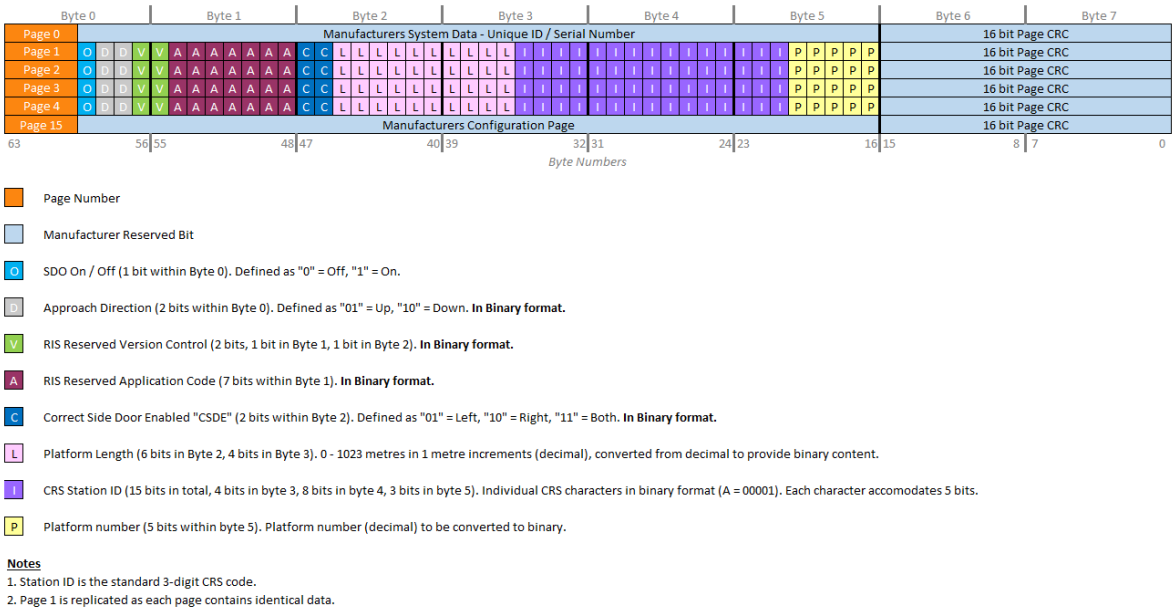


Figure 5: ASDO data structure

Appendix C Automatic Power Mode Control (APCO)

C.1 APCO Data Structure

Guidance

G C.1.1 This application code is for Automatic Power Change Over (APCO), either statically or manually.

G C.1.2 *G B.1.1* to *G B.1.5* apply for this application code.

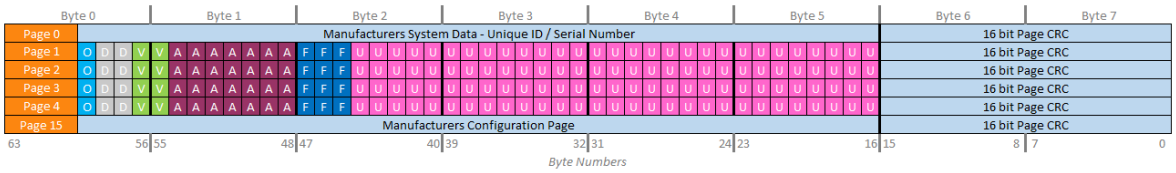
G C.1.3 Further details on different APCO systems are provided in RIS-2713-RST.

G C.1.4 There are spare values of variable F and 29 bits that are unused. New values for these may be requested using the process set out in *5.4*. The spare values of variable F are set out in *Table 2*.

Spare 'Passes Information' Codes	Spare 'Demands Action' Codes
100	110
101	111
110	
111	

Table 2: Spare values of F

G C.1.5 The data structure is set out in *Figure 6*.



Page Number

Manufacturer Reserved Bit

O APCO On / Off (1 bit within Byte 0). Defined as "0" = Off, "1" = On. Determines whether "Function" F demands action or passes information

D Approach Direction (2 bits all within Byte 0). Defined as "01" = Up, "10" = Down. **In Binary format.**

V RIS Reserved Version Control (2 bits, 1 bit in Byte 1, 1 bit in Byte 2). **In Binary format.**

A RIS Reserved Application Code (7 bits all within Byte 1). **In Binary format.**

F Function Code (3 bits all within Byte 2). Determined by the value of "APCO On/Off" O bit as follows:

Function Code (Binary)	APCO On/Off Bit = 0 "Passes Information"	APCO On/Off Bit = 1 "Demands Action"
000	Test	Retract All Collectors
001	Arm Direction Detection	Change to AC
010	Trigger Direction Detection	Change to DC
011	Cancel Direction	Invalid
100	Not Defined	Charging Mode
101	Not Defined	Deploy All Collectors
110	Not Defined	Not Defined
111	Not Defined	Not Defined

U Not defined (29 bits, 5 bits in byte 2, all bits in bytes 3, 4 and 5). All set to zero.

Notes

1. Four configured pages are to be read.
2. Page 1 is replicated as each page contains identical data.
3. APCO On/Off and Approach Direction are intended to be consistent with the ASDO application data format.
4. The provision of beacons emitting the 'Test' message (APCO On / Off = 0, Function Code = 000) at known locations is a means of testing the on-board receiver.
5. Beacons read in the sequence 'Arm' then 'Trigger' allow the train to determine its current direction, according to the value of the associated 'Approach Direction' bits. Subsequent beacons with a APCO On / Off = 1 value, whose 'Approach Direction' value indicates the opposite direction will be ignored, reading either:

(a) a 'Cancel Direction' beacon **or**

(b) an 'Arm' beacon followed by anything other than a 'Trigger' beacon with the same 'Approach Direction' value as the 'Arm' beacon, which forces the train to forget it's current direction and to act on all subsequent 'Action' beacons, regardless of their 'Approach Direction' value.

Figure 6: APCO data structure

Appendix D Automatic Power Mode Control (APMC)

D.1 APMC Data Format Structure

Guidance

G D.1.1 This application code is for Automatic Power Mode Control (APMC) either statically or dynamically.

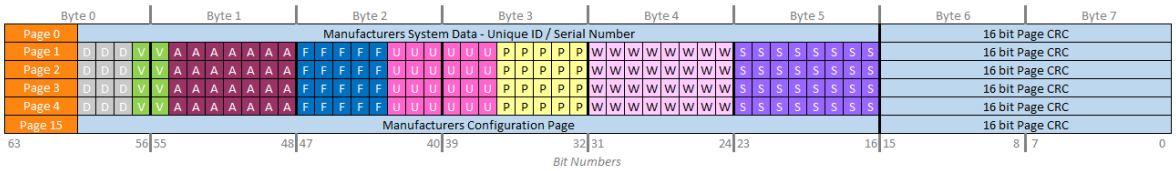
G D.1.2 *G B.1.1* to *G B.1.5* apply for this application code.

G D.1.3 There are 6 bits that are unused which are:

a) Bits 40 to 42 in byte 2; and
b) Bits 37 to 39 in byte 3.

G D.1.4 An APMC beacon contains data which describes the infrastructure, rather than the desired effect on the unit, in order to be agnostic to the available power modes supported by the unit. The railway undertaking and the train builder can define the appropriate reaction of the unit based on a risk assessment which may include other inputs, such as drivers actions or vehicle speed.

G D.1.5 The data structure is set out in *Figure 7*.



Page Number

Manufacturer Reserved Bit

D — Direction control (3 bits within byte 0). To set a direction, use three beacons with codes 5, 6 and 7. If two beacons are detected in ascending order, the unit sets direction UP. If two beacons are detected in descending order, the unit sets direction DOWN. Equal values are ignored. **In Binary format.**

Direction Code (Decimal)	Direction Code (Binary)	Function
0	000	Tag valid only when no direction is set
1	001	Tag valid only when UP direction is set
2	010	Tag valid only when DOWN direction is set
3	011	Tag valid for any direction
4	100	Ignore tag value, clear stored direction and set direction to none
5	101	Ignore tag value, direction value = 5
6	110	Ignore tag value, direction value = 6
7	111	Ignore tag value, direction value = 7

V — RIS Reserved Version Control (2 bits, 1 bit in Byte 1, 1 bit in Byte 2). **In Binary format.**

A — RIS Reserved Application Code (7 bits all within Byte 1). **In Binary format.**

F — Function Code (5 bits all within byte 2). See Table 3. **In Binary format.**

U — Not defined (6 bits, 3 bits in byte 2, 3 bits in byte 3). All set to zero.

P — OLE Power (1 + 4 bits all within byte 3). Composed of a range-bit and a 4-bit number. When the range-bit is 0, the 4-bit number represents 25..375 kW in increments of 25 kW, when range-bit is 1, the 4-bit number represents 400..3200 kW in increments of 200 kW. A value of 00000 will not change the power limitation. A value of 11111 removes the power restriction. Power limit is on per-unit basis. The unit shall not draw more than [P] kW from the external supply. E.g. 0(x)0101 = 125 kW, 1(x)0101 = 1000 kW, 0(x)0000 = keep previous power limit setting, 1(x)1111 = removes any power restriction and resets the vehicle to a default power limit. **In Binary format.**

W — Distance (1 + 7 bits all within byte 4). Composed of a multiplier and 7-bit number. Multiplier can be 0 (3m) or 1 (100m). Remaining bits permit range from 0-127. The value is rounded to the nearest safe distance. **In Binary format.**

S — Speed (8 bits all within byte 5). 0-250km/h in 1km/h steps. '0' value refers to zero speed / door release. When value is '0', traction is also inhibited whilst pantograph is raised. Binary values for 251-253 (decimal) are reserved for special use. Binary value for 254 (decimal) will reset system to default. Binary value for 255 (decimal) is ignored. **In Binary format.**

Notes
1. Four configured pages are to be read.
2. Page 1 is replicated as each page contains identical data.
3. D, S, F, U, P, W and V values are user configurable.

Figure 7: APMC data structure

	Function Code (Binary Format)																														
Function Description	00000	00001	00010	00011	00100	00101	00110	00111	01000	01001	01010	01011	01100	01101	01110	01111	10000	10001	10010	10011	10100	10101	10110	10111	11000	11001	11010	11011	11100	11101	11110	11111
Direction information	✓																															
Exhaust limited										✓		✓		✓		✓		✓		✓		✓		✓								
Exhaust not limited		✓		✓		✓		✓																		✓		✓		✓		✓
Noise limited											✓	✓			✓	✓				✓	✓			✓	✓							
Noise not limited			✓	✓			✓	✓																			✓	✓		✓		✓
Energy collection device deployed, charging available																					✓	✓	✓	✓		✓	✓	✓				
Vehicle using on-board energy system (OBES)					✓	✓	✓	✓						✓	✓	✓																
Discontinuity of fixed energy installation																													✓	✓	✓	✓
Apply, change or remove vehicle power draw limit					✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vehicle operating using fixed energy installation only									✓	✓	✓	✓																				
Reserved (for future use)													✓				✓															

Table 3: APMC function code table

Definitions

active RFID tag	There are two types of active RFID tags: transponders and beacons. A transponder only communicated when it is in the immediate vicinity of a reader. A beacon broadcasts constantly. **Note:** Balises or Eurobalise are an apparatus in the track by means of which data are transmitted to a train to update the trainborne automatic protection equipment regarding the track and signal conditions of the line ahead. Source: *IEV 821-08-15*
antenna	That part of a radio transmitting or receiving system which is designed to provide the required coupling between a transmitter or a receiver and the medium in which the radio wave propagates. **Note:** In practice, the terminals of the antenna or the points to be considered as the interface between the antenna and the transmitter or receiver should be specified. **Note:** If a transmitter or receiver is connected to its antenna by a feed line, the antenna may be considered to be a transducer between the guided waves of the feed line and the radiated waves in space. Source: *IEV 712-01-01*
Automatic Power Change Over (APCO)	No definition.
Automatic Power Mode Control (APMC)	No definition.
Automatic Selective Door Operation (ASDO)	A type of door selection system.
beacon [generic non-technical]	A means of providing digital information, comprised of a tag embedded in a mechanical housing, known as balises or Eurobalises for certain applications.
Consultative Committee for International Telephony and Telegraphy (CCITT)	No definition.
Control Command and Signalling (CCS)	No definition.
cyclic redundancy check (CRC)	No definition.
effective radiated power (in a given direction) (ERP)	The product of the power supplied to an antenna and the relative gain of the antenna in a given direction, with respect to a half-wave dipole. Source: *IEC 60050*. *http://www.electropedia.org/*. IEV ref: 712-02-52.

	Note: The use of the concept of equivalent isotropically radiated power is to be preferred to that of effective radiated power.
Electrically Erasable Programmable Read-Only Memory (EEPROM)	No definition.
hamming distance	The number of digit positions in which the corresponding digits of two n-bit bytes of the same length are different. Source: *IEV 721-08-05*
Ingress Protection (IP)	Ingress Protection as set out in *BS IEC 60529*.
IP-X	An RFID air-interface protocol.
ITU-T	Telecommunication Standardization Sector of the International Telecommunications Union.
least significant bit LSB	No definition.
most significant bit (MSB)	No definition.
Ofcom (Office of Communications)	No definition.
On-Board Energy System (OBES)	The power source on-board to move the vehicle, for example diesel or battery traction.
passive RFID tag	A type of RFID tag that does not contain an internal power source and is usually of a single or dual chip design. Passive RFID tags are beam-powered using the electromagnetic energy of a tag reader.
Radio and Telecommunications Terminal Equipment (RTTE)	No definition.
Radio Frequency (RF)	No definition.
Radio Frequency Identification (RFID)	A method of storing and retrieving data via electromagnetic transmission to a radio-frequency-compatible integrated circuit.
RFID reader	A device that is used to read and/or write data to RFID tags.
selective door operation (SDO)	A type of door selection system.
tag	An electronic identification device that is made up of an integrated chip and antenna.
Tag Talks Only (TTO)	Where no reader intervention (in the form of commands requiring reader modulation) is needed to effect transmission of the EEPROM data pages.
track	The support system made up of rails and sleepers which is supported on either ballasted formation or other varying forms.
Ultra High Frequency (UHF)	No definition.

unique identification number (UID)	A non-essential serial number which assists in beacon identification during normal system operation. The UID provides a reference number for identifying the unique tag ID.
unique identification number (UID)	A non-essential serial number which assists in beacon identification during normal system operation. The UID provides a reference number for identifying the unique tag ID.
write	The transfer of data to an RFID tag. The tag's internal operation can include reading data in order to verify the operation.

References

The Standards catalogue gives the current issue number and status of documents published by RSSB: http://www.rssb.co.uk/railway-group-standards.

RGSC 01	Railway Group Standards Code
RGSC 02	Standards Manual

Documents referenced in the text

Railway Group Standards

GERT8073	Requirements for the Application of Standard Vehicle Gauges
GIRT7073	Requirements for the Position of Infrastructure and for Defining and Maintaining Clearances
GMRT2173	Requirements for the Size of Vehicles and Position of Equipment

RSSB documents

RIS-2747-RST	Functioning and Control of Exterior Doors on Passenger Vehicles
RIS-0796-CCS	Train to Infrastructure RFID Compatibility
RIS-2713-RST	System Requirements for the Introduction and Operation of Multi-Mode Rolling Stock

Other references

Affini report	Evaluation of RFID Coexistence and Interference Risks on the Railway for Network Rail, August 2015.Written by Affini Technology.
BS ISO/IEC 18000-6:2013	Information technology. Radio frequency identification for item management. Parameters for air interface communications at 860 MHz to 960 MHz General
BS ISO/IEC 18000-63:2015	Information technology. Radio frequency identification for item management. Parameters for air interface communications at 860 MHz to 960 MHz Type C
ETSI EN 302 208 v3.1.0 (2016-02)	Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W and in the band 915 MHz to 921 MHz with power levels up to 4 W; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU
IR 2030/13/3	UK Interface Requirements 2030 Licence Exempt Short Range Devices. Issued by Ofcom
Radio Equipment Directive (RED)	Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of

radio equipment and repealing Directive 1999/5/EC Text with EEA relevance