PD IEC/TS 62773:2014

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Railway applications — Procedure to determine the performance requirements for radio systems applied to radio-based train control systems

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The UK participation in its preparation was entrusted to Technical Committee GEL/9, Railway Electrotechnical Applications.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2014

ISBN 978 0 580 77870 4
ICS 45.060.01

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 June 2014.

Amendments/corrigenda issued since publication

Date	Text affected

IEC TS 62773

Edition 1.0 2014-04

TECHNICAL SPECIFICATION

colour inside

Railway applications – Procedure to determine the performance requirements for radio systems applied to radio-based train control systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE X

ICS 45.060

ISBN 978-2-8322-1519-7

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

RAILWAY APPLICATIONS – PROCEDURE TO DETERMINE THE PERFORMANCE REQUIREMENTS FOR RADIO SYSTEMS APPLIED TO RADIO-BASED TRAIN CONTROL SYSTEMS

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62773, which is a technical specification, has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
9/1823/DTS	9/1899/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

The purpose of this Technical Specification is to provide a guideline for the rail transport authority and/or the supplier of the radio system to determine performance requirements of the radio system from the conditions of the railway systems using the radio-based train control systems.

This Technical Specification specifies the procedure to determine the performance requirements for radio system applied to the radio-based train control systems. The performance requirements are related to the radio parameters. Each radio parameter needs to be set to an appropriate value to enable data exchange with quality of service that will meet the requirements from the railway system as a whole and particularly the train control functions. Radio parameters are then decided based on the analysis of the conditions of the railway system using the train control system.

RAILWAY APPLICATIONS – PROCEDURE TO DETERMINE THE PERFORMANCE REQUIREMENTS FOR RADIO SYSTEMS APPLIED TO RADIO-BASED TRAIN CONTROL SYSTEMS

1 Scope

The objective of this Technical Specification is to establish a procedure to be used by rail transport authorities and/or radio suppliers to determine the appropriate performance requirements of radio system for a radio-based train control system, consistent with their specific business needs and existing conditions: the Technical Specification itself consists in defining a procedure linking preconditions to some radio parameters. Then, the appropriate performance requirements are deduced by the user of the Technical Specification from the radio parameters.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

None.

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
capacity
maximum amount of information transmitted and received per unit time on the radio link

3.1.2
data rate
amount of data transmitted over a given period of time (usually expressed in “bits per second” or “bytes per second”)

Note 1 to entry: The minimum data rate needs to take into account the maximum amount of transmitted data per unit time for the train control system.

3.1.3
encryption
method of transmitting information so that third parties cannot decode it

Note 1 to entry: It serves to enhance the secrecy of information transmitted and received within the system.

3.1.4
handover
shift of connection to an adjacent radio base station

3.1.5
measures against masquerading
measures involving the performance of electronic authentication or validity checks, providing network firewalls, or physically isolating systems to prevent tampering or spoofing of electronic messages

3.1.6
modulation method
method of varying one carrier signal to contain the information of a baseband signal

Note 1 to entry: It is determined in consideration of frequency, bandwidth, data rate and/or propagation characteristics such as antenna parameters.

3.1.7
number of connections
number of mobile radios that can simultaneously communicate with one wayside radio

3.1.8
period
time between the start of transmission of two consecutive packets at the physical radio interface

3.1.9
quality of service
quality of the communication service provided in terms of guaranteed throughput, jitter, latency and packet loss

3.1.10
type of transmission
open or closed transmission based on IEC 62280

3.2 Abbreviations

ATP Automatic Train Protection
GOA1 Grade Of Automation 1
GOA2 Grade Of Automation 2
GOA4 Grade Of Automation 4
GPS Global Positioning System
QoS Quality of Service
TC Train Control

4 Outline of the process for determining performance requirements

The determination of performance requirements of a radio system for radio-based train control systems requires specification of the conditions that may influence them, evaluation of these individual circumstances, and judgment of whether or not to reflect them in the performance requirements. An outline of the process is described in this clause, which helps specifying the various conditions that may influence these requirements.

The following factors need to be taken into consideration when determining the performance requirements of the radio system.

– Preconditions on available spectrum:
  Environmental conditions and regulatory constraints
– Preconditions on railway operation:

Railway line conditions, operating conditions, TC communication requirements and required type of transmission

– Radio parameters:

Security parameters and transmission parameters

These factors have to be in line with the expression of performance requirements defined at the level of the train control system as a whole.

Preconditions influence the radio parameters both directly and indirectly. Environmental conditions, regulatory constraints, railway line conditions, operational conditions, and train control communication requirements determine the transmission parameters. These preconditions determine the performance requirements of the radio system.

The relationships that exist among them are shown in Figure 1, and items related to the preconditions and radio parameters are listed in Table 1.

Individual preconditions are defined in Clause 5 and Clause 6, and radio parameters are defined in Clause 7. Clause 8 outlines the correlation between them.

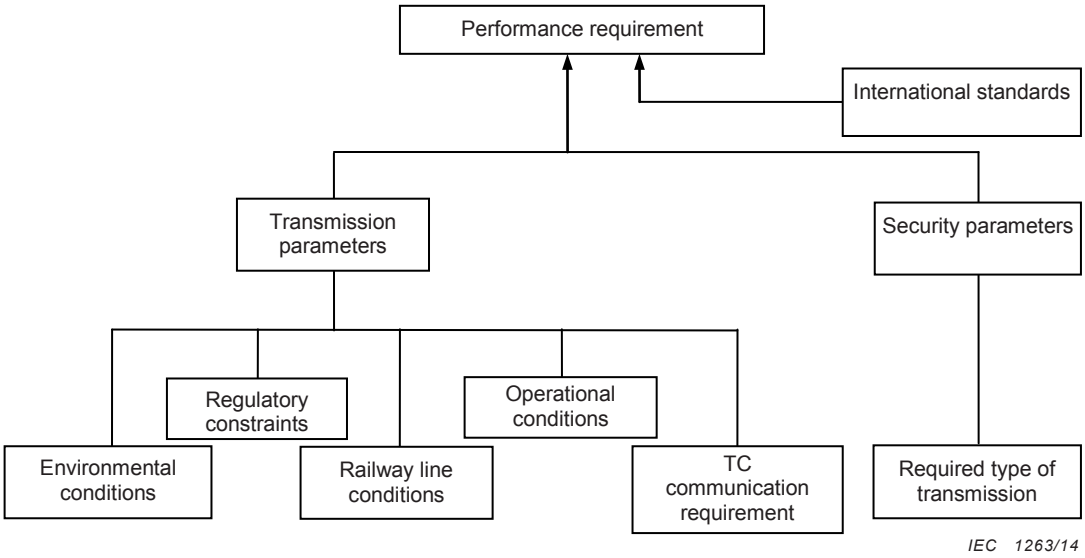

Figure 1 – Factors influencing performance requirements

Table 1 – List of preconditions and radio parameters

	Major division	Subclassification
Preconditions on available spectrum	Environmental conditions (5.1)	Obstacle, climate conditions, electromagnetic interference, etc.
	Regulatory constraints (5.2)	
Preconditions on railway operation	Railway line conditions (6.1)	Line maximum speed, track conditions (tunnels, etc.), line configurations, station configurations, etc.
	Operational conditions (6.2)	Minimum design headway, maximum number of trains in one control area (number of trains controlled at any one time).
	TC communication requirement (6.3)	Maximum tolerable loss of communication, network latency, TC transmission period, TC throughput, control area, maintenance conditions, etc.
	Required type of transmission (6.4)	
Radio parameters	Security parameters (7.2)	Encryption, measures against masquerading, etc.
	Transmission parameters (7.3)	Period, capacity (e.g. throughput), number of connections, handover, frequency, bandwidth, data rate, modulation method, type of propagation, etc.
NOTE Additional operational and system conditions for the train control systems can be found in Annex A and Annex B.		

5 Definition of preconditions on available spectrum

5.1 Environmental conditions

5.1.1 General

This subclause describes the environmental conditions which are the available spectrum constraints for a radio system applied to a radio-based train control system considered by a rail transport authority. Environment conditions are considered when transmission parameters such as frequency, modulation method and capacity of the radio system applied to the train control system are determined.

5.1.2 Obstacle

Obstacle described in this Technical Specification means structure (building, bridge, retaining wall and topography of the land, etc.) which may affect the performance of a radio system used for train control.

It is necessary for selecting the radio wave, the type of antenna and the placement of antennas, to consider the shape and the placement of obstacles along the line for securing the transmission and reception of radio waves. Multipath propagation from obstacles may cause a weak electric field area as a result of fading and shadowing.

Conditions of buildings along the line may change by environs development in the future.

Geographic characteristic such as the existence and shape of hills and rivers may affect range or absorption characteristic of radio waves.

A geometric profile may change unexpectedly due to a change of natural environments (e.g. growth of tree, natural disaster) over time.

These conditions affect the decision of characteristics, the placement and the number of antennas as well as their installation and maintenance.

5.1.3 Climate conditions

Climate conditions described in this Technical Specification means climate conditions that may affect the performance of a radio system used for train control.

In particular, rain (precipitation, squall or not), snowfall, lightning and fog may influence the propagation of radio waves and impact the quality of received radio signal depending on the frequency.

5.1.4 Electromagnetic interference

Electromagnetic interference from radio noise sources in neighbouring facilities (e.g. high voltage equipment, power lines, high-frequency equipment, electric switching devices, etc.) affects data transmission quality. Interference from radio equipment which is not used for train control or mobile radios such as a radio communication system for business use should also be considered.

This environment changes continually.

5.2 Regulatory constraints

This subclause describes legal conditions concerning radio systems which a rail transport authority should consider when a radio-based train control system is used.

For example, legal conditions concerning radio systems include the height of antenna installed on the ground, frequency, radiation power, type of antenna (gain and/or directivity), kind of polarized wave, etc.

The application (e.g. design and operation) of the radio system should be compliant with laws of the country or area that define the rules for radio transmission. Laws or regulations for obstacle or landscape may be considered.

6 Definition of preconditions on railway operation

6.1 Railway line conditions

6.1.1 General

This subclause describes the line conditions impacting radio parameters that a rail transport authority should ascertain when using a radio-based train control system.

6.1.2 Line maximum speed

The line maximum speed is the maximum speed in a particular section (referred to herein as the line) on a railway network defined by the rail transport authority. The factors that determine the line maximum speed include service limitations such as the type of service or considerations regarding the ambient environment, in addition to physical limitations such as track structure and vehicle performance.

6.1.3 Track conditions

Track conditions that affect radio communication include types of structures such as tunnels. Taking a tunnel as an example, the track conditions include its location on the track, its length, its structure (cross-sectional and three-dimensional shape considerations such as curve/inclination/vertical curve), the material of the tunnel wall surface, and the presence/absence of objects installed inside the tunnel. Other such structures include cut-slopes and obstacles on curved lines.

6.1.4 Line configurations

Line configuration described in this Technical Specification means configuration of tracks between stations such as single, double, or quadruple track. It is necessary to consider the line configuration for deciding control area or transmission system, etc.

6.1.5 Station configurations

Station configuration conditions described in this Technical Specification means the scale of the station and structure. Scale of the station described means conditions such as track layout, the number of platforms and size (related to the number of trains that can be present at the same time) of the station that may affect the capacity of system other than physical area of station affecting the coverage of radio. Structure of the station means conditions such as elevated structures, basement structures, multi-layer structures that may affect the electric field strength of radios.

6.2 Operational conditions

6.2.1 General

This subclause describes the operation conditions that a rail transport authority should ascertain when using a radio-based train control system. It should be noted that this Technical Specification does not preclude the implementation of suggestions from system suppliers or from a third party (e.g. consultant) for some conditions.

6.2.2 Minimum design headway

Minimum design headway is the minimum time interval between two successive trains achievable regarding track profile, braking performance, train length and performance of train control system.

6.2.3 Maximum number of trains in one control area

The maximum number of trains in one control area represents the number of trains in one area which can be controlled simultaneously by a radio-based train control system. In case that the area to be controlled is divided into more than one section for train control, it is defined in each of the divisions. (see Figure 2)

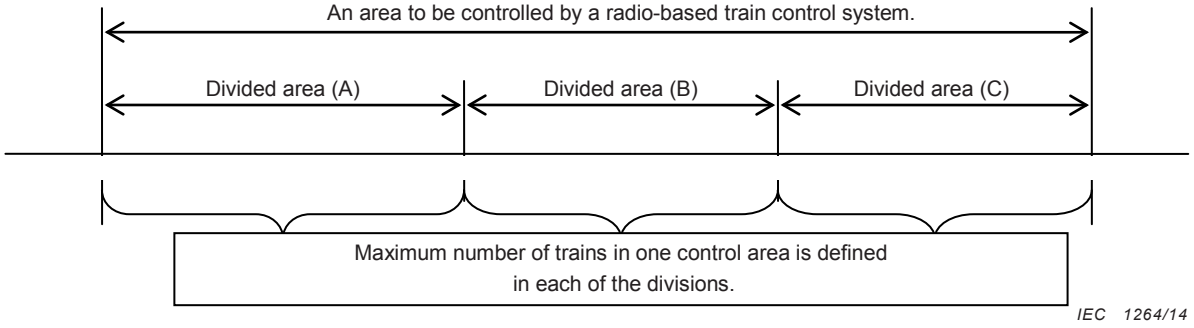

Figure 2 – Maximum number of trains in case of divided area

6.3 TC communication requirement

6.3.1 Maximum tolerable loss of communication

On a single instance, the maximum duration (seconds) without communication that does not degrade the train control system performance.

6.3.2 Network latency

The elapsed time from the moment a network data packet is transmitted into the network from a source node until it reaches the intended destination node.

6.3.3 TC transmission period

The minimum amount of time between two consecutive message transmissions issued by one equipment of the TC.

6.3.4 TC throughput

The rate of data exchanged between the onboard and wayside components of a train control system, measured on a per train basis. Throughput for the uplink direction is independent of the throughput for the downlink direction.

6.3.5 Control area

Control areas are areas in which radio-based TC information is transmitted between the wayside and the train, and are classified as whole line, sections or stations.

Whole line refers to the case where radio-based information transmission between the train and the wayside is possible in all places along the line.

Sections refer to the case where radio-based information transmission between the train and the wayside is possible in certain sections along the line.

Stations refer to the case where radio-based information transmission between the train and the wayside is possible only at stations. Such areas include the vicinity of stations in a condition that allows communication over a certain distance from, for example, an in-house signal device or a departure signal device to the center of the station.

6.3.6 Maintenance conditions

When performing train speed control for ensuring safety with regard to vehicles or workers involved in maintenance of tracks and trackside facilities, specific functions shall be considered, e.g. the ability to communicate with trackside workers via radio transmission and communicate work zone information to them.

6.4 Required type of transmission

Type of transmission is whether a transmission system is open or closed. Open and closed transmission systems are to be considered as defined below.

A closed transmission system has fixed number or fixed maximum number of participants linked by a transmission system with well known and fixed properties, and where the risk of unauthorised access is considered negligible.

An open transmission system has an unknown number of participants, having unknown, variable and non-trusted properties, used for unknown telecommunication services and having the potential for unauthorised access.

7 Radio parameters

7.1 General

The following parameters determine the performance of radio systems.

7.2 Security parameters

Security parameters listed below deal with the steps taken to prevent intrusion into the system.

a) Encryption

b) Measures against masquerading

7.3 Transmission parameters

Transmission parameters listed below refer to the parameters to be chosen to satisfy the conditions of the system among the variables that determine the performance of radio system.

a) Period

b) Capacity

c) Number of connections

d) Handover

e) Frequency

This is the frequency determined to be used for transmission and reception of information between the wayside and the train.

f) Bandwidth

This refers to the frequency domain that can be ensured continually in the radio frequency used for communication between the wayside and the train. The bandwidth is determined in consideration of the maximum amount of data required to be transmitted by the train control system.

g) Data rate

h) Modulation method

i) Type of propagation

The radio transmission can be ensured through guided propagation media (e.g. leaky cables, waveguides, inductive loops) or through free propagation (free space radio and associated antennas).

8 Relationship between preconditions and radio parameters

8.1 General

It is important to consider the relevance of the details of preconditions and radio parameters to determine the specific performance requirements for radio systems applied to radio-based train control systems. Here, the relationship between these factors is outlined in Table 2.

Table 2 – Relationship matrix between preconditions and radio parameters

Preconditions – INPUT / Radio parameters – OUTPUT			Security		Transmission								
			Encryption	Measures against masquerading	Period	Capacity	Number of connections	Handover	Frequency	Bandwidth	Data rate	Modulation method	Type of propagation
			1	2	3	4	5	6	7	8	9	10	11
Environmental conditions	Obstacle	1	-	-	I	-	-	I	I	-	I	I	S
	Climate conditions	2	-	-	I	-	-	I	I	-	I	I	I
	Electromagnetic Interference	3	-	-	I	-	-	I	I	-	I	I	S
Regulatory constraints		4	-	-	-	-	-	I	S	S	-	S	S
Railway line conditions	Line maximum speed	5	-	-	-	-	-	S	I	-	-	I	-
	Track conditions	6	-	-	I	I	I	I	I	-	I	I	S
	Line configurations	7	-	-	-	S	S	-	-	-	-	-	-
	Station configurations	8	-	-	I	S	S	-	-	-	-	-	S
Operational conditions	Minimum design headway	9	-	-	-	S	S	S	-	I	-	-	-
	Maximum number of trains in one control area	10	-	-	S	S	S	-	-	I	-	-	-
TC communication requirement	Maximum tolerable loss of communication	11	-	-	-	-	S	S	S	-	-	S	S
	Network latency	12	-	-	S	S	S	I	S	-	S	S	S
	TC transmission period	13	-	-	S	S	S	S	S	S	S	S	S
	TC throughput	14	-	-	S	S	S	S	S	S	S	S	S
	Control area	15	-	-	-	-	S	-	-	-	-	-	-
	Maintenance conditions	16	-	-	I	I	I	-	-	-	-	-	-
Required type of transmission		17	S	S	-	-	-	-	-	-	-	-	-

S: Strong relation between precondition and performance condition.

I: Indirect relation between precondition and performance condition.

-: No relation between precondition and performance condition.

8.2 Environmental conditions

8.2.1 Obstacle and radio parameters

Table 3 provides the relationship between obstacle and radio parameters.

Table 3 – Obstacle and radio parameters

Radio parameters		Relationship between obstacle and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	In sections where the electric field might be weak because of fading and/or shadowing due to shielding and multipath caused by obstacles, the possibility of corruption of messages (e.g. packet loss, alterations) may increase. A smaller packet size resulting in a shorter period could mitigate this problem.
	Capacity	N/A
	Number of connections	N/A
	Handover	In areas where the electric field might be weak depending on the transmission parameters because of fading and/or shadowing due to shielding and multipath caused by obstacles, the installation density of antennas might be higher in some places, and frequent handovers as well as decrease of reliability of handovers should be considered.
	Frequency	In sections where the electric field might be weak because of fading and/or shadowing due to shielding and multipath caused by obstacles, the radio frequency band might be selected to reach the required performance.
	Bandwidth	N/A
	Data rate	In sections where the electric field might be weak because of fading and/or shadowing due to shielding and multipath caused by obstacles, data rate should be considered in order to ensure required capacity for communication.
	Modulation method	In sections where the electric field might be weak because of fading and/or shadowing due to shielding and multipath caused by obstacles, the proper modulation method should be chosen.
	Type of propagation	In sections where the electric field might be weak because of fading and/or shadowing due to shielding and multipath caused by obstacles, selection of the transmission media and equipment installation conditions (directivity, arrangement, etc.) shall be considered to ensure the necessary QoS.

8.2.2 Climate conditions and radio parameters

Table 4 provides the relationship between climate conditions and radio parameters.

Table 4 – Climate conditions and radio parameters

Radio parameters		Relationship between climate conditions and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	In sections where the electric field might be weakened because of climate conditions, the possibility of corruption of messages (e.g. packet loss, alterations) may increase. A smaller packet size resulting in a shorter period could mitigate this problem.
	Capacity	N/A
	Number of connections	N/A
	Handover	In sections where the electric field might be weakened because of climate conditions, the installation density of antennas should be higher in some places, and frequent handovers as well as decrease of reliability of handovers should be considered.
	Frequency	In sections where the electric field might be weak because of fading caused by climate condition, the radio frequency band might be selected to reach the required performance.
	Bandwidth	N/A
	Data rate	In sections where the electric field might be weakened because of climate conditions, data rate should be considered in order to ensure required capacity for communication.
	Modulation method	In sections where the electric field might be weakened because of climate conditions, the proper modulation method should be chosen.
	Type of propagation	In sections where the electric field might be weakened because of climate conditions, selection of the type of propagation and equipment installation conditions (directivity, etc.) should be considered to ensure the necessary QoS.

8.2.3 Electromagnetic Interference and radio parameters

Table 5 provides the relationship between electromagnetic interference and radio parameters.

Table 5 – Electromagnetic interference and radio parameters

Radio parameters		Relationship between electromagnetic interference and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	In sections where the electric field might be weakened because of electromagnetic interference, the possibility of corruption of messages (e.g. packet loss, alterations) may increase. A smaller packet size resulting in a shorter period could mitigate this problem.
	Capacity	N/A
	Number of connections	N/A
	Handover	Artificial electromagnetic environmental conditions may interrupt the communication, thus reducing the range of the wayside radio. To mitigate the reduced range, the distance between wayside radios should be reduced. However, if the distance between wayside radios is reduced too much, handovers will become too frequent such that QoS requirements cannot be met.
	Frequency	The radio frequency band to be used should be considered in order to avoid interference due to other artificial electromagnetic environmental conditions, etc.
	Bandwidth	N/A
	Data rate	In sections where there might be a risk of interference by other artificial electromagnetic environmental conditions, etc., effective data rate for train control response is reduced due to packet loss caused by interferences. Data rate should be considered in order to ensure required capacity for communication. In some modulation methods, to mitigate packet loss, the data rate should be reduced.
	Modulation method	If the influence of interference is considered to be due to other artificial electromagnetic environmental conditions, etc., the modulation method should be considered.
	Type of propagation	In sections where there might be a risk of interference by other artificial electromagnetic environmental conditions, etc., selection of type of propagation and the equipment installation conditions (directivity, arrangement, etc.) shall be considered to ensure the necessary QoS.

8.3 Regulatory constraints and radio parameters

Table 6 provides the relationship between regulatory constraints and radio parameters.

Table 6 – Regulatory constraints and radio parameters

Radio parameters		Relationship between regulatory constraints and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	N/A
	Capacity	N/A NOTE In some countries, capacity has to be declared to the regulator after the design phase and therefore makes it difficult to change at a later stage.
	Number of connections	N/A NOTE In some countries, number of connections has to be declared to the regulator after the design phase and therefore makes it difficult to change at a later stage.
	Handover	As the installation density of antennas might be higher in some places from limitation of transmission extent due to regulatory constraints on antenna height or antenna types, frequent handover as well as decrease of reliability of handover should be considered.
	Frequency	The influence of radio wave propagation characteristics related to regulatory constraints on allowed frequency range shall be considered to ensure selection of frequency for the required QoS.
	Bandwidth	The influence of radio wave propagation characteristics related to regulatory constraints on allowed frequency range shall be considered to ensure appropriate bandwidth for the required communication capacity. Bandwidth shall be determined to ensure the necessary QoS in consideration of limitation of transmission extent due to regulatory constraints on radiation power.
	Data rate	N/A
	Modulation method	The influence of radio wave propagation characteristics related to regulatory constraints on allowed frequency range shall be considered to ensure implementation of a modulation method for the necessary level of communication quality. The modulation method shall be determined to ensure the necessary QoS in consideration of limitation of transmission extent due to regulatory constraints on radiation power.
	Type of propagation	Type of propagation shall be determined to ensure the necessary QoS in consideration of limitation of transmission extent due to regulatory constraints on antenna height. The influence of radio wave propagation characteristics related to regulatory constraints on antenna types or allowed frequency range shall be considered to ensure the use of suitable communication media for the necessary level of communication quality. Suitable communication media shall be determined to ensure the necessary level of communication quality in consideration of limitation of transmission extent due to regulatory constraints on radiation power.

8.4 Railway line conditions

8.4.1 Line maximum speed and radio parameters

Table 7 provides the relationship between line maximum speed and radio parameters.

Table 7 – Line maximum speed and radio parameters

Radio parameters		Relationship between line maximum speed and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	N/A
	Capacity	N/A
	Number of connections	N/A
	Handover	Effect on connection switching time during handover due to a higher line maximum speed shall be considered.
	Frequency	The influence of fading and Doppler shift due to a higher line maximum speed should be considered.
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	The modulation method should be considered depending on the influence of fading and Doppler shift due to higher line maximum speed.
	Type of propagation	N/A

8.4.2 Track conditions and radio parameters

Table 8 provides the relationship between track conditions and radio parameters.

Table 8 – Track conditions and radio parameters

Radio parameters		Relationship between track conditions and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	In sections where the electric field might be weak because of fading and/or shadowing due to shielding and multipath caused by track conditions (sections that may have a short radio range for each antenna in tunnels or on curves), the possibility of corruption of messages (e.g. packet loss, alterations) may increase. A smaller packet size resulting in a shorter period could mitigate this problem.
	Capacity	Due to track conditions, the electric fields might be weakened in some sections, e.g. sections with a short radio range in tunnels or on curves and capacity might be decreased. Capacity increase should be considered in these cases (e.g. by a bandwidth increased and/or higher data rate).
	Number of connections	A number of connections should be considered that allows communication with the required train in sections that may have weak electric fields e.g. sections with a short radio range in tunnels or on curves and number of connections might be decreased (sections that may have a small transmission area for each antenna in tunnels or on curves).
	Handover	Increased handover frequency and reduced reliability of handover processing should be considered, as antenna installation density can increase in areas that may have weak electric fields depending on the transmission parameters due to geographical conditions.
	Frequency	The relationship between the radio frequency band used and the communication distance (the influence of the surrounding environment on the band used, etc.) should be considered.
	Bandwidth	N/A
	Data rate	It should be considered to ensure communication at the required data rate in sections that may have weak electric fields, e.g. sections with a short radio range in tunnels or on curves and data rate might be reduced (sections that may have a small transmission area for each antenna in tunnels or on curves).
	Modulation method	The modulation method should be considered if any influence from fading is possible depending on geographical conditions.
	Type of propagation	Selection of the type of propagation and the conditions of installation for related equipment (antenna directivity, etc.) shall be considered to also allow the required QoS in sections that may have weak electric fields (sections that may have a small transmission area for each antenna in tunnels or on curves).

8.4.3 Line configurations and radio parameters

Table 9 provides the relationship between line configurations and radio parameters.

Table 9 – Line configurations and radio parameters

Radio parameters		Relationship between line configurations and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	N/A
	Capacity	For line configurations with multiple tracks arranged in parallel, simultaneous communication with a number of trains is often necessary. The maximum number of simultaneously controlled trains shall be considered to determine communication capacity.
	Number of connections	For line configurations with multiple tracks arranged in parallel, simultaneous communication with a number of trains is often necessary. The number of connections shall be determined to ensure communication between the ground and vehicles in order to allow treatment of the maximum number of trains to be controlled with the period necessary for such control.
	Handover	N/A
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

8.4.4 Station configuration and radio parameters

Table 10 provides the relationship between station configuration and radio parameters.

Table 10 – Station configuration and radio parameters

Radio parameters		Relationship between station configuration and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	In sections where the electric field might be weak because of fading and/or shadowing due to shielding and multipath caused by station configuration, the possibility of corruption of messages (e.g. packet loss, alterations) may increase. A smaller packet size resulting in a shorter period could mitigate this problem.
	Capacity	The presence of station obstacles and roofs at stations impairs communication quality and increases error rate, causing a risk of communication failure. Accordingly, radio capacity shall be determined in consideration of station structures.
	Number of connections	Simultaneous communication with different trains at stations is often necessary because multiple trains may stop there at the same time. The number of connections shall be determined to ensure communication between the ground and vehicles in order to allow treatment of the maximum number of trains to be controlled with the period necessary for such control.
	Handover	N/A
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	Communication media at stations shall be selected in consideration of station structures due to the presence of station obstacles and roofs.

8.5 Operational conditions

8.5.1 Minimum design headway and radio parameters

Table 11 provides the relationship between minimum design headway and radio parameters.

Table 11 – Minimum design headway and radio parameters

Radio parameters		Relationship between minimum design headway and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	N/A
	Capacity	Capacity shall be considered to allow communication with the required number of train sets depending on the minimum design headway.
	Number of connections	The number of connections shall be considered to allow communication with the required number of train sets depending on the minimum design headway.
	Handover	In order that the frequency of handover processing per unit time increases as the minimum design headway becomes shorter, the necessity of raising the reliability of handover processing shall be considered.
	Frequency	N/A
	Bandwidth	The bandwidth should be considered to ensure a number of connections that can control the required number of train sets depending on the minimum design headway.
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

8.5.2 Maximum number of trains in one control area and radio parameters

Table 12 provides the relationship between maximum number of trains in one control area and radio parameters.

Table 12 – Maximum number of trains in one control area and radio parameters

Radio parameters		Relationship between maximum number of trains in one control area and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	The period shall be considered to allow communication with the required maximum number of trains in one control area.
	Capacity	Capacity shall be considered to allow communication with the required maximum number of trains in one control area.
	Number of connections	The number of connections shall be considered to allow communication with the required maximum number of trains in one control area.
	Handover	N/A
	Frequency	N/A
	Bandwidth	The bandwidth should be considered to ensure a number of connections that can control the required maximum number of trains in one control area.
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

8.6 TC communication requirement

8.6.1 Maximum tolerable loss of communication and radio parameters

Table 13 provides the relationship between maximum tolerable loss of communication and radio parameters.

Table 13 – Maximum tolerable loss of communication and radio parameters

Radio parameters		Relationship between maximum tolerable loss of communication and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	N/A
	Capacity	N/A
	Number of connections	The number of connections shall not exceed the capacity of the radio so that it will not contribute to any communication loss.
	Handover	The handover shall be determined in order to have a loss of communication below the maximum tolerated one in consideration of connection switching time during handover.
	Frequency	The frequency shall be determined to minimize any contribution to communication loss.
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	The modulation method shall be selected to ensure enough transmission speed, etc. in consideration of maximum tolerable loss of communication.
	Type of propagation	The type of propagation shall be selected to ensure necessary QoS in consideration of maximum tolerable loss of communication.

8.6.2 Network latency and radio parameters

Table 14 provides the relationship between network latency and radio parameters.

Table 14 – Network latency and radio parameters

Radio parameters		Relationship between network latency and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	The period shall be determined taking into account the network latency.
	Capacity	The capacity shall be determined to ensure network latency requirements are met in consideration of maximum number of trains controlled at any time.
	Number of connections	The number of connections shall be determined to ensure network latency requirements are met in consideration of maximum number of trains controlled at any one time.
	Handover	The handover should be determined to ensure network latency requirements are met in consideration of connection switching time during handover.
	Frequency	The frequency shall be determined to ensure network latency in consideration of characteristic of using frequency (communication distance, data rate, etc.).
	Bandwidth	N/A
	Data rate	The data rate shall be considered to meet the required network latency. The network latency can be decreased by increasing the data rate.
	Modulation method	The modulation method shall be selected to meet the data rate required for a given network latency.
	Type of propagation	The type of propagation shall be selected to ensure necessary QoS in consideration of network latency.

8.6.3 TC transmission period and radio parameters

Table 15 provides the relationship between TC transmission period and radio parameters.

Table 15 – TC transmission period and radio parameters

Radio parameters		Relationship between TC transmission period and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	The period shall be determined consistently with the specified TC transmission period and the maximum number of connections.
	Capacity	The capacity shall be determined to ensure TC transmission period in consideration of maximum number of trains controlled at any one time.
	Number of connections	The number of connections shall be determined to ensure TC transmission period in consideration of maximum number of trains controlled in one control area.
	Handover	The handover shall be determined to ensure TC transmission period in consideration of connection switching time during handover.
	Frequency	The frequency shall be determined in combination with the modulation method to achieve the required data rate for the TC transmission period.
	Bandwidth	The bandwidth shall be considered to ensure sufficient number of connections for TC transmission period in consideration of maximum number of trains in one control area.
	Data rate	The data rate shall be considered to ensure enough transmission speed for TC transmission period.
	Modulation method	The modulation method shall be determined in combination with the frequency to achieve the required data rate for the TC transmission period.
	Type of propagation	The type of propagation shall be selected to ensure necessary QoS for TC transmission period.

8.6.4 TC throughput and radio parameters

Table 16 provides the relationship between TC throughput and radio parameters.

Table 16 – TC throughput and radio parameters

Radio parameters		Relationship between TC throughput and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	The period shall be determined ensuring that the required throughput is fulfilled. Reducing the period will reduce the throughput due to additional overhead for packet management.
	Capacity	The capacity shall be determined to ensure TC throughput in consideration of maximum number of trains controlled at any one time.
	Number of connections	The number of connections shall be determined to ensure TC throughput in consideration of maximum number of trains controlled in one control area.
	Handover	The handover shall be determined to ensure TC throughput in consideration of connection switching time during handover.
	Frequency	The frequency shall be determined in combination with the modulation method to achieve the required TC throughput.
	Bandwidth	The bandwidth shall be considered to ensure enough data rate for TC throughput in consideration of maximum number of trains in one control area.
	Data rate	The data rate shall be considered to achieve the required TC throughput.
	Modulation method	The modulation method shall be selected to ensure enough data rate, etc., for TC throughput.
	Type of propagation	The type of propagation shall be selected to ensure necessary QoS for TC throughput.

8.6.5 Control area and radio parameters

Table 17 provides the relationship between control area and radio parameters.

Table 17 – Control area and radio parameters

Radio parameters		Relationship between control area and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	N/A
	Capacity	N/A
	Number of connections	In the case of a system where the control area covers the whole line, the number of connections shall be determined in consideration of maximum number of trains in the control area as required for the system along the whole line. In the case of a system where control areas are confined to some specified sections, the number of connections shall be determined in consideration of maximum number of trains in the control area as required for the system in control areas. In the case of a system where control areas are confined to station yards and their vicinities, the number of connections shall be determined in consideration of maximum number of trains in the control area as required for the system in control areas.
	Handover	N/A
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

8.6.6 Maintenance conditions and radio parameters

Table 18 provides the relationship between maintenance conditions and radio parameters.

Table 18 – Maintenance conditions and radio parameters

Radio parameters		Relationship between maintenance conditions and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	A transmission period should be considered to satisfy the maximum response time required for the exchange of information of track side maintenance workers and maintenance trains.
	Capacity	Capacity should be considered to accommodate the increase of data in cases that multiple works should be processed at the same time.
	Number of connections	The number of connections should be considered to accommodate the increase of data in cases that multiple works should be processed at the same time.
	Handover	N/A
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

8.7 Required type of transmission and radio parameters

Table 19 provides the relationship between required type of transmission and radio parameters.

Table 19 – Required type of transmission and radio parameters

Radio parameters		Relationship between required type of transmission and radio parameters
Security parameters	Encryption	When open transmission is used, appropriate security measures (encryption) shall be applied to compensate for the low secrecy.
	Measures against masquerading	When open transmission is used, appropriate security measures against masquerading shall be applied to prevent intrusions into TC transmission related to malicious attacks.
Transmission parameters	Period	N/A
	Capacity	N/A
	Number of connections	N/A
	Handover	N/A
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

Annex A
(informative)

Additional preconditions

A.1 Operational conditions

A.1.1 Overlay on existing facilities

The existing facilities described herein refer not only to wayside signal equipment, but also to the entire train control system, which is different from a radio-based train control system. Overlay on existing facilities means that a radio-based train control system and other train control systems may coexist on the same line. For example, it is necessary to consider overlay on existing facilities when employing mixed operation or introducing a radio-based train control system step by step.

Operation conditions herein relate to whether or not the rail transport authority employs overlay on existing facilities, and how the system is realized and operated when overlay is employed.

A.1.2 Signal aspect

Signal aspect methods can be classified into the cab signal method and the wayside signal method. The cab signal method indicates signals to onboard signal devices. The wayside signal method indicates signals to wayside signal devices.

Operation conditions herein relate to whether the rail transport authority employs the cab signal method or the wayside signal method.

A.1.3 Block

A block is a method of controlling the separation between trains by dividing the line into sections with, normally, no more than one train in each section. The block can either be a fixed block or a moving block.

Block conditions herein relate to operation conditions, such as whether the rail transport authority employs fixed blocks, moving blocks or a combination of the two (moving blocks between stations, fixed blocks in station yards, etc.).

A.2 System conditions

A.2.1 General

This clause describes the functions that should be considered in the system when performing radio-based control of train speeds or wayside facilities.

A.2.2 Train localization

The system detects a train’s location on the track and controls its speed and wayside facilities using this information. The location may be detected on the vehicle itself or on the wayside. In on-vehicle detection, a tacho-generator or a GPS receiver may be used, and the detected location information is transmitted to the wayside via radio communication. In wayside detection, the passing of the train through the entrance and exit of a section may be detected by radio communication (check-in/check-out), or the distance between onboard transceiver positions may be detected using the delay time of radio propagation.

A.2.3 Continuous control/intermittent control

Depending on line conditions and installation/management costs, it is possible to use a method that continually maintains communication in the system (continuous control) or one that performs control at particular sites or in short sections (intermittent control). With continuous control, it is possible to constantly transmit speed restriction commands and emergency stop commands from the wayside, whereas such data can be transmitted only to a limited area under intermittent control.

A.2.4 Train protection profile

The system creates a train protection profile associating the movement distance with speed restrictions in consideration of the distance to the point where the train stops/decelerates, the vehicle's brake performance and track information such as inclination. When the distance to the point where the train stops/decelerates varies as the vehicle moves, this information is transmitted from the wayside via radio communication.

A.2.5 System entry/exit

A process of system switching is applied when a train crosses the boundary between a radio-based train control system and another system. Areas of radio-control and those controlled by other systems therefore partially overlap at the boundary, where registration of entering trains and deletion of exiting trains from the system are performed via radio communication.

A.2.6 Temporary speed restriction

A planned speed restriction imposed for temporary conditions such as track maintenance.

A.2.7 Emergency stop command

When it is necessary to urgently stop the train due to changes in weather or track failure, stop commands are transmitted to the vehicle from the wayside via radio communication. In principle, such commands should be transmitted from the required location whenever necessary.

A.2.8 Interlocking control/route control

In order to set the movement route in the station yard, the system switches and locks points, and determines movement authority limits according to setting requirements. During train operation based on cab signals, route setting information is transmitted to the vehicle from the wayside via radio communication. When the train location is detected on the vehicle itself to enable route setting automatically according to position, wayside equipment related to route control receives the location information via radio communication.

A.2.9 Level crossing control

The system performs warning control for level crossings according to the train location and the approach warning period. When the train location is detected on the vehicle itself, the level crossing receives a warning request via radio communication. The warning/closed state of the level crossing is transmitted to the on-vehicle system via radio communication, and braking is performed if the state is incomplete or if an obstacle is present on the crossing.

A.2.10 Couple and split a train

The system performs coupling and splitting operation of trains depending on vehicle operation. In the case of splitting, the system recognizes trains after splitting as separate units and performs position detection and speed control accordingly. In the case of coupling, the system recognizes trains after coupling as a single unit and performs position detection and speed control based on the train protection profile and operation method to prevent collision.

A.2.11 Automatic train operation

The subsystem within the automatic train control system that performs any or all of the functions of speed regulation, programmed stopping, door control, performance level regulation, or other functions otherwise assigned to the train operator.

A.3 Relationship between preconditions and radio parameters

A.3.1 General

Table A.1 provides the relationship between preconditions and radio parameters.

Table A.1 – Relationship matrix between preconditions and radio parameters

Preconditions – INPUT / Radio parameters – OUTPUT			Security		Transmission								
			Encryption	Measures against masquerading	Period	Capacity	Number of connections	Handover	Frequency	Bandwidth	Data rate	Modulation method	Type of propagation
			1	2	3	4	5	6	7	8	9	10	11
Operational conditions	Overlay on existing facilities	1	-	-	I	I	I	-	-	-	-	-	-
	Signal aspect	2	I	I	I	I	I	I	-	-	-	-	-
	Block	3	I	I	I	I	I	I	-	-	-	-	-
System conditions	Train localization	4	I	I	I	I	I	I	-	-	-	-	-
	Continuous control/ Intermittent control	5	-	-	I	I	I	I	-	-	-	-	-
	Train protection profile	6	-	-	-	-	-	I	-	-	-	-	-
	System entry/exit	7	-	I	I	I	I	-	-	-	-	-	-
	Temporary speed restriction	8	I	I	I	I	I	-	-	-	-	-	-
	Emergency stop command	9	I	I	I	I	I	-	-	-	-	-	-
	Interlocking control/ Route control	10	I	I	I	I	I	-	-	-	-	-	-
	Level crossing control	11	I	I	I	I	I	-	-	-	-	-	-
	Couple and split a train	12	-	I	I	I	I	-	-	-	-	-	-
	Automatic train operation	13	I	I	I	I	I	-	-	-	-	-	-

I: Indirect relation between precondition and performance condition.

-: No relation between precondition and performance condition.

A.3.2 Operational conditions

A.3.2.1 Overlay on existing facilities and radio parameters

Table A.2 provides the relationship between overlay on existing facilities and radio parameters.

Table A.2 – Overlay on existing facilities and radio parameters

Radio parameters		Relationship between overlay on existing facilities and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	In the case of overlaying the radio-based train control system on the existing facilities, the multiple typed operation systems working simultaneously may cause mutual interference within the related devises. This may cause interference to the transmission quality. Therefore, the effect on the transmission period is taken into consideration. In the case where a non-equipped train being controlled by a wayside signal device, a transmission period is considered that affects the difference between radio-based control and the indications of wayside signal devices.
	Capacity	In the case of overlaying the radio-based train control system on the existing facilities, the condition of multiple systems operating simultaneously may cause mutual interference in the related devices. This may cause interference to the transmission quality. Therefore, the effect on the transmission capacity is taken into consideration.
	Number of connections	In the case of overlaying the radio-based train control system on the existing facilities, multiple systems operating simultaneously may cause mutual interference in the related devices. This may cause interference to the transmission quality. Therefore, the effect on the number of connections is taken into consideration.
	Handover	N/A
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

A.3.2.2 Signal aspect and radio parameters

Table A.3 provides the relationship between signal aspect and radio parameters.

Table A.3 – Signal aspect and radio parameters

Radio parameters		Relationship between signal aspect and radio parameters
Security parameters	Encryption	Encryption is applied to prevent tampering when exchanging aspect information.
	Measures against masquerading	Measures against masquerading are applied when exchanging aspect information.
Transmission parameters	Period	It is considered whether the period of transmission and reception is appropriate when exchanging aspect information.
	Capacity	It is considered whether the capacity of transmission and reception is appropriate when exchanging aspect information.
	Number of connections	It is considered whether the number of connections for transmission and reception is appropriate when exchanging aspect information.
	Handover	It is considered whether the communication of aspect information is performed appropriately when carrying out handover.
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

A.3.2.3 Block and radio parameters

Table A.4 provides the relationship between block and radio parameters.

Table A.4 – Block and radio parameters

Radio parameters		Relationship between block and radio parameters
Security parameters	Encryption	Encryption is applied to prevent tampering when exchanging block information.
	Measures against masquerading	Measures against masquerading are applied when exchanging block information.
Transmission parameters	Period	A period is considered to allow appropriate transmission and reception of the required information (e.g., block information) according to the operation frequency.
	Capacity	Capacity is considered to allow appropriate transmission and reception of the required information (e.g., block information) according to the operation frequency.
	Number of connections	The number of connections is considered to allow appropriate transmission and reception of the required information (e.g., block information) according to the operation frequency.
	Handover	Handover conditions are considered to allow appropriate transmission and reception of the required information (e.g., block information). In the case of line with fixed block, handover conditions are set in consideration of block border.
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

A.3.3 System conditions

A.3.3.1 Train localization and radio parameters

Table A.5 provides the relationship between train localization and radio parameters.

Table A.5 – Train localization and radio parameters

Radio parameters		Relationship between train localization and radio parameters
Security parameters	Encryption	Encryption is performed when transmitting train location information or exchanging information required for determining train locations.
	Measures against masquerading	Measures against masquerading are applied when transmitting train location information or exchanging information required for determining train locations.
Transmission parameters	Period	For reliable train localization, a sufficiently short transmission period is ensured in order to achieve the transmission of train location information or exchange of information required for determining train locations in a timely manner.
	Capacity	For reliable train localization, sufficient transmission capacity is ensured in order to achieve the transmission of train location information or exchange of information required for determining train locations in a timely manner.
	Number of connections	For reliable train localization, a sufficient number of connections are ensured in order to achieve the transmission of train location information or exchange of information required for determining train locations in a timely manner.
	Handover	For reliable train localization, quick and reliable completion of handover procedure is done at a boundary between radio stations in order to achieve the reliable transmission of train location information or exchange of information required for determining train locations.
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

A.3.3.2 Consideration of difference between continuous control and intermittent control

Radio parameters are derived by considering that the train control system uses intermittent control or continuous control. Especially, for the system with intermittent control, transient phenomena when entry to the transmission area and time for data transmission are considered to determine the radio parameters (transmission parameters, etc.).

A.3.3.3 Train protection profile and radio parameters

Table A.6 provides the relationship between train protection profile and radio parameters.

Table A.6 – Train protection profile and radio parameters

Radio parameters		Relationship between train protection profile and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	N/A
Transmission parameters	Period	N/A
	Capacity	N/A
	Number of connections	N/A
	Handover	If such a control method is adopted that a train employs a train protection profile which, in front of a boundary between radio stations, sets the boundary as a temporary movement authority limit until handover completion, and the train switches to original train protection profile which adopts the original movement authority limit after handover completion, quick and reliable completion of handover procedure is performed so that the switching of these train protection profiles at the boundary between radio stations does not interrupt train control.
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

A.3.3.4 System entry/exit and radio parameters

Table A.7 provides the relationship between system entry/exit and radio parameters.

Table A.7 – System entry/exit and radio parameters

Radio parameters		Relationship between system entry/exit and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	Authentication is performed at the time of system entry.
Transmission parameters	Period	A sufficiently short transmission period is ensured in order to achieve quick changing of control methods at the time of system entry.
	Capacity	Sufficient transmission capacity is ensured in order to achieve quick changing of control methods at the time of system entry.
	Number of connections	A sufficient number of connections are ensured in order to achieve quick changing of control methods at the time of system entry.
	Handover	N/A
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

A.3.3.5 Temporary speed restriction and radio parameters

Table A.8 provides the relationship between temporary speed restriction and radio parameters.

Table A.8 – Temporary speed restriction and radio parameters

Radio parameters		Relationship between temporary speed restriction and radio parameters
Security parameters	Encryption	Encryption is performed when exchanging information required for temporary speed restrictions.
	Measures against masquerading	Measures against masquerading are applied when exchanging information required for temporary speed restrictions.
Transmission parameters	Period	A sufficiently short transmission period is ensured in order to achieve transmission of information required for temporary speed restrictions in a timely manner.
	Capacity	In case that multiple temporary speed restrictions are required to be processed simultaneously on a train, sufficient transmission capacity is ensured.
	Number of connections	In case that multiple temporary speed restrictions are required to be processed simultaneously on a train, a sufficient number of connections is ensured.
	Handover	N/A
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

A.3.3.6 Emergency stop command and radio parameters

Table A.9 provides the relationship between emergency stop command and radio parameters.

Table A.9 – Emergency stop command and radio parameters

Radio parameters		Relationship between emergency stop command and radio parameters
Security parameters	Encryption	Encryption is performed when exchanging an emergency stop command.
	Measures against masquerading	Measures against masquerading are applied when exchanging an emergency stop command.
Transmission parameters	Period	A sufficiently short transmission period is ensured in order to allow the exchange of an emergency stop command when required by the system.
	Capacity	Sufficient transmission capacity is ensured in order to allow the exchange of an emergency stop command when required by the system.
	Number of connections	A sufficient number of connections are ensured in order to allow the exchange of an emergency stop command when required by the system.
	Handover	N/A
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

A.3.3.7 Interlocking control/route control and radio parameters

Table A.10 provides the relationship between interlocking control/route control and radio parameters.

Table A.10 – Interlocking control/route control and radio parameters

Radio parameters		Relationship between interlocking control/route control and radio parameters
Security parameters	Encryption	Encryption is performed when exchanging control information.
	Measures against masquerading	Measures against masquerading are applied when exchanging control information.
Transmission parameters	Period	Sufficiently short transmission period is ensured in order to allow the exchange of control information when required by the system.
	Capacity	Sufficient transmission capacity is ensured in order to allow the exchange of control information when required by the system.
	Number of connections	A sufficient number of connections are ensured in order to allow the exchange of control information when required by the system.
	Handover	N/A
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

A.3.3.8 Level crossing control and radio parameters

Table A.11 provides the relationship between level crossing control and radio parameters.

Table A.11 – Level crossing control and radio parameters

Radio parameters		Relationship between level crossing control and radio parameters
Security parameters	Encryption	In case that level crossing control is performed by a radio-based train control system, encryption is performed when exchanging level crossing control information.
	Measures against masquerading	In case that level crossing control is performed by a radio-based train control system, measures against masquerading are applied when exchanging level crossing control information.
Transmission parameters	Period	In case that level crossing control is performed by a radio-based train control system, a sufficiently short transmission period is ensured in order to achieve reliable exchange of level crossing control information when required by the system.
	Capacity	In case that level crossing control is performed by a radio-based train control system, sufficient transmission capacity is ensured in order to achieve reliable exchange of level crossing control information when required by the system.
	Number of connections	In case that level crossing control is performed by a radio-based train control system, a sufficient number of connections are ensured in order to achieve reliable exchange of level crossing control information when required by the system.
	Handover	N/A
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

A.3.3.9 Couple and split a train and radio parameters

Table A.12 provides the relationship between couple and split a train and radio parameters.

Table A.12 – Couple and split a train and radio parameters

Radio parameters		Relationship between couple and split a train and radio parameters
Security parameters	Encryption	N/A
	Measures against masquerading	Measures against masquerading of communication are designed to be applied when exchanging control information required for coupling and splitting so that a hindrance to the exchange of such information may not cause disruption of train operation. Measures against masquerading are accordance with A.3.3.4 when the system is started when the trains are coupled or split.
Transmission parameters	Period	A sufficiently short transmission period is designed to be ensured in order to allow the exchange of control information required for coupling and splitting when required by the system.
	Capacity	Sufficient capacity should be ensured to allow the change in the amount of information between the wayside and the train due to coupling and splitting operation. The change in the amount of information can be results from the following factors: – change in train set configuration – number of trains – number of onboard equipment on the train
	Number of connections	A sufficient number of connections should be ensured to allow the reconfiguration of the communication between the wayside and the train due to couple and splitting operation. The reconfiguration can be results from the following factors: – change in number of trains – change in number of onboard equipment on the train – status of onboard equipment on the train (e.g power-off, sleeping, stand-by or operation)
	Handover	N/A
	Frequency	N/A
	Bandwidth	N/A
	Data rate	N/A
	Modulation method	N/A
	Type of propagation	N/A

A.3.3.10 Automatic train operation and transmission parameters

Automatic train operation function (GOA2 to GOA4) may require train control performance with higher accuracy (position, velocity, time, etc.) than ATP function (GOA1). In such a case, it is necessary to check the relationship between the train control performance and the radio system performance.

Driverless operation of trains requires functions other than ATP function (i.e. control of train door and platform screen, board surveillance, reaction for emergency situation, etc.).

In such a case, it is necessary to check the relationship between the required train control performance and the radio system performance.

If the capacity of the radio link is not enough for implementing the required functions, priority control or traffic control may be required for radio-based information transmission between the wayside and trains.

Annex B
(informative)

Considerations for in-continuity

B.1 Communication in in-continuity

When applying a radio system for train control to implement traffic failure notification tasks, the relevant capabilities and levels of performance regarding how such communication is handled (e.g., the beginning and end of transmission, priorities, etc.) and the transmission content (data (text), voice, animations, etc.) should be specified to meet the relevant quality requirements.

B.2 Considerations for in-continuity in radio systems

B.2.1 General issues

This clause describes matters to be considered in regard to transmission failure in radio systems for train operation and data communication. While practical action against such failure is generally stipulated locally by individual operators, the clause covers principal points that should be globally discussed.

Major issues to be studied in general are categorized as follows:

- Communicative faults due to external system factors, including conditional fluctuation of wireless access lines
- Communicative faults caused by internal system factors, including the protocol and control function of the radio system and its actual operation in regard to function against failure

B.2.2 Specific issues related to failure caused by external system factors

Regarding safety issues in correspondence, the regulations defined in IEC 62280 are discussed. The performance requirements needed for a radio system should be determined by examining external system factors that may disturb normal transmission of wireless messages to another party. Artificial factors other than those stated above (such as improper maintenance) should also be kept in mind.

Unexpected events regarding incorrect data transmission may include receipt of the wrong words or incomplete sentences, duplicated or delayed messages (especially in systems with memory functions), and arrival in the wrong order. Additionally, intrusion by unauthorized information and receipt of forged documents may also occur as a result of hostile activities.

When configuring a radio system, the level of performance required therefore is fixed after appropriate consideration of how such anomalies will be detected and acted upon, including cost estimation, and of the quality required for the system.

B.2.3 Specific issues related to failure caused by internal system factors

Considerations in this regard relate to the radio system control mechanism and how the system maneuvers the controller in response to actual faults, including:

a) the minimum time taken to complete wireless connection and auxiliary functions for incorrect coupling (for example, connection to a facility other than the proper base station to legally communicate with a running train);
b) a deliberate duration of interruption specified to allow handover in order to maintain correspondence when passing into a different wireless area, and a failsafe function for such handover;

c) capabilities for detecting and acting on channel disconnection based on channel monitoring information (or the time taken to complete reconnection if necessary);

and other matters.

Depending on the protocol and control mechanism of the radio system, these events may affect the quality of correspondence associated with internal system factors. The functional requirements are clearly adjusted in line with the quality requirements.

Bibliography

IEC 62278, *Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS)*

IEC 62280, *Railway applications – Communication, signalling and processing systems – Safety related communication in transmission systems*

IEC 62290-1, *Railway applications – Urban guided transport management and command/control systems – Part 1: System principles and fundamental concepts*

IEC 62290-2, *Railway applications – Urban guided transport management and command/control systems – Part 2: Functional requirements specification*

IEC 62498-1, *Railway applications – Environmental conditions for equipment – Part 1: Equipment on board rolling stock*

IEC 62498-3, *Railway applications – Environmental conditions for equipment – Part 3: Equipment for signalling and telecommunications*

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