



BSI Standards Publication

Railway applications — Energy measurement on board trains

Part 4: Communication

National foreword

This British Standard is the UK implementation of EN 50463-4:2017+A1:2025. It supersedes BS EN 50463-4:2017, which will be withdrawn on 31 July 2028.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CENELEC text carry the number of the CENELEC amendment. For example, text altered by CENELEC amendment A1 is indicated by A1 A1.

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 committee manager.

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Published by BSI Standards Limited 2025

ISBN 978 0 539 30562 3

ICS 45.060.10

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 October 2017.

Amendments/corrigenda issued since publication

Date	Text affected
31 July 2025	Implementation of CENELEC amendment A1:2025

English Version

Railway applications - Energy measurement on board trains - Part 4: Communication

Applications ferroviaires - Mesure d'énergie à bord des
trains - Partie 4 : Communication

Bahnanwendungen - Energiemessung auf Bahnfahrzeugen
- Teil 4: Kommunikation

This European Standard was approved by CENELEC on 2017-05-08. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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European foreword

This document (EN 50463-4:2017) has been prepared by CLC/TC 9X “Electrical and electronic applications for railways”.

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2018-04-06
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2020-10-06

This document supersedes EN 50463-4:2012.

EN 50463-4 includes the following significant technical changes with respect to EN 50463-4:2012:

- general replacement of the text of 4.3 with new complete protocols for data transfer between EMS and DCS to make it interoperable (Clause 4);
- introduction of link to the EN 61375 Communication standard series (Clause 4);
- introduction of the normative Annexes D to F containing the XML schemas to detail the requirements of Clause 4.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For the relationship with EU Directive(s) see informative Annex ZZ, which is an integral part of this document.

This document is Part 4 of the EN 50463 series which consists of the following parts, under the common title *Railway applications — Energy measurement on board trains*:

- *Part 1: General*;
- *Part 2: Energy measuring*;
- *Part 3: Data handling*;
- *Part 4: Communication*;
- *Part 5: Conformity assessment*.

This series of European Standards follows the functional guidelines description in EN ISO/IEC 17000:2004, Annex A “Principles of conformity assessment”, tailored to the Energy Measurement System (EMS).

The requirements for Energy Measurement Systems in the relevant Technical Specifications for Interoperability are supported by this series of European Standards.

European foreword to Amendment 1

This document (EN 50463-4:2017/A1:2025) has been prepared by CLC/TC 9X “Electrical and electronic applications for railways”.

The following dates are fixed:

- latest date by which this document has to be (dop) 2026-07-31
implemented at national level by publication of
an identical national standard or by
endorsement
- latest date by which the national standards (dow) 2028-07-31
conflicting with this document have to be
withdrawn

EN 50463-4:2017 is amended to align with EN IEC 61375-2-6:2018, as required by CLC/TC 9X decisions 57/10 and 69/21.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

This document is read in conjunction with EN IEC 61375-2-6:2018, “*Electronic railway equipment - Train communication network (TCN) - Part 2-6: On-board to ground communication*”.

This document has been prepared under a standardization request addressed to CENELEC by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

Any feedback and questions on this document should be directed to the users’ national committee. A complete listing of these bodies can be found on the CENELEC website.

Introduction

The Energy Measurement System provides measurement and data suitable for billing and may also be used for energy management, e.g. energy saving.

This series of European Standards uses the functional approach to describe the Energy Measurement System and on-ground Data Collecting System. These functions are implemented in one or more physical devices. The user of this series of standards is free to choose the physical implementation arrangements.

a) Structure and main contents of the EN 50463 series:

This series of European Standards is divided into five parts. The titles and brief descriptions of each part are given below:

1) EN 50463-1 — General:

The scope of EN 50463-1 is the Energy Measurement System (EMS).

EN 50463-1 provides system level requirements for the complete EMS and common requirements for all devices implementing one or more functions of the EMS.

2) EN 50463-2 — Energy measuring:

The scope of EN 50463-2 is the Energy Measurement Function (EMF).

The EMF provides measurement of the consumed and regenerated active energy of a railway traction unit. If the traction unit is designed for use on AC traction systems the EMF also provides measurement of reactive energy. The EMF provides the measured quantities via an interface to the Data Handling System.

The EMF consists of the three functions: Voltage Measurement Function, Current Measurement Function and Energy Calculation Function. For each of these functions, accuracy classes are specified and associated reference conditions are defined. EN 50463-2 also defines all specific requirements for all functions of the EMF.

The Voltage Measurement Function measures the voltage of the Contact Line system and the Current Measurement Function measures the current taken from and returned to the Contact Line system. These functions provide signal inputs to the Energy Calculation Function.

The Energy Calculation Function inputs the signals from the Current and Voltage Measurement Functions and calculates a set of values representing the consumed and regenerated energies. These values are transferred to the Data Handling System and are used in the creation of Compiled Energy Billing Data (CEBD).

The standard has been developed taking into account that in some applications the EMF may be subjected to legal metrological control. All relevant metrological aspects are covered in EN 50463-2.

EN 50463-2 also defines the conformity assessment of the EMF.

3) EN 50463-3 — Data handling:

The scope of EN 50463-3 is the Data Handling System (DHS) and the associated requirements of Data Collecting System (DCS).

The on board DHS receives, produces and stores data, ready for transmission to any authorized receiver of data on board or on ground. The main goal of the DHS is to produce Compiled Energy Billing Data and transfer it on an interoperable basis to an on-ground Data Collecting System (DCS). The DHS can support other functionality on board or on-ground with data, as long as this does not conflict with the main goal.

The DCS on-ground receives Compiled Energy Billing Data and transfer it to settlement system.

EN 50463-3 also defines the conformity assessment of the DHS and for the transfer of CEBD to an on-ground Data Collecting System (DCS).

4) EN 50463-4 — Communication:

The scope of EN 50463-4 is the communication services.

This part of EN 50463 gives requirements and guidance regarding the data communication between the functions implemented within EMS as well as between such functions and other on board units where data are exchanged using a communications protocol stack over a dedicated physical interface or a shared network.

It includes the on board to ground communication service and covers the requirements necessary to support data transfer between DHS and DCS including the transfer of CEBD on an interoperable basis.

EN 50463-4 also defines the conformity assessment of the communications services.

5) EN 50463-5 — Conformity assessment:

The scope of EN 50463-5 is the conformity assessment procedures for the EMS.

EN 50463-5 also covers re-verification procedures and conformity assessment in the event of the replacement of a device of the EMS.

b) EMS functional structure and dataflow:

Figure 1 illustrates the functional structure of the EMS, the main sub-functions and the structure of the dataflow and is informative only. Only the main interfaces required by this standard are displayed by arrows.

Since the communication function is distributed throughout the EMS, it has been widely omitted for clarity, except for the train to ground communication. Not all interfaces are shown.

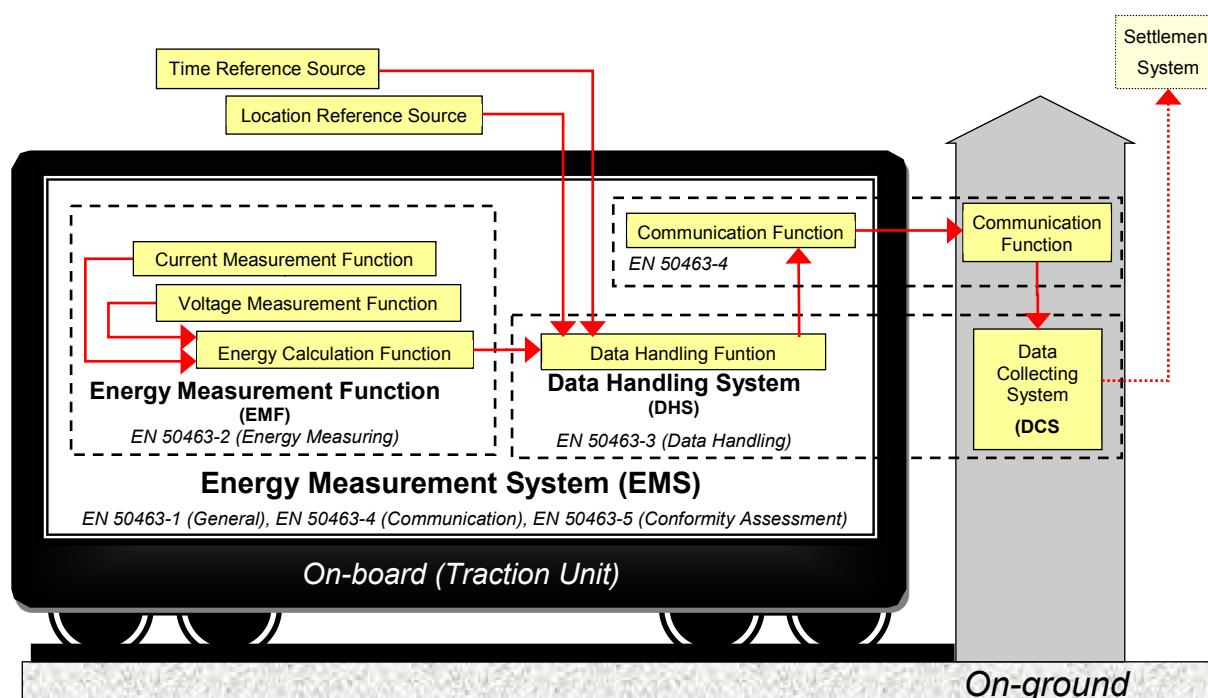


Figure 1 — EMS functional structure and dataflow diagram

1 Scope

This European Standard applies to the on board and on board to ground communication services, i.e. it covers the data communication using digital interfaces:

- a) between functions implemented within the EMS;
- b) between EMS function and other on board subsystems;
- c) between EMS and ground communication services.

The on board data communication services of the EMS cover the data exchange between functions of the EMS and the data exchange between EMS and other on board units, where data are exchanged using a communications protocol stack over a dedicated physical interface or a shared communication network.

The on board to ground communication services cover the wireless data communication between the DHS and the on ground server.

Furthermore, this document includes conformity assessment requirements.

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.

EN 50463-1:2017, *Railway applications — Energy measurement on board trains — Part 1: General*

EN 50463-2:2017, *Railway applications — Energy measurement on board trains — Part 2: Energy measuring*

EN 50463-3:2017, *Railway applications — Energy measurement on board trains — Part 3: Data handling*

EN 50463-5:2017, *Railway applications — Energy measurement on board trains — Part 5: Conformity assessment*

EN 60870-5 (all parts), *Telecontrol equipment and systems — Part 5: Transmission protocols (IEC 60870-5 series)*

EN 61158-2:2014, *Industrial communication networks — Fieldbus specifications — Part 2: Physical layer specification and service definition (IEC 61158-2:2014)*

EN 61375-1:2012, *Electronic railway equipment — Train communication network (TCN) — Part 1: General architecture (IEC 61375-1:2012)*

EN IEC 61375-2-6, *Electronic railway equipment — Train communication network (TCN) — Part 2-6: On-board to ground communication (IEC 61375-2-6)* ^{A1}

EN 61375-3-1:2012, *Electronic railway equipment — Train communication network (TCN) — Part 3-1: Multifunction Vehicle Bus (MVB) (IEC 61375-3-1:2012)*

EN 61375-3-3:2012, *Electronic railway equipment — Train communication network (TCN) — Part 3-3: CANopen Consist Network (CCN) (IEC 61375-3-3:2012)*

EN 61375-3-4:2014, *Electronic railway equipment — Train communication network (TCN) — Part 3-4: Ethernet Consist Network (ECN) (IEC 61375-3-4:2014)*

EN ISO 3166-1:2014, *Codes for the representation of names of countries and their subdivisions — Part 1: Country codes (ISO 3166-1:2013)*

EN ISO/IEC 9646-1:1996¹⁾, *Information technology — Open Systems Interconnection — Conformance testing methodology and framework — Part 1: General concepts (ISO/IEC 9646-1:1994)*

ISO 8601:2004, *Data elements and interchange formats — Information interchange — Representation of dates and times*

ISO 11898-1:2015, *Road vehicles — Controller area network (CAN) — Part 1: Data link layer and physical signalling*

ISO 11898-2:2016, *Road vehicles — Controller area network (CAN) — Part 2: High-speed medium access unit*

ISO/IEC 8482:1993, *Information technology — Telecommunications and information exchange between systems — Twisted pair multipoint interconnections*

ISO/IEC/IEEE 8802-3:2017, *Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements — Part 3: Standard for Ethernet*

ITU-T/Recommendation V.24:2000, *List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)*

RFC 1321:1992, *The MD5 Message-Digest Algorithm*

RFC 1952:1996, *GZIP file format specification*

RFC 2616:1999, *Hypertext Transfer Protocol – HTTP/1.1*

RFC 3275:2002, *XML-Signature Syntax and Processing*

RFC 3986:2005, *Uniform Resource Identifier (URI): Generic Syntax*

RFC 4001:2005, *Textual Conventions for Internet Network Addresses*

RFC 4051:2005, *Additional XML Security Uniform Resource Identifiers (URIs)*

RFC 4648:2006, *The Base16, Base32, and Base64 Data Encodings*

TIA/EIA-422-B, May 1994, *Electrical Characteristics of Balanced Voltage Digital Interface Circuits*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 50463-1:2017 and the following apply.

Note 1 to entry: When possible, the following definitions have been taken from the relevant chapters of the International Electrotechnical Vocabulary (IEV), the IEC 60050 series. In such cases, the appropriate IEC reference is given. Certain new definitions or modifications of IEC definitions have been added in this standard in

¹⁾ Also available as ITU-T/Recommendation X.290 (04/95), *OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications — General concepts*.

order to facilitate understanding. Expression of the performance of electrical and electronic measuring equipment has been taken from EN 60359.

3.1.1

Board to Ground Interface

BGI

interface used for the communication between the train and the ground

3.1.2

consist

single vehicle or a group of vehicles which are not separated during normal operation

Note 1 to entry: A consist can contain no, one or several consist networks.

Note 2 to entry: A consist can contain one or more traction units.

[SOURCE: IEC 60050-811:FDIS2016, 811-37-20]

3.1.3

consist network

CN

bus connecting equipment within a consist, e.g. the MVB, and which conforms or adapts to the TCN real-time protocols

Note 1 to entry: It is possible that more than one CN is installed in the same consist.

[SOURCE: IEC 60050-811:FDIS2016, 811-37-21]

3.1.4

Consist Network Interface

CNI

interface to an on board consist network used by the EMS and by other on board devices interfacing with the EMS

3.1.5

Coordinated Universal Time

UTC

time scale which forms the basis of a coordinated radio dissemination of standard frequencies and time signals and which corresponds exactly in rate with international atomic time, but differs from it by an integral number of seconds

Note 1 to entry: Coordinated universal time is established by the International Bureau of Weights and Measures (BIPM) and the International Earth Rotation Services (IERS).

Note 2 to entry: The UTC scales is adjusted by the insertion or deletion of seconds, so called positive or negative leap seconds, to ensure approximate agreement with UT1.

[SOURCE: IEC 60050-713:1998, 713-05-20]

3.1.6

DHS to MCF Interface

DMI

interface between the DHS and the MCF, which may be dedicated or shared on CNI

3.1.7

DHS to Service Interface

DSI

interface between the DHS and a maintenance/administration tool

3.1.8

EMF to DHS Interface

EMDI

interface between the EMF and the DHS

3.1.9

EMF to Service Interface

ESI

interface between the EMF and a maintenance/administration tool

3.1.10

energy delta value

energy consumed and/or regenerated during a time period

Note 1 to entry: See Figure 2 for example.

3.1.11

energy index value

total accumulated energy consumption and/or energy regeneration at the end of a time period

Note 1 to entry: See Figure 2 for example.

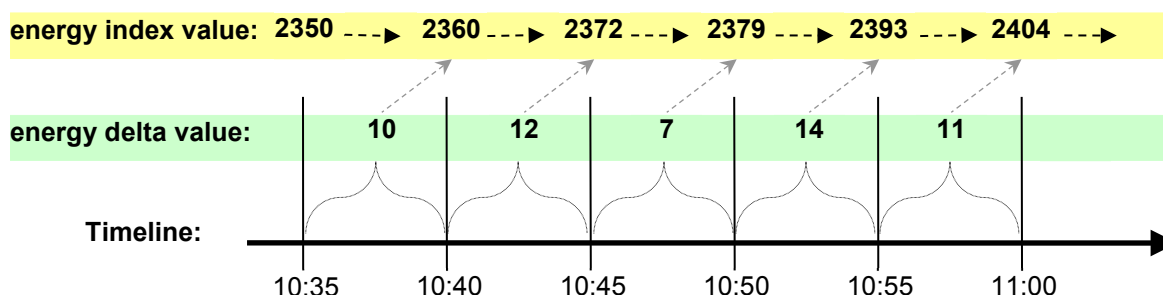


Figure 2 — Example of energy index value

3.1.12

flag

code indicating information relevant to the functioning of the EMS

Note 1 to entry: Examples include data quality, operational status, etc.

3.1.13

Fully Qualified Domain Name

FQDN

domain name which specifies its exact location in the tree hierarchy of the Domain Name System (DNS)

Note 1 to entry: FQDN specifies all domain levels, starting from the host name up to the top-level domain.

3.1.14

Ground Station

GS

station on ground which is able to communicate with the EMS

Note 1 to entry: A GS may host different services such as DCS or any EMS management service.

3.1.15**Implementation Under Assessment****IUA**

implementation of one or more protocols specified in this part of EN 50463 in an adjacent user/provider relationship being a part of the EMS that is submitted to the conformity assessment

3.1.16**integrity <of information>**

state in which information is complete and not altered

[SOURCE: IEC 60050-821:FDIS2016, 821-11-26]

3.1.17**Internet Engineering Task Force****IETF**

organized activity of the Internet Society in charge of producing technical documents relevant to the design, use and management of the Internet

3.1.18**location data**

data describing the geographical position of the traction unit

3.1.19**Location Function to DHS Interface****LFDI**

interface linking the location function to the DHS

Note 1 to entry: The location function can be interfaced with the DHS via a CNI.

3.1.20**Mobile Communication Function****MCF**

function performing the EMS to on ground communication

Note 1 to entry: It includes the sub-function(s) for the wireless link between the train and ground and the sub-functions that execute the communication protocols up to the application interface.

3.1.21**Mobile Communication Gateway****MCG**

device that implements the MCF

Note 1 to entry: It may be embedded into the DHS, shared on CNI or connected as a dedicated device by means of the DMI.

3.1.22**non-voluntary change**

accidental or unintentional change

Note 1 to entry: Accidental change is caused by unpredictable physical influences, and unintentional change is the effect caused by user functions and residual defects of the software even though the best efforts in development techniques have been applied.

3.1.23**payload <of the message>**

part of the message containing the useful data produced by the source application and used by the destination application

3.1.24

protective interface

interface which permits intended data to be exchanged, and prevents unintended data being exchanged

3.1.25

Protocol Analyser

PA

instrument which is used to record and analyse the frames produced by the IUA during the protocol testing

3.1.26

Protocol Frame Generator

instrument which is used to inject the testing frames into the interface of the IUA

3.1.27

Protocol Implementation Conformity Statement

PICS

document containing the information of the claim of conformity of the IUA in respect of the specification

3.1.28

Protocol Implementation Extra Information for Testing

PIXIT

document used when testing the user defined aspects of the protocol for the IUA

3.1.29

sensor

device performing the VMF and/or CMF

Note 1 to entry: Sensor is used as a general term and encompasses a wide variety of technology / devices for measurement purposes e.g. inductive transformers, hall-effect devices, capacitive and resistive dividers, and resistive shunts, etc.

Note 2 to entry: One sensor can perform multiple functions.

3.1.30

software

programs, procedures, rules, documentation and data of an information processing system

EXAMPLE Requirements and design specifications; source code listings, check lists and comments; "Help" text and messages for display at the computer/human interface; instructions for installation and operation; and support guides for hardware and software maintenance.

Note 1 to entry: Software is an intellectual creation that is independent of the medium upon which it is recorded.

Note 2 to entry: Software requires hardware devices to execute programs, and to store and transmit data.

Note 3 to entry: Types of software include firmware, system software, and application software.

[SOURCE: IEC 60050-192:2015, 192-01-07]

3.1.31

test authority

organization responsible for conformity testing

3.1.32**test bench**

arrangement of test equipment for testing an IUA

Note 1 to entry: Test equipment may include oscilloscopes, signal generators and other instruments.

3.1.33**Time Reference Period****TRP**

period of time for which CEBD is produced

3.1.34**Train Control and Monitoring System****TCMS**

set of interrelated objects providing on board control and monitoring of the train

3.1.35**UTC source to DHS interface****TFDI**

dedicated interface of the UTC Source to the DHS

Note 1 to entry: The UTC source can be interfaced with the DHS via a CNI.

3.1.36**verdict**

statement of “pass”, “fail”, or “inconclusive”, as specified in an abstract test case, concerning conformity of an IUA with respect to the test case when it is executed

3.1.37**VMF/CMF to ECF Interface****VEI**

interface between a VMF/CMF and an ECF

Note 1 to entry: It may be a combined interface for VMF and CMF or two separated interfaces.

3.1.38**voluntary change**

intentional change consisting in a modification of software elements and/or modification, loading or swapping of the memory

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

All the abbreviations are listed in alphabetical order.

The definition of some of the abbreviations can be found in EN 50463-1:2017, Clause 3.

BGI	Board to Ground Interface
CEBD	Compiled Energy Billing Data
CMF	Current Measurement Function
CNI	Consist Network Interface
CPID	Consumption Point ID
CRC	Cyclic Redundancy Check
DCS	Data Collecting System
DHS	Data Handling System

DMI	DHS interface to Mobile Communication Function
DSI	Data Handling System to service interface
ECF	Energy Calculation Function
ECN	Ethernet Consist Network
EMDI	Energy Measurement Function To Data Handling System interface
EMF	Energy Measurement Function
EMS	Energy Measurement System
ESI	Energy Measurement Function to service interface
EVN	European Vehicle Number
FQDN	Fully Qualified Domain Name
GS	Ground Station
IETF	Internet Engineering Task Force
IUA	Implementation Under Assessment
LFDI	Location Function to Data Handling System interface
MCF	Mobile Communication Function
MCG	Mobile Communication Gateway
MVB	Multifunction Vehicle Bus
PA	Protocol Analyser
PICS	Protocol Implementation Conformity Statement
eXtra	Protocol Implementation Extra Information for Testing
TCMS	Train Control and Monitoring System
TCN	Train Communication Network
TFDI	UTC Source to Data Handling System interface
TRP	Time Reference Period
UTC	Coordinated Universal Time
VEI	VMF/CMF to ECF interface
VMF	Voltage Measurement Function

4 Requirements

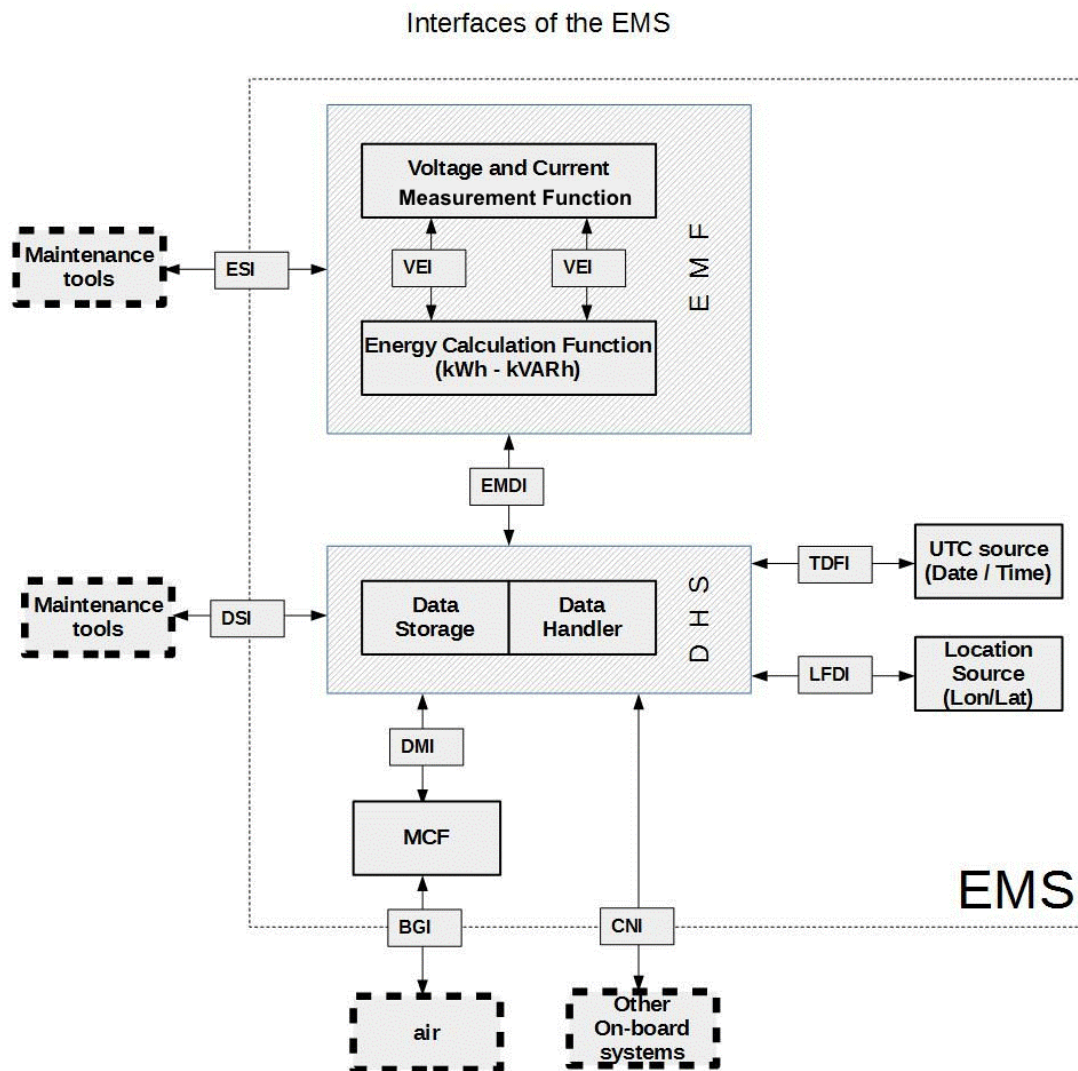
4.1 General

The requirements in EN 50463-1:2017, Clause 4, apply to any device containing one or more implementation of the Communication Services where applicable. EN 50463-4 defines additional requirements specific to the Communication Services.

4.2 Communication between functions of the EMS

4.2.1 General

Figure 3 shows the EMS functions which communicate through interfaces. The BGI interface is specified in 4.3.



Key

BGI	Board to Ground interface
CNI	Consistent Network interface between DHS and other on board subsystems
DMI	interface between DHS and MCF
EMDI	interface between EMF and DHS
ESI	interface between EMF and the maintenance tools
DSI	interface between DHS and the maintenance tools
LFDI	interface between the DHS and location device
TDFI	interface between the DHS and UTC source
VEI	interface between VMF and/or CMF and ECF

Figure 3 — EMS block diagram and interface

ESI and DSI are exposed interfaces which are intended to be used for:

- 1) maintenance;
- 2) EMF and/or DHS administration;
- 3) testing.

More than one interface, dedicated to this purpose, may exist according to the structure of the EMS implementation, e.g. if the EMF and DHS are implemented in two separate devices, it is possible to implement one interface attached to EMF and one attached to DHS.

The interface LFDI is required if the data are exchanged between DHS and a dedicated location function. Alternatively, the location function may be interfaced with the DHS via the CNI.

The interface TFDI is required if the data are exchanged between DHS and a dedicated UTC source device. Alternatively, the UTC source may be interfaced with the DHS via the CNI.

The interface DMI is required if the data are exchanged between DHS and a dedicated Mobile Communication Function. Alternatively, the Mobile Communication Function may be interfaced with the DHS via the CNI.

The interface CNI is required if the data are exchanged between DHS and external TCMS subsystems or non-embedded EMS function, e.g. TCMS subsystems attached to the consist network or location device linked to DHS via the shared consist network.

4.2.2 Communication protocols stack

The communication protocol stack executed by each on board physical interface (excluding VEI, TFDI, LFDI and DMI) shall be one of those listed below. A different protocol stack may be used for each interface.

Table 1 — List of permitted protocol stacks

Protocol stack	Physical layer Reference standard	Link layer Reference standard	Upper layer Reference standard
RS232	ITU-T/Recommendation V.24	user defined.	user defined
RS485	ISO/IEC 8482	EN 60870–5 series	Application specific using the following services: S1 (send/no reply) S2 (send/confirm) S3 (request/respond)
RS422	TIA/EIA-422-B, May 1994	EN 60870–5 series	Application specific using the following services: S1 (send/no reply) S2 (send/confirm) S3 (request/respond)
CANopen	ISO 11898-2	ISO 11898-1	EN 61375–3–3
ETHERNET	ISO/IEC 8802-3	EN 61375–3–4	EN 61375–3–4
MVB	EN 61375–3–1	EN 61375–3–1	EN 61375–3–1
FIP	EN 61158–2	EN 61158–2	EN 61158–2
User defined	User defined	User defined	User defined
The RS232 is listed but should be used with care because it is not sufficiently robust for the demanding electromagnetic environment found typically on board of trains.			
NOTE The USB is not listed because it is not specified by a standardization body recognized by CENELEC. Nevertheless, it may be possible to use.			

Irrespective of the chosen protocol and in order to execute the conformity Design Review and the Conformity Test procedure, the IUA Supplier shall provide the PICS relevant to this protocols stack and the mapping to the specifications stated in the clauses relevant to the design review and to the Conformity module test procedure.

4.2.3 Communication security

4.2.3.1 General

Subclause 4.2.3 specifies the requirements for achieving the proper level of communication security of the interface. The communication security shall ensure the integrity and authenticity of the exchanged payload data.

Referring to integrity, it shall be ensured that the risk of accepting exchanged information containing unintentional or accidental changes and/or intentional changes is reduced to an acceptable level.

Referring to authenticity, it shall be ensured that the risk of accepting exchanged data transmitted by a wrong source function/sub-function and received by the wrong consumer function/sub-function is reduced to an acceptable level.

In order to reach an acceptable level, two cases are considered:

- 1) data transfer is protected by physical means;
- 2) data transfer is protected by software means.

The protection by physical means is specified in EN 50463-1:2017, 4.3.5.2 and 4.3.5.3.

4.2.3.2 Security implemented by software

4.2.3.2.1 General

If the physical means cannot ensure an adequate security level, the security shall be ensured by a dedicated software layer that shall be added to the communication protocol stack of the relevant interface.

The protection by software shall respect the general requirements specified in EN 50463-1:2017, 4.3.4.3, 4.3.4.4, 4.3.4.5, 4.3.4.6 and 4.3.5.4.

The software security layer shall provide:

- a) the data integrity at application level;
- b) the authenticity to ensure data transfer over the interface only occurs between the correct devices. This is optional if the requirement a) adequately covers the detection of data changes (caused by intentional and unintentional actions).

NOTE Binding is one method for ensuring authenticity.

When the secrecy of data are required by the purchaser and agreed with the supplier, the software security layer may provide encryption of the transferred data.

4.2.3.2.2 Data integrity

The integrity of the data shall be ensured by an error detecting code applied at application level on the payload data.

The type of error detecting code and its length shall be chosen considering the payload length in order to ensure at a reasonable level that any change in the payload data are detected.

NOTE CRC is one method for communication error detecting.

4.2.3.2.3 Binding procedure and data encryption

This subclause is informative.

The binding procedure is applied in order to generate a secret key that is transferred under controlled condition between the two units that communicate throughout the interface. The key is generated by the master unit and transferred in a controlled environment to the slave unit. This key is used to

encrypt the payload by the transmitting unit and to decrypt the payload extracted from the received frame by the receiving unit.

This procedure is executed by attaching the maintenance tool (e.g. a PC) to the maintenance interface of the master unit and activating the procedure after a successful authentication based on User ID and password owned only by the authorized personnel.

As soon as the binding procedure is started, the following events occur.

- a) The master unit generates a key and stores it in a dedicated memory cell that cannot be accessed in the future except by the software that decrypts the payload.
- b) The key is transmitted to the slave unit that stores it in a dedicated memory cell that cannot be accessed in the future except by the software that encrypts the payload.
- c) The encryption and decryption of a known payload is transmitted from the master unit to the slave unit and vice-versa to check that the two are correctly bounded.
- d) The procedure is closed.

4.2.4 VMF/CMF to ECF Interface (VEI)

If this interface is digital, it shall be implemented according to EN 50463-2:2017, 4.3 and 4.4, and the requirements listed in this document under 4.2.2 and 4.2.3.

An example of implementation is given in informative Annex A.

VEI may be implemented as a shared interface like CNI provided that the performance, safety and security level is adequate and comparable with the level of a direct and exclusive interface.

4.2.5 EMF to DHS interface (EMDI)

This shall be a protective interface.

This interface shall be implemented according to one of the following options:

- a) a direct and exclusive interface between EMF and DHS;
- b) a shared interface like CNI provided that the security level is adequate and comparable with the level of a direct and exclusive interface.

The interface shall transfer at least the data in accordance with EN 50463-2 and EN 50463-3.

4.2.6 Maintenance/testing interfaces (DSI and ESI)

This shall be a protective interface.

This is an interface to be used by the tools dedicated to the EMS maintenance and testing.

If the EMF and DHS functions are implemented in a single device, at least one interface shall be provided for the maintenance and testing purposes.

If the EMF and DHS functions are implemented in two separate devices, one of the two cases shall apply:

Case 1: there is only one maintenance/testing interface that shall be controlled by the main processing unit of the DHS. In this case, a software module, called the agent, is in charge of routing the information relevant to the maintenance/testing of EMF through the EMDI interface invoking a software module, called the manager, which is in charge of executing the maintenance/testing tasks in the EMF.

Case 2: there are two interfaces dedicated to maintenance/testing, one attached to the device implementing the DHS function and one attached to the device implementing the EMF function.

NOTE The above statements give maintenance/testing interfaces requirements when the implementation of an EMS is done with multiple devices.

The access shall be controlled according to the requirements specified in EN 50463-1:2017, 4.3.2.2.3 and 4.3.2.3.

4.2.7 DHS to location function

Two interfaces are possible:

- a) the LFDI interface;
- b) the CNI interface that connects the DHS to the location function by means of the consist network digital interface.

If a) applies, the interface shall be a direct and exclusive interface to the location function.

If b) applies, requirements are given in 4.2.9.

The interface shall transfer location information in accordance with EN 50463-3:2017, 4.4.

If this interface is able to provide UTC information compliant to the specification given in EN 50463-3:2017, 4.2, it can be used as UTC source interface.

4.2.8 DHS to UTC source

Two interfaces are possible:

- a) the TFDI interface;
- b) the CNI interface that connects the DHS to the UTC source by means of the consist network digital interface.

If case a) applies, the interface shall be a direct and exclusive interface between a UTC source and the DHS. No other on board subsystem shall be attached to this time function by any means or interface.

If the case b) applies, requirements are given in 4.2.9.

The information from UTC source is used to synchronize the internal DHS clock. This interface may be an interface that is transmitting date and time or an interface plus a pulse per second line.

The communication shall ensure that the synchronization error, due to the communication itself, is less than 500 ms.

If the UTC source does not provide a UTC date and time updated according to the leap second adjustment, it shall provide the information of the offset of its own date and time to the UTC date and time with leap second adjustment.

4.2.9 DHS to Consist Network digital interface (CNI)

This interface shall be compliant to EN 61375-3-1 (MVB) or EN 61375-3-4 (ECN).

4.3 Communication between the EMS and ground

4.3.1 General

This subclause sets out the specification of the on board to ground communication subsystem. The basic requirements are set in EN 50463-1 and EN 50463-3.

In order to achieve the communication between the EMS and a user on ground (e.g. DCS, traction unit owner or energy management system), this clause defines:

- the EMS set-up;
- the application services between EMS and a user on ground (service layer);
- the data structures that the application services use (data layer);

- the message mechanism for implementing the application services (message layer);
- the application protocols for supporting the message mechanism;
- the communication architecture for supporting the application protocols;
- a set of security mechanisms for securing the application services.

The user on ground connects to the EMS through a GS.

NOTE 1 More than one user could have the role of DCS.

NOTE 2 A system connected to the EMS local interface or other traction unit subsystems could use this protocol.

4.3.2 EMS set-up

A train includes a number of networked devices that are involved in some services like passenger information, train identification, fleet management and energy measuring for billing and saving purposes. The train is connected to the Ground Station with a set of wireless connections and is capable of switching between them “on the fly” according to the requirement of bandwidth requested by the “service”.

Figure 4 shows one example of a communication scenario. The following clauses cover the interaction between the network’s elements existing between the Ground Station and the on board mobile communication gateway (MCG). The behaviour of the MCG is transparent for the linkage of the EMS to ground, independent from the MCG architecture option, but the implementation can depend, for example:

- in case of a shared MCG, it acts as a proxy, representing the train functional structure to the ground network;
- in case of a dedicated MCG, it acts as an IP sub domain allowing each function/service to be reached through its functional address.

Considering the existing network structures and services of the railway operators, key points are the interoperability of the system and the communication protocols of the applications.

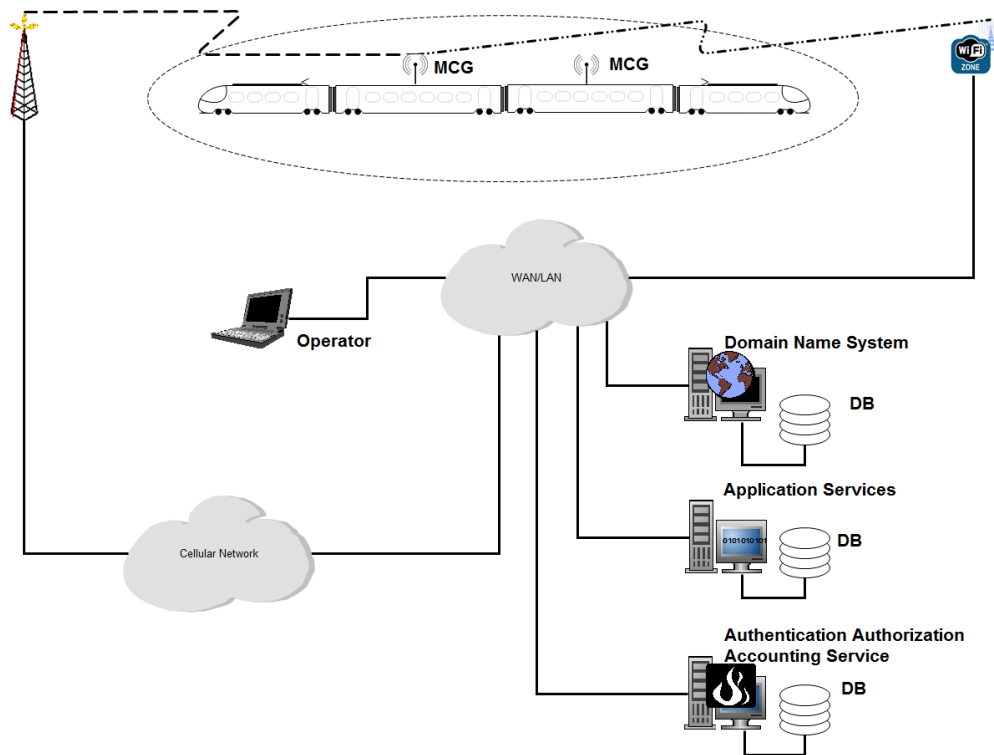


Figure 4 — Communication components (example)

The EMS, during its power-up sequence, can have different states as illustrated in Figure 5. The binding process to set-up the consumption point (EMS installed on the traction unit type) is managed in the Maintenance/Commissioning state. The exchange of CEBDs between the consumption point and DCS and the retrieve of the consumption point information (e.g. EMS configuration, Traction unit information, actual DCS address) are managed in the Normal Operation state.

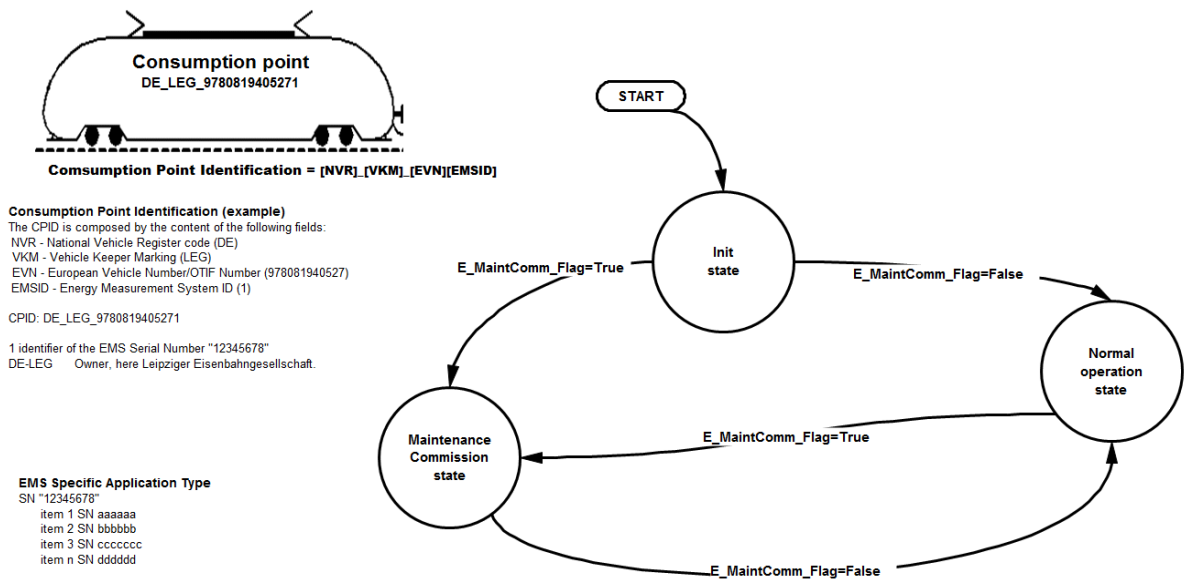


Figure 5 — Consumption point operational states

The binding process to set-up the consumption point (EMS installed on the traction unit type) in the Maintenance/Commissioning state could be either managed through the communication interface or by the service interface/manual procedure. In any case the main states of the binding process are illustrated in Figure 6. The transition between the Normal Operation state and the Maintenance Commissioning state should only be possible in accordance with a documented procedure, taking into account the need for authentication and authorization.

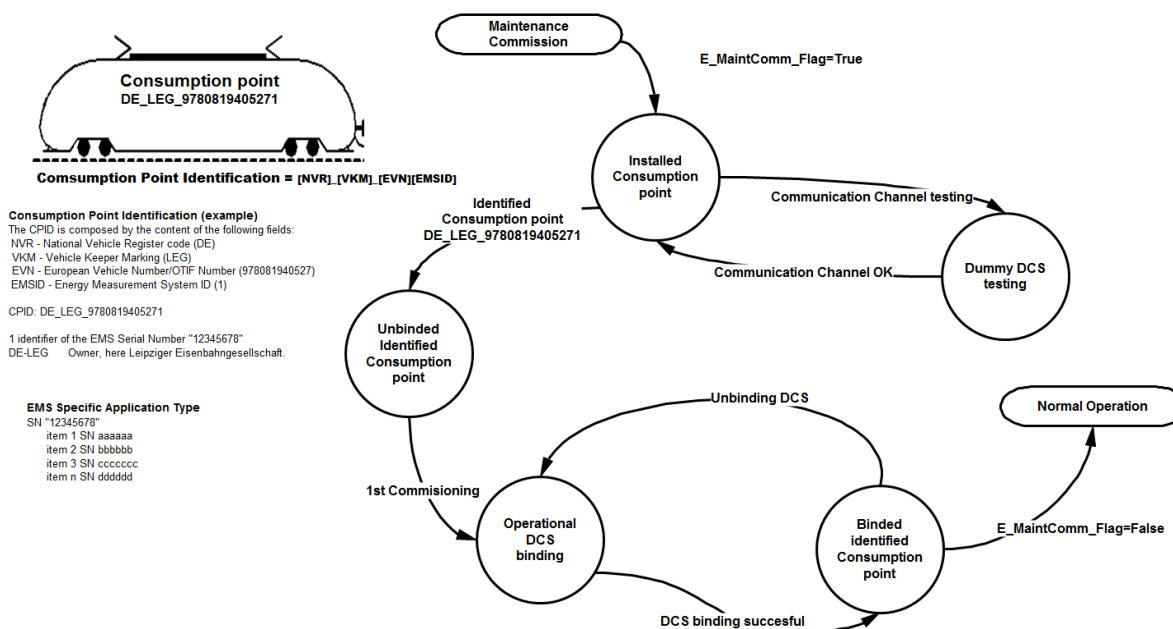


Figure 6 — Maintenance Commissioning states

The maintenance commissioning state and the binding process shall be described and agreed between by the relevant parties. The binding process includes the definition of the options of the communication.

4.3.3 Application services (service layer)

4.3.3.1 Services related with the transfer of CEBDs from EMS to a user on ground

All EMS and DCS shall support these services:

- automatic transfer of CEBD blocks (AutomaticTransferCEBDBlocks);
- request CEBD blocks (RequestCEBDBlocks);
- automatic transfer of a heartbeat (AutomaticTransferHeartbeat).

The tag name of the application service appears between parentheses.

Other users on ground may be supported.

A CEBD block is a sequence of CEBDs with additional information, e.g. EMS identification.

A heartbeat is a message sent from an EMS to a user on ground that facilitates the EMS discovery.

4.3.3.2 Other services

All EMS shall support these services.

- request EMS events (RequestEvents);

The following services are optional:

- request reading blocks (RequestReadingBlocks);
- request EMS communication configuration (RequestCommunicationConfig);
- change EMS communication configuration (ChangeCommunicationConfig);
- request EMS asset data (RequestAssetData);
- request EMS state (RequestState);
- automatic transfer of reading blocks (AutomaticTransferReadingBlocks);
- automatic transfer of a new asset configuration (AutomaticTransferAssetData);
- automatic transfer of a new communication configuration (AutomaticTransferCommunicationConfig);
- automatic transfer of events (AutomaticTransferEvents);
- periodic transfer of EMS state (PeriodicTransferState).

If any of these optional services are implemented, they shall comply with the requirements in this standard.

A reading block is a sequence of readings, e.g. energy measurements with its own time period, and can be used for energy management, e.g. energy saving or losses calculation.

Other services (e.g. software update) which are not listed above are not standardized in this standard.

4.3.3.3 User access rights to the application services

In order to fulfill the EN 50463-1 access security requirements and the communication requirements, Table 2 defines the types of user access rights and their available application services, from the point of view of communication between the EMS and a user on ground.

Table 2 — Types of user access rights

Type of user access right	Available application services
NotChange	RequestCEBDBlocks AutomaticTransferCEBDBlocks AutomaticTransferHeartbeat RequestEvents AutomaticTransferEvents (if available) RequestReadingBlocks (if available) AutomaticTransferReadingBlocks (if available) RequestAssetData (if available) AutomaticTransferAssetData (if available) RequestState (if available) PeriodicTransferState (if available) RequestCommunicationConfig (if available) AutomaticTransferCommunicationConfig (if available).
ChangeOwn	Same as NotChange with this additional application service if it's available: ChangeCommunicationConfig restricted to the communication configuration data of the user.
ChangeAll	All available services without user restriction.

NOTE A user with access right “NotChange” is typically a basic user. A user with access right “ChangeAll” is typically an administrator.

A user who does not have ChangeAll access rights shall not receive data about other users.

If the EMS includes the ChangeCommunicationConfig service, it shall implement, at least, one user with the user access right ChangeOwn. If the scope of the ChangeCommunicationConfig is more than the user communication configuration, the EMS shall implement, at least, one user with the user access right ChangeAll.

In the case of more than one user on ground, that shares application services affected by confidentiality and management restriction, the use of these types of user access rights is recommended. Nevertheless, the rules for the on ground management of user access rights is outside the scope of this standard.

4.3.4 Data structures (data layer)

4.3.4.1 General

Data structures used by application services shall comply with the XML schema indicated by Table 3. The M/O/C column defines whether the data structure is mandatory (“M”), or optional (“O”) or conditional (“C”). The value C is an indication that a condition exists for this data structure, given under the table. C may have an index to handle multiple conditions. The column Annex indicates the annex where to find the normative XML schema.

Table 3 — XML schema of each data structure

Data structure name (XML schema name)	Application services using this data structure	M/O/C	Description	Annex
CEBDBlock (CEBDBlock.xsd)	RequestCEBDBlocks AutomaticTransferCEBDBlocks	M	See 4.3.4.2	E
EventSet (EventSet.xsd)	RequestEvents AutomaticTransferEvents	M	See 4.3.4.3	E
Heartbeat (Heartbeat.xsd)	AutomaticTransferHeartbeat	M	See 4.3.4.4	E
ReadingBlock (ReadingBlock.xsd)	RequestReadingBlocks AutomaticTransferReadingBlocks	C1	See 4.3.4.5	F
CommunicationConfig (CommunicationConfig.xsd)	RequestCommunicationConfig AutomaticTransferCommunicationConfig	C2	See 4.3.4.6	F
ChangeCommunicationConfig (ChangeCommunicationConfig.xsd)	ChangeCommunicationConfig	C3	See 4.3.4.7	F
AssetData (AssetData.xsd)	RequestAssetData AutomaticTransferAssetData	C4	See 4.3.4.8	F
State (State.xsd)	RequestState PeriodicTransferState	C5	See 4.3.4.9	F

Condition C1: Data structure and schema are mandatory if the EMS supports the service RequestReadingBlocks or AutomaticTransferReadingBlocks.

Condition C2: Data structure and schema are mandatory if the EMS supports the service RequestCommunicationConfig or AutomaticTransferCommunicationConfig.

Condition C3: Data structure and schema are mandatory if the EMS supports the service ChangeCommunicationConfig.

Condition C4: Data structure and schema are mandatory if the EMS supports the service RequestAssetData or AutomaticTransferAssetData.

Condition C5: Data structure and schema are mandatory if the EMS supports the service RequestState or PeriodicTransferState.

NOTE Annex G provides XML examples of the data structures.

The data structures ReadingBlock, CommunicationConfig, ChangeCommunicationConfig, AssetData and State use optional elements.

The following subclauses describes the data structures using graphics. The graphical conventions used are explained in 4.3.4.2.

4.3.4.2 CEBDBlock

The CEBDBlock is a sequence of CEBDs with additional information. Figure 7 describes the structure of CEBDBlock.

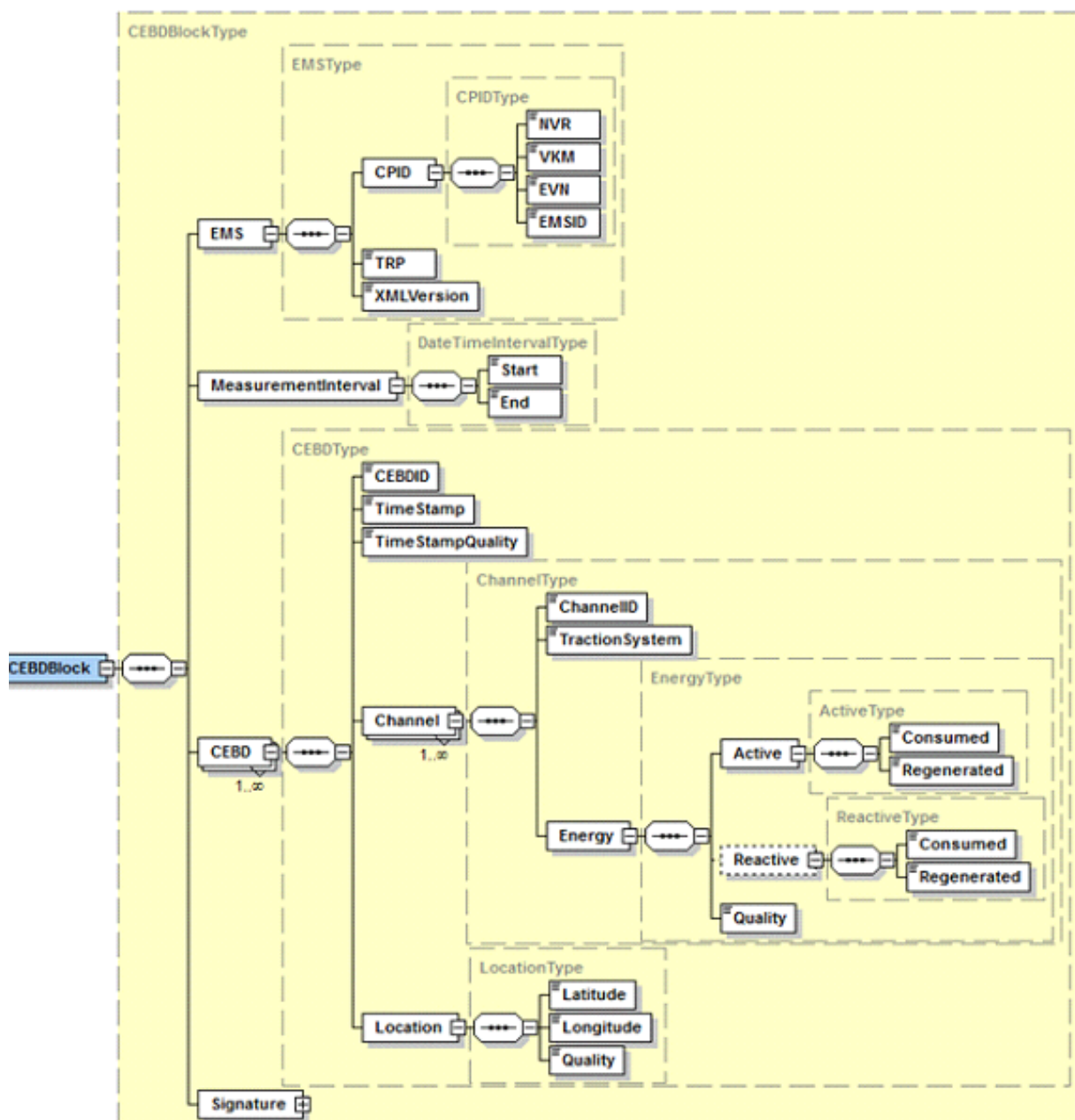


Figure 7 — CEBDBlock structure

The graphical representation used in this document (see Figure 7 for example) uses the convention set out below:

- white or blue rectangle indicates an element;
- symbol – indicates that the element contains child elements. The graphic shows the child elements on the right;
- symbol + indicates that the element contains child elements. The graphic does not show the child elements;
- white or blue rectangle with solid border indicates that the element is mandatory;
- white or blue rectangle with dashed border indicates that the element is optional;
- symbol 1..∞ indicates one or more elements;
- symbol 0..∞ indicates zero or more elements;
- yellow rectangle with dashed border indicates that element has been defined as a complex type;
- symbol  indicates a sequence of elements.

Table 4 to Table 8 define the CEBDBlock elements. The multiplicity of the elements is set out in the normative schema.

Table 4 — Definition of CEBDBlock elements

Element	M/O/C	XSD Type	Description
EMS	M	EMSType (see Table 5)	EMS that has calculated the CEBDBlock.
MeasurementInterval	M	DateTimeIntervalType (see Table 126)	Measurement interval for which the sequence of CEBDs has been produced. Start is the date and time at the beginning of the time period for which the first CEBD of the sequence is produced. End is the date and time at the end of the time period for which the last CEBD of the sequence is produced.
CEBD	M	CEBDType (see Table 6)	Sequence of CEBDs.
Signature	M	ds:SignatureType (see 4.3.4.12)	Digital signature of the CEBDBlock

The element End of the element MeasurementInterval and the element TimeStamp of the last CEBD of the sequence shall have the same value.

Table 5 — Definition of EMSType elements (CEBDBlock)

Element	M/O/C	XSD Type	Description
CPID	M	CPIDType (see Table 125)	Consumption Point ID.
TRP	M	xs:duration	Time Reference Period. The value is fixed to “PT5M” (5 min).
XMLVersion	M	XMLVersionType (see Table 128)	EN 50463-4 XML schema version.

Table 6 — Definition of CEBDType elements (CEBDBlock)

Element	M/O/C	XSD Type	Description
CEBDID	M	NumericID (see Table 128)	Sequential number to identify each CEBD.
TimeStamp	M	ZuluDateTimeType (see Table 128)	Date and time at the end of the time reference period.
TimeStampQuality	M	TimeQualityCodeType (see Table 128)	Quality of the TimeStamp value.
Channel	M	ChannelType (see Table 7)	Channels in which the CEBD measurement is placed.
Location	M	LocationType (see Table 127)	Location at the end of the time reference period.

Table 7 — Definition of ChannelType elements (CEBDBlock)

Element	M/O/C	XSD Type	Description
ChannelID	M	NumericID (see Table 128)	Unique identifier for the channel.
TractionSystem	M	StandardTractionSystemType (see Table 128)	Type of traction system that the channel is connected to at the end of the time reference period.
Energy	M	EnergyType (see Table 8)	Energy consumed/regenerated measured by the channel during the time reference period.

Table 8 — Definition of EnergyType elements (CEBDBlock)

Element	M/O/C	XSD Type	Description
Active	M	ActiveType (see Table 123)	Active energy delta values.
Reactive	C1	ReactiveType (see Table 124)	Reactive energy delta values.
Quality	M	MeasurementQualityCodeType (see Table 128)	Quality code of the energy measurement

Condition C1: Mandatory if the channel is measuring an AC traction system.

4.3.4.3 EventSet

The EventSet is a set of events with additional information. Figure 8 describes the structure of EventSet.

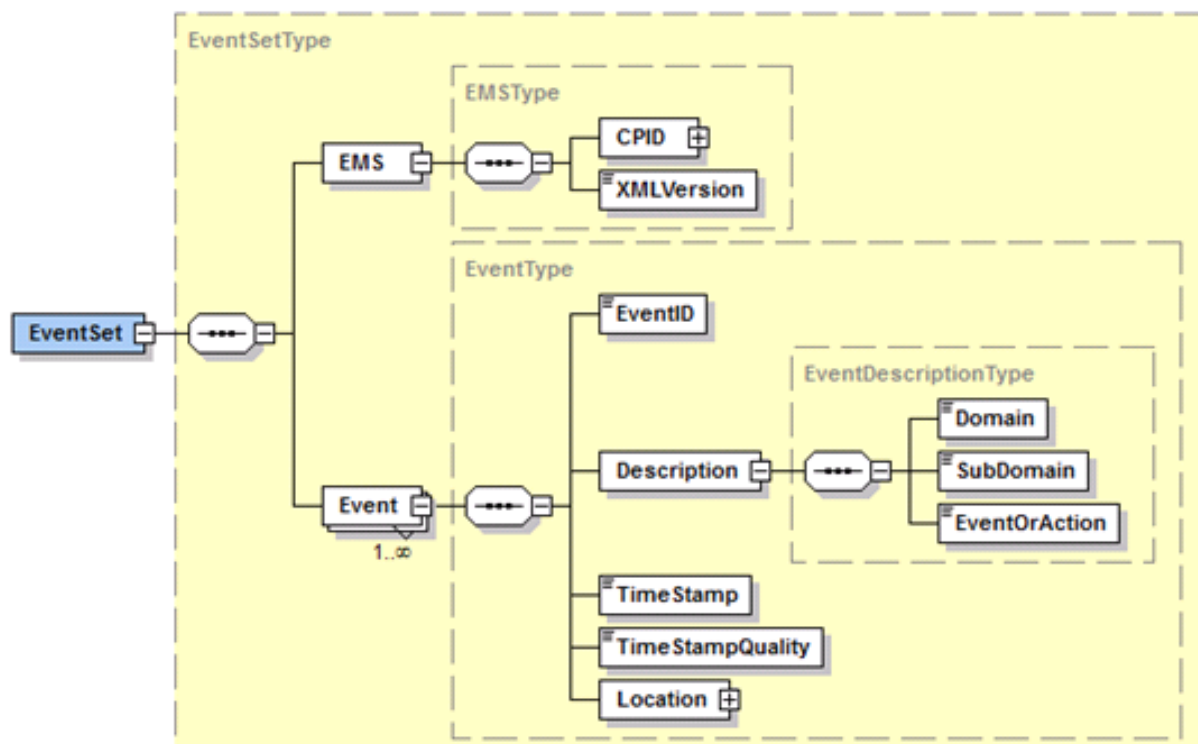


Figure 8 — EventSet structure

Table 9 to Table 12 define the EventSet elements.

Table 9 — Definition of EventSet elements

Element	M/O/C	XSD Type	Description
EMS	M	EMSType (see Table 10)	EMS that has generated the events.
Event	M	EventType (see Table 11)	Set of events.

Table 10 — Definition of EMSType elements (EventSet)

Element	M/O/C	XSD Type	Description
CPID	M	CPIDType (see Table 125)	Consumption Point ID.
XMLVersion	M	XMLVersionType (see Table 128)	EN 50463-4 XML schema version.

NOTE EventSet uses a slightly different definition of EMSType than CEBDBlock.

Table 11 — Definition of EventType elements (EventSet)

Element	M/O/C	XSD Type	Description
EventID	M	NumericID (see Table 128)	Sequential number to identify each event
Description	M	EventDescriptionType (see Table 12)	Event description.
TimeStamp	M	ZuluDateTimeType (see Table 128)	Date and time when the event has been processed.
TimeStampQuality	M	TimeQualityCodeType (see Table 128)	Quality of the TimeStamp value.
Location	M	LocationType (see Table 127)	Location where the event has been processed.

Table 12 — Definition of EventDescriptionType elements

Element	M/O/C	XSD Type	Description
Domain	M	LongRestrictedStringType (see Table 128)	High-level nature of the event. By properly classifying events by a small set of domain codes, a system can more easily run reports based on the types of events that have occurred or been received. In the case of EMS it indicates the EMS functionality or EMS component where the event has appeared.
SubDomain	M	LongRestrictedStringType (see Table 128)	More specific nature of the event, as a further sub-categorization of 'domain'.
EventOrAction	M	ShortRestrictedStringType (see Table 128)	The most specific part of this event type. It is mainly in the form of a verb that gives action to the event which has occurred.

Table 13 describes the used variables for defining the values of Domain and SubDomain.

Table 13 — Variables for defining events

Variable	Description
UserName	Unique identifier for each user who connects to the EMS
ECFID	Unique identifier for each ECF.
VMFID	Unique identifier for each VMF.
CMFID	Unique identifier for each CMF.
FunctionID	Unique identifier for each EMS function that is not ECF type or VMF type or CMF type.
SensorID	Unique identifier for each physical sensor of the EMS.
MeterID	Unique identifier for each device containing one or more ECFs.
DeviceID	Unique identifier for each device of the EMS that is not sensor type or meter type.
ParameterID	Unique identifier for each configurable parameter of the EMS.
SoftwareID	Unique identifier for each software component of the EMS.

If the EMS is using the application services related with asset data and communication configuration, the variables of Table 13 shall use the values defined by Table 14.

Table 14 — Value of variables for defining events

Variable	Value
UserName	UserID of the user in CommunicationConfig
ECFID	ECFID of the ECF in AssetData
VMFID	VMFID of the VMF in AssetData
CMFID	CMFID of the ECF in AssetData
FunctionID	FunctionID of the Function in AssetData
SensorID	SensorID of the Sensor in AssetData
MeterID	MeterID of the Meter in AssetData
DeviceID	DeviceID of the Device in AssetData
ParameterID	Path in CommunicationConfig to the element using xxxID if it is necessary. Examples: “CommunicationConfig.DataGeneration.ReadingBlockConfig.TimePeriod” “CommunicationConfig.User_[UserID].Protocol.HTTP.Web”
SoftwareID	SoftwareID of the Software in AssetData

Table 15 to Table 20 define the values of Domain, SubDomain and EventOrAction for different types of events. “[x]” indicates the expression shall be replaced by the value of the indicated variable. The CEBD column indicates if the event is a CEBD related event.

Table 15 — Hardware and software alarms

Domain	SubDomain	EventOrAction	M/O/C	CEBD	Description
EMS	Status	Error	M	Y	Critical error.
EMS	Status	Normal	M	Y	Recovered from a critical error.
EMS	Power	Up	M	Y	Power up.
EMS	Power	Down	M	Y	Power down.
DHS	Status	Error	M	Y	Internal error.
DHS	Status	Normal	M	Y	Recovered from internal error.
DHS	Memory	Full	M	Y	Memory full. Free memory is exhausted or under mandatory minimum free space.
DHS	Memory	Error	M	C1	Memory error.
DHS	Memory	Normal	M	C1	Recovered from memory error.
DHS	Logs	Cleared	M	Y	Event logs cleared.
Device_[DeviceID]	Status	Error	O	C2	Internal error in the EMS device defined by [DeviceID].
Device_[DeviceID]	Status	Normal	O	C2	Recovered from internal error.
Function_[FunctionID]	Status	Error	O	C3	Internal error in the EMS function defined by [FunctionID].
Function_[FunctionID]	Status	Normal	O	C3	Recovered from internal error.
EMS	Enclosure	Open	O	C4	An enclosure is open.
EMS	Enclosure	Closed	O	C4	An enclosure is closed.
EMS	TerminalCover	Open	O	C5	A terminal cover is open.
EMS	TerminalCover	Closed	O	C5	A terminal cover is closed.

Condition C1: Yes if the memory stores CEBDs.

Condition C2: Yes if the device is involved in the CEBD.

Condition C3: Yes if the function is involved in the CEBD.

Condition C4: Yes if opening the enclosure might indicate a threat to the integrity of the CEBD.

Condition C5: Yes if opening the cover might indicate a threat to the integrity of the CEBD.

Table 16 — User management events

Domain	SubDomain	EventOrAction	M/O/C	CEBD	Description
DHS	Passwords	Reset	M	N	Initialization of user names and passwords with default values.
User_[UserName]	Remote	Login	M	N	Remote login of the user defined by [UserName].
User_[UserName]	Remote	Logout	M	N	Remote user logout.
User_[UserName]	Remote	Failed	M	N	Remote user login failure: e.g wrong password.
User_[UserName]	Local	Login	M	N	Local user login.
User_[UserName]	Local	Logout	M	N	Local user logout.
User_[UserName]	Local	Failed	M	N	Local user login failure: e.g invalid password.
DHS	Communication	InvalidMessage	M	N	The EMS has received an invalid message
User_[UserName]	Communication	InvalidRequest	M	N	The EMS has received from this user an invalid request.

An InvalidMessage shall be generated when a failure in the decryption of the message, or invalid origin of the message or invalid user ID occurs.

Table 17 — Measurement alarms

Domain	SubDomain	EventOrAction	M/O/C	CEBD	Description
ECF_[ECFID]	Status	Error	M	Y	Internal error of the ECF defined by [ECFID].
ECF_[ECFID]	Status	Normal	M	Y	Recovered from internal error.
VMF_[VMFID]	Status	Error	O	Y	Internal error.
VMF_[VMFID]	Status	Normal	O	Y	Recovered from internal error.
VMF_[VMFID]	SignalStatus	Error	O	Y	Signal is wrong.
VMF_[VMFID]	SignalStatus	Normal	O	Y	Recovered from signal error.
CMF_[CMFID]	Status	Error	O	Y	Internal error.
CMF_[CMFID]	Status	Normal	O	Y	Recovered from internal error.
CMF_[CMFID]	SignalStatus	Error	O	Y	Signal is wrong.
CMF_[CMFID]	SignalStatus	Normal	O	Y	Recovered from signal error.
Sensor_[SensorID]	Status	Error	O	C1	Internal error.
Sensor_[SensorID]	Status	Normal	O	C1	Recovered from internal error.
Meter_[MeterID]	Status	Error	O	Y	Internal error.
Meter_[MeterID]	Status	Normal	O	Y	Recovered from internal error.
DHS	CEBDMemory	Cleared	M	Y	CEBD memory cleared.
ECF_[ECFID]		CurrentWithoutVoltage	O	Y	Current without voltage.

Condition C1: Yes if the sensor can detect a critical error and it can compromise the CEBD.

Table 18 — Synchronization alarms and events

Domain	SubDomain	EventOrAction	M/O/C	CEBD	Description
Clock	Status	Error	M	Y	Internal error.
Clock	Status	Normal	M	Y	Recovered from internal error.
Clock	TimeSync	Reset	M	Y	Clock synchronization out of the automatic synchronization process (e.g. manual synchronization)
Clock	TimeSync	Failed	M	Y	More than the maximum time between synchronizations.
Clock	TimeSync	MajorCorrection	M	Y	A change of the time exceeding the maximum permitted deviation.

Table 19 — Communication events

Domain	SubDomain	EventOrAction	M/O/C	CEBD	Description
EMS	IPAddress	[New value]	M	N	New IP value. Example: "130.24.24.133"
EN 61375SharedConnection	Communication	Error	C3	N	Ground communication failure.
EN 61375SharedConnection	Communication	Normal	C3	N	Recovered from ground communication failure.
EN 61375DedicatedConnection	Communication	Error	C2	N	Ground communication failure.
EN 61375DedicatedConnection	Communication	Normal	C2	N	Recovered from ground communication failure.
DedicatedWirelessConnection	Communication	Error	C1	N	Ground communication failure.
DedicatedWirelessConnection	Communication	Normal	C1	N	Recovered from ground communication failure.
Function_[FunctionID]	Communication	Error	O	N	Function communication error. The function is related with ground communications.
Function_[FunctionID]	Communication	Normal	O	N	Recovered from function communication error.
User_[UserName]	ReceivedCEBD	[Interval start]_[Interval end]	M	N	The user has received the specific interval of new CEBD.
User_[UserName]	ReceivedReading	[Interval start]_[Interval end]	O	N	The user has received the specific interval of new Readings.

Condition C1: Mandatory if the EMS is using the DedicatedWirelessConnection.

Condition C2: Mandatory if the EMS is using the EN 61375DedicatedConnection.

Condition C3: Mandatory if the EMS is using the EN 61375SharedConnection.

A "Ground communication failure" event represents failures in the level of the communication architecture or in the associated application protocol.

[Interval start] and [Interval end] shall use the same format as ZuluDateTimeType (Table 128).
[Interval end] shall be greater than [Interval start].

Table 20 — Configuration events

Domain	SubDomain	EventOrAction	M/O/C	CEBD	Description
User_[UserName]	[ParameterID]	[New value]	M	C1	The user has changed the value of the element referred by ParameterID and the new value is indicated. In the case of passwords or keys [New value] is substituted by the word "Changed".
User_[UserName]	[SoftwareID].Version	[New version]	M	C2	New version of the software referred by SoftwareID.
User_[UserName]	Sensor_[SensorID]	Changed	M	C3	Sensor changed
User_[UserName]	CMF_[CMFRID].kfactor	[New value]	M	Y	New k-factor
User_[UserName]	VMF_[VMFRID].kfactor	[New value]	M	Y	New k-factor
User_[UserName]	[ParameterID]	Wrong	M	N	The EMS has received a configuration value out of range or the field doesn't exist
User_[UserName]	[ParameterID]	InsufficientRights	M	N	The user does not have the necessary rights to change this field.

Condition C1: Yes if the parameter is involved in the CEBD.

Condition C2: Yes if the software is involved in the CEBD.

Condition C3: Yes if the sensor is involved in the CEBD.

The event list may be extended with extra events depending on implementation following the same structure.

4.3.4.4 Heartbeat

Figure 9 describes the structure of Heartbeat elements.

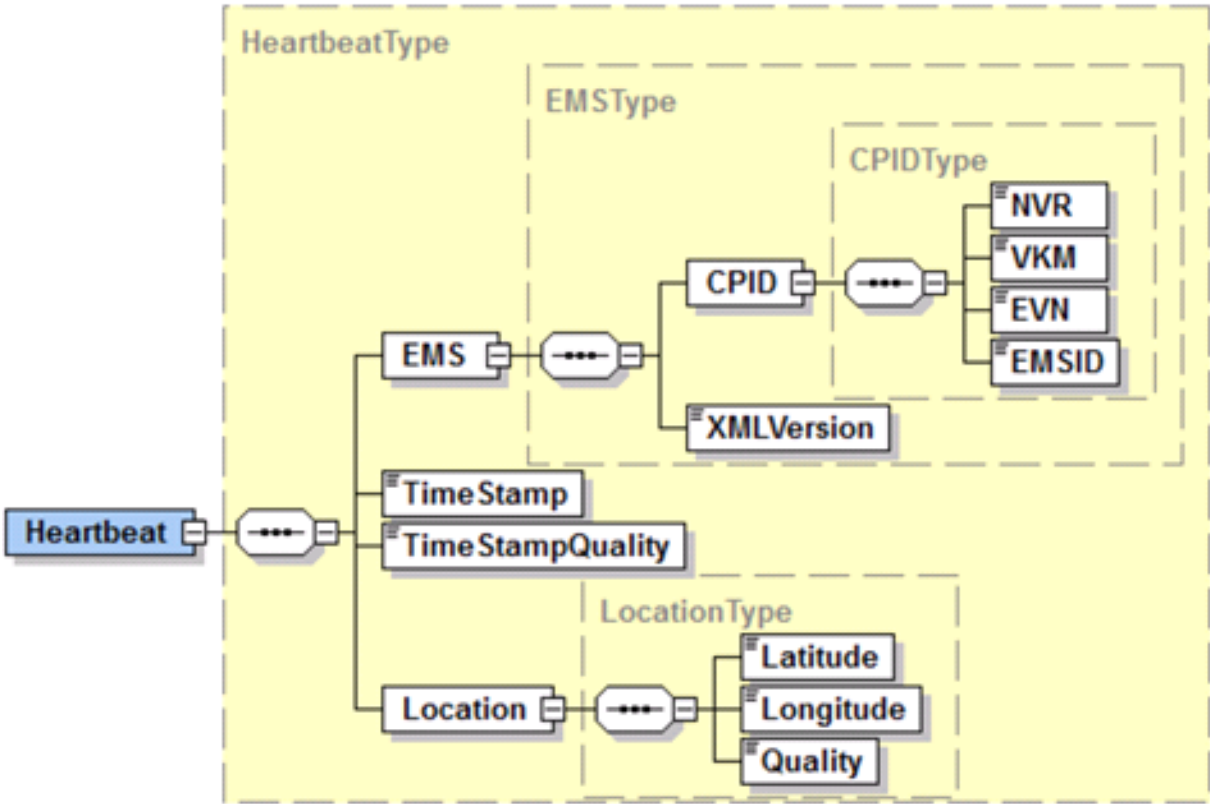


Figure 9 — Heartbeat structure

Table 21 defines the Heartbeat elements.

Table 21 — Definition of Heartbeat elements

Element	M/O/C	XSD Type	Description
EMS	M	EMSType (see Table 10)	The EMS which has generated the heartbeat.
TimeStamp	M	ZuluDateTimeType (see Table 128)	Date and time when the heartbeat has been generated.
TimeStampQuality	M	TimeQualityCodeType (see Table 128)	Quality of the TimeStamp value.
Location	M	LocationType (see Table 127)	Location where the heartbeat has been generated.

4.3.4.5 ReadingBlock

The ReadingBlock is a sequence of readings with additional information. Figure 10 describes the main structure of the ReadingBlock.

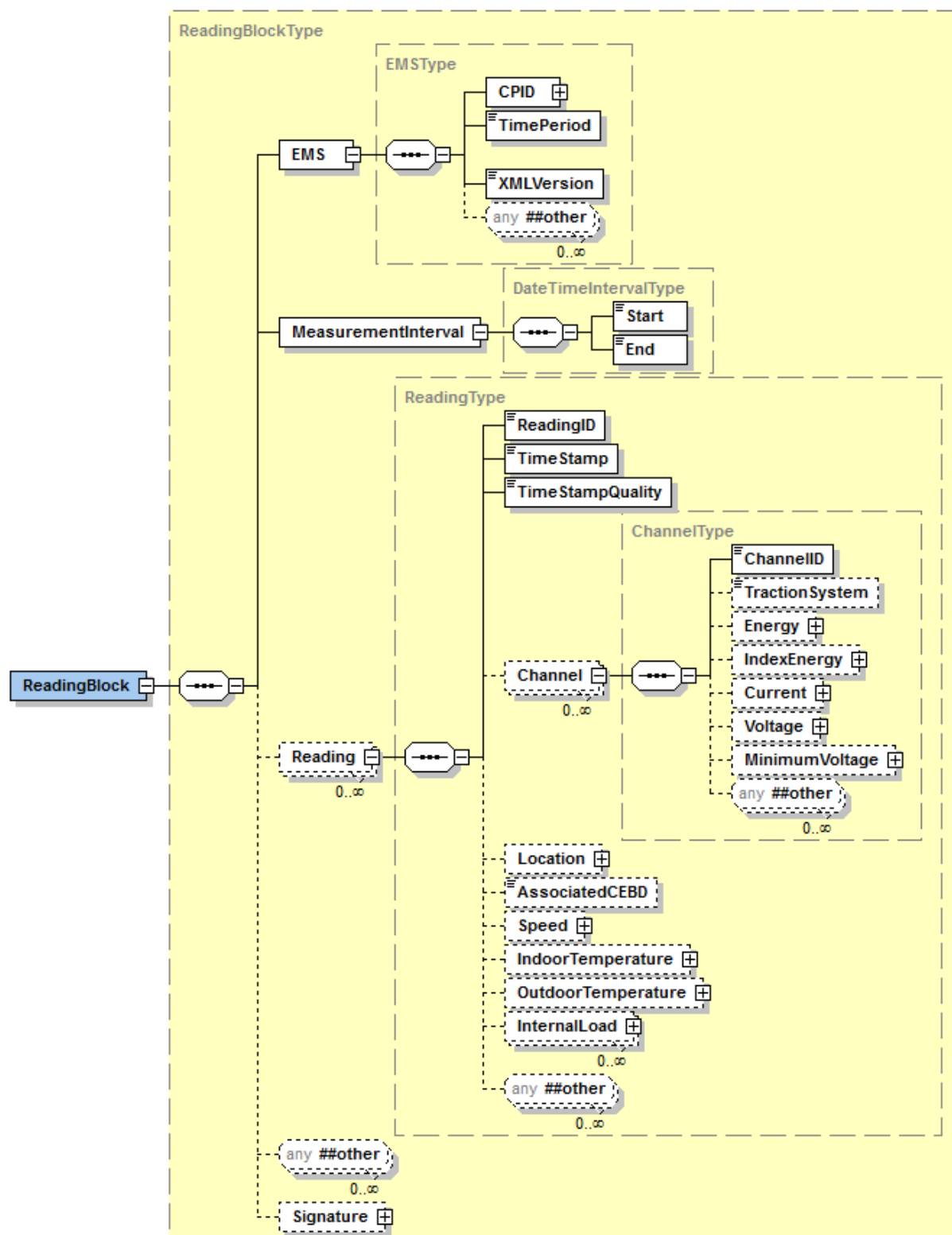


Figure 10 — ReadingBlock structure

Table 22 to Table 36 define the ReadingBlock elements.

The production of the optional elements related with measurement (four-quadrant reactive energy, current, voltage, minimum voltage, speed, indoor temperature, outdoor temperature and internal load) is not addressed in the EN 50463 series.

NOTE 1 The inclusion of these optional elements in this part of the EN 50463 series, does not necessarily imply an intention to specify them more extensively in future.

Table 22 — Definition of ReadingBlock elements

Element	M/O/C	XSD Type	Description
EMS	M	EMSType (see Table 23)	EMS that has calculated the ReadingBlock.
MeasurementInterval	M	DateTimeIntervalType (see Table 126)	Measurement interval for which the sequence of Readings has been produced. Start is the date and time at the beginning of the time period for which the first Reading of the sequence is produced. End is the date and time at the end of the time period for which the last Reading of the sequence is produced.
Reading	O	ReadingType (see Table 24)	Sequence of Readings.
any	O	other	Used to allow custom extensions.
Signature	O	ds:SignatureType (see 4.3.4.12)	Digital signature of the ReadingBlock.

The element End of MeasurementInterval and the element TimeStamp of the last Reading of the sequence shall have the same value.

Table 23 — Definition of EMSType elements (ReadingBlock)

Element	M/O/C	XSD Type	Description
CPID	M	CPIDType (see Table 125)	Consumption Point ID.
TimePeriod	M	xs:duration	Period of time for which Reading is produced. Value examples: "PT1M" (1 min), "PT30S" (30 s).
XMLVersion	M	XMLVersionType (see Table 128)	EN 50463-4 XML schema version.
any	O	other	Used to allow custom extensions

NOTE 2 ReadingBlock uses a slightly different definition of EMSType than CEBDBlock.

Table 24 — Definition of ReadingType elements (ReadingBlock)

Element	M/O/C	XSD Type	Description
ReadingID	M	NumericID (see Table 128)	Sequential number to identify each Reading.
TimeStamp	M	ZuluDateTimeType (see Table 128)	Date and time at the end of the time period. In this section 'time period' refers to the time period for which Reading is produced.
TimeStampQuality	O	TimeQualityCodeType (see Table 128)	Quality of the TimeStamp value.
Channel	O	ChannelType (see Table 25)	Channel in which the measurement is placed.
Location	O	EnhancedLocationType (see Table 32)	Location at the end of the time period.
AssociatedCEBD	O	NumericID (see Table 128)	The Reading could be associated to a CEBD (the value is the CEBDID of the associated CEBD)
Speed	O	SpeedType (see Table 33)	Train speed data in the time period.
IndoorTemperature	O	TemperatureType (see Table 34)	Indoor train temperature at the end of time period.
OutdoorTemperature	O	TemperatureType (see Table 34)	Outdoor train temperature at the end of time period.
InternalLoad	O	InternalLoadType (see Table 35)	Energy consumed by internal loads of the train during the time period.
any	O	other	Used to allow custom extensions.

Table 25 — Definition of ChannelType elements (ReadingBlock)

Element	M/O/C	XSD Type	Description
ChannelID	M	NumericID (see Table 128)	Number to identify each channel.
TractionSystem	O	StandardTractionSystemType (see Table 128)	Type of traction system that the channel is connected to at the end of the time period.
Energy	O	EnergyType (see Table 26)	Energy consumed/regenerated measured by the channel during the time period.
IndexEnergy	O	IndexEnergyType (see Table 28)	Index energy values at the end of the time period.
Current	O	CurrentType (see Table 29)	Current data during the time period.
Voltage	O	VoltageType (see Table 30)	Voltage data during the time period.
MinimumVoltage	O	MinimumVoltageType (see Table 31)	Information related with the minimum voltage value during the time period.
any	O	other	Used to allow custom extensions.

Table 26 — Definition of EnergyType elements (ReadingBlock)

Element	M/O/C	XSD Type	Description
Active	O	ActiveType (see Table 123)	Active energy delta values.
Reactive	O	ReactiveType (see Table 124)	Reactive energy delta values.
Reactive4Q	O	Reactive4QType (see Table 27)	Reactive energy delta values (four quadrants).
Quality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the energy measurement.
any	O	other	Used to allow custom extensions.

Table 27 — Definition of Reactive4QType elements (ReadingBlock)

Element	M/O/C	XSD Type	Description
Q1	M	BasicReactiveType (see Table 128)	Reactive quadrant 1.
Q2	M	BasicReactiveType	Reactive quadrant 2.
Q3	M	BasicReactiveType	Reactive quadrant 3.
Q4	M	BasicReactiveType	Reactive quadrant 4.

Table 28 — Definition of IndexEnergyType elements (ReadingBlock)

Element	M/O/C	XSD Type	Description
Active	O	ActiveType (see Table 123)	Active energy index value.
Reactive	O	ReactiveType (see Table 124)	Reactive energy index value.
Reactive4Q	O	Reactive4QType (see Table 27)	Reactive energy index values (four quadrants).
Quality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the energy measurement.
any	O	other	Used to allow custom extensions.

Table 29 — Definition of CurrentType elements (ReadingBlock)

Element	M/O/C	XSD Type	Description
Minimum	O	BasicCurrentType (see Table 132)	Minimum rms AC or DC current during the time period.
Average	O	BasicCurrentType	Average rms AC or DC current during the time period.
Maximum	O	BasicCurrentType	Maximum rms AC or DC current during the time period.
Quality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the current measurement.
any	O	other	Used to allow custom extensions.

Table 30 — Definition of VoltageType elements (ReadingBlock)

Element	M/O/C	XSD Type	Description
Minimum	O	BasicVoltageType (see Table 132)	Minimum rms AC or DC voltage during the time period.
Average	O	BasicVoltageType	Average rms AC or DC voltage during the time period.
Maximum	O	BasicVoltageType	Maximum rms AC or DC voltage during the time period.
Quality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the voltage measurement.
any	O	other	Used to allow custom extensions.

Table 31 — Definition of MinimumVoltageType elements (ReadingBlock)

Element	M/O/C	XSD Type	Description
TimeStamp	M	ZuluDateTimeType (see Table 128)	Date and time when rms AC or DC voltage is minimum.
Voltage	M	BasicVoltageType (see Table 132)	rms AC or DC voltage value.
VoltageQuality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the voltage measurement
Current	O	BasicCurrentType (see Table 132)	rms AC or DC current value at the minimum voltage.
CurrentQuality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the current measurement.
Energy	O	EnergyType (see Table 26)	Energy consumed and/or regenerated from the beginning of the time period to the instant where the minimum voltage has been detected.
Location	O	EnhancedLocationType (see Table 32)	Location where the minimum voltage has been detected.
any	O	other	Used to allow custom extensions.

Table 32 — Definition of EnhancedLocationType elements (ReadingBlock)

Element	M/O/C	XSD Type	Description
Latitude	M	LatitudeType (see Table 128)	Latitude.
Longitude	M	LongitudeType (see Table 128)	Longitude.
Quality	O	LocationQualityCodeType (see Table 128)	Quality of location data.
any	O	other	Used to allow custom extensions.

Table 33 — Definition of SpeedType elements (ReadingBlock)

Element	M/O/C	XSD Type	Description
Minimum	O	BasicSpeedType (see Table 130)	Minimum speed during the time period.
Average	O	BasicSpeedType	Average speed during the time period.
Maximum	O	BasicSpeedType	Maximum speed during the time period.
Quality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the speed measurement.
any	O	other	Used to allow custom extensions.

Table 34 — Definition of TemperatureType elements (ReadingBlock)

Element	M/O/C	XSD Type	Description
Value	M	BasicTemperatureType (see Table 129)	Measurement value.
Quality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the temperature measurement value.

Table 35 — Definition of InternalLoadType elements (ReadingBlock)

Element	M/O/C	XSD Type	Description
Kind	M	ShortRestrictedStringType (see Table 128)	Kind of internal load. Table 36 shows possible values.
Value	M	xs:decimal	Active energy value.
Unit	M	ShortRestrictedStringType	Value unit.
Quality	O	MeasurementQualityCodeType (see Table 128)	Measurement quality code.

Table 36 — Value examples for kind in InternalLoadType (ReadingBlock)

Value	Description
Lighting	Lighting
HVAC	HVAC
ElectricHeating	Electrical heating
TractionConverterConsumedActive	Energy active consumption for traction converters.
TractionConverterConsumedReactive	Energy reactive consumption for traction converters.
TractionConverterRegeneratedActive	Energy active regenerated for traction converters.
TractionConverterRegeneratedReactive	Energy reactive regenerated for traction converters.
AuxConverterConsumedActive	Energy active consumption for auxiliary converters.
AuxConverterConsumedReactive	Energy reactive consumption for auxiliary converters.
BreakResistorConsumedActive	Energy active consumption for brake resistors.

4.3.4.6 CommunicationConfig

The CommunicationConfig defines the communication configuration of the EMS. Figure 11 describes the structure of CommunicationConfig.

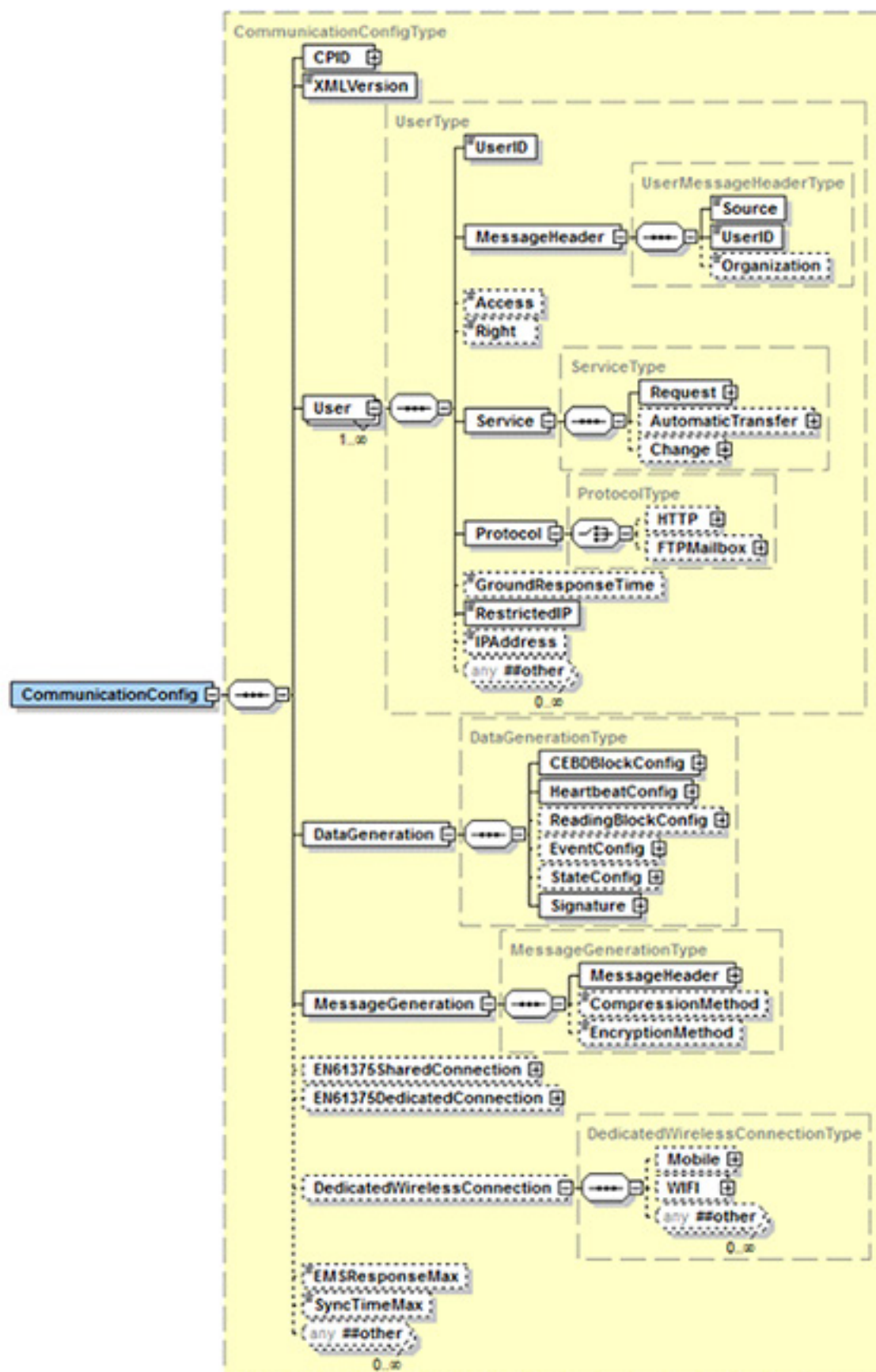


Figure 11 — CommunicationConfig structure