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Title: BS EN IEC 61375-2-5 Electronic railway equipment - Train communication network (TCN)

Part 2-5: Ethernet train backbone

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



9/3147/CD

COMMITTEE DRAFT (CD)

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SECRETARIAT: France		SECRETARY: Mr Denis MIGLIANICO
OF INTEREST TO THE FOLLOWING COMMITTEES: SC 65C		HORIZONTAL FUNCTION(S):
ASPECTS CONCERNED:		

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TITLE: Electronic railway equipment – Train communication network (TCN) – Part 2-5: Ethernet train backbone

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**ELECTRONIC RAILWAY EQUIPMENT –
TRAIN COMMUNICATION NETWORK (TCN) –****Part 2-5: Ethernet train backbone****FOREWORD**

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The text of this standard is based on the following documents:

FDIS	Report on voting
9/1933/FDIS	9/1961/RVD

Full information on the voting for the approval of this standard 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.

A list of all parts in the IEC 61375 series, published under the general title *Electronic railway equipment – Train communication network (TCN)*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

IEC 61375-2-5 defines the Ethernet Train Backbone so as to achieve interoperability between Consists of different types when coupled in the same train composition.

The standard follows the ISO-OSI model and specifies the whole protocols stack from the physical layer up to the application layer.

A Protocol Implementation Conformance Statement (PICS) pro-forma allows suppliers to state their conformity to this standard. The PICS pro-forma specification and the related conformity test are not in the scope of this standard.

The creation of this second edition of the standard has been motivated by advances in technology and additional use cases, namely:

- Improved Quality of Service in Ethernet communication by Strict Priority Queuing (802.1Q)
- Support of Frame Replication and Elimination for Reliability (802.1CB)
- Extensions for multiple network domains
- Support 1000BASE-T (GbE) and 10BASE-T backbone (e.g. as required for freight trains)
- Support for extended train composition (e.g., as required for freight trains)
- Extensions needed for reaching a higher safety level in Train inauguration (BEACON proxy function)
- Extension of ETB Management and monitoring by using NetConf.
- Extensions needed to support Cybersecurity

Furthermore, enhancements in the standard text are made to improve readability and to lower the risk of misinterpretations by improving clarity.

On the other hand, the IEC 61375-1:202x defines two potential configurations of transmission medium redundancy:

- Aggregated architecture, which was defined in an earlier version of the standard.
- Segregated architecture, which is a new architecture defined as an option.

Aggregated and segregated architectures are incompatible and cannot be connected to the same train backbone. As a result, it is necessary to adapt some clauses of this document to identify appropriately the differences and incompatibilities between them. For that, the following criteria will be used throughout the document:

- If a clause only applies to one architecture, it will be clearly indicated.
- If a clause does not reference either architecture, it applies to both.

Additionally, including certain options and features outlined in this standard may raise conditions that, in specific instances, lead to interoperability issues. This implies that two Consists with identical architecture types, but different options may lack interoperability when coupled within the same train composition. Annex F provides additional insights into these conditions.

ELECTRONIC RAILWAY EQUIPMENT – TRAIN COMMUNICATION NETWORK (TCN) –

Part 2-5: Ethernet train backbone

1 Scope

This part of IEC 61375 defines Ethernet Train Backbone (ETB) requirements to fulfil open train data communication system based on Ethernet technology.

Respect of this standard ensures interoperability between local Consist subnets whatever Consist network technology (see IEC 61375-1 for more details).

All Consist network definitions should take into account this standard to preserve interoperability.

This standard may be additionally applicable to closed trains and multiple-unit trains when so agreed between purchaser and supplier.

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.

IEC 61076-2-101:2012, *Connectors for electronic equipment – Product requirements – Part 2-101: Circular connectors – Detail specification for M12 connectors with screw-locking*

IEC 61156-1:2007, *Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification*

IEC 61156-5, *Multicore and symmetrical pair/quad cables for digital communications – Part 5: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Horizontal floor wiring – Sectional specification*

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

IEEE 802.1AB, *IEEE Standard for Local and metropolitan area networks – Station and Media Access Control Connectivity Discovery*

IEEE 802.1AX:2008, *IEEE Standard for Local and metropolitan area networks – Link Aggregation*

IEEE 802.1D:2012, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges*

IEEE 802.1Q, *IEEE Standard for Local and metropolitan area networks – Virtual Bridged Local Area Networks*

IEEE 802.3:2012, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

3 Terms, definitions, symbols, abbreviations and conventions

3.1 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org>

3.1.1

application layer

upper layer in the OSI model, interfacing directly to the application

3.1.2

application process

element within a real open system which performs the information processing for a particular application

[SOURCE: IEC 60050-811:2017, 811-37-05]

3.1.3

bridge <in a train communication network>

device which stores and forwards frames from one bus to another on the base of their Link Layer addresses

[SOURCE: IEC 60050-811:2017, 811-37-09]

3.1.4

broadcast

nearly simultaneous transmission of the same information to several destinations

Note 1 to entry: broadcast in the TCN is not considered reliable, i.e. some destinations can receive the information and others not.

[SOURCE: IEC 60050-811:2017, 811-37-10]

3.1.5

Bus <in a train communication network>

communication medium which broadcasts the same information to all attached participants at nearly the same time, allowing all devices to obtain the same sight of its state, at least for the purpose of arbitration

[SOURCE: IEC 60050-871:2018, 871-05-02]

3.1.6

closed train

train composed of one or a set of Consists, where the train composition does not change during normal operation

EXAMPLE Metro, sub-urban train, or high-speed train unit.

Note 1 to entry: Consists are coupled in a workshop to establish a closed train for operation.

[SOURCE: IEC 60050-811:2017, 811-37-17]

3.1.7

communication device

devices connected to the consist Network or Train Backbone with the ability to source and sink data

3.1.8

composition

number and characteristics of the vehicles forming a train

[SOURCE: IEC 60050-811:2017, 811-37-18]

3.1.9

configuration

definition of the topology of a network, the devices connected to it, their capabilities and the traffic they produce; by extension, the operation of loading the devices with the configuration information before going to regular operation

3.1.10

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

[SOURCE: IEC 60050-811:2017, 811-37-20]

3.1.11

Consist Network

CN

communication network interconnecting communication devices in one Consist

Note 1 to entry: Consist networks do not spread beyond consist boundaries.

“[SOURCE: IEC 60050-811:2017, 811-37-21, modified – The definition has been replaced with “communication network interconnecting communication devices in one consist”]

3.1.12

cybersecurity <in railway application>

set of activities and measures taken with the objective to prevent, detect, react to unauthorized access or cyberattack which could lead to an accident, an unsafe situation, or railway application performance degradation

[SOURCE: EN TS 50701:2017]

3.1.13

Domain

Network subnet associated to a well-defined set of functionalities, such as TCMS, OMTS.

3.1.14

End Device

ED

unit connected to one Consist Network or to one set of Consist Networks prepared for redundancy reasons

[SOURCE: IEC 60050-811:2017, 811-37-33]

3.1.15

end node

node which terminates the Train Backbone

[SOURCE: IEC 60050-811:2017, 811-37-34]

3.1.16
function <in a train communication network>
application process which exchanges messages with another Application Process

3.1.17
Gateway <in a train communication network>
connection between different communication technologies busses at the application layer requiring application-dependent data analysis and protocol conversion

[SOURCE: IEC 60050-811:2017, 811-37-44]

3.1.18
group address
address of a multicast group to which a device belongs

[SOURCE: IEC 60050-811:2017, 811-37-45]

3.1.19
host
any addressable unit connected to the network: End Devices, Network Devices, etc.

3.1.20
integrity, <in a train communication network>
property of a system to recognize and to reject wrong data in case of malfunction of its parts

3.1.21
intermediate node
node which establishes continuity between two bus sections connected to it, but does not terminate them

[SOURCE: IEC 60050-811:2017, 811-37-49]

3.1.22
linear topology
topology where the nodes are connected in series, with two nodes each connected to only one other node and all others each connected to two other nodes (i.e. , connected in the shape of a line)

[SOURCE: IEC 60050-811:2017, 811-37-51]

3.1.23
Local Area Network, <in a train communication network>
part of a network characterized by a common medium access and address space

[SOURCE: IEC 60050-811:2017, 811-37-60]

3.1.24
Medium Access Control, <in a train communication network>
sublayer of the Link Layer, which controls the access to the medium (arbitration, mastership transfer, polling)

3.1.25**medium, <in a train communication network>**

physical carrier of the signal: electrical wires, optical fibers, etc.

3.1.26**message, <in a train communication network>**

information which is transmitted in one or several packets from a sender to one or more receivers[SOURCE: IEC 60050-821:2017, 821-37-29]

3.1.27**multicast**

transmission of the same message to a group of receivers, identified by their Group Address

Note 1 to entry: The word "multicast" is used even if the group includes all receivers.

[SOURCE: IEC 60050-811:2017, 811-37-66]

3.1.28**multimedia data**

data used for onboard multimedia and telematic services (OMTS), like video/audio streams or file transfer

3.1.29**multiple unit train**

train comprising one or more consist-units which can be controlled simultaneously from one cab and able to operate at normal speed in either direction without re-marshalling

[SOURCE: IEC 60050-811:2017, 811-02-12]

3.1.30**network, <in a train communication network>**

set of possibly different communication systems which interchange information in a commonly agreed way

[SOURCE: IEC 60050-811:2017, 811-37-68]

3.1.31**network address**

address which identifies a communication device on network layer

[SOURCE: IEC 60050-811:2017, 811-37-69]

3.1.32**network device****ND**

components used to set up Consist Networks and Train Networks

Note 1 to entry: these can be passive components such as cables or connectors, active unmanaged components such as repeaters, media converters or (unmanaged) switches, or active managed components such as gateways, routers and (managed) switches.

3.1.33 [SOURCE: IEC 60050-811:2017, 811-37-70]**network layer**

layer in the OSI model responsible for routing between different busses

[SOURCE: IEC 60050-811:2017, 811-37-72]

3.1.34
network management, <in a train communication network>
operations necessary to remotely configure, monitor, diagnose and maintain the network

[SOURCE: IEC 60050-811:2017, 811-37-73]

3.1.35
node, <in a train communication network>
device on the Train Backbone that acts as a gateway between Train Backbone and Consist Network

[SOURCE: IEC 60050-811:2017, 811-37-74]

3.1.36
octet
byte
ordered set of eight binary digits, operated on as an entity

[SOURCE: IEC 60050-171:2019, 171-02-12]

3.1.37
open train
train composed of one or a set of consists, where the configuration can change during operation

EXAMPLE Locomotive-hauled international UIC (International Union of Railways, the international railways operators association) trains

3.1.38 [SOURCE: IEC 60050-811:2017, 811-37-79]
operator
enterprise or organization which operates trains

3.1.39
packet, <in a train communication network>
unit of a message (information, acknowledgement or control) transmitted by protocols on network or transport layer

3.1.40
receiver, <in a train communication network>
electronic device which can receive signals from the physical medium

3.1.41
repeater
connection at the Physical Layer between bus segments, providing an extension of the bus beyond the limits permitted by passive means

Note 1 to entry: The connected segments operate at the same speed and with the same protocol. The delay introduced by a repeater is in the order of one bit duration.

[SOURCE: IEC 60050-811:2017, 811-37-90]

3.1.42
ring topology
active network where each node is connected in series to two other nodes

Note 1 to entry Ring can also be referred to as loop.

[SOURCE: IEC 60050-811:2017, 811-37-91]

3.1.43**router, <in a train communication network>**

connection between two busses at the Network Layer, which forwards datagrams from one bus to another on the base of their Network Address

3.1.44**service, <in a train communication network>**

capabilities and features of a sub-system (e.g. a communication layer) provided to a user

[SOURCE: IEC 60050-811:2017, 811-37-93]

3.1.45**switch, <in a train communication network>**

MAC bridge as defined in IEEE 802.1D

Note 1 to entry: MAC means "Medium Access Control", a sub-layer within the Link Layer ruling which device is entitled to send on the bus.

[SOURCE: IEC 60050-811:2017, 811-37-101]

3.1.46**topology**

possible cable interconnection and number of devices a given network supports

[SOURCE: IEC 60050-811:2017, 811-37-106]

3.1.47**topology counter**

counter in a node which at each Train inauguration memorises CRC of Train Network Directory

3.1.48**train**

combination of rolling stock coupled together

Note 1 to entry: Rolling stock includes banking locomotives.

[SOURCE: IEC 60050-811:2011, 811-01-08]

3.1.49**train communication network**

data communication network for connecting programmable electronic equipment on-board rail vehicles

[SOURCE: IEC 60050-811:2017, 811-37-108]

3.1.50**train backbone, <in a train communication network>****train bus**

bus connecting the consists of a train, in particular the wire train bus, and which conforms to the TCN

[SOURCE: IEC 60050-811:2017, 811-37-107]

3.1.51**train backbone node, <in a train communication network>
node**

device on the Train Backbone that acts as a gateway between the train backbone and the consist network

[SOURCE: IEC 60050-811:2017, 811-37-74]

3.1.52

train backbone node number

node address

node number

unique number assigned to a node during train inauguration indicating the position of the train backbone node on the train backbone

Note 1 to entry: this number can be used as part of the train network address for addressing devices in the consist, the train backbone node belongs to, from any location in the train.

3.1.53

train composition

sequence, orientation and characteristics of consists which represent a train

3.1.54

train inauguration

operation executed in case of train composition change, which gives all nodes of the train backbone their train backbone node number, their orientation and information about all named nodes on the same backbone, and which determines the actual train composition

3.1.55

train network address

dynamic network address, which is used to address communication devices in other consist networks

Note 1 to entry: this address can change after each train inauguration.

[SOURCE: IEC 60050-811:2017, 811-37-109]

3.1.56

train network directory

data structure which describes the sequence of train backbone nodes, the sequence of consist networks and the orientation of the consists, in which the nodes are located in.

3.2

3.2.1

transport layer

layer of the OSI model responsible for end-to-end flow control and error recovery

[SOURCE: IEC 60050-811:2017, 811-37-113]

3.3 Symbols and abbreviations

CAN	Controller Area Network
CCTV	Closed Circuit Television
CIDR	Classless Inter Domain Routing
CN	Consist Network
CRC	Cyclic Redundancy Check
CSTINFO	ConSisT INfOrMation
CstUUID	Consist Universally Unique IDentifier
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System

383	ECN	Ethernet Consist Network
384	ED	End Device
385	EMC	Electro Magnetic Compatibility
386	ETB	Ethernet Train Backbone
387	ETBN	Ethernet Train Backbone Node
388	FLR	Frame Loss Rate
389	FQDN	Fully Qualified Domain Name
390	GbE	Gigabit Ethernet
391	IEEE	Institute of Electrical and Electronics Engineers
392	IETF	Internet Engineering Task Force
393	IH	Inner-Consist HELLO
394	IP	Internet Protocol
395	LACP	Link Aggregation Control Protocol
396	LAG	Link Aggregation Group
397	LLDP	Link Layer Discovery Protocol
398	LLDPDU	LLDP Data Unit
399	MAC	Medium Access Control
400	MCG	Mobile Communication Gateway
401	MDI	Media Dependent Interface
402	MTU	Maximum Transmission Unit
403	MVB	Multifunction Vehicle Bus
404	NAT	Network Address Translation
405	ND	Network Device
406	NTP	Network Time Protocol
407	OSI	Open System Interconnection
408	PCS	Physical Coding Sublayer
409	PD	Powered Device (about PoE)
410	PD/MD	Process Data/Message Data
411	PICS	Protocol Implementation Conformance Statement
412	PMA	Physical Medium Attachment
413	PMD	Physical Medium Dependent
414	PoE	Power Over Ethernet
415	PSE	Power Source Equipment (about PoE)
416	RFC	Request For Comments
417	TBN	Train Backbone Node
418	TCMS	Train Control and Management System
419	TCN	Train Communication Network
420	TCP	Transport Control Protocol
421	TLV	Type/Length/Value
422	TNDir	Train Network Directory
423	TSN	Time Sensitive Network
424	TTDP	Train Topology Discovery Protocol
425	UDP	User Data protocol

UML	Unified Modeling Language
VLAN	Virtual Local Area Network
WTB	Wire Train Bus
XML	eXtensible Markup Language

3.4 Conventions

3.4.1 Base of numeric values

This standard uses a decimal representation for all numeric values unless otherwise noted.

Analog and fractional values include a comma.

EXAMPLE The voltage is 20,0 V.

Binary and hexadecimal values are represented using the ASN.1 (ISO/IEC 8824) convention.

EXAMPLE Decimal 20 coded on 8 bits = '0001 0100'B = '14'H.

3.4.2 Naming conventions

Keywords are written with a capital letter at the beginning.

If the keyword name is composed, the different parts of the name are united with a space, and all parts begin with a capital letter.

EXAMPLES "Train Backbone", "Consist", "Consist Network".

Parameters are written with a capital letter at the beginning.

If the parameter name is composed, the different parts of the name are united without a space, and all parts begin with a capital letter.

EXAMPLE "NumberOfConsists".

3.4.3 State diagram conventions

State diagrams are defined following the notation of UML state machines.

3.4.4 Annotation of data structures

Data structures are defined following ISO ASN.1 syntax. A superset of ASN.1 defined in IEC 61375-2-1:2012, 6.4 "Presentation and encoding of transmitted and stored data" is also used.

4 ETB physical layer

4.1 Train regions

ETB use physical lines along the train to connect the active network devices together (ETBN, Repeater, etc.). These lines are also called physical segments, and shall use passive components such as cables and connectors, dedicated to Ethernet.

Along the train, three regions shall be distinguished for the ETB network (see Figure 1 below):

- **Intra Vehicle:** Passive components (cabling) and active network devices inside a vehicle (or locomotive, etc.).

- **Inter Vehicle** : Passive components (cabling) at the interface between 2 vehicles. This category refers also to optional active network devices outside the vehicle (such as under body, etc.).
- **Inter Consist**: Passive components (cabling) at the interface between 2 Consists using a manual coupler, or auto coupler. This category refers also to optional active network devices outside the vehicle.

These regions are characterized by different train contexts and environments (mechanical, thermal, EMC, etc.). As a consequence, cabling (cables and connectors) are different on these 3 regions.

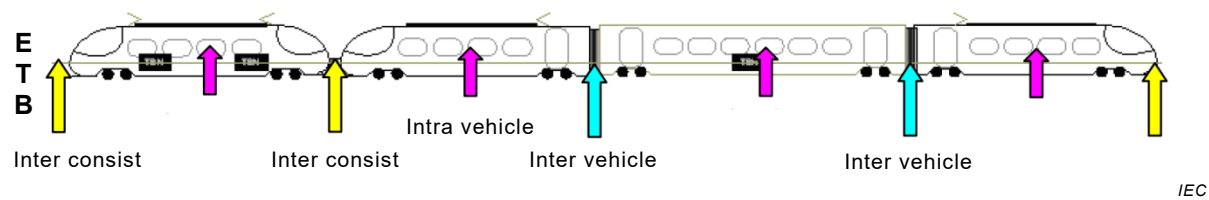


Figure 1 – ETB train regions

4.2 Physical characteristics

4.2.1 General

The following tables summarize network physical layer requirements for passive components (cables and connectors) and active network devices (ETBN, Repeater, etc.) depending on the 3 regions defined. For each region, three mutually exclusive options of physical network layers are defined.

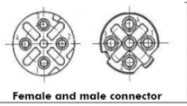
4.2.2 Intra vehicle physical layer

Table 1, Table 2 and Table 3 below define each alternative option of the physical layer requirements that shall be considered as a whole.

(M: Mandatory, O: Optional, C: Conditional, X: Prohibited)

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Table 1 – ETB Intra vehicle 100 BASE TX physical layer interface

ETB Intra vehicle physical layer interface																							
OSI Layers	Requirements	Type	Description																				
Application Presentation Session Transport Network Data Physical	100 BASE TX Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3:2012, Clauses 24 and 25																				
	Full Duplex Mode	M	Conformance to IEEE 802.3:2012, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet																				
	Physical Layer auto-Negotiation	X	Conformance to IEEE 802.3:2012, Clause 28 Prohibited on the ETB backbone.																				
	Physical Layer crossover	M	Conformance to IEEE 802.3:2012, 25.4.8 Just one crossover shall be made on a line between 2 ports (ETBN, etc.)																				
	Physical layer auto-polarity/auto-sensing	X	Prohibited due to fixed cabling, and non-normalized solution																				
	By-pass relay on ETBN ports	M/X	Mandatory for aggregated architecture; segregated architecture not supported																				
	Power over Ethernet (PoE)	O	Conformance to IEEE 802.3:2012, Clause 33 Called also: Data terminal equipment (DTE) Power via Medium Dependent Interface (MDI) PSE or PD mode supported See 4.3 for more details																				
	Connector for active Network Devices M12 D coded	M	Crimped contacts recommended Female connector on active network device, male connector on train cable Conformance to 61076-2-101, which defines the pin out: <table border="1"> <thead> <tr> <th>Signal</th><th>Function</th><th>Cable wire colour</th><th>M12 D-coding contact number</th></tr> </thead> <tbody> <tr> <td>TD+</td><td>Transmission Data +</td><td>Yellow</td><td>1</td></tr> <tr> <td>TD-</td><td>Transmission Data -</td><td>Orange</td><td>3</td></tr> <tr> <td>RD+</td><td>Receiver Data +</td><td>White</td><td>2</td></tr> <tr> <td>RD-</td><td>Receiver Data -</td><td>Blue</td><td>4</td></tr> </tbody> </table>  NOTE: It is possible to use push-pull connectors (IEC 61076-2-010), keeping the above pinout.	Signal	Function	Cable wire colour	M12 D-coding contact number	TD+	Transmission Data +	Yellow	1	TD-	Transmission Data -	Orange	3	RD+	Receiver Data +	White	2	RD-	Receiver Data -	Blue	4
Signal	Function	Cable wire colour	M12 D-coding contact number																				
TD+	Transmission Data +	Yellow	1																				
TD-	Transmission Data -	Orange	3																				
RD+	Receiver Data +	White	2																				
RD-	Receiver Data -	Blue	4																				
	Connector for interior cabling (between walls, cabinets, container, etc.)	O	Ethernet circular cell arranged in a quartet distribution. Pin out distribution identical to M12: TD+: Contact 1, TD-: Contact 3 RD+: Contact 2, RD-: Contact 4																				

ETB Intra vehicle physical layer interface			
OSI Layers	Requirements	Type	Description
	Cables CAT5e	M	Conformance to ISO/IEC 11801 and IEC 61156-5 Two pairs shielded or unshielded: See screening practices ISO/IEC 11801:2002, Clause 11. The conductor shall be an annealed copper stranded conductor, in accordance with 5.2.1 of IEC 61156-1:2007 and should have a nominal diameter between 0,5 mm and 0,65 mm. A conductor diameter of up to 0,8 mm may be used if compatible to connecting hardware
	Segment performance	M	Segment (D-class) include cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR) shall be below a trigger value. To be defined depending on application. – Ethernet Certification compliant to ISO/IEC 11801 (conformance test category) • Cables shall be compliant with Clause 9 of ISO/IEC 11801:2002 • Connectors shall be compliant with Clause 10 of ISO/IEC 11801:2002 • ;The Telecommunication outlet (TO) is the M12 instead of the RJ45 • Channel shall be compliant with Clause 6 of ISO/IEC 11801:2002. Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.

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Table 2 – ETB Intra vehicle 1000BASE-T physical layer interface

ETB Intra vehicle physical layer interface																																												
OSI Layers	Requirements	Type	Description																																									
<table><tr><td>Application</td></tr><tr><td>Presentation</td></tr><tr><td>Session</td></tr><tr><td>Transport</td></tr><tr><td>Network</td></tr><tr><td>Data</td></tr><tr><td>Physical</td></tr></table>	Application	Presentation	Session	Transport	Network	Data	Physical	1000 BASE TX Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3:2012, Clauses 40																																		
	Application																																											
	Presentation																																											
	Session																																											
	Transport																																											
	Network																																											
	Data																																											
Physical																																												
Full Duplex Mode	M	Conformance to IEEE 802.3:2012, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet																																										
Physical Layer auto-Negotiation	M	Conformance to IEEE 802.3:2012, Clause 28																																										
Physical Layer crossover	M	Conformance to IEEE 802.3:2012,25.4.8 Just one crossover shall be made on a line between 2 ports (ETBN,etc.)																																										
Physical layer auto-polarity/auto-sensing	M	Conformance to IEEE 802.3:2012, Clauses 40																																										
By-pass relay on ETBN ports	M/X	Mandatory for aggregated architecture; Segregated architecture not supported NOTE recovery time of 1000BASE-T (>2 seconds) is probably unrealistic for some ETB error scenarios, in particular when bypass relays of intermediate ETBNs are activated/deactivated.																																										
Power over Ethernet (PoE)	O	Conformance to IEEE 802.3:2012, Clause 33 Called also: Data terminal equipment (DTE) Power via Medium Dependent Interface (MDI) PSE or PD mode supported See 4.3 for more details																																										
	Connector for active Network Devices M12 X coded	M	Crimped contacts recommended Female connector on active network device, male connector on train cable Conformance to IEC 61076-2-109, which defines the pin out: <table><tr><th>Pair</th><th>Contact</th><th>Colour</th><th></th><th></th></tr><tr><td rowspan="2">2</td><td>1</td><td>white-orange</td><td>1</td><td>DA+</td></tr><tr><td>2</td><td>orange</td><td>2</td><td>DA-</td></tr><tr><td rowspan="2">3</td><td>3</td><td>white-green</td><td>3</td><td>DB+</td></tr><tr><td>4</td><td>green</td><td>4</td><td>DB-</td></tr><tr><td rowspan="2">4</td><td>5</td><td>white-brown</td><td>5</td><td>DD+</td></tr><tr><td>6</td><td>brown</td><td>6</td><td>DD-</td></tr><tr><td rowspan="2">1</td><td>7</td><td>white-blue</td><td>7</td><td>DC-</td></tr><tr><td>8</td><td>blue</td><td>8</td><td>DC+</td></tr></table>  NOTE: It is possible to use push-pull connectors (IEC 61076-2-010), keeping the above pinout.	Pair	Contact	Colour			2	1	white-orange	1	DA+	2	orange	2	DA-	3	3	white-green	3	DB+	4	green	4	DB-	4	5	white-brown	5	DD+	6	brown	6	DD-	1	7	white-blue	7	DC-	8	blue	8	DC+
Pair	Contact	Colour																																										
2	1	white-orange	1	DA+																																								
	2	orange	2	DA-																																								
3	3	white-green	3	DB+																																								
	4	green	4	DB-																																								
4	5	white-brown	5	DD+																																								
	6	brown	6	DD-																																								
1	7	white-blue	7	DC-																																								
	8	blue	8	DC+																																								

ETB Intra vehicle physical layer interface			
OSI Layers	Requirements	Type	Description
	Connector for interior cabling (between walls, cabinets, container, etc.)	O	Ethernet circular cell arranged in a quartet distribution. Pin out distribution identical to M12: TDa+: Contact 1, TDa-: Contact 2 RDb+: Contact 3, RDb-: Contact 4 TDc+: Contact 8, TDc-: Contact 7 RDd+: Contact 5, RDd-: Contact 6
	Cables CAT5e or higher	M	Conformance to ISO/IEC 11801 and IEC 61156-5 Four pairs shielded or unshielded: See screening practices ISO/IEC 11801:2002, Clause 11. The conductor shall be an annealed copper stranded conductor, in accordance with 5.2.1 of IEC 61156-1:2007 and should have a nominal diameter between 0,14 mm and 0,25 mm.
	Segment performance	M	Segment (D-class) include cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR) shall be below a trigger value. To be defined depending on application. – Ethernet Certification compliant to ISO/IEC 11801 (conformance test category) • Cables shall be compliant with Clause 9 of ISO/IEC 11801:2002 • Connectors shall be compliant with Clause 10 of ISO/IEC 11801:2002 • ;The Telecommunication outlet (TO) is the M12 instead of the RJ45 • Channel shall be compliant with Clause 6 of ISO/IEC 11801:2002. Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.

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Table 3 – ETB Intra vehicle 10 MBit (10BASE-T1L) physical layer interface

ETB Intra vehicle physical layer interface			
OSI Layers	Requirements	Type	Description
Application	10BASE-T1L Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3:20XX, Clause 146. If not otherwise defined, 2.4 Vpp operating mode shall be configured by default
Presentation			
Session			
Transport			
Network			
Data			
Physical	Full Duplex Mode	M	Conformance to IEEE 802.3:2012, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet
	Physical Layer auto-Negotiation	X	Conformance to IEEE 802.3:2012, Clause 28 Prohibited on the ETB backbone.
	Physical Layer crossover	-	Not applicable
	Physical layer auto-polarity/auto-sensing	X	Prohibited due to fixed cabling, and non-normalized solution
	By-pass relay on ETBN ports	M/X	Mandatory for aggregated architecture; Segregated architecture not supported
	Power over Dataline (PoDL)	O	Conformance to IEEE 802.3:20XX, Clause 104 PSE or PD mode supported
	Connector for active Network d	M	Crimped contacts recommended Female connector on active network device, male connector on train cable Conformance to IEC63171-6:20XX
	Connector for interior cabling (between walls, cabinets, container, etc.)	O	Ethernet2-pole plug connector. Pin out distribution : DA+: Contact 1, DA-: Contact 2
	Cables	M	Conformance to IEC 61156-13
	Segment performance	M	Segment (D-class) include cables, connectors, and port devices EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR) shall be below a trigger value. Depending on application. Ethernet Certification compliant to ISO/IEC 11801-1 Amendment 1. Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.

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It has to be noted that the number of connectors on an Ethernet physical segment and the length of the cable are not indicated in the table. Instead, a minimum requirement of electric performance and compliance to ISO/IEC 11801 is defined. It means that the electric parameters of a cabling depend not only on the number of connectors and the cable length, but also on some more complex parameters like shield, type of connectors, quality of cabling, installation, etc. As a consequence, it is proposed a global concept of verification in being compliant to the electric Ethernet parameters ISO/IEC 11801.

Inside a vehicle, all shields of cables and connectors shall be connected to the mechanical earth of the vehicle. To prevent EMC influences, a cable shield shall be connected on a 360° circular basis in the connector.

4.2.3 Inter vehicle physical layer

4.2.3.1 General

Table 4, Table 5, and Table 6 below define each alternative option of the physical layer requirements that shall be considered as a whole.

(M: Mandatory, O: Optional, C: Conditional, X: Prohibited)

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Table 4 – ETB Inter vehicle 100 BASE TX physical layer interface

ETB Inter vehicle physical layer interface			
OSI Layers	Requirements	Type	Description
Application Presentation Session Transport Network Data Physical	100 BASE TX Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3:2012, Clauses 24 and 25
	Full Duplex Mode	M	Conformance to IEEE 802.3:2012, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet
	Physical Layer auto-Negotiation	X	Conformance to IEEE 802.3:2012, Clause 28. Prohibited on the ETB backbone
	Physical Layer crossover	M	Conformance to IEEE 802.3:2012, 25.4.8 Just one crossover shall be made on a line between 2 ports (ETBN,etc.)
	Physical layer auto-polarity/auto-sensing	X	Prohibited due to fixed cabling, and non-normalized solution
	Power over Ethernet (PoE)	O	IEEE 802.3:2012, Clause 33 Called also: Data terminal equipment (DTE) Power via Medium Dependent Interface (MDI) PSE or PD mode supported. See 4.3 for more details.
	Connector for inter vehicle	O	Specific connector different from M12 connector. Ethernet circular cell arranged in a quartet. Pin out distribution identical to M12: TD+: Contact 1, TD-: Contact 3 RD+: Contact 2, RD-: Contact 4
	Cables CAT5e	M	Conformance to ISO/IEC 11801, IEC 61156 Shielded or unshielded: See screening practices ISO/IEC 11801:2002, Clause 11. The conductor shall be an annealed copper stranded conductor, in accordance with 5.2.1 of IEC 61156-1:2007 and should have a nominal diameter between 0,5 mm and 0,65 mm. A conductor diameter of up to 0,8 mm may be used if compatible to connecting hardware.

ETB Inter vehicle physical layer interface			
OSI Layers	Requirements	Type	Description
	Segment performance	M	Segment (D-class) includes cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR) shall be below a trigger value. To be defined depending on application. – Ethernet Certification compliant to ISO/IEC 11801 (conformance test category) • Cables shall be compliant with Clause 9 of ISO/IEC 11801:2002 • Connectors shall be compliant with Clause 10 of ISO/IEC 11801:2002; The Telecommunication outlet (TO) is the inter-vehicle connector instead of the RJ45 • Channel shall be compliant with Clause 6 of ISO/IEC 11801:2002 Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.

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Table 5 – ETB Inter vehicle 1000BASE-T physical layer interface

ETB Inter vehicle physical layer interface			
OSI Layers	Requirements	Type	Description
Application	1000 BASE TX Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3:2012, Clauses 40
Presentation			
Session			
Transport			
Network			
Data			
Physical	Full Duplex Mode	M	Conformance to IEEE 802.3:2012, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet
	Physical Layer auto-Negotiation	M	Conformance to IEEE 802.3:2012, Clause 28
	Physical Layer crossover	M	Conformance to IEEE 802.3:2012, 25.4.8 Just one crossover shall be made on a line between 2 ports (ETBN, etc.)
	Physical layer auto-polarity/auto-sensing	M	Conformance to IEEE 802.3:2012, Clauses 40
	Power over Ethernet (PoE)	O	Conformance to IEEE 802.3:2012, Clause 33 Called also: Data terminal equipment (DTE) Power via Medium Dependent Interface (MDI) PSE or PD mode supported See 4.3 for more details
	Connector for inter vehicle	O	Ethernet circular cell arranged in a quartet distribution. Pin out distribution identical to M12: TDa+: Contact 1, TDa-: Contact 2 RDb+: Contact 3, RDb-: Contact 4 TDc+: Contact 8, TDc-: Contact 7 RDd+: Contact 5, RDd-: Contact 6
	Cables CAT5e or higher	M	Conformance to ISO/IEC 11801 and IEC 61156-5 Four pairs shielded or unshielded: See screening practices ISO/IEC 11801:2002, Clause 11. The conductor shall be an annealed copper stranded conductor, in accordance with 5.2.1 of IEC 61156-1:2007 and should have a nominal diameter between 0,14 mm and 0,25 mm.

ETB Inter vehicle physical layer interface			
OSI Layers	Requirements	Type	Description
	Segment performance	M	Segment (D-class) include cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR) shall be below a trigger value. To be defined depending on application. – Ethernet Certification compliant to ISO/IEC 11801 (conformance test category) • Cables shall be compliant with Clause 9 of ISO/IEC 11801:2002 • Connectors shall be compliant with Clause 10 of ISO/IEC 11801:2002 • ;The Telecommunication outlet (TO) is the M12 instead of the RJ45 • Channel shall be compliant with Clause 6 of ISO/IEC 11801:2002. Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.

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Table 6 – ETB Inter vehicle 10 MBit (10BASE-T1L) physical layer interface

ETB Inter vehicle physical layer interface			
OSI Layers	Requirements	Type	Description
Application Presentation Session Transport Network Data Physical	10BASE-T1L Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3:20XX, Clause 146. If not otherwise defined, 2.4 Vpp operating mode shall be configured by default
	Full Duplex Mode	M	Conformance to IEEE 802.3:2012, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet
	Physical Layer auto-Negotiation	X	Conformance to IEEE 802.3:2012, Clause 28 Prohibited on the ETB backbone.
	Physical Layer crossover	-	Not applicable
	Physical layer auto-polarity/auto-sensing	X	Prohibited due to fixed cabling, and non-normalized solution
	Power over Dataline (PoDL)	O	Conformance to IEEE 802.3:20XX, Clause 104 PSE or PD mode supported
	Connector for inter vehicle	O	Ethernet 2-pole plug connector.. Pin out distribution DA+: Contact 1, DA-: Contact 2 .
	Cables	M	Conformance to IEC 61156-13.
	Segment performance	M	Segment (D-class) include cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR) shall be below a trigger value. Depending on application. – Ethernet Certification compliant to ISO/IEC 11801-1 Amendment 1. Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.

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516 It has to be noted that the number of connectors on an Ethernet physical segment and the
517 length of the cable are not indicated in the table. Instead, a minimum requirement of electric
518 performance and compliance to ISO/IEC 11801 is defined. It means that the electric
519 parameters of a cabling depend not only on the number of connectors and the cable length,
520 but also on some more complex parameters like shield, type of connectors, quality of cabling,
521 installation, etc. As a consequence, it is proposed a global concept of verification in being
522 compliant to the electric Ethernet parameters ISO/IEC 11801.

523 Two use cases have to be considered:

524 – The two adjacent vehicles are at the same potential.

- The two adjacent vehicles are at a different potential.

4.2.3.2 Inter Vehicle at same potential

For information only:

A braid connects two adjacent vehicles which therefore are at the same potential. The Ethernet shield could have the continuity from vehicle N to vehicle N+1; in this case, no interruption of shielding is necessary (see Figure 2).

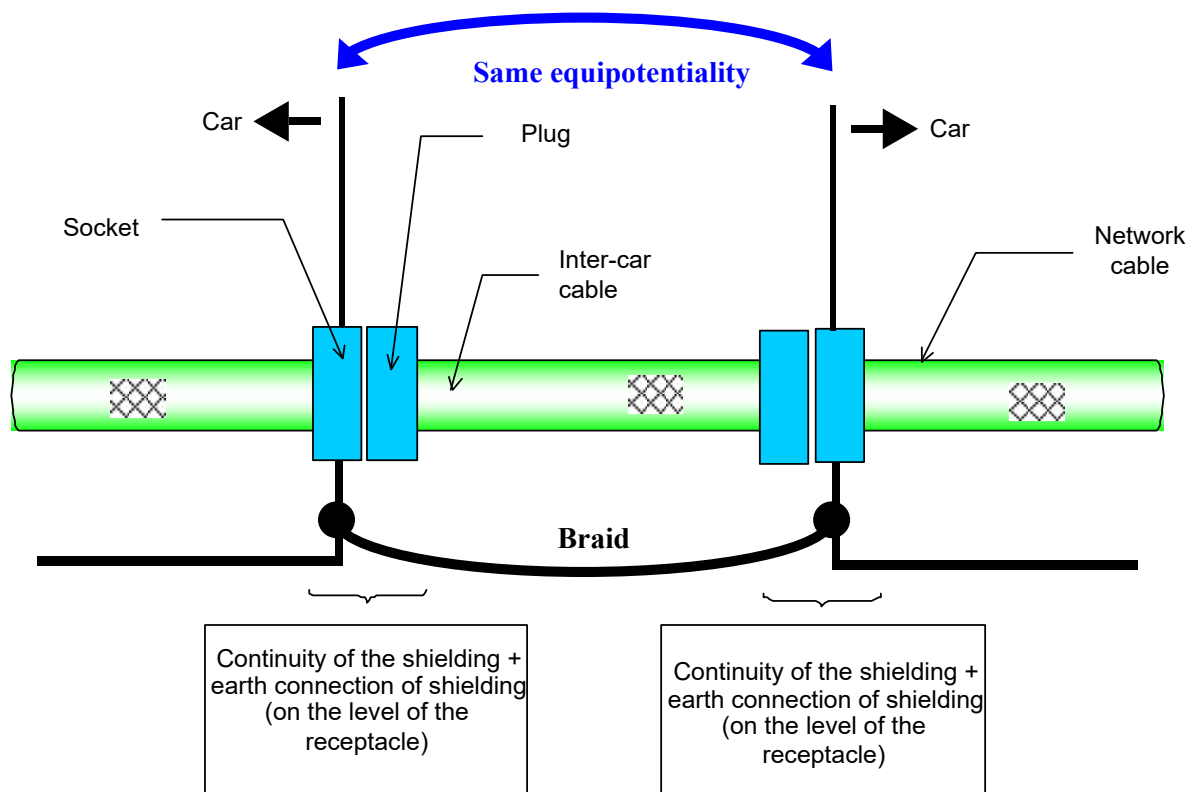


Figure 2 – ETB Inter vehicle at same potential

4.2.3.3 Inter Vehicle not at the same potential

For information only:

In some cases, the inter vehicle cannot be at the same potential: Refurbishment, etc. Therefore, the Ethernet cable shield could be interrupted to avoid ground current flowing between vehicles (see Figure 3).

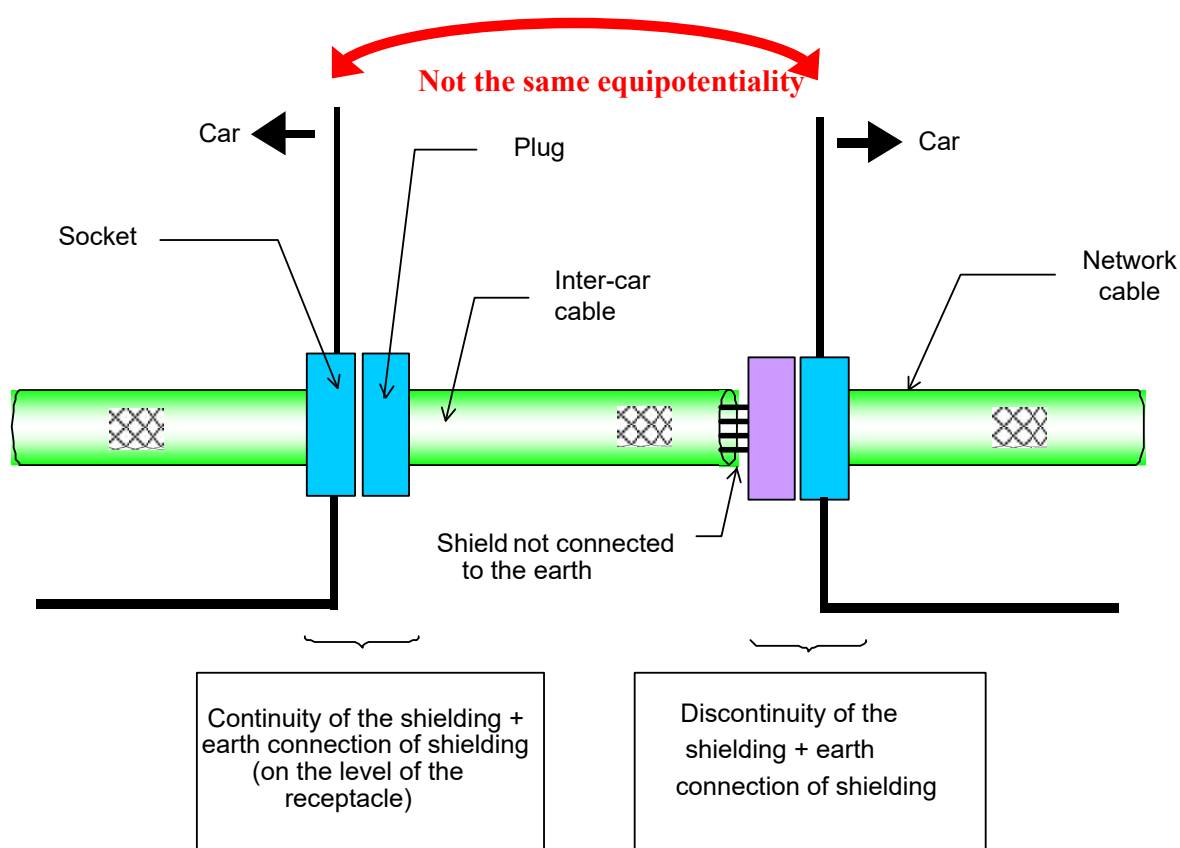


Figure 3 – ETB Inter vehicle not at the same potential

NOTE The implementation of the shielding solution is not in the scope of this standard.

4.2.4 Inter Consist physical layer

Table 7, Table 8, and Table 9 below define each alternative option of the physical layer requirements that shall be considered as a whole.

(M: Mandatory, O: Optional, C: Conditional, X: Prohibited)

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Table 7 – ETB Inter consist 100 BASE TX physical layer interface

ETB Inter consist physical layer interface			
OSI Layers	Requirements	Type	Description
Application Presentation Session Transport Network Data Physical	100 BASE TX Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3, Clauses 24 and 25
	Full Duplex Mode	M	Conformance to IEEE 802.3, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet
	Physical Layer auto-Negotiation	X	Conformance to IEEE 802.3, Clause 28. Prohibited on the ETB backbone
	Physical Layer crossover	M	Conformance to IEEE 802.3, 25.4.8 Just one crossover shall be made on a line between 2 ports (ETBN, etc.) Straight (MDI) on the male connector auto coupler side, crossover (MDI-X) on the female connector auto coupler side
	Physical layer auto-polarity/auto-sensing	X	Prohibited due to fixed cabling, and non-normalized solution
	Power over Ethernet (PoE)	O	IEEE 802.3, Clause 33 Called also: Data terminal equipment (DTE) Power via Medium Dependent Interface (MDI) PSE or PD mode supported. See 4.3 for more details.
	Connector for inter Consist	O	Specific connector different from M12 connector. Ethernet circular cell arranged in a quartet. Pin out distribution identical to M12: TD+: Contact 1, TD-: Contact 3 RD+: Contact 2, RD-: Contact 4
	Cables CAT5e	M	Conformance to ISO/IEC 11801, IEC 61156 Shielded or unshielded: See screening practices ISO/IEC 11801, Clause 11. The conductor shall be an annealed copper stranded conductor, in accordance with 5.2.1 of IEC 61156-1 and should have a nominal diameter between 0,5 mm and 0,65 mm. A conductor diameter of up to 0,8 mm may be used if compatible with connecting hardware

ETB Inter consist physical layer interface			
OSI Layers	Requirements	Type	Description
	Segment performance	M	Segment (D-class) includes cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR shall be below a trigger value. To be defined depending on application. – Ethernet Certification compliant to ISO/IEC 11801 (conformance test category) • Cables shall be compliant with Clause 9 • Connectors shall be compliant with Clause 10; The Telecommunication outlet (TO) is the inter-Consist connector instead of the RJ45 • Channel shall be compliant with Clause 6 Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.
	Consist orientation Reversing	C	Refers to the change of orientation of a Consist In order to provide Consists reversing capability, physical connection between two Consists requires two lines (see Figure 4 below).

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Table 8 – ETB Inter consist 1000BASE-T physical layer interface

ETB Inter consist physical layer interface			
OSI Layers	Requirements	Type	Description
Application Presentation Session Transport Network Data Physical	1000 BASE TX Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3:2012, Clause 40
	Full Duplex Mode	M	Conformance to IEEE 802.3:2012, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet
	Physical Layer auto-Negotiation	M	Conformance to IEEE 802.3:2012, Clause 28
	Physical Layer crossover	M	Conformance to IEEE 802.3:2012, 25.4.8 Just one crossover shall be made on a line between 2 ports (ETBN, etc.) Straight (MDI) on the male connector auto coupler side, crossover (MDI-X) on the female connector auto coupler side
	Physical layer auto-polarity/auto-sensing	M	Conformance to IEEE 802.3:2012, Clauses 40
	Power over Ethernet (PoE)	O	Conformance to IEEE 802.3:2012, Clause 33 Called also: Data terminal equipment (DTE) Power via Medium Dependent Interface (MDI) PSE or PD mode supported See 4.3 for more details
	Connector for inter Consist	O	Ethernet circular cell arranged in a quartet distribution. Pin out distribution identical to M12: TDa+: Contact 1, TDa-: Contact 2 RDb+: Contact 3, RDb-: Contact 4 TDc+: Contact 8, TDc-: Contact 7 RDd+: Contact 5, RDd-: Contact 6
	Cables CAT5e or higher	M	Conformance to ISO/IEC 11801 and IEC 61156-5 Four pairs shielded or unshielded: See screening practices ISO/IEC 11801:2002, Clause 11. The conductor shall be an annealed copper stranded conductor, in accordance with 5.2.1 of IEC 61156-1:2007 and should have a nominal diameter between 0,14 mm and 0,25 mm.

ETB Inter consist physical layer interface			
OSI Layers	Requirements	Type	Description
	Segment performance	M	Segment (D-class) include cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR) shall be below a trigger value. To be defined depending on application. – Ethernet Certification compliant to ISO/IEC 11801 (conformance test category) • Cables shall be compliant with Clause 9 of ISO/IEC 11801:2002 • Connectors shall be compliant with Clause 10 of ISO/IEC 11801:2002 • ;The Telecommunication outlet (TO) is the M12 instead of the RJ45 • Channel shall be compliant with Clause 6 of ISO/IEC 11801:2002. Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.
	Consist orientation Reversing	C	Refers to the change of orientation of a Consist In order to provide Consists reversing capability, physical connection between two Consists requires two lines (see Figure 4 below).

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Table 9 – ETB Inter consist 10 MBit (10BASE-T1L) physical layer interface

ETB Inter consist physical layer interface			
OSI Layers	Requirements	Type	Description
Application Presentation Session Transport Network Data Physical	10BASE-T1L Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3:20XX, Clause 146. If not otherwise defined, 2.4 Vpp operating mode shall be configured by default.
	Full Duplex Mode	M	Conformance to IEEE 802.3:2012, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet
	Physical Layer auto-Negotiation	X	Conformance to IEEE 802.3:2012, Clause 28 Prohibited on the ETB backbone.
	Physical Layer crossover	-	Not applicable
	Physical layer auto-polarity/auto-sensing	X	Prohibited due to fixed cabling, and non-normalized solution
	Power over Dataline (PoDL)	O	Conformance to IEEE 802.3:20XX, Clause 104 PSE or PD mode supported
	Connector for inter Consist	O	2x2 contact pins in automatic coupler.
	Cables	M	To be defined cable type.
	Segment performance	M	Segment (D-class) include cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR) shall be below a trigger value. Depending on application. – Ethernet Certification compliant to ISO/IEC 11801-1 Amendment 1. Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.
	Consist orientation Reversing	C	Refers to the change of orientation of a Consist In order to provide Consists reversing capability, physical connection between two Consists requires two lines (see Figure 4 below).

553

554 It has to be noted that the number of connectors on a physical Ethernet segment and the
555 length of the cable are not indicated in the table. Instead, a minimum requirement of electric
556 performance and compliance to ISO/IEC 11801 is defined. It means that the electric
557 parameters of a cabling depend not only on the number of connectors and the cable length,
558 but also on some more complex parameters like shield, type of connectors, quality of cabling,
559 installation, etc. As a consequence, it is proposed a global concept of verification in being
560 compliant to the electric Ethernet parameters ISO/IEC 11801.

Figure 4 below illustrates the Consist reversing connection constraint: connectors shall be placed on Consist extremities with a central symmetry. When using male/female connectors, they shall be placed in an alternate / inversed way and be an even number.

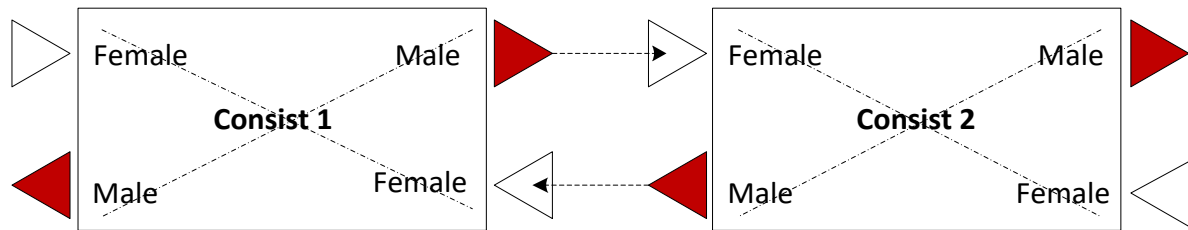


Figure 4 – ETB Consist reversing

For information only:

Typically, the same potential between 2 Consists cannot be ensured. In this case, the interruption of the Ethernet cable shield could be required (see Figure 5).

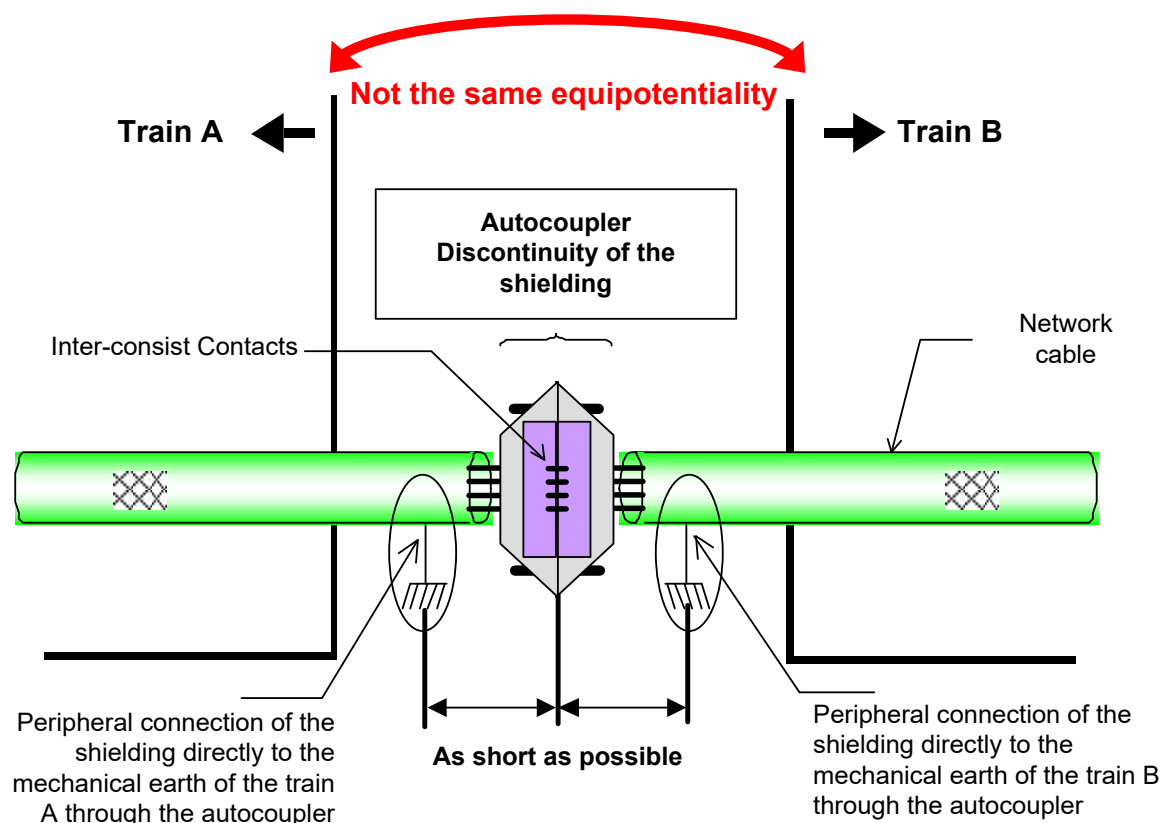


Figure 5 – ETB Inter Consist segment

NOTE The implementation of the shielding solution is not in the scope of this standard.

4.3 Power over Ethernet (PoE)

Figure 6 and Figure 7 give some use cases of PoE usage in ETBN:

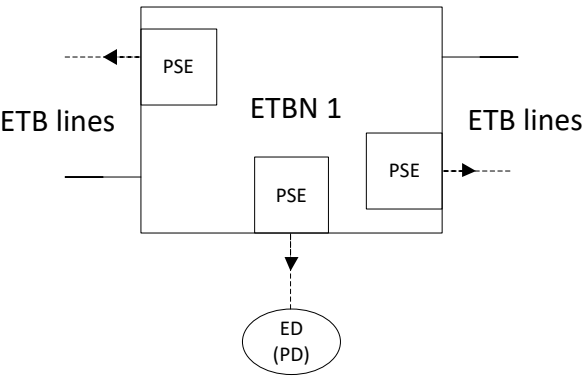


Figure 6 – ETBN PSE PoE use case

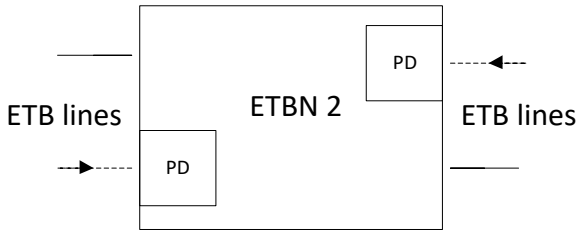


Figure 7 – ETBN PD PoE use case

In intra-vehicle PoE could be used to power an ED (CCTV, etc.). The ND Ethernet port acts as a PSE (Power Source Equipment).

In inter-vehicle and inter-Consist, PoE could be used to power a ND. A PSE interface shall be connected to a PD interface. In case of ETB link redundancy, PSE and PD interfaces shall be alternated in order to keep a symmetrical rotation of vehicle (see Figure 8 below). PSE interfaces shall be associated with female connectors and PD interfaces shall be associated with male connectors if male/female connectors are used for inter-Consist interface (see Figure 4).

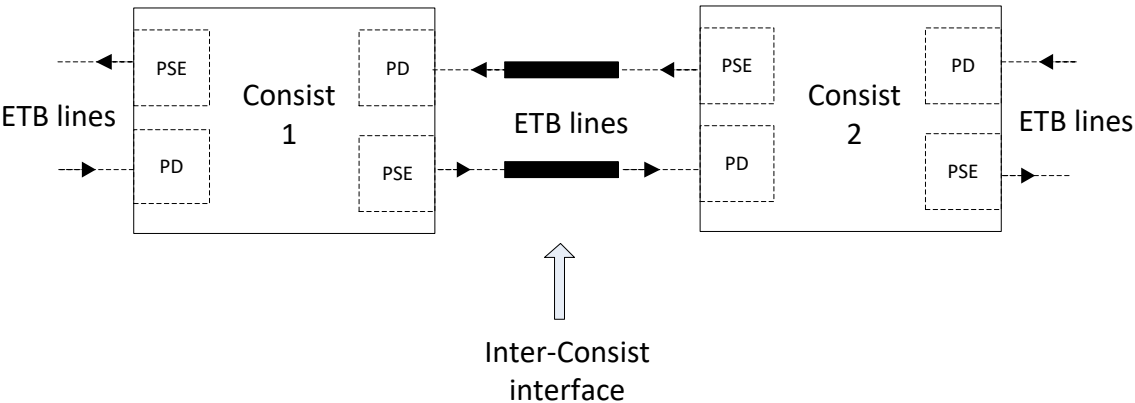
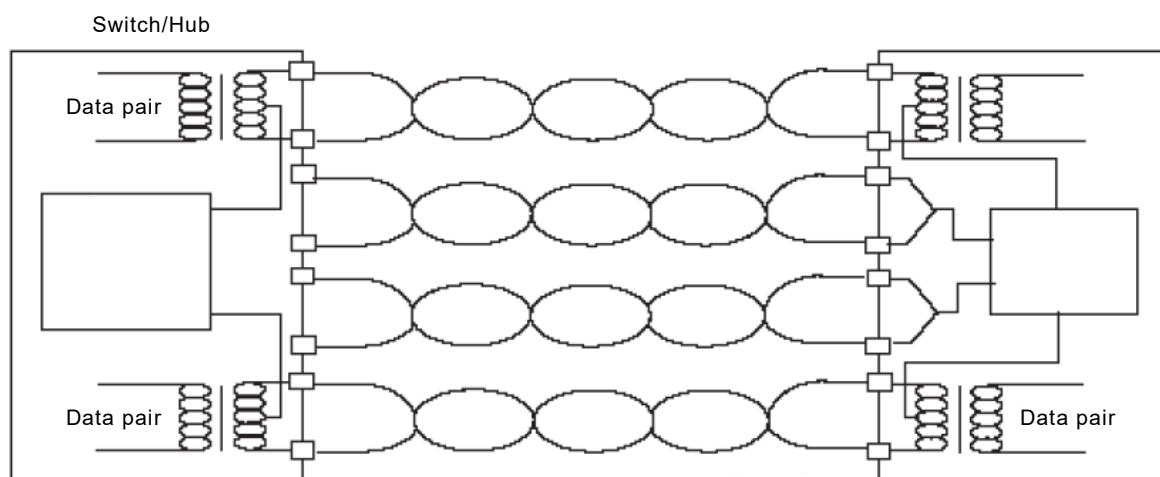


Figure 8 – PoE in inter-Consist

Figure 9 shows the connection between PSE and PD. The alternative A of PoE IEEE 802.3 Clause 33 shall be used because only two pairs are used (Tx/Rx).



Endpoint PSE, Alternative A

Figure 9 – PoE PSE alternative A

4.4 ETB physical architecture and redundancy

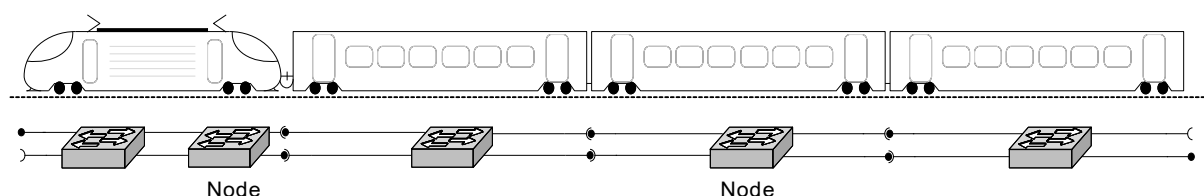
4.4.1 General

IEC 61375-1 describes two potential architectures applicable to ETB depending on the configuration of transmission medium redundancy (see 5.2.3 “Train Backbone based on switched technology”). These architectures are named as aggregate architecture, described in IEC61375-2-5:2015, and segregated architecture, defined for the first time in this version of the standard.

Both architectures are incompatible and cannot be connected to the same train backbone. It means two Consist with different architecture types will not be interoperable when coupled in the same train composition. To detect this incompatibility, during the inauguration process, ETBNs can identify the type of architecture through the version of TTDP HELLO frames, specifically the HELLO-TLV version field (see 8.7.5). If TTDP HELLO frames are not the same version, the inauguration process will fail. For more details about potential incompatibilities see Annex F

On top of that, the term “domain” is introduced along with its identification “domain id”, replacing legacy term “backbone id”, moving from a mandatory physical separation of ETBs, identified by legacy term “backbone”, to a logical separation – physical or not – identified by “domain”.

An illustration of aggregated architecture is shown on Figure 10 below:



IEC

Figure 10 – Redundant train backbone architecture (aggregated architecture)

The general requirements for the ETB physical layer for aggregated architecture are the following:

- As a switched technology is used, nodes shall provide a data transmission medium to each of their direct neighbour nodes, if present. Each ETBN has at least one ETB forward port and one ETB backward port statically defined.
- When optional redundancy is required, data transmission medium shall be at least doubled.
- Even without redundancy requirement, the link between 2 ETBNs shall be doubled using normal switch ports when Consist reversing capability is required. Physical connection between two Consists needs two cables in this case (see 4.2.4).
- A bypass relay function shall bridge a node if the node is powerless or not operating.
- Architecture suitable for the following train compositions (see 6.3.3) :
 - Regular train composition are typically used for passenger trains with a maximum of 63 consists.
 - Extended train composition are often used for freight trains with a maximum of 127 consists
- Domains approach may be supported, with the following considerations:
 - It is optional for regular train composition where « reserved bit » should remain unused for IP addressing (See Section 6.4).
 - It is mandatory for extended train composition as IP addressing rules for consist id are required
 - Regarding Domains naming and concept, it is consistently used throughout the document, but the following equivalences are established should the older nomenclature from previous revisions of this part of the standard be preferred.
 - « Domain Id » is equivalent to « Backbone Id », liberating the rule of explicitly using [b] bits as identification for backbone id, indicating physical network separation
 - « Consist Id » is equivalent to « Subnet Id », liberating the rule of explicitly using [s] bits as identification for consist id
 - In spite of the above equivalences, the usage and rules remain different.

An illustration of aggregated architecture is shown on Figure 11 below:

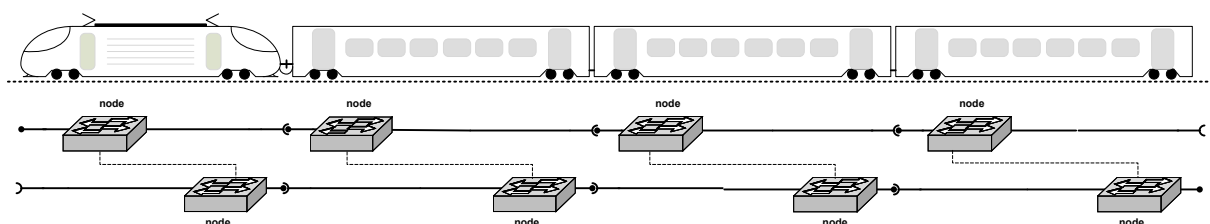


Figure 11 – Redundant train backbone architecture (segregated architecture)

The general requirements for the ETB physical layer for segregated architecture are the following:

- Redundancy is inherent in this architecture having two independent Ethernet Train Backbone (ETB) data transmission lines to create redundant communication channels. For this purposes, A-Plane/B-Plane concept is introduced in clause 4.4.3.1, and allow having redundancy in the following functions:
 - Train Inauguration process (see 8.4.1.3).
 - Data transmission using frame replication (802.1CB) – option –
 - Best effort traffic or non-critical data.

- Bypass relay function is prohibited.
- Architecture suitable for the following train compositions (see 6.3.3) :
 - Regular train composition are typically used for passenger trains with a maximum of 32 consists.
 - Extended train composition are not supported.
- Domains approach is mandatory.

4.4.2 Aggregated architecture

4.4.2.1 Link aggregation architecture

When there are multiple lines between 2 ETBNs (e.g. when redundancy or Consist reversing is required), link aggregation layer from IEEE 802.1AX shall be used.

As having a single, non-redundant line for ETB communications can be considered as a degraded mode of link aggregation, it will be assumed (and so described) in the rest of this standard that link aggregation is used.

Link aggregation described in IEEE 802.1AX is managed at OSI layer 2, and allows one or more lines to be aggregated together to form a logical group, able to manage the link redundancy (see Figure 12 below).

Link aggregation combines several individual lines, each having a physical and MAC layer. From the MAC client, a single MAC interface is provided.

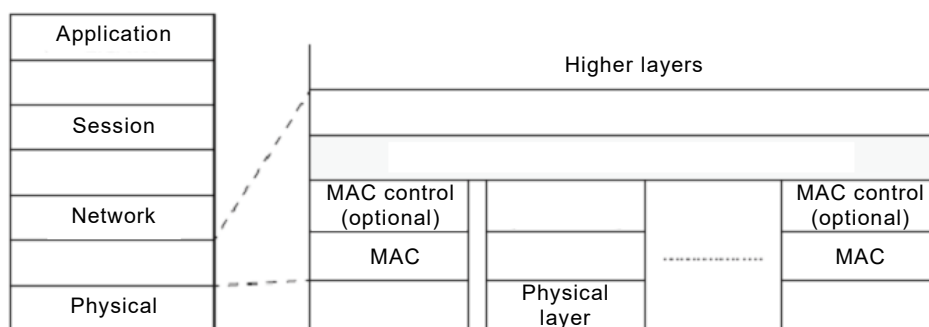


Figure 12 – Link aggregation model

On an ETB node, up to four physical ports are allowed to provide redundancy for a communication link, and will be defined as a link aggregation group (also called hereinafter logical link).

When Consist reversing is required, for symmetry reasons (see 4.2.4), 2 or 4 physical lines shall be used in each aggregation group. As stated before, the special case of a single line (no symmetry needed when Consist reversing not required) is considered as a degraded mode of link aggregation. So, a link aggregation group on ETB may contain 1, 2 or 4 physical lines.

Between 2 ETB nodes, there is only one link aggregation group which contains the redundant Ethernet segments. The link aggregation process is only defined as a relation between 2 ETB nodes.

In some cases, due to the specific railway context, some repeaters could be placed on lines between two ETBNs (e.g. to regenerate electric signal). This requires the use of a protocol that can take into account this architecture (see Figure 13 below and 4.4.2.2.2), because the only use of the “line status” becomes insufficient: only a frame exchange can solve this problem. According to IEEE 802.1AX, the usual way to perform this function is to implement LACP (Link Aggregation Control Protocol). For this ETB specification, and in order to limit network load, instead of using LACP, line port statuses are managed by Train Topology Discovery Protocol (TTDP) described below using LLDP frame with a specific organizational HELLO TLV (TTDP HELLO frame).

A logical link is usable as long as at least one of its physical lines is ok (as in standard link aggregation). The degraded state information of a link when it loses a physical line can be retrieved by SNMP (see 13.5.2.1 for details) or NetConf (see 13.5.2.2 for details).

An intermediate repeater Network Device shall transfer LLDP frames without any change between these two interfaces.

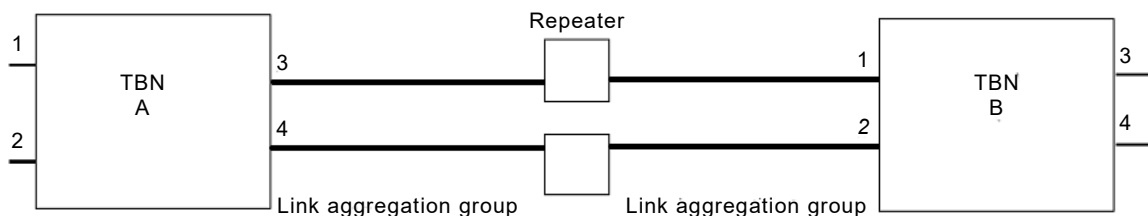


Figure 13 – Link aggregation group

NOTE Link aggregation supports the way to optionally add ports and lines between ETBNs, in order to improve reliability and performances (allocating more bandwidth).

4.4.2.2 Functions

4.4.2.2.1 Data flow principles

A load sharing is supported on the train backbone, meaning that MAC client traffic is distributed across the lines.

IEEE 802.1AX does not specify any particular distribution algorithm. To ensure interoperability between different systems, this algorithm shall cause neither disordering of any given conversation (TCP, IP, etc.), nor duplication of frames.

Each conversation uses only one line at a time. This ensures the interoperability between 2 train nodes even with different algorithms. Figure 14 below illustrates different conversations, but each on the same line:

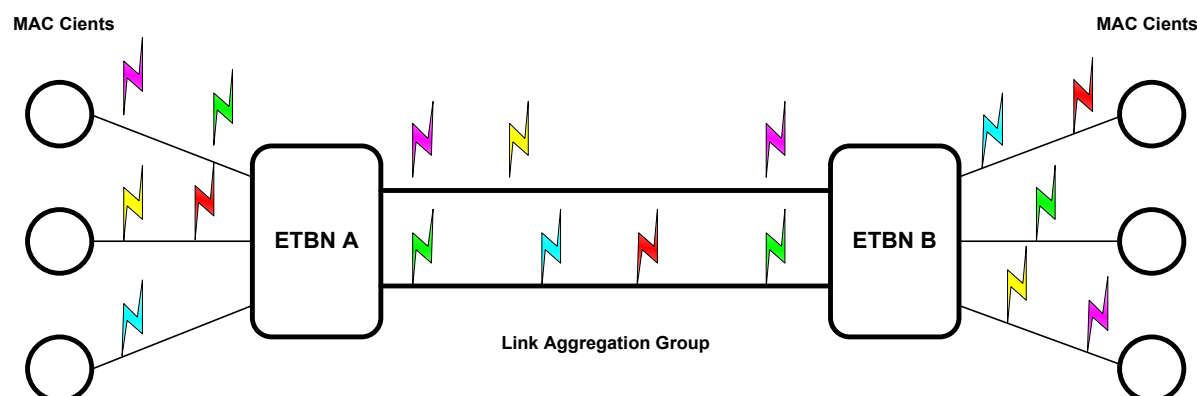


Figure 14 – Conversations over LAG

4.4.2.2.2 Configuration

Link aggregation configuration is set statically at initialisation time of ETBN. Configuration shall follow link availability. ETB line status is computed using TTDP HELLO frame and Ethernet port status, see 8.6.4 for details.

4.4.2.2.3 Reconfiguration

The reconfiguration of the redundant lines shall be made in case of change of physical connectivity (failover). The link aggregation process shall quickly converge to a new configuration of the redundant lines in a time below 200 ms (see 8.9.1).

. Reconfiguration is managed by observing the ETB line statuses (see 8.6.4 for details) of all ports in an aggregate.

4.4.2.2.4 Compliance

Link aggregation shall never add or change the content of frames exchanged between devices.

Compliance is defined in PICS, coming from IEEE 802.1AX: 2014, A.2. Applicable sections include A.2.4, A.2.5, A.2.7 and A.2.8,. Requirements on handling incoming marker packets should be optional (A.2.7), and use of destination MAC address, packet type and control protocol (A.2.7 and A.2.8) , should be adapted inline with specification of TTDP HELLO in 61375 - 2 - 5 (this document)

4.4.3 Segregated architecture

4.4.3.1 A-Plane/B-Plane concept

A-Plane/B-Plane concept Consists on creating two virtual planes (A-Plane and B-Plane) on top of the physical ETB network as shown in Figure 15, where each Consist direction is represented as IEC61375-1 defines.

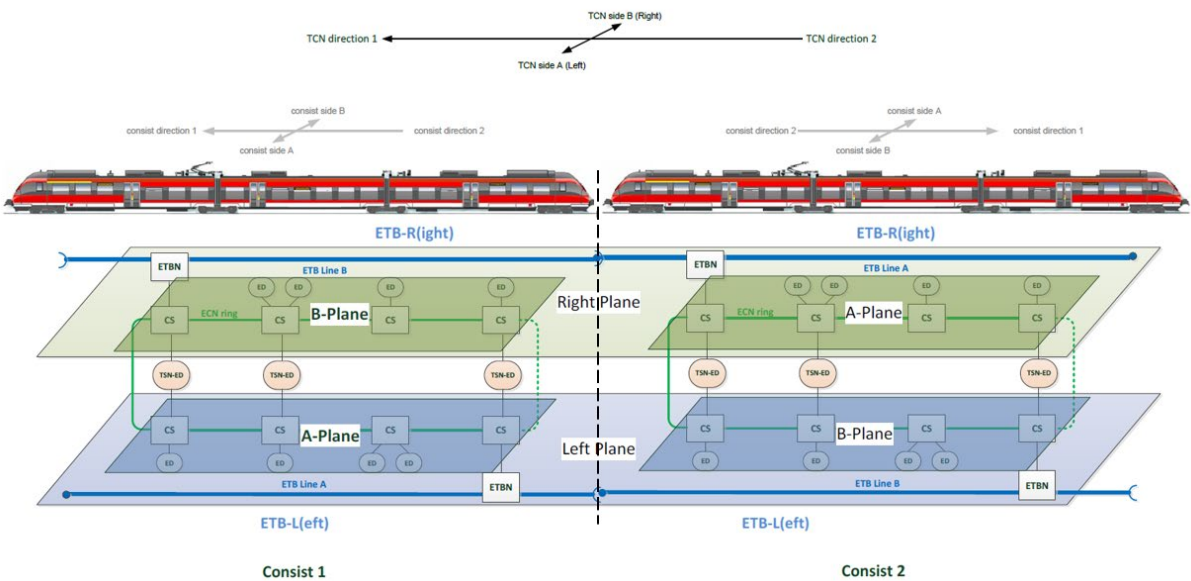


Figure 15 – Train-wide A-Plane/B-Plane definition

Each plane constitutes a set of VLANs, and all Ethernet ports assigned to a plane become member of that set. However, to clearly distinguish the two trainwide ETB lines, an extension is made by assigning a side direction (left/right). That means it is distinguished between a left-side ETB-L(left) and a right-side ETB-R(right).

Within Consists, the two ETB lines are still assigned to Consist sides A (ETB line A) and B (ETB line B) as this is statically defined during Consist design. But when Consists are coupled, those Consist sides are mapped to the corresponding train sides (left/right). This can be seen in Figure 15, where the two Consists have different orientations.

Since this architecture splits ETB lines, each one for a virtual plane, link aggregation used in the aggregated architecture (4.4.2.1) is not applicable here. However, for simplicity, the two ETB lines at one Consist side is still called the ETB aggregate, while the exchange of TTDP HELLO frames has a bit different from the aggregated architecture (see 8.4.2).

Communication in the trainwide planes follows the same principles as Consist plane communication: critical data traffic is confined to the respective plain, and this is implemented with VLANs.

5 ETB data link layer

Table 10 summarizes network data link layer requirements for a switch device connected to the train backbone subnet.

(M: Mandatory, O: Optional, C: Conditional, X: Prohibited)