

INTERNATIONAL STANDARD

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**Electronic railway equipment – Train communication network (TCN) –
Part 2-1: Wire Train Bus (WTB)**

**Matériel électronique ferroviaire – Réseau embarqué de train (TCN) –
Partie 2-1: Bus de Train Filaire (WTB)**



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**ELECTRONIC RAILWAY EQUIPMENT –
TRAIN COMMUNICATION NETWORK (TCN) –****Part 2-1: Wire Train Bus (WTB)**

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

FDIS	Report on voting
9/1642/FDIS	9/1666/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 of IEC 61375 series, 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- withdrawn,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.

This first edition cancels and replaces the clauses of IEC 61375-1 second edition published in 2007, relevant to the specification of WTB and constitutes a technical revision.

It was prepared taking into account IEC 61375-1, third edition.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This part of IEC 61375 specifies one component of the Train Communication Network, the Wire Train Bus (WTB), a serial data communication bus designed primarily, but not exclusively, for interconnecting consists which are frequently coupled and uncoupled, as is the case of international UIC trains.

Figure 1 illustrates the WTB application.

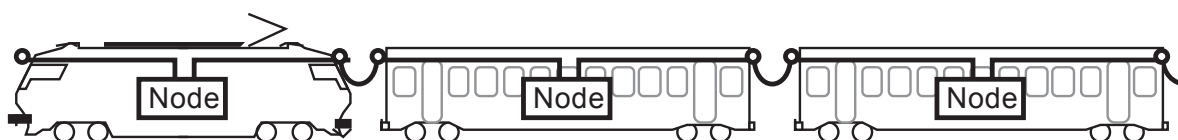


Figure 1 – Wire Train Bus

This standard defines these interfaces as connections to a data communication network, called the Train Communication Network (TCN).

The TCN has a hierarchical structure with two levels of networks, a Train Backbone and a Consist network:

- a) for interconnecting consists in Open Trains (see definition) such as international UIC trains, this standard specifies a Train Bus called the Wire Train Bus (WTB);
- b) for connecting standard on-board equipment a Consist network e.g. the Multifunction Vehicle Bus (MVB) can be used.

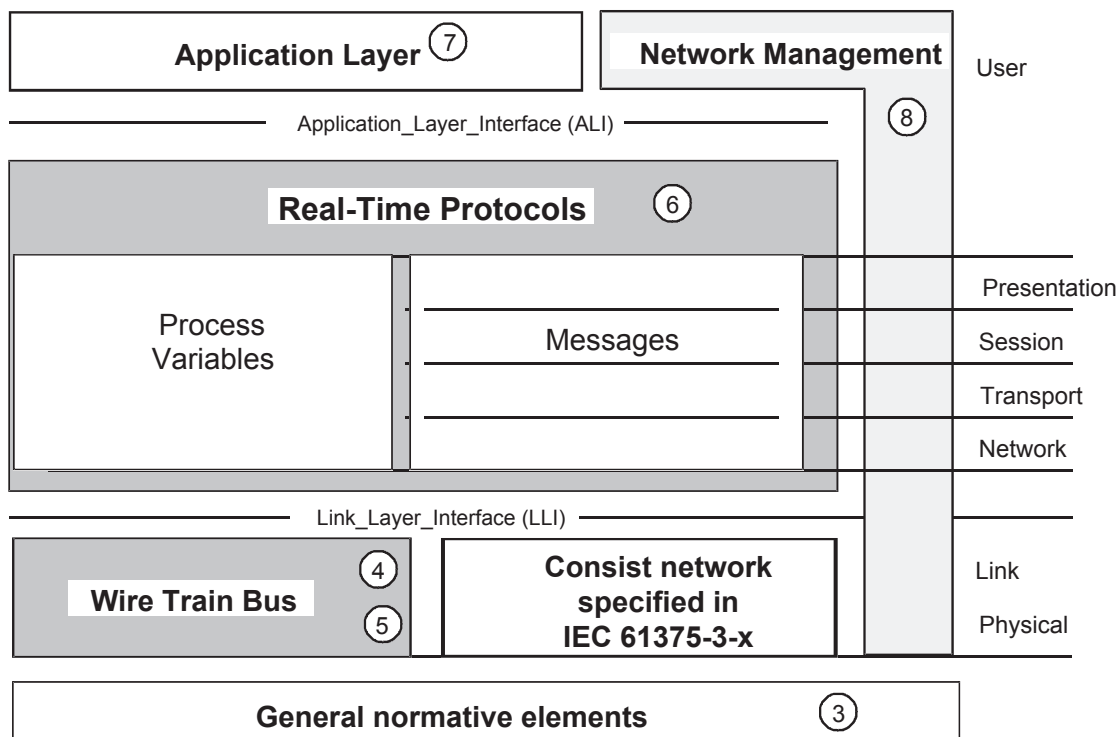
In the TCN architecture, WTB features Real-Time Protocols, which offer two communication services:

- c) Process Variables, a distributed, real-time database, periodically refreshed through broadcasting;
- d) messages, transmitted on demand either as:
 - unicast messages (point-to-point) or/and
 - multicast messages.

WTB in the TCN offers a common Network Management, which allows debugging, commissioning and maintenance over the network.

The Consist network MVB shares Real-Time Protocols and Network Management with WTB. Other implementations of consist networks need adaption to the Real-Time Protocols and Network Management of WTB.

The TCN is structured similarly to the Open System Interconnection model defined in ISO/IEC 7498-1 (see Figure 2).



NOTE The circled numbers refer to the clauses of this standard.

Figure 2 – Layering of the TCN

This standard has been, for editorial reasons, divided into eight clauses:

Clause 1

- Scope;

Clause 2

- Normative references;

Clause 3

- Terms and definitions, abbreviations, conventions;

Clause 4 and 5: Wire Train Bus,

- Physical layer and Link Layer Control;

Clause 6: Real-Time protocols,

- Variables: Link Layer Interface and Application Layer Interface;
- Messages: Link Layer Interface, Protocols, Application Layer Interface;
- Data Representation;

Clause 7: Application Layer

- Process Data Marshalling
- WTB Line Fault Location Detection

Clause 8: Train Network Management

- Configuration, supervision and control of the network.

ELECTRONIC RAILWAY EQUIPMENT – TRAIN COMMUNICATION NETWORK (TCN)–

Part 2-1: Wire Train Bus (WTB)

1 Scope

This part of IEC 61375 applies to data communication in Open Trains, i.e. it covers data communication between consists of the said open trains and data communication within the consists of the said open trains.

The applicability of this standard to the train communication bus (WTB) allows for interoperability of individual consists within Open Trains in international traffic. The data communication bus inside consists (e.g. MVB) is given as recommended solution to cope with the said TCN. In any case, proof of compatibility between WTB and a proposed consist network will have to be brought by the supplier.

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

NOTE 1 For a definition of Open Trains, Multiple Unit Trains and Closed Trains, see Clause 3.

NOTE 2 Road vehicles such as buses and trolley buses are not considered in this standard.

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 60571, *Electronic equipment used on rail vehicles*

IEC 60807 (all parts), *Rectangular connectors for frequencies below 3 MHz*

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

IEC 61375-2-2:2012, *Electronic railway equipment – Train communication network (TCN) – Part 2-2: Wire Train Bus conformance testing*

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

ISO/IEC 8802-2, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical link control*

ISO/IEC 8824 (all parts), *Information technology – Abstract Syntax Notation One (ASN.1)*

ISO/IEC 8825 (all parts), *Information technology – ASN.1 encoding rules*

ISO/IEC 8859-1, *Information technology – 8-bit single-byte coded graphic character sets – Part 1: Latin alphabet No. 1*

ISO/IEC 9646 (all parts), *Information technology – Open Systems Interconnection – Conformance testing methodology and framework*

ISO/IEC 10646, *Information Technology – Universal Multi-Octet Coded Character Set (UCS)*

ISO/IEC 13239, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures*

ITU-T Recommendation V24, *List of definitions for interchange circuits between data terminal equipment (DTE) and data-circuit terminating equipment (DCE)*

ITU-T Recommendation Z.100, *Specification and Description Language (SDL)*

IEEE 754, *Standard for Binary Floating-Point Arithmetic*

UIC CODE 556, *Information transmission in the train (train-bus)*

UIC CODE 557, *Diagnostics on passenger rolling stock*

3 Terms and definitions, abbreviations, conventions

3.1 Terms and definitions

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

NOTE Keywords in this standard are written with the first letter of each word in upper case and, when they are composed of two or several words, these are joined by an underscore. This convention allows keywords to be tracked in the documents.

3.1.1

address

identifier of a communication partner, of which several types exist, depending on the layer

3.1.2

agent

application process in a Station which accesses the local managed objects on behalf of the Manager

3.1.3

Aperiodic Data

transmission of Process Data on a demand basis. This service is not used

3.1.4

Application Layer

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

3.1.5

Application Layer Interface

definition of the services offered by the Application Layer

3.1.6

Application Messages Adapter

code directly called by the application implementing the Messages services

3.1.7**Application Messages Interface**

definition of the Messages services

3.1.8**Application Process**

communicating entity, implemented for instance by a task

3.1.9**Application Processor**

processor which runs a communicating Application Process

3.1.10**Application Supervision Interface**

definition of the Supervision services available in particular to the Agent

3.1.11**Application Variables Adapter**

code directly called by the application implementing the Variables services

3.1.12**Application Variables Interface**

definition of the Variables services

3.1.13**arbiter**

device, or common protocol followed by several devices, which selects one of several devices competing for mastership

3.1.14**Auxiliary Channel**

channel used for detecting additional Nodes

3.1.15**Basic Period**

bus activity is divided into periods. The shortest is the Basic Period, which consists of a Periodic Phase (for Periodic Data) and of a Sporadic Phase (for Message Data and Supervisory Data)

3.1.16**big-endian**

ordering scheme for storing or transmitting data in which the most significant part of a multiple-octet data is stored at the lowest octet address, and transmitted first

3.1.17**bit-stuffing**

method specified by ISO/IEC 13239 to prevent Frame Data from being misinterpreted as a Flag, consisting of inserting an additional "0" symbol after each string of five "1" symbols and removing this "0" at reception

3.1.18**bridge**

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

3.1.19

broadcast

nearly simultaneous transmission of the same information to several destinations. Broadcast in the TCN is not considered reliable, i.e. some destinations may receive the information and others not

3.1.20

bus

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

3.1.21

Bus Controller

processor or integrated circuit in charge of the Link Layer of communication

3.1.22

Bus Switch

switch or relay within a WTB Node which connects electrically the cable sections of the two directions

3.1.23

Caller

Application Process which initialises a message exchange

3.1.24

Check Sequence

method of error detection based on appending to the transmitted useful data a checksum or a cyclic redundancy check (CRC) calculated on the useful data

3.1.25

Check Variable

Process Variable of type antivalent boolean protecting another Process Variable

3.1.26

Check Offset

bit offset of a Check Variable within a Dataset

3.1.27

Closed Train

train consisting of a set of consists, where the composition does not change during normal operation, for instance metro, suburban train, or high-speed train units

3.1.28

composition

number and characteristics of the consists forming a train

3.1.29

configuration

definition of the topology of a bus, 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

3.1.30

Connect Confirm

response of the Consumer to the Connect Request of the Producer

3.1.31**Connect Request**

first packet of a message sent from Producer to Consumer

3.1.32**Consist**

Singe vehicle or a group of vehicles which are not separated during normal operation. A Consist could contain no, one or several Consist networks.

3.1.33**Consist network**

bus connecting equipment within a consist, e.g. the MVB, and which conforms or adapts to the TCN Real-Time protocols as described in this document

3.1.34**consistency**

Dataset consisting of several elements is consistent if all elements are read or written in one indivisible operation

3.1.35**Consumer**

receiver of a message at the Transport Layer (see: Producer)

3.1.36**continuity consist**

consist without an operational Train Bus Node, but carrying a section of the bus to connect passively the Train Bus of its adjacent consists.

3.1.37**conversation**

data exchange at the Application Layer, consisting of a Call Message and a Reply Message (the latter is missing in the multicast protocol). A conversation starts with the first Connect Request frame and ceases when the last acknowledgement for the Reply Message has been received or is no longer expected

3.1.38**datagram**

frame containing all information necessary to forward it to its final destination, without knowledge of previous frame's contents. Datagrams do not use a previous connection establishment and they are not acknowledged at the Link Layer

3.1.39**Dataset**

all Process Variables transmitted in one Process Data frame

3.1.40**delimiter**

sequence of signals which includes code violation symbols (neither "1" nor "0") which is used to delimit the start (Start Delimiter) and the end (End Delimiter) of a frame, as defined for instance in IEC 61158-2

3.1.41**Destination Device**

receiver of a frame at the Link Layer (see: Source Device)

3.1.42**device**

unit connected to one or more busses

3.1.43

Device Address

Device Address identifies a device within a bus; On the WTB, the Device Address has 8 bits, the least significant 6 bits being the Node Address;

A device connected to several busses may have a different Device Address for each bus. Special devices such as repeaters only participate at the Physical Layer and have no Device Address

3.1.44

Direction 1

one direction of a WTB Node

3.1.45

Direction 2

other direction of a WTB Node

3.1.46

End Delimiter

sequence which ends a frame before the medium returns to idle

3.1.47

End Node

Node which terminates the two bus segments connected to it but does not establish continuity between them

3.1.48

Event Round

sequence of polls in which all events pending at the start are read

3.1.49

extension box

wiring box where the trunk cable is interrupted and passively extended by an extension cable to connect a device

3.1.50

extension cable

cable inserting a Node in a trunk cable, consisting of two separate twisted wire pairs per line, possibly of smaller cross-section than the trunk cable itself

3.1.51

field device

device attaching simple sensors and actuators to the bus, outside a rack

3.1.52

final

receiver of a packet (data or acknowledgement) at the Network Layer. When two devices communicate within the same bus, the final is located in the destination device (see: origin)

3.1.53

Flag

sequence of "1" and "0" symbols which serves to delimit the beginning or the end of a frame. Flags which would appear in the transmitted data are modified by bit-stuffing, as defined for instance in ISO/IEC 13239

3.1.54**frame**

sequence of consecutive symbols sent in one time slot by a transmitter, between two slots where the line is idle

3.1.55**Frame Check Sequence**

16-bit FCS specified in ISO/IEC 13239

3.1.56**Frame Data**

data transmitted between the Preamble and the End Delimiter (on the WTB)

3.1.57**fritting**

electrical cleaning of oxidised contacts by applying a breakdown voltage over the contact

3.1.58**Function**

Application Process which exchanges messages with another Application Process

3.1.59**Function Directory**

directory which maps a Function Identifier to a Station Identifier and vice-versa

3.1.60**Function Identifier**

8-bit identifier of a Function

3.1.61**F code**

in a Master Frame, indicates the request and the expected response Slave Frame size

3.1.62**gateway**

connection between different busses at the Application Layer requiring application-dependent data analysis and protocol conversion

3.1.63**Group Address**

address of a multicast group to which a Node belongs

3.1.64**Group Directory**

directory which indicates to a Node to which multicast group it pertains

3.1.65**hamming distance**

minimum number of bits of a given correct bit sequence, which, if inverted, create a false bit sequence indistinguishable from a correct one

3.1.66**HDLC**

High-level Data Link Control, a set of standardised protocols, including ISO/IEC 13239 for data transmission

3.1.67

HDLC Data

data transmitted in an HDLC frame

3.1.68

Inauguration

operation executed in case of composition change, which gives all Nodes of the WTB their address relative to the Master, their orientation and the descriptor of all named Nodes on the same bus

3.1.69

Individual Period

interval between two successive transmissions of the same Process Data from the same source. The Individual Period is a power-of-2 multiple of the Basic Period

3.1.70

instance

a) one of several objects which share the same definition (object instance)

b) one of several (simultaneous or not) executions of the same program (process instance)

3.1.71

integrity

property of a system to recognise and to reject wrong data in case of malfunction of its parts

3.1.72

Intermediate Node

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

3.1.73

jumper cable

cable connecting the trunk cables of two consecutive consists, possibly of a larger cross-section than the trunk cable, and which is plugged by hand in the case of the UIC-cable. There are generally two jumper cables between consists

3.1.74

Line

non-redundant bus. A dual-thread bus consists of two lines

3.1.75

Line Unit

all circuits providing the electrical attachment to a line

3.1.76

Link Address

address supplied to the Link Layer to identify to which Bus and to which Device Address a packet is sent or received

3.1.77

Link Control

field in the HDLC frame which indicates the type of frame

3.1.78

Link Data

data transported by the Link Layer, but not relevant to it

3.1.79**Link Header**

part of a Message Data frame relevant to the Link Layer

3.1.80**Link Layer**

layer in the OSI model establishing point-to-point and broadcast connections between devices attached to the same bus

3.1.81**Link Layer Interface**

interface between Link Layer and higher communication layers

3.1.82**Link Layer Management**

interface controlling the Link Layer for management purposes

3.1.83**little-endian**

ordering scheme for storing or transmitting data in which the least significant part of a multiple-octet data is stored at the lowest octet address, and transmitted first

3.1.84**local area network**

part of a network characterised by a common medium access and address space

3.1.85**logical link control**

protocols and associated frame formats which serve to control the Link Layer

3.1.86**Logical Address**

address which is not bound to a specific device (e.g. the Process Data address)

3.1.87**Logical Port**

ports of a device used for the Process Data traffic and addressed by the Logical Address

3.1.88**Macro Cycle**

number of Basic Periods corresponding to a Macro Period

3.1.89**Macro Period**

longest Individual Period, after which the periodic traffic returns to the same pattern, counted in milliseconds

3.1.90**Main Channel**

channel over which the main bus traffic is received

3.1.91**Management Message**

message exchanged between a Manager and an Agent for Network Management.

3.1.92

Manager

Function in a Station which is dedicated to Network Management and which send management Call Messages through System Addresses

3.1.93

marshalling

allocation of application addresses or names to the Process Variables of a dataset, that, on the WTB, depends on the Node Type and Version

3.1.94

Master

device which spontaneously sends information on a bus to a number of slave devices. It may give a Slave the right to transmit for one Slave Frame only within a limited time

3.1.95

Master Frame

frame sent by a Master

3.1.96

Master Start Delimiter

Start Delimiter of a Master Frame

3.1.97

medium access control

sublayer of the Link Layer, which controls the access to the medium (arbitration, mastership transfer, polling)

3.1.98

medium dependent interface

mechanical and electrical interface between the transmission medium and a Medium Attachment Unit

3.1.99

medium

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

3.1.100

Medium Attachment Unit

device used as a coupler to the transmission medium

3.1.101

message

data item transmitted in one or several packets

3.1.102

Messages

transmission service of the TCN

3.1.103

Message Data

data transmitted sporadically by the Link Layer in relation to message transmission; the corresponding Link Layer service

3.1.104**messenger**

communication stack caring for end-to-end message communication and interfacing to the application

3.1.105**multicast**

transmission of the same message to a group of Repliers, identified by their Group Address. The word "multicast" is used even if the group includes all Repliers

3.1.106**Multifunction Vehicle Bus
MVB**

Consist network to be used for connecting programmable stations and simple sensors/actors.

3.1.107**Multiple Unit Train**

train consisting of a set of closed trains, where the composition of the set may change during normal operation

3.1.108**network**

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

3.1.109**Network Address**

address which identifies a Function or a Station within the network. It can be either a User Address or a System Address

3.1.110**Network Header**

part of a Message Data frame relevant to the Network Layer

3.1.111**Network Layer**

layer in the OSI model responsible for routing between different busses

3.1.112**Network Management**

operations necessary to remotely configure, monitor, diagnose and maintain the network

3.1.113**Node**

device on the Wire Train Bus, which may act as a gateway between Train Bus and Consist network

3.1.114**Node Address**

address of a Node on the Train Bus (6 bits). It is equal to the least significant 6 bits of the 8-bit Device Address on the WTB

3.1.115**Node Descriptor**

24-bit data structure which indicates for a Node its Node Period and its Node Key

3.1.116

Node Directory

directory which maps the Node Address to the Device Address (one-to-one mapping in WTB)

3.1.117

Node Key

16-bit identifier selected by the application to identify a Node's type and version. The Master distributes it to all other Nodes after each composition change and before exchanging data

3.1.118

Node Period

on the WTB, desired Individual Period of a Node (identical to Individual Period except if overload occurs)

3.1.119

octet

8-bit word stored in memory or transmitted as a unit *

3.1.120

Open Train

train consisting of a set of consists where the configuration may change during normal operation, for instance international UIC trains

3.1.121

origin

sender of a packet (data or acknowledgement) at the Network Layer. When two devices communicate within the same bus, the Origin is located on the source device (see: final)

3.1.122

packet

unit of a message (information, acknowledgement or control) transmitted in exactly one Message Data frame

3.1.123

period

time unit after which a periodic pattern repeats itself

3.1.124

Periodic Data

Process Data transmitted periodically, at an interval which is the Individual Period

3.1.125

Periodic List

list of Nodes, addresses or devices to be polled in each period of a Macro Cycle

3.1.126

Periodic Phase

phase during which the Master polls for Periodic Data according to its Periodic List

3.1.127

Physical Address

The Node Address on the WTB which identify communicating devices on the same bus

* IEC prescribes 'octet ' instead of 'byte'.

3.1.128**Physical Port**

Port used for the Message Data or the Supervisory Data traffic and addressed by the Device Address

3.1.129**pitch**

distance between adjacent devices on the same electrical bus required to avoid clustering of bus loads

3.1.130**polling**

sending of a Master Frame in order to receive a Slave Frame

3.1.131**Port**

memory structure which contains data for transmission or reception, and in which a new value overwrites the former value (buffer, not queue). A Port provides means for simultaneous access by the bus and the application(s)

3.1.132**Port Index Table**

look-up table which deduces the memory address of a port from the Logical Address of the Process Data

3.1.133**Preamble**

sequence of signals heading a frame for the purpose of synchronising the receiver, used on the WTB

3.1.134**Presentation Layer**

layer in the OSI model responsible for data representation and conversion

3.1.135**Process Data**

source-addressed data broadcast periodically by the link layer in relation with Process Variables transmission; the corresponding Link Layer service

3.1.136**Process Variable**

variable expressing the state of a process (e.g. speed, brake command)

3.1.137**Producer**

sender of a message at the Transport Layer (see: Consumer)

3.1.138**Publisher**

source of a Dataset for broadcasting (see: Subscriber)

3.1.139**PV Name**

identifier of a Process Variable

3.1.140

PV Set

set of Process Variables belonging to the same Dataset

3.1.141

queue

memory storing an ordered set of frames in a first-in, first-out fashion

3.1.142

rack

equipment containing one or more devices, attached to the same segment

3.1.143

reassembly

act of regenerating a long message from several packets generated by segmentation

3.1.144

receiver

electronic device which may receive signals from the physical medium

3.1.145

Receive Queue

queue for receiving Message Data in a device

3.1.146

regular operation

normal bus activity as opposed to Inauguration (WTB)

3.1.147

repeater

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

3.1.148

Replier

Application Process which has been requested by the Caller to receive a Call Message and to reply with a Reply Message

3.1.149

residual error rate

probability of integrity breach (unrecognised wrong bit) per transmitted bit

3.1.150

router

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

3.1.151

scan

polling of devices in a certain sequence for supervisory purposes

3.1.152

section

part of a segment, which is passively connected to another section without terminator in between

3.1.153**segment**

piece of cable to which devices are attached, terminated at both ends by its characteristic impedance. Segments may consist of several sections (non-terminated) connected by connectors

3.1.154**segmentation**

division of a long message into several shorter frames for transmission

3.1.155**Send Queue**

queue for sending Message Data in a device

3.1.156**service**

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

3.1.157**Session Header**

part of a Message Data frame relevant to the Session Layer

3.1.158**Session Layer**

OSI layer in charge of establishing and closing communication

3.1.159**Side A**

one side of a consist with respect to a WTB Node

3.1.160**Side B**

other side of a consist with respect to a WTB Node

3.1.161**Slave**

device which receives information from the bus or sends information on the bus in response to a request (also called a poll) from the Master

3.1.162**Slave Frame**

frame sent by a Slave

3.1.163**Source Device**

sender of a frame at the Link Layer (see: destination device)

3.1.164**sporadic transmission**

transmission which is made upon demand, when an event external to the network requires it (also called aperiodic, event-driven, demand-driven transmission)

3.1.165**Sporadic Data**

data frames transmitted on demand to carry Message Data or Supervisory Data

3.1.166

Sporadic Phase

second half of a Basic Period, dedicated to the demand-driven transmission of messages and bus management data

3.1.167

star coupler

device which takes the light of an optical fibre and redistributes it to several other fibres

3.1.168

Station

device capable of message communication, by contrast to simple devices, and which supports an Agent Function

3.1.169

Station Directory

directory which maps a Station Identifier to a Link Address and vice-versa

3.1.170

Station Identifier

8-bit identifier of a Station

3.1.171

Station Status Word

16-bit descriptor of the status and capabilities of a Station

3.1.172

Strong Master

Strong Node is currently Master and will not relinquish mastership until demoted to Weak Node status

3.1.173

Strong Node

Node selected by the application to become Strong Master. There may be only one Strong Master on a bus segment

3.1.174

stub

T-connection branching from an electrical bus line (at the tap), connecting a device to the line

3.1.175

Subscriber

one of the sinks of a broadcast Dataset (see: Publisher)

3.1.176

Supervisory Data

data transmitted within one bus only for the purpose of Link Layer supervision (e.g. Inauguration on the WTB)

3.1.177

System Address

Network Address of a Management Message exchanged between Manager and Agent, consisting of Node Address and Station Identifier

3.1.178

tap

place where a segment is tapped. A tap is a three-way electrical fork

3.1.179**Telegram**

Master Frame and the corresponding Slave Frame, treated as a whole

3.1.180**terminator**

circuit which closes an electrical transmission line, ideally by its characteristic impedance

3.1.181**Terminator Switch**

switch which inserts the Terminator at the end of a segment on the WTB

3.1.182**Topography**

data structure describing the Nodes attached to the Train Bus, including their address, orientation, position and Node Descriptor

3.1.183**topology**

possible cable interconnection and number of devices a given network supports

3.1.184**Topography Counter**

counter in a Node which is incremented at each new Inauguration

3.1.185**Traffic Store**

shared memory accessed both by the network and the user, which contains the Process Data Port

3.1.186**Train Communication Network**

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

3.1.187**Train Bus, Train Backbone**

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

3.1.188**Train Network Management**

services of the Network Management for TCN

3.1.189**transceiver**

combination of a transmitter and of a receiver

3.1.190**transmitter**

electronic device which can transmit a signal on the physical medium

3.1.191**Transport Data**

data carried by the Transport Layer, but not relevant to it

3.1.192

Transport Header

part of a Message Data frame relevant to the Transport Layer

3.1.193

Transport Layer

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

3.1.194

trunk cable

cable which runs along the consists, as opposed to extension cable or jumper cable

3.1.195

User Address

Network Address of a User Message exchanged between Functions, consisting of Node Address (or Group Address) and Function Identifier

3.1.196

User Message

messages exchanged between user Functions

3.1.197

Variables

transmission service of the TCN

3.1.198

Var_Offset

bit offset of a Process Variable within a Dataset

3.1.199

Vehicle Descriptor

application-dependent information about a particular vehicle, such as length and weight

3.1.200

Weak Master

Weak Node is currently Master and which will relinquish mastership if it finds another, stronger Master

3.1.201

Weak Node

Node which may take over the bus mastership spontaneously, but which releases it if it detects a stronger Node

3.1.202

Wire Train Bus (WTB)

Train Bus for frequently coupled and uncoupled consists, such as international UIC trains

3.2 Abbreviations

ALI	Application Layer Interface, the definition of the semantics of all network services used by the application (a set of primitives, expressed as procedures, constants and data types)
AMA	Application Messages Adapter, the code directly called by the application which implements the Messages service
AMI	Application Messages Interface, the definition of the message services
ANSI	American National Standard Institute, a standardisation body in the United States
ASI	Application Supervision Interface, the definition of the Management services

ASN.1	Abstract Syntax Notation Number 1 on data presentation (ISO/IEC 8824)
AVA	Application Variables Adapter, the code directly called by the application implementing the Process Variable services
AVI	Application Variables Interface, the definition of the Process Variable services
BER	Basic Encoding Rules, a transfer syntax for ASN.1 data types (ISO/IEC 8825)
BR	Bit Rate, the rate of data throughput on the medium expressed in bits per second (bit/s) or in hertz (Hz), whichever is appropriate
BT	Bit Time, the duration of the transmission of one bit, expressed in μ s
ITU	International Telecommunication Union, the international standardisation body for telecommunications based in Geneva
CRC	Cyclic Redundancy Check, a data integrity check based on polynomial division
DIN	Deutsches Institut für Normung, the German national standardisation body
EIA	Electronics Industries Association, a standardisation body in the United States
EP	Electro-Pneumatic brake cable as described in UIC leaflet 648
ERRI	European Railways Research Institute, laboratory based in Utrecht, Netherlands
FCS	Frame Check Sequence, an error detection code appended to the transmitted data, as specified in ISO/IEC 13239
HDLC	High-level Data Link Control, a Link Layer protocol whose frame format is defined in ISO/IEC 13239
IEC	International Electrotechnical Commission, Geneva
IEEE	Institute of Electrical and Electronics Engineers, New York
ISO	International Standard Organisation, Geneva
LFLD	Line Fault Location Detection
LLC	Logical Link Control, a sub-layer within the Link Layer ruling the data exchange
LME	Layer Management Entity, the entity in charge of supervising a layer on behalf of Network Management
LMI	Layer Management Interface, the services provided by the LME
MAC	Medium Access Control, a sub-layer within the Link Layer ruling which device is entitled to send on the bus
MAU	Medium Attachment Unit, the part of a Node which interfaces electrically to the bus and which provides/accepts binary logic signals
MIB	Management Information Base, the set of all objects accessed by Network Management
MTB	Multifunction Vehicle Bus, a Consist network
NRZ	Non-Return to Zero, the simplest encoding scheme in which one bit is represented by one level for a "1" and the other level for a "0", or vice-versa, with a separate clocking
ORE	Office de Recherches et d'Essais, a UIC laboratory based in Utrecht, Netherlands
OSI	Open System Interconnection, a universal communication model defined in the ISO/IEC 7498
PDM	Process Data Marshalling
PICS	Protocol Implementation Conformance Statement, defined in ISO/IEC 9646
PTA	Process Data to Traffic Store Adapter, the component which accesses one of the Traffic Stores
RIC	Regulation for the reciprocal use of coaches and vans in international traffic, issued by UIC
RTP	Real-Time Protocols, the common communication protocols given in Clause 6 of this standard

SDL	Specification and Description Language, a specification language defined by ITU-T Z100 Annex D for communication protocols
TCN	Train Communication Network, a set of communicating consist networks and Train Backbones
TNM	Train Network Management
UIC	International Union of Railways , the international railways operators association
WTB	Wire Train Bus

3.3 Conventions

3.3.1 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 1 The voltage is 20,0 V.

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

EXAMPLE 2 Decimal 20 coded on 8 bits = '0001 0100'B = '14'H.

3.3.2 Naming conventions

Keywords in the TCN specifications are written with a capital letter at the beginning.

If the word is composed, the different parts of the word are united with a space.

When a data structure is associated with a keyword, its type consists of the same basic words separated by an underscore.

When the value corresponding to the keyword is transmitted in a message, the corresponding field has the same name as the type, but in lower case.

When the value is passed as parameter, the parameter has the same name as the field in a message.

In the SDL diagrams, the corresponding variable has the same name as the type, but without underscores.

EXAMPLES

Topo Counter is a counter of the link layer;

It is of the type Topo_Counter, which is an UNSIGNED6.

When its value is transmitted in a message, the corresponding field is called 'topo_counter'.

When its value is transmitted across a procedural interface, the parameter is called 'topo_counter', its C-type is Type_Topo_Counter.

In the SDL diagrams, the variable representing the counter is called TopoCounter.

3.3.3 Time naming conventions

Time values beginning with a lower case (e.g. t mm) are measurable time intervals.

Time values beginning with an uppercase (e.g. T reply) are parameters or time-out values.

3.3.4 Procedural interface conventions

A procedural interface is defined by a set of service primitives, which represent an abstract, implementation-independent interaction between the service user and the service provider.

These primitives are expressed in this standard as procedures in the ANSI C syntax with typed parameters.

This ought to be considered as a semantic description only, which does not imply a particular implementation or language. Any interface which provides the same semantics is allowed.

Conformance to the syntax of this interface cannot be claimed. Implementations are free to change the procedure or parameters names, to add parameters or to split procedures, as long as the specified service is provided.

Interface procedures are defined in the ANSI C syntax using the Courier font.

Procedure names, variables and parameters appear in all lower case.

EXAMPLE 1 `lm_send_request`

Constants and type definitions appear in all upper case.

EXAMPLE 2 `UNSIGNED32`

The name of a procedure or of a type is prefixed:

for the Variables service by

- `lp_` or `LP_` Link Layer
- `ap_` or `AP_` Application Layer

for the Messages service by

- `MD_` messages in general
- `lm_` or `LM_` Link Layer
- `nm_` or `NM_` Network Layer
- `tm_` or `TM_` Transport Layer
- `sm_` or `SM_` Session Layer
- `am_` or `AM_` Application Layer

Table 1 shows a template used for procedures and types.

Table 1 – Template for the specification of an interface procedure

Definition	<i>The service or data type is expressed here.</i> <i>In case of an indication procedure, the event which triggers the call is indicated here, beginning with "When"</i> <i>The name and parameters of the service procedure are defined here.</i> <i>In case of an indication procedure, the type of the procedure is specified.</i> <i>Input parameters, output parameters and return parameters are distinguished</i>	
Syntax	<pre>MD_RESULT lm_send_request (/* example */ unsigned, destination, UNSIGNED8 link_control, MD_PACKET * p_packet ENUM8 * status)</pre>	
Input	<i>Input parameters are supplied to the procedure, which is not allowed to modify them</i>	
	destination	The data type "unsigned" is compiler-dependent
	link_control	parameter passed by reference, not modified by the procedure. The data type is an 8-bit word
	p_packet	The "*" denotes a pointer to the p_packet data structure, which is of type MD_PACKET, defined elsewhere in this standard
Output	<i>Output parameters are expected to be modified by the call</i>	
	status	The type ENUM8 is an 8-bit enumeration type
Result	<i>The Result parameter is an optional output parameter which expresses success or failure of the call, but not necessarily of the service</i>	
	MD_RESULT	The Result parameter is of the type: AM_RESULT for the AMI, MD_RESULT for the LMI, LP_RESULT for the LPI, AP_RESULT for the AVI, The template specifies the error codes expected for each procedure individually. The Result parameter is not explicitly described if the only two values expected are: xx_OK = 0 successful completion; xx_FAILURE <> 0 some problem. The result can also be returned as an output parameter in the parameter list, depending on the implementation
Usage	The rules listed after the procedure template indicate how the procedure should be used. Although usage rules are not mandatory, not following them produces unpredictable results.	
NOTE Data structures represented in this table are interface specifications which should not be confused with formats of the same data structures when transmitted over a bus, see 3.3.5.		

3.3.5 Specification of transmitted data

The format of transmitted data, single frames as well as whole messages, is specified in two forms:

- a graphical form, which is not normative, but shows the message structure at a glance;
- a textual form based on ASN.1, with encoding rules specified in 6.3.

EXAMPLE 1 A graphical form of a message is shown in Table 2, the corresponding textual form is shown in Table 3.

Table 2 – Example of message structure

		first transmitted octet								next transmitted octet							
bit->	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	snu	gni	node_id						station_id								
2	next_station_id								rsv1	Tvd	topo_counter						
4	tnm_key								sif_code (= 3)								
6	parameter 1																
8	parameter 2								parameter 3						par4		
	parameter 5: ARRAY [n] OF (repeat following field (n) times)																
	parameter 5.1																
	parameter 5.2																
	parameter5.3: STRING32																
	(CHARACTER8)								last character or 0								

^octet

The bit numbering follows the representation of power of two value in a byte or word. The bit numbering does not indicate the sequence of transmission on the bus, which can be different: MSB first or LSB first.

In the graphical form, one line is used for each word of 16 bits, but in Clause 5 (WTB Link Layer Control), lines are 8-bit oriented.

Arrays of parameters are preceded by a repetition frame on the top and to its left.

Repetitions can be nested (see parameter 5.3 in Table 2).

If the size of a parameter may be longer than three words, three lines are allocated for it and the middle one has a shaded border.

Table 3 – Example of textual message form (corresponding to Table 2)

```

Call_Mgt_Message ::= RECORD
{
  snu                BOOLEAN1 (=1)      -- this '1' means that message
                                         uses system addressing
  gni                BOOLEAN1 (=0)      -- this '0' means that final
                                         is an individual device
  node_id            UNSIGNED6          -- 6-bit node address of final
  station_id         UNSIGNED8          -- 8-bit identifier of the
                                         station
  next_station_id    UNSIGNED8          -- 8-bit identifier of next
                                         station
  rsv1              BOOLEAN1 (=0)      -- this bit is always 0
  tvd               BOOLEAN1          -- this bit indicates if
                                         topography counter is valid
  topo_counter       UNSIGNED6          -- 6-bit topography counter
  tnm_key            UNSIGNED8,         -- announces a network
                                         management call message.
  sif_code           UNSIGNED8,         -- there is a different
                                         SIF_code for each
                                         Management Message
  parameter1         INTEGER16,        -- a 16-bit value. If the
                                         parameter has less than 16
                                         bits, the value is right-
                                         justified and sign-extended
                                         (e.g. one single octet is
                                         transmitted as the second
                                         octet).
  parameter2         INTEGER8,         -- this value is transmitted
                                         in the most significant
                                         part of a word.
  parameter3         UNSIGNED6         -- this value is transmitted
                                         in the least significant
                                         octet, but the lower two
                                         bits of that octet are
                                         reserved for parameter4.
  par4              ANTIVALENT2        -- parameter4 has two bits
  parameter5         ARRAY [n] OF     -- parameter5 represents a
                                         structured data to be
                                         {
                                         -- repeated n times,
                                         containing:
                                         parameter5.1      INTEGER16      -- first parameter of the
                                         repeated field
                                         parameter5.2      UNIPOLAR4.16    -- second parameter of the
                                         repeated field
                                         parameter5.3      STRING32      -- third parameter is a string
                                         (array of up to 32 8-bit
                                         characters);
                                         - a string is closed by a
                                         '0' character, or by two
                                         such '0' characters to
                                         align on a 16-bit word
                                         boundary;
                                         - a void string consists of
                                         32 '0' characters;
                                         - the actual size of a
                                         string is deduced from the
                                         number of significant
                                         characters before the zero.
                                         },
}

```

Fields names begin with a lower case letter, their type begins with an upper case. Sometimes, the same type is used as a transmission format, in which case only the first letter is upper case, and as a C-type, in which case the whole type is in upper case.

EXAMPLE 2 Am_Result (transmission format) and AM_RESULT (C-type of an interface procedure).

3.3.6 State diagram conventions

The transport protocol state machine is described as in ISO/IEC 8802-2 (Logical Link Layer) in the form of a table, which specifies the transitions between the possible states in which a state machine may be.

Transitions between states are governed by events, coming from the Network Layer (inbound packets), from the Session Layer (commands) or from time-outs.

An action depending on the event is executed before leaving the state. This action defines the next state.

Figure 3 shows an example of a state transition diagram.

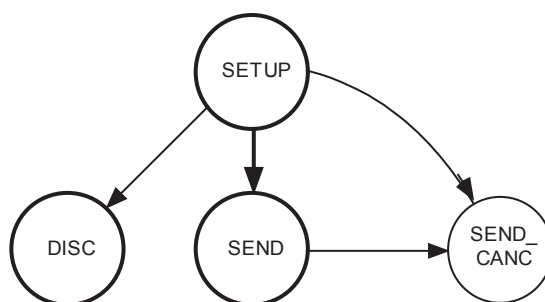


Figure 3 – State transition example

From “SETUP”, the machine may go to three different states, DISC, SEND or SEND_CANC.

The transition between these states is governed as Table 4 shows.

Table 4 – State transitions table

Current state	Event	Action(s)	Next state (if <> current)
SETUP	rcv_DR	close_send (DR_reason);	DISC
	rcv_CC AND (conn_ref = CC_conn_ref)	IF (eot) THEN close_send (AM_OK); ELSE credit:= CC_credit; send_not_yet:= credit; send_data_or_cancel; END;	DISC SEND or SEND_CANC
	TMO AND (rep_cnt = MAX_REP_CNT)	close_send (AM_CONN_TMO_ERR);	DISC

According to Table 4, there are three events which cause a transition from SETUP to the DISC state:

- rcv_DR (received Disconnect_Request, a network event). The corresponding action consists in closing the connection (close_send) before going to state DISC;
- another network event (received Connect_Confirm with correct reference), leading either to state DISC, SEND or SEND_CANC, depending on the outcome of the send_data or cancel procedure;
- A time-out conditioned by the predicate (rep_cnt = MAX_REP_CNT), which also causes the closing of the connection.

3.4 General considerations

3.4.1 Interface between equipment

This standard defines the data communication interface of equipment located in a consist as a connection of devices to a Consist network, as shown in Figure 4.

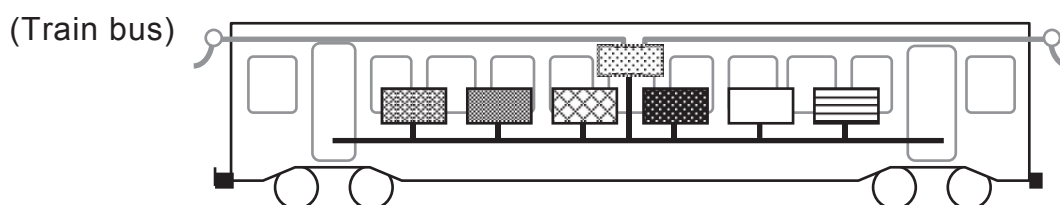


Figure 4 – Interfaces between equipment

A Consist Network is designed primarily, but not exclusively, for interconnecting equipment where interoperability and interchangeability is needed.

3.4.2 Interface between consists

This standard defines the data communication interface between consists as the connection of Nodes located in consists to a Train Bus, as shown in Figure 5.

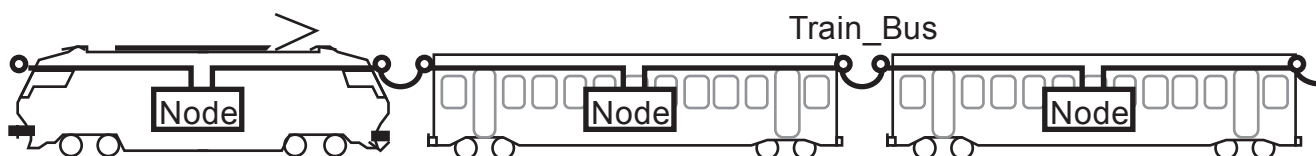


Figure 5 – Interfaces between consists

As Train Bus, this standard specifies the Wire Train Bus (WTB), a serial data communication bus designed primarily, but not exclusively, for interconnecting consists of Open Trains.

NOTE For a definition of Open Trains, see Clause 3.

3.4.3 Real-Time Protocols

This standard defines the architecture of the TCN as a hierarchy consisting of two levels, a Train Bus and a Consist network, as shown in Figure 6.

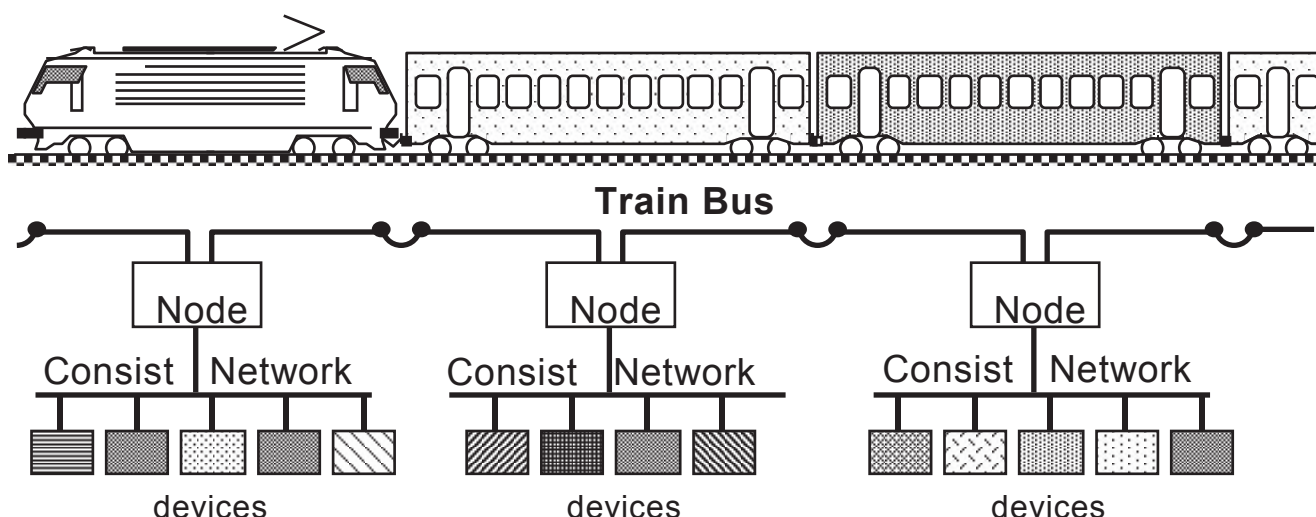


Figure 6 – Train Bus and Consist network

As communication protocols, Clause 6 of this standard specifies the Real-Time Protocols (RTP), used by all nodes on the WTB. The devices on the Consist network can use the same RTP (e.g. MVB) or adapt the Consist network protocol to the RTP of the WTB nodes.

The RTP specify the Application Interface which the TCN provides, consisting of two basic services: Variables and Messages.

The RTP specify the transmission protocols which handle in particular routing, flow control and error recovery.

The RTP specify the interface which the busses are expected to provide to the transmission protocols, and in particular the two basic services:

- a) cyclic, source-addressed broadcast of Process Data; and
- b) sporadic, connectionless transmission of Message Data.

3.4.4 Network Management

As Network Management, Clause 8 of this standard specifies the TCN Network Management (TNM) as a collection of messages exchanged between Manager and Agent to provide the basic services.

3.4.5 Configurations

This standard can be used in parts or as a whole. For instance, it is possible to use:

- a) the WTB without a consist network or with another consist network than MVB;
- b) the RTP with other busses than the WTB or the MVB.

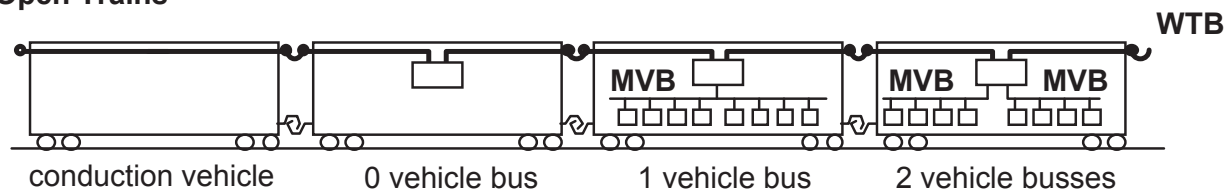
Figure 7 shows three configurations corresponding to three application domains:

- c) the Open Trains configuration shows an Open Train, such as a UIC train, which require automatic configuration. The WTB is used as the standard Train Bus, supporting up to 32 Nodes. There may be 0, 1 or more Nodes per consist. To each Node, up to 15 Consist networks (MVB or others) may be attached;
- d) the Multiple Unit Train configuration shows two connected closed trains. When these closed trains are coupled and uncoupled frequently, the WTB can be used as a standard

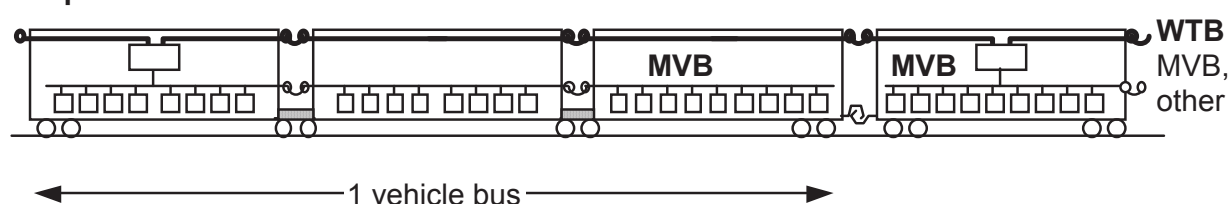
Train Bus, but when configuration by other means is possible, other busses such as the MVB can be used instead. The Consist network can span several vehicles;

- e) the Closed Trains configuration shows a closed train, in which the Consist network (e.g. MVB) can be used both as Train Bus and as Consist network.

Open Trains



Multiple Unit Trains



Closed Trains

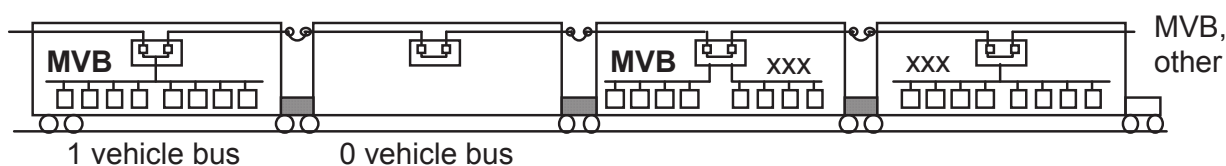


Figure 7 – TCN configurations

In all three configurations of Figure 7 the Consist network MVB is used to connect on-board equipment, but other busses may be used as Consist network.

3.4.6 Structure of a standard device

This subclause specifies permitted options in a TCN device. The options are described in the corresponding clauses and summarised in Figure 8.

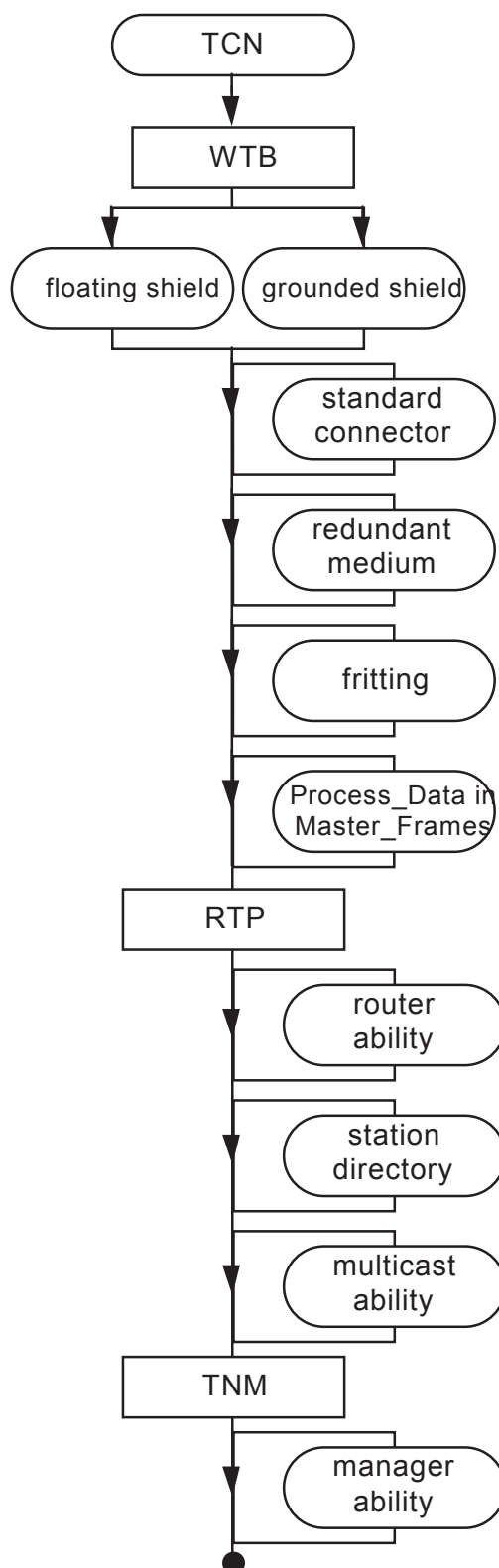


Figure 8 – TCN WTB device configuration options

3.4.6.1 TCN device

A TCN compliant WTB device shall implement at least one bus MAU for the WTB.

3.4.6.2 WTB options

A WTB MAU shall be configurable for either a floating shield or a grounded shield.

A WTB MAU may use a connector as specified in this standard.

A WTB MAU may use a redundant medium as specified in this standard.

A WTB MAU may implement fritting as specified in this standard.

A WTB MAU may transfer Process Data in Master Frames as specified in this standard.

3.4.6.3 RTP options

A TCN device shall implement the Variables services.

A TCN device, except for MVB Class 1 device, shall implement the Messages services.

A TCN device may implement the router function if it has more than one MAU.

A TCN node may implement the node directory.

A TCN device may implement the station directory.

A TCN device may implement the multicast protocol.

3.4.6.4 TNM options

A TCN device shall implement the Agent function.

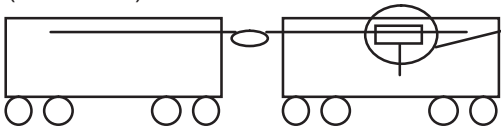
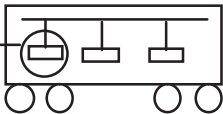
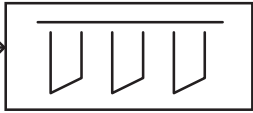
A TCN device may implement the Manager function.

3.5 Conformance test

To claim conformance to the TCN standard, devices are expected to pass a suite of tests.

To ensure that interoperability is guaranteed according to Table 5, this standard comprises a set of Guidelines for Conformance Test, which are listed in IEC 61375-2-2.

Table 5 – Interoperability testing

	COVERED BY	
	IEC 61375	End USER
Level 1 Interface between consists (Train BUS) 	PROTOCOL PHYSIC/ELEC Node connector cable specification (Z: attenuation)	USER MESSAGES MECHANICAL (connectors/cables)
Level 2 Interface between equipment (Consist Network) 	PROTOCOL PHYSIC/ELEC MECHANICAL (connectors/cables)	USER MESSAGES
Level 3 Interface between boards or Inter components 	Not covered	Not covered

4 Physical layer

This clause specifies the physical medium of the WTB as a shielded, twisted wire pair bus operated at 1,0 Mbit/s.

This standard intends that the different sections, nodes and connectors provide an electrical medium as uniform as possible in respect of signal propagation.

4.1 Topology

4.1.1 Bus sections

The WTB bus shall consist of nodes interconnected by bus sections of the following types:

- a) trunk cables running along a consist (continuity vehicles only have a trunk cable);
- b) jumper cables connecting the trunk cables of different consists;
- c) extension cables extending the trunk cable to reach a node.

4.1.2 Couplers

Connectors and junction boxes may be used to assemble nodes and cable sections.

Each consist carries a portion of the bus and a number of nodes.

4.1.3 Nodes

In regular operation, each node shall be inserted into the trunk cable and connected to two bus sections:

- a) nodes located at the ends of the bus, or End Nodes, shall electrically terminate the two bus sections attached to them;
- b) nodes located in the middle of the bus, or Intermediate Nodes, shall electrically connect the two bus sections attached to them.

The two cable sections attached to a node shall be named Direction_1 and Direction_2.

There may be one node per consist or several nodes per one single vehicle in a train, as shown in Figure 9.

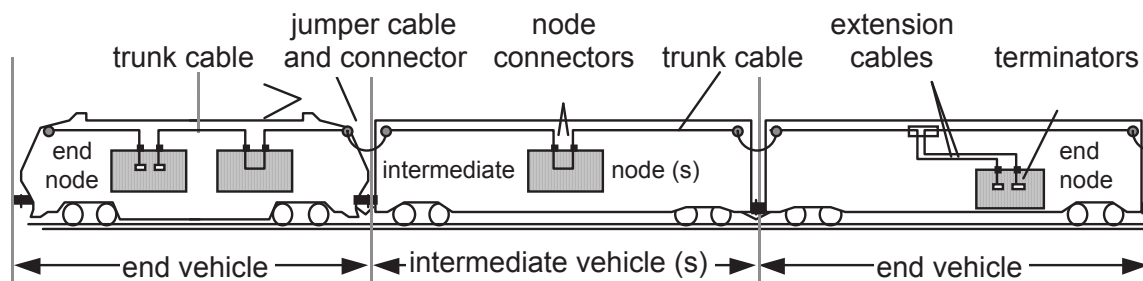


Figure 9 – Train Composition (two Intermediate Nodes shown)

4.1.4 Consist orientation

Where orientation of the nodes is critical to the left-right recognition, the following conventions shall be observed:

- a) one end of the consist is identified as Extremity 1, the other as Extremity 2;

- c) if Direction_1 points north, the side of the consist that points west is named side A, the side which points east is named side B;
- d) a node uses the same conventions for A and B as the consist it is located in.

NOTE 1 Direction_1 of one node may point either to Direction_1 or Direction_2 of another node, except if both nodes are in the same consist, since the orientation of consists with respect to one another is not predictable.

NOTE 2 Extremity 1 of a consist is the end of the consist opposite to where the parking brake is located.

4.1.5 Consist specification (informal)

Since a manufacturer may supply individual consists or nodes rather than a complete train, the specifications of the bus, the consist and the nodes are treated separately.

This standard specifies the characteristics of the whole bus and of each node. For a particular application, the consist characteristics are deduced from them. The conformance of the train is then met providing the number of vehicles, consists or nodes is not exceeded.

The following calculations apply to railway vehicles as specified in UIC CODE 556. Other applications, such as mass transit, may use a similar calculation.

The reference train composition in UIC CODE 556 consists of 22 vehicles, giving a cable length of 860,0 m without the use of repeaters. There is normally only one node per consist, but up to 10 consists composed of one single vehicle (e.g. driving trailer) may support a second node, for a total of 32 nodes.

According to 4.5.2, a node attenuates the signal by less than 0,3 dB (at the nominal frequency), the total attenuation due to the nodes will not exceed $32 \times 0,3 \text{ dB} = 9,6 \text{ dB}$.

According to 4.6.3, receivers can handle a dynamic range of 20,0 dB, the remaining attenuation over the whole train for the cable, connectors and other elements may not exceed $20,0 - 9,6 = 10,4 \text{ dB}$.

The maximum attenuation allocated to a vehicle is therefore $10,4 \text{ dB}/22 = 0,5 \text{ dB}$.

This value is measured with the node(s) removed and their connections short-circuited. The jumper cable is considered in the measurement, as shown in Figure 10.

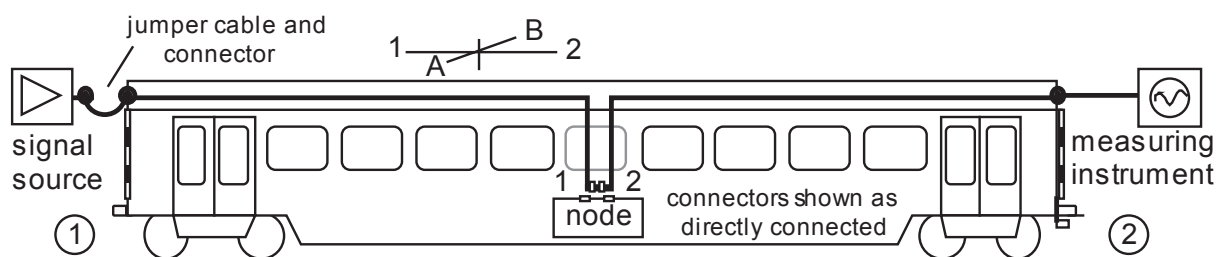


Figure 10 – Vehicle measurement

Due to meanders and extension cables, the cable length per vehicle is about 150 % of the vehicle length. Assuming a vehicle length of 26,0 m, the medium shall span a distance in excess of 860 m ($22 \times 26,0 \times 1,5 = 858,0 \text{ m}$).

To meet these requirements, the medium should present an attenuation of less than 10,4 dB/860,0 m, or 12,0 dB/km. Since jumper cables, connectors and splices may introduce a higher attenuation, a trunk cable with less attenuation than 10,0 dB/km is recommended (4.2.4).

The same principle is applicable to the other distortion parameters. The measurement scheme is explained in 4.5.2.1.

When the consist is equipped with redundant Line_A and Line_B, the test applies to each line individually.

4.2 Medium specifications

4.2.1 Topology

Nodes shall be inserted into the WTB cable, each node being attached to two bus sections, as shown in Figure 11.

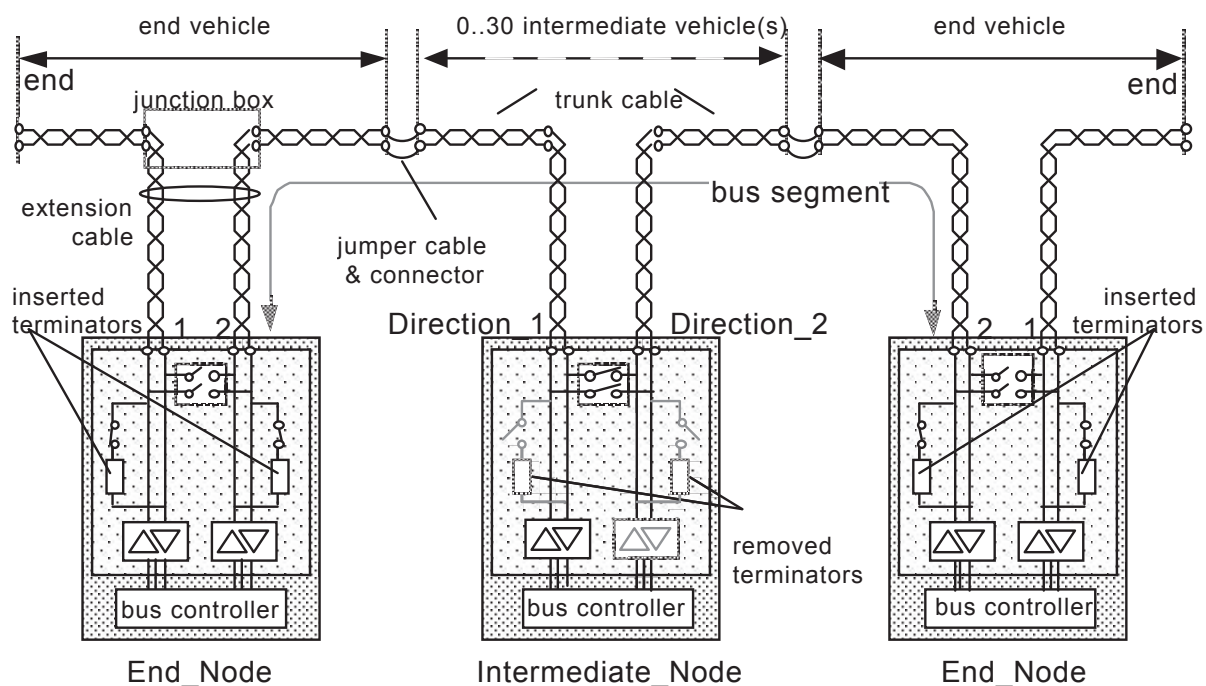


Figure 11 – Connected nodes in regular operation

A node shall be able either:

- to establish electrical continuity between the two bus sections connected to it, to perform as Intermediate Node, or
- to terminate electrically the bus sections attached to it through a terminator (impedance adaptation network), to perform as End Node.

End Nodes shall be able to send and receive over both their bus sections independently, while Intermediate Nodes shall have only one of their transceivers enabled.

4.2.2 Duplicated medium (option)

This standard defines a redundancy scheme in which each node is attached to two lines, through independent Line Units, as shown in Figure 12.