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# MODURBAN

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## MODCOMM SUBPROJECT

– DELIVERABLE REPORT –

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Responsible partner:	Thales
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## SECTION I – DELIVERABLE SUMMARY

### DATA COMMUNICATION SYSTEM FUNCTIONAL REQUIREMENTS

<b>Deliverable ID , associated WP &amp; Subproject</b>	<i>D39 MODCOMM / WP9</i>
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<b>Before start</b>		
<b>During task implementation</b>		



## DATA COMMUNICATION SYSTEM FUNCTIONAL REQUIREMENTS

**Deliverable Abstract**

The D39 deliverable define the functional requirements of the urban transit Data Communication System in order to meet all the need of operators, and such that a single communication system can be used in place of the multiple communication systems that are often used in transit systems today.

The D39 addresses all communication needs for an urban rail system. This includes providing a communication link to equipment on the trains, equipment on the wayside, equipment at stations and equipment at the OCC.

The following is excluded :

- Communication between equipment at the OCC
- Communication between/with equipment specific to the train such as motors and brakes.

The D39 addresses the communication needs of all kind of urban rail applications (Signalling, CCTV, Passenger Information, Remote Train Diagnostic, Phone, etc) and describes the communication services available on the DCS such as Throughput control, Protection against network intrusion, Maintenance access and Quality of Service.

The D39 describes also the interchangeability needs related to the DCS in order to provide a standardized interface to other subsystems on top of the communication layer of OSI level 3.

**Associated Milestone (if relevant):**

<b>Contribution to MODURBAN Objectives as mentioned in the Description of Work</b>		
<b><i>Objective Definition</i></b>	<b><i>Comments</i></b>	<b><i>Quantification</i></b>



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## SECTION 2 – DELIVERABLE DETAILED DESCRIPTION

### 1. S0 – INTRODUCTION

#### 1.1 Preamble

This section addresses the objectives of the document, the reference documents, the bibliography, the abbreviations and useful definitions.

#### 1.2 Objectives

According to the description of WP9, this D39 document (« Data Communication System Functional Requirements») has to:

- Define the functional requirements of the Communication System, and specifically the features relevant for the urban transit environment
- Meet all the need of operators, such that a single communication system can be used in place of the multiple communication systems that are often used in transit systems today.

The D39 addresses all communication needs for an urban rail system. This includes providing a communication link to equipment on the trains, equipment on the wayside, equipment at stations and equipment at the OCC.

The following is excluded:

- Communication between equipment at the OCC
- Communication between/with equipment specific to the train such as motors and brakes.

However, the on-board network for communication between radio and on-board equipment is included, and the reconfiguration of this network in case of train coupling/uncoupling is included also. In this on-board equipment, it is possible to have redundant or multiple On-Board ATC computers.

The D39 addresses the communication needs of all kind of urban rail applications (Signalling, CCTV, Passenger Information, Remote Train Diagnostic, Phone, etc) and describes the communication services available on the DCS such as Throughput control, Protection against network intrusion, Maintenance access and Quality of Service (priority, pre-emption (done by upper layers – applicative), etc).

Only the services related to security such as the service of protection against masquerade are provided by the DCS. The DCS cannot guarantee integrity of data transmission; this must be done at the application level, in particular for safety-related applications.

The D39 describes also the interchangeability needs related to the DCS in order to provide a standardized interface to other subsystems on top of the communication layer of OSI level 3.

This document will be further completed in WP9 with:

- D40. Data Communication System Performance, Reliability and Maintainability Requirements
- D41. Data Communication System Architecture.

### **1.3 References**

This first draft section is built upon:

- [DOW] Annex I - "Description of Work" DOW-MODURBAN-516380-final.pdf
- [D77] D77 Common Definition of MODURBAN Train Protection System  
MODSYSTEM\_WP21\_D77\_Deliverable report.pdf
- [D81] First MODURBAN prescriptions: overall architecture and allocation of vital functions
- [D9 UGTMS] UGTMS functions and architecture. D9\_v1.9 04-06-04.pdf
- [EN 50159-2] Railway applications – Communication, signalling and processing system  
Part 2: Safety-related communication in open transmission system  
(CEI 62280-2)
- [GL] MODURBAN Glossary. GL-0050\_RATP\_WP20
- [ISO 7498] Basic reference model for Open System Interconnection (OSI) and its two addenda  
about OSI Management & Security

### **1.4 Bibliography**

- [ESCORT, 01] "State of the Art Report" ESCORT - Deliverable D2011- project IST March 2001,  
Dr. M. Berbineau & ESCORT WP2 partners
- [CERTU 113, 01] "Communication avec les mobiles: application au trafic et aux transports routiers"  
Collections du Certu n° 113, Mars 2001, Y. David, Y. Robin-Jouan, M. Heddebaut
- [ETSI] [www.etsi.org](http://www.etsi.org) - Web site of the European Telecommunication Standards Institute
- [ANFR] [www.anfr.fr](http://www.anfr.fr) - Web site of ANFR (Agence Nationale des Fréquences)

## **1.5 Glossary**

ANFR	Agence Nationale des Fréquences (
AODV	Ad hoc On Demand Distance Vector
AP	Radio Access Point
ATC	Automatic Train Control
AVI	Automatic Vehicle Identification
AWS	Automatic Warning System
CC	Car borne Controller
CCTV	Close Circuit Television
CEPT	Conférence Européenne des Postes et Télécommunications
CIDR	Classless Inter-Domain Routing
D	D(efinition)
DCS	Data Communications System
DSU	Data Storage Unit
EC	European Community
EMC	Electromagnetic Compatibility
ERC	European Radiocommunications Committee
ERM	Electromagnetic compatibility and Radio spectrum Matters
ERTMS	European Railway Traffic Management System
ETCS	European Train Control System
ETSI	European Telecommunications Standards Institute
FFFIS	Form Fit Functional Interface Specification
FTP	File Transfer Protocol
GOA	Grade of Automation
GOA4	Unattended train operation
GSM-R	Global System for Mobile communications-Railways
HMI	Human Machine Interface
HMIP	Hierarchical Mobile Internet Protocol
I	I(nformative)
I/O	Input/Output
IL	Interlocking
IM	Interchangeable Module
IP	Internet Protocol
LAN	Local Area Network
LF	Low Frequencies
LRU	Line Replaceable Unit
M	Mandatory
MAC	Medium Access Control
MMS	Maintenance Management System
NEMO	NEtwork MObility
NMS	Network Management System
NTP	Network Time Protocol
O	Optional
OCC	Operations Control Centre
OIS	Onboard passenger Information System
OLSR	Optimized Link State Routing
OSI	Open System Interconnection
PDIU	Platform Door Interface Unit
PMR	Professional Mobile Radio



QoS	Quality of Service
R	R(equirement)
RPC	Remote Procedure Call
SCADA	Supervision, Control And Data Acquisition
SIL	Safety Integrity Level
SMTP	Simple Mail Transfer Protocol
SNMP	Simple Network Management Protocol
SNTP	Simple Network Time Protocol
SRD	Short Range Device
TCP	Transmission Control Protocol
ToS	Type of Service
TTL	Time-To-Live
TV	Television
TVM	Transmission Voie-Machine
UDP	Uniform Datagram Protocol
UHF	Ultra High Frequency
UIC	International Union of Railways (Union Internationale des Chemins de fer)
UWB	Ultra Wideband
VHF	Very High Frequency
WDCN	Wayside Data Communication Network
WiFi	Wireless Fidelity
Wimax	Worldwide Interoperability for Microwave Access
WIS	Wayside passenger Information System
ZC	Zone Controller

## **1.6 Definitions**

Basic services	Services common to almost all client services
Client services	Services offered by the DCS to equipment connected on the DCS.
Complex train	A complex train is composed of several train sets (2 or 3 in general) coupled together.
DCS degraded mode	Mode in which nominal data exchange can't take place (DCS device failure, transmission interference, ...)
DCS Interchangeability	DCS Interchangeability is a way of defining the DCS so that it can be either entirely replaced by a DCS of another supplier or extended by a supplier different from the one who provided the original DCS.
DCS failed mode	Mode in which no service is available
DCS fully operational mode	Normal mode of operation in which all services are completely supported.
DCS user	DCS user includes mobile users and fixed users.
Fixed user	User of the DCS wired to the wayside network. The user can be a human through a device or just a device.
Line Replaceable Unit	The Line Replaceable Unit is the units of each sub-system which are replaced for the Maintenance Level 1
Mobile user	User of the DCS linked to the wayside network through a wireless link. The user can be a human through a device or just a device. He can be part of a mobile network (Indirect Mobile User such as a device connected to the train network) or be directly wireless linked to the DCS (Direct Mobile User).
Mobility	The ability of a network to provide continuous communication services to mobile users.
Nominal	Intended value about which there may be statistical variation.
Quality of Service of communication (QoS)	The quality of the communication service provided in terms of guaranteed throughput, jitter, latency and packet loss.
Scalability	Scalability is the possibility to expand a line by adding equipment of the kind already in use
Seamless connections	Connections whereby the application is unaware of any OSI 2 & 3 operations being performed to support mobility.
Train set	The minimum part of a train that can be operated separately.

## 2. OPERATIONAL CONSTRAINTS

### 2.1 Introduction

This section describes the urban transit operational constraints on the DCS. These constraints are related to the train configuration, the train wake-up, the guideway configuration and the needs for future extension or evolution.

In particular, the general operational parameters which impact the dimensioning of the DCS are identified in this section in order to define a typical and a maximum configuration in the D40.

### 2.2 Train configuration

#### 2.2.1 Train consist configuration (1 or / several train set per train consist)

- I The choice of such configuration (simple train or complex train) can be either static or dynamic. For instance, complex trains can be used during peak hours and set apart the rest of the day.
- R01 The DCS shall work for any train set configuration (one or several cars). The number of cars per train set and the length of each car are defined in D40 specifications.
- R02 DCS shall provide the same nominal services for any train consist configuration (simple and complex trains). The number of train set per train consist is defined in D40 specifications.
- R03 DCS shall guarantee the same nominal performance for any train configuration (simple and complex trains).

#### 2.2.2 Physical orientation of the train in relation to the line Orienting (as/if required by the infrastructure)

- I On some lines, the orientation of trains can be different due to guideway turnaround design. So if specific frequencies, hopping sequences, or spreading codes are used for each track direction, the onboard radios must be able to work in both directions.
- R01 DCS shall not be impacted by modification of the physical orientation of a train consist.

### 2.3 “Wake up” mode

- I There are three ways of “waking up” an CC:
  - the driver prepares the train
  - the power supply is restored (Indeed a train can “fall asleep” after a long loss of power supply)
  - remotely controlled waking up. (remote control from the Operation Control Center (OCC))
- R01 DCS shall support the applicative requirement for remote controlled wake up of a train

- R02 At least one set of DCS device shall stay active during train sleeping in order to transmit wake-up remote control to onboard equipment (ATC system, others...)
- R03 During train sleeping, power consumption of on board DCS devices shall be limited. The value is defined in the D40 document.

## **2.4 Guideway configuration**

- R01 DCS shall be adaptable to more or less linear structure, junctions, branches, loops. The length and number of these structures are defined in D40 specifications.
- R02 DCS shall be adaptable to lines, stations and inter-stations of different length. The length of stations and inter-stations and the number of stations per line are defined in D40 specifications.
- R03 DCS shall be adaptable to the different line topologies: mono-tube tunnels, bi-tube tunnels, aerial lines, opened trench. The length per line of each kind of section is defined in D40 specifications.
- R04 DCS shall cope with a bigger number of trains in train parking areas. The number of trains in train parking areas is defined in D40 specifications.
- I Workshops can be located either along the line or in dedicated places.
- R05 DCS used for maintenance purpose shall not disturb the line haul when the workshop is located along the line.
- R06 DCS used for maintenance purpose shall not interfere (EMC compatible) with the specific maintenance equipments in a dedicated workshop.
- R07 DCS shall be resistant in the following operational conditions: interconnection of several lines, proximity of other lines, common stations, shared platforms.
- R08 DCS shall cope with the number of trains on the guideway during peak hours. The number of communicating trains during peak hours is defined in D40 specifications.
- R09 DCS shall cope with train density resulting from degraded operational conditions (train jamming). The density of train is defined in D40 specifications.
- R10 DCS shall cope with track section (possibly including stations) common to several lines.

## ***2.5 Needs for future extension or evolution***

### **a) DCS scalability**

I Scalability is a very important need for operators; metro lines are extended from time to time, and it is necessary that DCS could be extended without problem. The addressing should also allow an eventual interconnection at network level with another DCS.

R01 It shall be possible to plug additional external devices into the DCS

R02 It shall be possible to add additional network switches to the WDCN

R03 It shall be possible to extend the radio coverage of the DCS

R04 It shall be possible to add additional mobile users to the DCS

### **b) DCS interchangeability**

I It should be possible to change the DCS system (for a new one for example) without changing anything on the other systems. There should be no need for the operators to have different provider of MODCOMM DCS for extension of the line (no need to define internal MODCOMM interface)

R01 The DCS shall be functionally independent from other systems

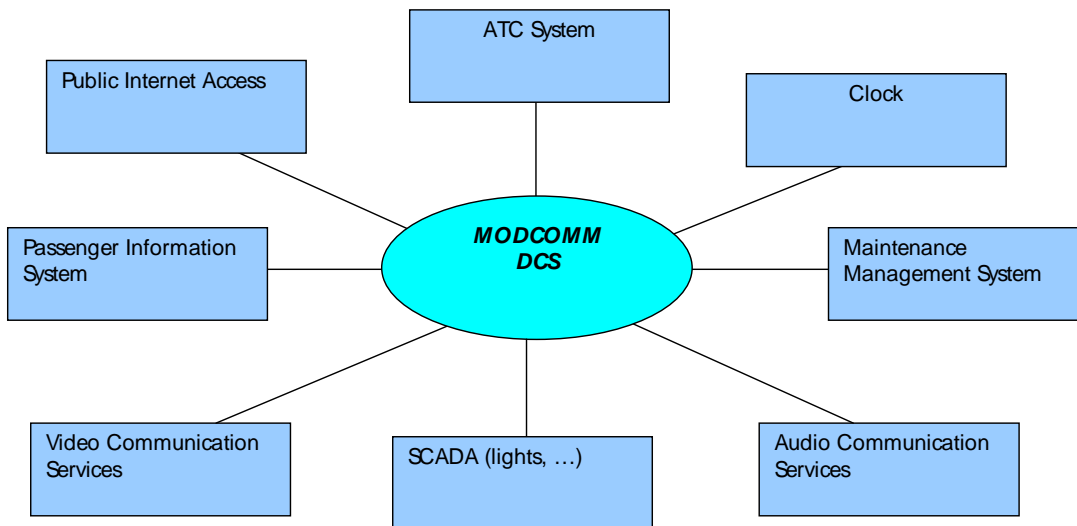
R02 DCS shall respect the OSI model for layers 1, 2 and 3. IP is considered as compliant for OSI 3.

I DCS is not required to provide interchangeability at the airgap level

### 3. CONTEXT DIAGRAMS WITH INTERFACES (CLIENT SERVICES...)

#### 3.1 Context Diagram

The following diagram depicts the MODCOMM DCS and its environment, i.e. the possible services that use MODCOMM DCS communication services.



The DCS can be in one of the 3 following modes:

- a fully operational mode
- a degraded mode
- a failed mode.

In the failed mode, the DCS is not able to ensure any transmission.

All services are expected to be completely supported in the fully operational mode, whereas some may be only partially supported in degraded mode.

The PXSS is not described in this version of the document.

#### 3.2 Client services

##### 3.2.1 Basic services

- I Some services called basic services are common to almost all client services.
- R01 The DCS shall be able to ensure communications between any fixed or mobile DCS user:
  - between mobile users
  - between fixed users
  - between fixed and mobile users.
- I The only required wireless link included in the DCS is the on-board to wayside link. Other wireless links are provided by applications outside the DCS.
- R02 The DCS shall be able to ensure communications whatever the geographical location:
  - surface

- underground
- onboard
- in stations
- along the track
- etc.

R03 The DCS shall transmit only previously digitised information.

R04 The DCS shall be able to interface with IP based applications.

### **3.2.2 ATC system**

I The ATC system is formed of the OCC, ZC and DSU ground based sub-systems and the CC train based sub-system and the Passenger Exchange Subsystem (PXSS). The ATC sub-systems exchange safety information as well as non-safety information.

R01 It shall be possible for the DCS to be configured such that ATC communications shall remain available in DCS degraded mode.

R02 The DCS shall provide mechanisms to guarantee that the ATC message content is transmitted with an error probability as defined in D40 specifications.

R03 The DCS shall provide authentication mechanisms [EN50159-2] to guarantee to the receiver of a message that the emitter identity is authentic.

R04 The DCS shall convey ATC messages in the time requirements defined in D40 specifications.

R05 The DCS shall present the reliability and availability performances for ATC defined in D40 specifications.

R06 The DCS shall provide the possibility to define a higher priority for safety data.

### **3.2.3 Passenger information system**

I This system mainly serves two purposes:

- It can inform passengers of events related to their journey through text or vocal messages ("next station", "door closing", "mind the gap").
- It can periodically inform passengers of the condition of use of the train (no smoking).

I Passenger information system is used to broadcast information to passengers within a train or on a platform, by means of an audio interface, and/or through the use of a passenger display system. The passenger information system is mostly local to the train or local to the platform.

I Its use of the DCS includes the following non-streamed data (pre-recorded messages):

- a) download of pre-recorded messages (text and audio) to update the database of the passenger information system
- b) reception of text messages in real time from the OCC for display
- c) reception of real-time commands from the OCC or CC to play audio or display a text message

Note: Depending on WP13 decision, it can be necessary also to include localisation information provided by the ATC system to the PIS.

- R01 The DCS shall support the download of text and pre-recorded audio messages from the OCC to remote passenger information systems on the trains and on station platforms
- R02 The DCS shall support real time transmission of text messages and commands to display/play a pre-recorded text-audio message from the OCC to remote passenger information systems on the train or the wayside.

### **3.2.4 Maintenance management system**

I This system is provided for maintenance teams, it provides three main services for this team:

#### **a) Configuration**

I The configuration is done either during operation or outside operation (for example during train wake-up). This configuration consists in downloading parameters used by the different subsystems while in operation.

R01 The DCS shall support the download of configuration data to any subsystem connected to the DCS.

R02 The DCS shall be able to deliver the configuration data with a minimum guaranteed bit rate defined in D40 specifications.

#### **b) Parameter retrieval**

I Subsystem parameter (measurements, status...) retrieval can take place on a regular basis (e.g. every hour) or upon request of the maintenance service team.

R01 The DCS shall be able to deliver the request of the maintenance team in specific limited amount of time defined in D40 specifications.

R02 The DCS shall support transmission of maintenance data coming from the different subsystems including the DCS itself to the Maintenance Management System.

R03 The DCS shall be able to configure statically the maximum (nominal) response time to the request of maintenance team (dynamically possible as an option).

#### **c) Alert/Warning**

I Alert/warning may be notified upon detection of an event, e.g. sub-system malfunction requesting corrective action.

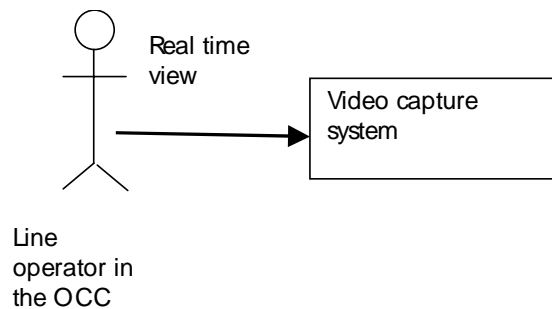
R01 The DCS shall support real-time transmission of alert/warning messages from remote subsystems to the Maintenance Management System.

R02 The DCS shall be able to manage different traffic priority levels given by the applications in relationship to the alert/warning levels.

### 3.2.5 Video Communication Services

#### Train to ground

- I Video transmission may take place from the train to the OCC, for the purpose of video surveillance of the train upon e.g. passenger alarm being pulled.
- I The Alarm is notified to the Line operator located in the OCC, who can then ask for real time view, by means of real time video transmission, of the inside of the car where the alarm happened.



- I Non real time download (video dump) for after-event analysis of a situation must also be available.
- R01 The DCS shall be able to adapt to different performances associated to different video applications (for instance, different video Codecs).
- R02 The DCS shall support the dynamical setting of the minimum and target bit rates for video streaming in the train to ground direction, for instance to fit into the remaining throughput.
- R03 The DCS shall guarantee the maximum nominal transport delay from the onboard video system to the OCC. The maximum transport delay is defined in D40 specifications.
- R04 The DCS shall be dimensioned to support steady video flows stemming from different trains driving on the same line in the same or in opposite directions. The maximum number of simultaneous video flows and the maximum number of simultaneous trains with video are defined in D40 specifications.
- R05 The DCS shall support the download of non-real time video data from the train to the OCC, regardless of where the train is on the guideway.
- R06 The DCS shall guarantee a maximum nominal packet loss rate for video streaming applications (real time) in the train to ground direction, regardless of where the train is on the guideway. The maximum nominal packet loss rate is defined in D40 specification.

#### Ground to Train

- I **The content provider** (may be internal or external to the train operator) may wish to download some information to be broadcast in loop mode in the train (e.g. advertising) this information may need to be refreshed on a periodical basis (e.g. news) in some case

real time information may be broadcast directly to the passengers (e.g. TV retransmission).

- I **The train driver** may directly view CCTV of the platform, from a display inside the driving cabin.
- R07 The DCS shall be able to adapt to different performances associated to different video applications (for instance, different video Codecs).
- R08 The DCS shall be able to broadcast video files to all trains.
- R09 The DCS shall support the transmission of video files to a predefined list of trains under the control of video application.
- R10 The DCS shall support the dynamical setting of the minimum and target bit rates for video streaming in the ground to train direction, for instance to fit into the remaining throughput.
- R11 The DCS shall support the download of non-real time video data from the OCC to the train, regardless of where the train is on the guideway.
- R12 The DCS shall guarantee a maximum nominal packet loss rate for video streaming applications (real time) in the ground to train direction, regardless of where the train is on the guideway. The maximum nominal packet loss rate is defined in D40 specification.

#### **Ground to Ground**

- I Video transmission may take place from the station to the OCC or to a Station Control Centre , for the purpose of video surveillance of the station on a permanent basis or upon user alarm being pulled.
- I **The content provider** (may be internal or external to the train operator) may wish to download some information to be broadcast in loop mode on the platform (e.g. advertising, entertainment) this information may need to be refreshed on a periodical basis (e.g. news) in some case real time information may be broadcast directly to the passengers (e.g. TV retransmission).
- R13 The DCS shall be able to adapt to different performances associated to different video applications (for instance, different video Codecs).
- R14 The DCS shall be dimensioned to support steady video flows stemming from different cameras in the station. The maximum number of simultaneous video flows and the maximum camera per station are defined in D40 specifications.
- R15 The DCS shall be able to broadcast video files to all stations.
- R16 The DCS shall support the transmission of video files to a predefined list of stations under the control of video application.
- R17 The DCS shall guarantee a maximum nominal packet loss rate for video streaming applications (real time) for ground video applications. The maximum nominal packet loss rate is defined in D40 specification.

### **3.2.6 Audio Communication services**

I Audio Communication services includes Public Address, Telephone and Radio telephony.

R01 The DCS shall support the following types of voice calls:

- point to point voice call (selective call)
- group voice call
- broadcast voice call
- multi-level priority calls
- pre-emption calls
- emergency calls.

#### **a) Train-Ground voice communication**

I Train ground voice communication shall be supported for driver to OCC communications. In the case of an unattended or driverless train, passenger can use emergency phones located inside the train to talk to the OCC, or OCC can also listen or talk to all passengers.

I Depending of WP13 results, at GOA4, DCS may need to support high integrity voice communications for use during train evacuation and other emergencies.

R02 The DCS shall be able to adapt to different performances associated to different audio applications (for instance, different voice Codecs).

R03 The DCS shall be dimensioned to support full duplex voice calls stemming from every audio sources in the train. The maximum number of simultaneous full duplex voice calls are defined in D40 specifications.

R04 The DCS shall guarantee a maximum packet loss rate for interactive audio applications in both direction, regardless of where the train is on the guideway. The maximum packet loss rate is defined in D40 specifications.

R05 The DCS shall support voice services with a delay and delay variation as specified in D40 specifications.

#### **b) Ground-to-Ground voice communication**

I The ground to ground voice communication includes application such as emergency calls on the platform and public address. No additional requirements is necessary in addition to train-ground ones.

#### **c) Mobile human users -optional**

I The audio communication service for mobile human users is the mobile phone connectivity. This service should allow to establish a phone communication whatever the location of the human user (wayside, on-board, station)

R01 The DCS shall support mobile phone connectivity for passengers and/or staff.

R02 The DCS shall support direct communication between the mobile phones of the staff.

R03 The DCS shall ensure that mobile phone connectivity for passengers cannot affect any professional services behaviour such as transmission of vital or maintenance information.

In particular, mobile phone connectivity shall not impact the network security of the DCS system.

### **3.2.7 Public Internet Access -optional**

- I Public Internet Access may optionally be offered for travelling passengers.
- R01 The DCS shall support an easy connection for passengers to the Internet (through additional hot-spot for example).
- R02 The DCS shall offer to the passengers an Internet throughput defined in D40 specifications.
- R03 The DCS shall ensure that public internet access cannot affect any professional services behaviour such as transmission of vital or maintenance information. In particular, public internet access shall not impact the network security of the DCS system.

### **3.2.8 Supervision, Control and Data Acquisition**

- I The SCADA allows remote supervision and control of remote devices such as fans, lights, escalators, lifts, power supplies, on-board heating.
- R01 The DCS shall transmit to the supervision system, the status coming from remote devices either periodically, or on demand, or on status change.
- R02 The DCS shall transmit to the remote devices, the commands sent by the supervision system.

### **3.2.9 Clock**

- I A clock external to the DCS provides the time for all the system.
- R01 The DCS shall transmit the time information as needed by the devices connected on the DCS.
- R02 The time of the DCS shall be synchronized with the time information provided by the external clock.

### 3.3 Interface Diagram

The interface to the other subsystems is on top of the network layer (OSI level 3). Any devices directly connected to the DCS will include the 3 lower layers defined by the MODCOMM subproject.

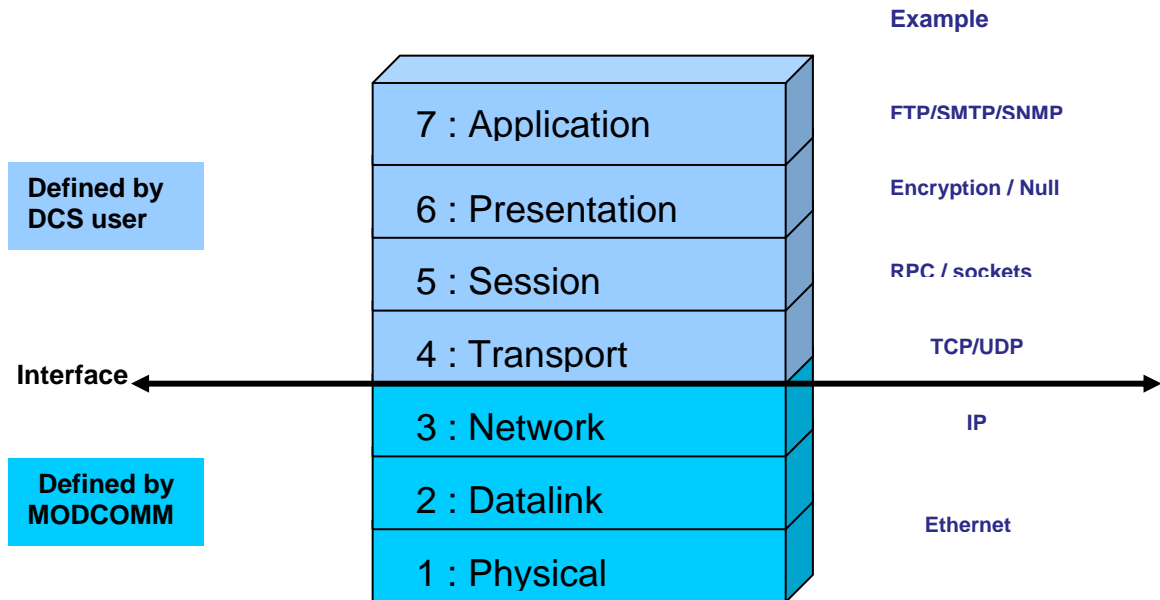


Fig.1 Interface diagram

The air-gap is internal to the DCS and will not be specified.

## 4. GENERAL REQUIREMENTS

### 4.1 DCS independency

- I The DCS is intended to be a stand-alone communications system and as such must manage the communications functions entirely with information obtained from within the DCS itself and cannot rely on outside sources of information. This is an essential quality for the DCS to provide authentication services for transmitting data from trusted sources.
- R01 The DCS shall consist of a communications network that is independent of the applications that will use it.
- R02 The DCS shall not require any information about the application equipment or the location and movement of this equipment (e.g. train locations).
- R03 Application equipment shall not require any information about the DCS network in order to perform its intended functions, other than the assignment of IP addresses.
- R04 Information generated by the DCS network for external use shall only be for network management purposes such as monitoring network performance and diagnosing failures in DCS component devices

### 4.2 Safety

- I The DCS has the capability to provide secured links. However, safety-related applications can provide their own security mechanism.

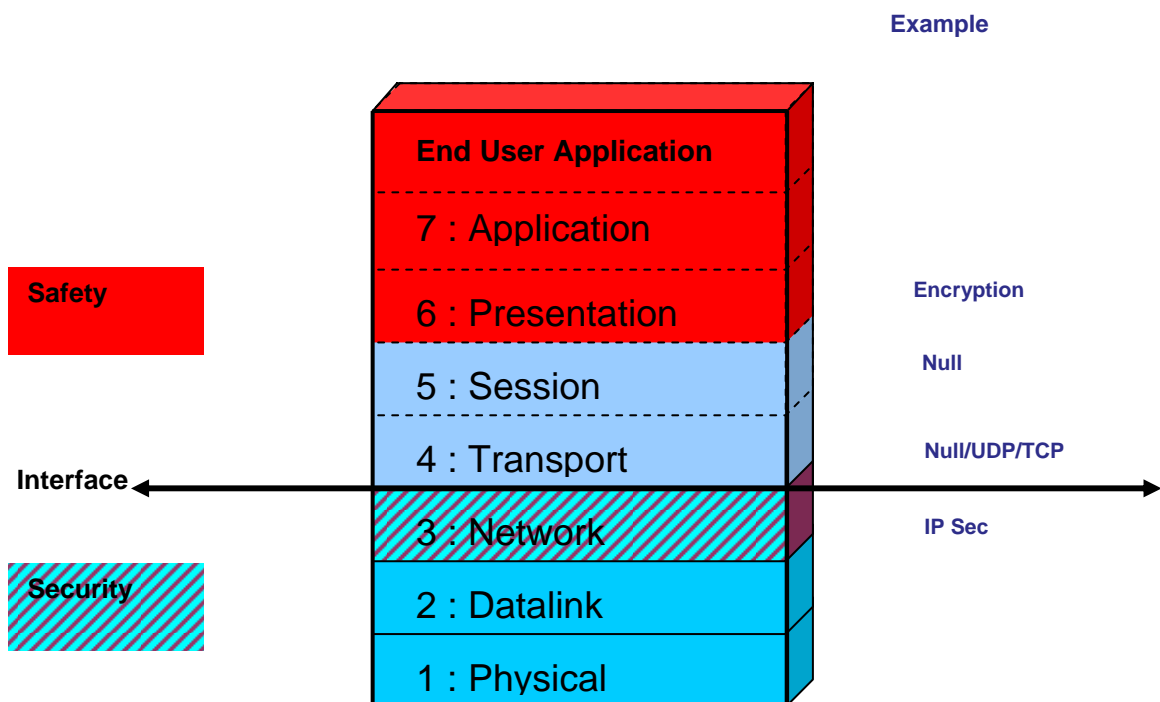


Fig.2 Security and Safety Model

- I The DCS is intended to be a communication system for which there are no intrinsic safety functions.
- R01 The DCS shall be classified as non-vital and have a SIL level of 0.
- I The DCS shall be considered by the applications as an open transmission system, a system whose characteristics are unknown or partly unknown. (Reference: EN 50159-2 and IEC 62280-2)
- I The DCS shall be considered by the client applications as absolutely untrustworthy. Therefore;
  - a) Any data packet received from the DCS network may contain any number of bit errors up to and including completely random data.
  - b) The DCS may introduce independent and random delays in data packet delivery up to and including an indefinite delay (i.e. lost packet).
  - c) The DCS may repeat, re-sequence the data packets transmitted, or insert extra data. (Reference: EN 50159-2 and IEC 62280-2)

### **4.3 Security**

- I The DCS is an open communications system as defined by CENELEC 50159-2 primarily because of the radio link. Therefore an authentication service must be provided to defend against emulation
- R01 The DCS shall provide both secure and unsecure communication links.
- R02 The DCS shall provide authentication services as a means for securing the data communications against eavesdropping and masquerading.

### **4.4 Network and radio organisation**

#### **4.4.1 Mobility**

- I Mobility is essentially aimed at managing the network addresses of the mobiles according to their current attachment to the fixed network. Applicative and physical addresses remain the same.
- D Three kinds of mobility are classically distinguished:
  - o Terminal mobility : an example is Mobile IP
  - o Sub-network mobility (a mobile node is used as a gateway): a mobile sub-network is a group of users with a specific node used as a gateway. An example is NEMO (IP Network MObility)
  - o Unrestricted mobility (any node can become a terminal, and any terminal can be used as a node): an example is Ad-Hoc networks (AODV and OLSR standards).
- R01 The DCS shall support terminal mobility and sub-network mobility.

- R02 The DCS shall provide continuous communications with mobile terminals and mobile sub-networks.
- R03 True seamless connections shall be provided to cope with critical applications like ATC or voice. The objective is no operational interrupt. The performance goal will be defined into D40.
- R04 The DCS shall manage mobility for train speeds up to 120 km/h.
- I Mobility at high speed imposes a cooperative effort of switching and transmission layers. An IEEE 802 trend is “L2.5 routing”, with a contribution of both L3 (routing) and L2 (transmission) Layers. In the same way, IP mobility which is not efficient enough, is now evolutive towards hierarchical mobility (HMIP v6).
- D Network mobility means mobility at switching/routing level, based on network addresses. An example is current IP mobility.
- D MAC-mobility or Micro-mobility means mobility at transmission level, based on MAC addresses.

#### **4.4.2 Addressing plan**

- D An addressing plan is a policy used with a distributed system to assign addresses to every device which communicates.
- I Most frequently, an addressing plan is multi-layered, i.e. involves for each DCS user a set of hierarchical addresses:
  - o applicative or logical addresses, as known by applications
  - o network addresses, used by the network
  - o MAC addresses, used by wired LANs or radio bubbles for transmission purpose
  - o physical addresses, registered at equipment level.
- I Communication functions are directly based on an addressing plan. Communication layers (transmission and switching) of a network currently use allocation mechanisms in the nodes, which are running on tables associating physical, MAC addresses and network addresses - but not applicative addresses.
- R01 The DCS shall be able to transfer packets between any DCS users using their current network or sub-network addresses.
- I The DCS shall not use the applicative addresses which are fully managed at the applicative level. Applicative to network address correspondence will not be implemented into the DCS, but into the applications or into the couplers of servers and terminals.
- R02 The DCS addressing plan shall take into account the multiple connections of redundant equipment.
- I The DCS is not in charge of the correspondence between the applicative address and the multiple network addresses of any redundant application or equipment.
- R03 The addressing plan of the DCS shall be defined by the DCS provider taking into account the user needs.

An addressing plan is proposed hereafter, for network and physical levels.

#### **4.4.3 Address allocation policy (Network level)**

- R01 The network allocation policy shall involve up to 4 fields:
- Address of network
  - Address of subnetwork
  - Address of user (i.e. connected device)
  - Spare field (for extension or for compatibility with existing legacy networks)

Net @	Sub-net @	Spare	User @
-------	-----------	-------	--------

Typically, one or few bytes should be given to each field.

- I As an example, an IP v4 addressing scheme may be considered. IP v6 conversion into compatible addresses should be possible later on.
- I With IP v4, a class B addressing plan is sufficient for small deployments, but CIDR should be necessary for large deployments.

#### **4.4.4 Address allocation policy (MAC and physical levels)**

- I Fixed devices have to comply to conventional rules of open wired networks. So this policy will apply mainly to mobiles users. Typically 8 to 16 active users are considered per train. “Active” only refers to the DCS train to trackside communications (other users can be present for on-board communications that remain local).

- R01 DCS shall support the use of MAC addresses within LANs, e.g. Ethernet addresses.

#### **4.4.5 Addressing mode**

- I DCS users may use four kinds of addressing modes:
  - Unicast (network and applicative level)
  - Multicast (network and applicative level)
  - Broadcast (network and applicative level)
  - Geographical (applicative level only).

The following requirements are only related to the network level:

- R01 The DCS shall provide for Unicast, Multicast, and Broadcast transmission capability, to be used by the applications as needed.
- R02 Application requiring authentication are restricted to Unicast mode.

#### **4.4.6 Radio channel organization**

- I The radio channel organisation refers to the way that radio resources should be managed inside a given frequency band allowed to DCS. Some following requirements should be taken into account:
  - R01 DCS radio resources shall be able to support the global information flow related to different types of messages.
  - R02 DCS shall be able to manage single share channel or multiple radio channels related to multiple services to mobiles according to regulatory constraints.
  - R03 In order to allow multiple users in a given geographic area, DCS shall manage radio resource in order to allow multiple communication links for a given wayside radio area.
  - R04 The radio resources management shall allow overlap of wayside radio areas including:
    - o junction between many lines,
    - o adjacent or redundant radio areas.

#### **4.5 Frequency allocation**

- I The frequency allocation refers to frequency band which should be allowed to operators in order to develop DCS. Following preliminary analyses could be necessary to give some guidelines requirements.

The frequency bands used in Europe vary from a country to another due to the fact that, until a recent period, railway engines movements were restricted to the national area [Appendix A]. Trains are travelling yet through different countries and the need of a common frequency band to allow interchange-ability becomes necessary also for a DCS system.
- I Three steps are necessary to implement a new application or equipment implying the use of a frequency band [ANFR]:
  - seek a suitable frequency band,
  - homologation of equipments,
  - ask for authorization of a given frequency band.
- I The attribution of a frequency is accompanied by the attribution of the authorized band or bandwidth to an identified user for a given service, may be on a given area. An authorization generally specifies an emission class (power, directivity, duty cycle, kind of modulation, information, signal etc.) [ETSI].
- R01 External DCS interfaces shall be defined in order that the DCS shall be independent from the radio resource allocation.
- I There are no specific restrictions on the frequency band that the DCS must use. However, because of the capacity, the frequency must be high enough and because of the propagation conditions (coverage, multipath, etc.) in different environment (free area, open trenches, viaduct), the frequency mustn't be too high. The tendency is to increase the frequency band used by wireless systems (e.g. Wifi around 2.4 or 5 GHz, Wimax up to 11 GHz, UWB up to 10 GHz or Radar System from 10 to 24 even 77 GHz).
- I The relatively low frequencies (VHF) have a good propagation (except inside tunnels) provide a relative low capacity, emissions are not very directive and it is difficult to control their range within regulatory constraints. Higher frequencies could provide a high capacity, have a better signals directivity but they are sensitive to masks.
- R02 The DCS shall be able to work in any Radio-Frequency channel belonging to the frequency range from 300 MHz to 20 GHz.

- R03 The DCS may operate at any frequency band that is suitable on regulatory or physical constraints.

#### **4.6 Environmental**

- I Nowadays, in the guided transports field, electronic and digital commands tend to replace electromechanical commands. This evolution concerns the driverless systems. Moreover, The multiplication of wireless communication systems, the presence of low power electronics on board the trains and a great number of different communications systems on the underground environment have increased the perturbation risks. Electromagnetic problems are created but also those related to system safety operation. Sensibility to electromagnetic disturbances could affect automatism availability and safety. It is then, necessary to avoid equipment sensibility to disturbances and to verify that it will not behave as a new electromagnetic pollution source [ESCORT, 01].
  - I In 1992 EMC recommendations appeared. The analyses of DCS have to be performed regarding the electromagnetic characteristics of the environment where the system will be deployed.
  - I In Europe, ETSI has performed some EMC standards applicable in the field of railway transport system. The electromagnetic compatibility aspect and the related studies are a mandatory stage when implementing a telecommunication system such as DCS because this will lead to a better immunity for the electronics and digital systems on board [ETSI].
- R01 DCS shall fulfill the following standards requirements edited in the field of railway systems:
- EN 61000- xx-xx related to Electromagnetic compatibility (tests and methods)
  - ETSI EN 300 330-1 Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Device (SRD); Radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the range 9 kHz to 30 MHz;  
Part1: Technical characteristics and test methods (Temperatures, external conditions, frequencies, radiating power, etc.)
  - ETSI EN 301 489-3 Electromagnetic compatibility and Radio spectrum Matters (ERM); Electromagnetic compatibility (EMC) standard for radio equipment and services;  
Part 3: Specific conditions for Short Range Device (SRD) operating on the frequencies between 9 kHz and 40 GHz.
  - EN 50121-(1/2/3/4) Railway applications - Electromagnetic compatibility (EMC) –  
Part 1: Generalities,  
Part 2: Emission of the railway system towards the external world,  
Part 3: Rolling stock,  
Part 4: Emission and immunity of the signalling and telecommunications apparatus,  
Part 5: Emission and immunity of fixed installations.
  - EN 50125- (1/3) Railway applications – Environment conditions for equipment –  
Part 1: Equipment on board rolling stock,  
Part 3: Equipment for signalling and telecommunications.

## **5. FUNCTIONAL REQUIREMENTS**

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## **5.1 Communication functions**

### **5.1.1 Overall**

#### *General requirements*

- R01 The DCS shall allow communication between each client connected to the DCS.
- R02 There shall be a master clock supplied to the DCS compliant with NTP or SNTP standards.
- R03 DCS devices' clocks shall be synchronised with the master clock.
- R04 Communication between NMS (refer section 5.2 for detailed NMS requirements) and DCS devices shall comply with SNMP standard.

#### *Functional requirements*

- R05 The DCS shall supply following functions:
  - Support end-to-end communication
  - Configure the system
  - Administrate the system
  - Monitor the system

#### *Support end-to-end communication*

- R06 The DCS shall support that the data are transmitted knowing only the address of the destination, provided by the source.
- R07 The mobility between wayside and carborne clients shall be managed by the DCS. (refer section 4.4.1 for detailed mobility requirements).
- R08 During operation, topology reconfiguration due to a DCS failure shall not exceed a maximum duration defined in D40 specifications.
- R09 The DCS shall provide a nominal data throughput and nominal delay.

#### *Configure the system*

- R10 It shall be possible to remotely access and modify any parameter of DCS devices, from the NMS to an authorised staff.

#### *Administrate and monitor the system*

- I This part lists overall communication requirements about the administration and the monitoring of the DCS (The detailed requirements are addressed in the Network Management System section 5.2).
- R11 The DCS shall permanently provide the status of all its equipment to the MMS.
- R12 The DCS shall be able to locate (e.g. in which station, in which Signalling room...) its LRU.



*DCS operation requirements*

- R13 The DCS shall be able to operate, after configuration, without operator intervention, except in case of fault.
- R14 Communication shall operate even if the network supervision system is disconnected or failed.
- R15 DCS shutdown time should be not greater than a value quantified in D40 specifications.
- R16 DCS start-up time should be not greater than a value quantified in D40 specifications.

*Expandability requirements*

The detailed expandability requirements are defined in section 2.5.



**5.1.2 Ground to Ground**

R01 The main parameters for the ground to ground communication are:

- Secure: The related link shall be secure (Yes/No)
- Applicative priority (for detailed requirements refer to section 5.3),
- Data rate in term of value, type (Sporadic, Periodic, Continuous) and scope,
- Delay variation: maximum variation of delay. This parameter is important to video and audio quality.
- Delay: maximum transmission time inside the DCS from the first bit transmitted by application to the first bit received by application
- Msg Error Tolerance: Maximum error per message accepted by the application (time and/or percentage)

These parameters are affected to each ground to ground communication link in the following table.

Client Services	Link		Mandatory/Optional For user	Secure	Applicative priority	Data rate			Delay	Delay variation	Msg Error Tolerance
						Value	Type	Scope			
<b>ATC system</b>											
	ZC	ZC	(1)	(1)	(1)	(1)	(1)	per ZC	(1)	(1)	(1)
	OCC	ZC	(1)	(1)	(1)	(1)	(1)	per ZC	(1)	(1)	(1)
	DSU	ZC	(1)	(1)	(1)	(1)	(1)	per ZC	(1)	(1)	(1)
	OCC	DSU	(1)	(1)	(1)	(1)	(1)	per DSU	(1)	(1)	(1)
	OCC	New IL	(1)	(1)	(1)	(1)	(1)	per New IL	(1)	(1)	(1)
	PDIU	OCC	(1)	(1)	(1)	(1)	(1)	Per PDIU	(1)	(1)	(1)
<b>MMS</b>											
	MMS	ZC	(1)	(1)	(1)	(1)	(1)	per ZC	(1)	(1)	(1)
	MMS	DSU	(1)	(1)	(1)	(1)	(1)	per DSU	(1)	(1)	(1)
	MMS	OCC	(1)	(1)	(1)	(1)	(1)	per OCC	(1)	(1)	(1)
	MMS	WIS	(1)	(1)	(1)	(1)	(1)	per WIS	(1)	(1)	(1)
	MMS	New IL	(1)	(1)	(1)	(1)	(1)	per New IL	(1)	(1)	(1)
	MMS	PDIU	(1)	(1)	(1)	(1)	(1)	per PDIU	(1)	(1)	(1)
	MMS	NMS	(1)	(1)	(1)	(1)	(1)	per NMS	(1)	(1)	(1)
<b>Video transmission</b>											
	Video Station	OCC	(1)	(1)	(1)	(1)	(1)	per camera	(1)	(1)	(1)
<b>Audio transmission</b>											
	Audio Station	OCC	(1)	(1)	(1)	(1)	(1)	?	(1)	(1)	(1)
	Audio Station	Audio Station	(1)	(1)	(1)	(1)	(1)	?	(1)	(1)	(1)
<b>Passenger information system</b>											
	WIS	OCC	(1)	(1)	(1)	(1)	(1)	per WIS (2)	(1)	(1)	(1)
<b>SCADA</b>											
	SCADA	OCC	(1)	(1)	(1)	(1)	(1)	per station (3)	(1)	(1)	(1)
<b>Public Internet access</b>											
	?	?	?	?	?	?	?	?	?	?	?

- (1) value defined in D40
- (2) data rate based on the number of platforms
- (3) data rate based on the average number of I/O in a station

**5.1.3 Train to Ground**



**Definition of the captions:**

**Mandatory (M) / Optional (O)**

R01 The main parameters for the train to ground communication are:

Client Services	Link		Mandatory/ Optional for user	Secure	Applicative priority	Data rate			Delay	Delay variation	Msg Error Tolerance
	Train	Ground				Value	Type	Scope			
<b>ATC system</b>											
	CC	ZC	M	(1)	(1)	(1)	(1)		(1)	(1)	(1)
	CC	OCC	M	(1)	(1)	(1)	(1)		(1)	(1)	(1)
	CC	DSU	M	(1)	(1)	(1)	(1)		(1)	(1)	(1)
<b>MMS</b>											
	OIS	MMS	O	(1)	(1)	(1)	(1)		(1)	(1)	(1)
	CC	MMS	M	(1)	(1)	(1)	(1)		(1)	(1)	(1)
<b>Video transmission</b>											
	Train Video	OCC	O	(1)	(1)	(1)	(1)		(1)	(1)	(1)
<b>Audio transmission</b>											
	Audio in Train	OCC		(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
<b>Passenger information system</b>											
	OIS	OCC	O	(1)	(1)	(1)	(1)		(1)	(1)	(1)
<b>Other</b>											
	Public address	?	O	(1)	(1)	(1)	(1)		(1)	(1)	(1)

(1) value defined in D40

**5.1.4 Train to Train (independent from coupling)**

R01 The main parameters for the train to train communication are:

Client Services	Link		Mandatory/ Optional for user	Secure	Applicative priority	Data rate			Delay	Delay variation	Msg Error Tolerance
	Mobile	Mobile				Value	Type	Scope			
	Mobile	Mobile	O	(1)	(1)	(1)	(1)		(1)	(1)	(1)

(1) value defined in D40



**5.1.5 Communications within train and between coupled trains**

**Definition of the captions:**

**Mandatory (M) / Optional (O)**

R01 The main parameters for the train to train communication are:

	Link		Mandatory/ Optional for user	Secure	Applicative priority	Data rate			Delay	Delay variation	Msg Error Tolerance
	Train	Train				Value	Type	Scope			
<b>Client Services</b>											
<b>ATC system</b>											
	CC	HMI	M	(1)	(1)	(1)	(1)		(1)	(1)	(1)
	CC	CC	M	(1)	(1)	(1)	(1)		(1)	(1)	(1)
	CC	Public Address	O	(1)	(1)	(1)	(1)		(1)	(1)	(1)
	CC	Train video	O	(1)	(1)	(1)	(1)		(1)	(1)	(1)
	CC	OIS	O	(1)	(1)	(1)	(1)		(1)	(1)	(1)

**5.2 Network Management System**

- I Network management covers any service data exchange inside the communication system and can be divided into:
  - o System level management (on a global basis)
  - o Communication layer management (specific to each layer).

R01 The DCS shall provide Management facilities for physical, transmission and network layers. These three layers shall be mediated at management level, i.e. diagnostic, control and measurement data shall be transferred to/from management level.

As a consequence, radio devices and wireless protocol modules shall be mediated.

- D From the standard point of view, 5 functional areas of Management are considered:
  - o Configuration management
  - o Fault and reconfiguration management
  - o Performance management
  - o Accounting management
  - o Security management.

Accounting management is not concerned with MODCOMM.

R02 Configuration management, fault & reconfiguration management, performance management and security management shall be provided by the DCS.

R03 Management should be a distributed facility, potentially available anywhere from the network, on an open platform.

R04 Secondary Management platforms may be delegated with limited rights, to specific areas or functions (e.g. Maintenance), on the responsibility of the Main management platform.

R05 No delegation shall be given for security management.

- R06 The management of the DCS shall be based on SNMP protocol (using UDP/IP layers).
- R07 Every communication device shall provide the facility to locally be configured by means of, at least, one standard fast interface (e.g. Ethernet).
- R08 Every communication device shall provide the facility to remotely be configured by using the DCS resources.

### **5.3 Traffic prioritisation**

- I Traffic prioritisation is used when multiple applications are present and the DCS has insufficient throughput to support all the demands.
- I Applicative priorities are relevant to applications. The DCS interfaces at OSI 3, therefore does not know a lot about applications. The DCS is concerned by traffic priority management but not by applicative priorities.
- I Traffic prioritization is currently effected through QoS mechanisms (Quality of Service) at network layer level.
- R01 The DCS shall provide a scheme for prioritising the traffic offered by the applications. This shall be at least equivalent to that offered by the maximum ToS provided in IPv4
- I Upper layers are relevant to the mapping of applicative priorities into traffic priorities. This mapping operation can be under the control of the couplers between servers (or users) and the network: this is currently the case for voice or video over IP. With IP v4, ToS values can be pre-loaded by the applications.
- R02 The DCS shall be able to set and change the priority attached to a communication flow by one or several of the following means:
  - at the level of the Network Management System by the operator,
  - automatically by the Network Management System (table change of application priorities) to reconfigure the DCS in degraded mode,
  - by the application using QoS facilities.

### **5.4 Interchangeability**

- D Interchangeability is capability to ensure communication between various IMs through their FFFIS (as defined in D81) whatever the IM's supplier.
- R01 DCS shall establish its physical addressing structure only from client's IM (e.g. vehicle number) and in a static way. Physical addressing shall not depend on external parameters, like vehicle position.
- R02 Physical addresses shall be defined uniquely across the whole fleet. In particular, IM suppliers shall ensure that they do not use a physical address that could be used by another supplier.
- R03 DCS shall support a QoS (Quality of Service) field in exchanged messages. The QoS field shall be used for message classifying under degraded conditions.
- R04 The DCS components behaviour for each QoS supported value shall be clearly defined and maintained across all suppliers.

- R05 DCS shall support broadcast addressing.
- R06 DCS shall support multicast addressing.
- R07 DCS shall implement a mechanism that destroys messages that can not be transferred in a given amount of time (see D40). This should be implemented like the TTL field in IP.

### **5.5 Redundancy and availability**

- R01 The DCS network shall include sufficient redundancy of equipment to ensure the availability of any one circuit between any two pieces of application equipment is met.
- R02 The entire DCS network shall be configured to recover from a single point equipment failure within a maximum time defined in D40 specifications.

### **5.6 Other functions**

- I This section contains other functions related to the communication system and the devices involved, but not related to any of the previous functions.

#### **5.6.1 Low consumption in power saving mode**

- I The proposal of this function is to minimise the energy consumption of the devices involved in the communication systems, mainly when connected but not performing any operation. This function is only applicable to onboard devices.

##### **- Requirements**

- R01 Every onboard communication device shall enter in 'power saving mode' after a configurable time without the application detecting activity.
- I After entering in 'power saving mode', only interfaces to re-enter in 'normal mode' will be working.
- R02 When the application of a communication device in 'power saving mode' detects any type of activity in their interfaces, it shall re-enter in 'normal mode' (fully in service) before a defined time.

#### **5.6.2 Downloading capacity**

- I In order to improve the DCS maintainability, it is necessary to provide specific requirements to update and / or upgrade firmware for every device, specially for those with difficult access.

##### **- Requirements**

- R01 Every communication device shall provide the facility to locally be upgraded (firmware version) by means of, at least, one standard fast interface (e.g. Ethernet).



- I The software selected to update and/or upgrade the DCS devices is not necessarily standard, but recommended. Proprietary software can be used.
  
- R02 Every communication device shall provide the facility to remotely be upgraded (firmware version) by using the DCS resources.

## **APPENDIX**

### **A. FREQUENCY ALLOCATION DETAILS**

The main bands used in France for railway applications are the following:

- Low-VHF band 70 - 88 MHz,
- high-VHF band 155 - 220 MHz,
- low-UHF band 420 - 470 MHz,

and specific allocation:

- frequency band of 2,4 GHz for RATP Line 13 ATC,
- frequency band of 5,9 GHz for RATP Lines 3, 5, 9, 10 and 12 ATC,

For the European railways, the frequency allocation of 457 - 468 MHz (UHF) band was obtained by the UIC from the CEPT.

In Europe the UHF frequency range 876-880 MHz and 921-925 MHz (2 x 4 MHz bandwidth) has also been obtained from CEPT by UIC. It is used for GSM-R protocol based for train control command systems. This is based on the ERC recommendation T/R 25-09 for the radio segment of the current ERTMS. RATP uses already MOBITEX system whose frequency band is 900 MHz.

The EC Interoperability Directive on High Speed International Trains implies also frequency allocation also for the sub-system EUROBALISE and EUROLOOP involved in ERTMS/ETCS. For EUROBALISE an uplink at 4,24 MHz and a downlink at 27,095 MHz (HF) are considered. In the same way, RATP equipments use KVB system with 27 MHz uplink frequency and 4,5 MHz downlink frequency.

In Germany, beside ETCS frequencies, several frequencies in the range from 50 kHz to 850 kHz are used for intermittent train control (e.g. INDUSI, ZUB).

In England, AWS (Automatic Warning System) system is used to perform transmission for train speed control from side to the board (uplink LF frequency is 147 kHz and downlink LF frequency is 73,5 kHz).

In France, main operators in Paris, RATP and SNCF are sharing some frequencies band. A lot of new transmission systems are today available and could answer some of the underground needs.

The frequency allocations for the others systems or equipment are around:

- about 100 Hz for magnetic coupling system ("transmission ribbon", "crossed wired" used to allow transmission between PCC and the train)
- 450 MHz Radio Services (speech and telecontrol) for international railway traffic, PMR system (380-470 MHz TETRA(POL) system used by SNCF to assume security in the network)
- 900 MHz Radio communications for PMR system (3-RD Mobitex) or GSM-R,
- 1,8 GHz, 2 GHz for transmission from the side to board e.g. TVM 430 of SNCF,
- 2,45 GHz, (5,8 GHz) for AVI (Automatic Vehicle Identification) systems in railways,
- 5,915 – 5,935 GHz granted by ART to SNCF (Freight security) and RATP (Mass transit ATC)
- 9,9 GHz for RATP system: SACEM used for exploitation and maintenance,
- and also 60 GHz.