# MODURBAN

## FP6 Project: TIP4 – 2005 – 516380

## EC Contract n°: 516380

# MODCOMM SUBPROJECT

## – DELIVERABLE REPORT –

| | |
|---|---|
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| Deliverable Title: | DATA COMMUNICATION SYSTEM PERFORMANCE, RELIABILITY AND MAINTAINABILITY REQUIREMENTS |
| Responsible partner: | Thales |
| Contributors: | WP9 Partners |

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## Approvals

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## Documents history

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| V1 | 050916 | First draft proposed by WP9 partners | WP9 Partners |
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| | | | |
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| V7A | 060908 | Tenth draft proposed by WP9 partners | WP9 Partners |
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# SECTION I – DELIVERABLE SUMMARY

| DATA COMMUNICATION SYSTEM PERFORMANCE, RELIABILITY AND MAINTAINABILITY REQUIREMENTS | |
|---|---|
| | |
| **Deliverable ID , associated WP & Subproject** | *D40*<br>*MODCOMM / WP9* |
| **Type of Deliverable** | *Reference document* |
| | |
| **Input / Starting stage** | |
| **Output / Final stage** | |

| **Lead partner(s)** | |
|---|---|
| | |
| **Achievement to date (%)** | 100 % |
| **Expected date of achievement** | |
| | |
| **Type of exploitation** | *Input for potential DCS suppliers* |
| **Exploitation potential** | |
| | |
| **Protection** | *Not relevant* |
| **Protection date** | *Not relevant* |

| ***IP's*** | ***Partners, (type, identification, date)*** |
|---|---|
| **Pre-existing Know-How** | *Not relevant* |
| **Exploitation Rights** | *Not relevant* |

| ***Associated Risk analysis*** | ***Type, solution envisaged, action, actors*** | ***Actual Reduction*** |
|---|---|---|
| **Before start** | | |
| **During task implementation** | | |

# DATA COMMUNICATION SYSTEM PERFORMANCE, RELIABILITY AND MAINTAINABILITY REQUIREMENTS

***Deliverable Abstract***

The D40 deliverable defines the performance, reliability and maintenance requirements of the urban transit Data Communication System.

The D40 includes an analysis of the overall capacity and timing requirements for communications of urban rail applications, and the additional requirements on the DCS necessary for a train control system to share a common communication system with other urban rail applications

The analysis of the overall capacity and timing requirements is done for a typical and maximum configuration of urban rail applications.

In the WP9, this document complements the D39 (Data Communication System Functional Requirements). In particular, for the performance requirements, only the values are defined in the D40 because the related requirements are already defined in the D39.

***Associated Milestone (if relevant):***

| **Contribution to MODURBAN Objectives as mentioned in the Description of Work** | | |
|---|---|---|
| ***Objective Definition*** | ***Comments*** | ***Quantification*** |
| Objective 1 - | | |
| Objective 2 – | | |
| Objective 3 … | | |
| Objective 4 … | | |

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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 D40 document (« Data Communication System Performance, Reliability and Maintainability Requirements») has to:

- Define the performance, reliability and maintenance requirements for communication equipment
- Analyze the capacity and timing requirements for communications of urban rail applications
- Determine the additional requirements on the DCS necessary for a train control system to share a common communication system with other urban rail applications

In the WP9, this document complements the D39 (Data Communication System Functional Requirements). In particular, for the performance requirements, only the values are defined in the D40 because the related requirements are already defined in the D39.

The analysis of the capacity and timing requirements is done for a typical and maximum configuration of urban rail applications.

This document will be further complemented in WP9 with:

- D41. Data Communication System Architecture

### *1.3 References*

| | |
|---|---|
| [DOW] | Annex I - “Description of Work” DOW-MODURBAN-516380-final.pdf |
| [D39] | D39 Data Communication System Functional Requirements |
| [D77] | D77 Common Definition of MODURBAN Train Protection System MODSYSTEM_WP21_D77_Deliverable report.pdf |
| [D85] | MODURBAN Architecture, Identification of Key Interfaces and Preliminary FIS |
| [EN 50126] | Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS) (CEI 62278) |
| [EN 50159-2] | Railway applications – Communication, signalling and processing system Part 2: Safety-related communication in open transmission system (CEI 62280-2) |
| [D129] | DEL_MODURBAN-D129_RATP_WP20_090317_V27 |
| [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 - Web site of the European Telecommunication Standards Institute

[ANFR] www.anfr.fr - Web site of ANFR (Agence Nationale des Fréquences)

### *1.5 Acronyms*

| | |
|---|---|
| ATC | Automatic Train Control |
| CC | Car borne Controller |
| DCS | Data Communications System |
| Dest | Destination |
| DSU | Data Storage Unit |
| GOA | Grade of Automation |
| HMI | Human Machine Interface |
| IL | Interlocking |
| LRU | Line Replaceable Unit |
| MMS | Maintenance Management System |
| MTBF | Mean Time Between Failures |
| MTTR | Mean Time To Restore |
| NMS | Network Management System |
| OCC | Operations Control Centre |
| OIS | Onboard passenger Information System |
| PDIU | Platform Door Interface Unit |
| SCADA | Supervision, Control And Data Acquisition |
| SNMP | Simple Network Management Protocol |
| Src | Source |
| WIS | Wayside passenger Information System |
| ZC | Zone Controller |

### 1.6 Definitions

| | |
|---|---|
| Client services | Services offered by the DCS to equipment connected on the DCS. |
| Data rate | Maximum data rate needed by the application at the required delay and message error rate |
| Delay | Nominal delay from the first bit transmitted by the application to the first bit received by the application |
| Delay variation | Standard deviation of delay |
| Fixed user | User of the DCS wired to the wayside network. The user can be a human through a device or just a device. |
| Interrupt time | Time during which there is a gap in DCS communication |
| Line Replaceable Unit | The Line Replaceable Unit is the units of each sub-system which are replaced for the Maintenance Level 1 |
| Lost message | Message received after the maximum delay time accepted by the application or not received at all |
| 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. |
| Msg error tolerance | Maximal nominal tolerance related to wrong or lost messages (application to application) for an average message length of 1kbit. |
| Nominal | Intended value about which there may be statistical variation |
| Phone Calls | Phone calls digitised voice link using IP packet |
| Throughput | Amount of payload data passed across a link in a given time. |
| Train consist | A train consist is composed of one or several train sets (1, 2 or 3 in general) coupled together. |
| Train set | The minimum part of a train that can be operated separately. |

## 2. PERFORMANCE REQUIREMENTS

### 2.1 DCS reference configuration

For each parameter of a metro system, two values are provided. The first value is the nominal value and the second gives the maximum value which can be reached on some networks.
The nominal reference configuration is defined by the first set of values.

However, it is not possible to combine the maximum values of different parameters found on different networks to obtain a consistent maximum reference configuration, because the results would be unrealistic. For example, if we combine the maximum car length with the maximum

number of cars per train set and with the maximum number of train set per train consist, the maximum train consist length would be 684 m, instead of 108 m .

Therefore, a MODCOMM DCS must at least be able to provide the performances required for the maximum parameters individually, but not necessarily the performances required for any combination of those parameters.

Some parameters are derived from others. In a specific application, if a maximum of a derived parameter is met, the maximum of the related source parameters may not be met.

Except for the parameter “Number of lines covered by the same DCS”, the values provided in the following tables are related to operation of a single line.

The configurations are based on the data extracted from the MODCOMM Questionnaire. Operators who have answered are the following: Glasgow, Rome, Istanbul, Poland, Nuremberg, Lisboa, Belgium and Paris.

### 2.1.1 Train configuration

| Parameter | Nom. | Max. | Comments | D39 section | Sub-section |
|---|---|---|---|---|---|
| Car Length (in meter) | 19 | 38 (Nuremberg) | | 2.2.1 | R01 |
| Number of cars per train set | 4 | 6 (Rome) | | 2.2.1 | R01 |
| Train Set Length (in meter) | 76 | 108 (Rome) | For nominal : Car Length * Number of cars per train set | - | - |
| Number of train set per train consist | 1 | 3 | | 2.2.1 | R02 |
| Number of cars per train consist | 4 | 10 (Belgium) | For nominal : Number of cars per train set * number of train set per train consist | - | - |
| Train Consist Length (in meter) | 76 | 108 (Rome) | For nominal : Number of cars per train set * Car Length | - | - |

### 2.1.2 Guideway configuration

| Parameter | Nom. | Max. | Comments | D39 section | Sub-section |
|---|---|---|---|---|---|
| Guideway structure | Linear | Linear+ 1Fork+ 1Loop | | 2.4. | R01 |
| Length of platform in stations (in meter) | 85 (RATP) | 140 (RATP) | | 2.4 | R02 |
| Length of inter-stations (in meter) | 615 | 2600 (RATP) | | 2.4 | R02 |
| Number of stations | 23 (RATP) | 38 (RATP) | | 2.4 | R02 |
| Guideway Length (in meter) | 15 485 | 74 000 | For nominal : (Number of stations * Length of platforms in station) + (Number of stations – 1) * Length of inter-stations<br>For maximum : value of London Central line | - | - |
| Number of trains per depot | 20 | 70 | Hypothesis : equal to the number of trains on the guideway | 2.4 | R04 |
| Number of trains on the guideway during peak hours | 20 | 70 | | 2.4 | R08 |
| Highest guideway train density | 4 | 6 | per station (platform + one inter-station)<br>Hypothesis : one train on each platform + one train on each track of the inter-station<br>For maximum, the number of trains have been increased to allow for example for an additional train on siding and one additional train in a turn-back track. | 2.4 | R09 |
| Number of lines covered by the same DCS | 1 | 14 (RATP) | Hypothesis for maximum : all the lines of an operator share the same DCS | - | - |
| Number of independent DCS that share the same propagation space | 1 | 3 (RATP) | Hypothesis for maximum : case of independent lines sharing the same tunnel but not the same track (if they share the same track, they will use the same zone controller and therefore the same radio) | 2.4 | R07 |

### 2.1.3 Reference on-board application configuration

| Parameter | Nom. | Max. | Comments | D39 section | Sub-section |
|---|---|---|---|---|---|
| Number of CC per train set | 1 | 2 | | - | - |
| Number of CC per train consist | 1 | 6 | Number of CC per train set* Number of train sets per train consist | - | - |
| Number of HMI per train set | 2 | 2 | | - | - |
| Number of HMI per train consist | 2 | 6 | Number of HMI per train set * Number of train sets per train consist | - | - |
| Number of OIS per train set | 1 | 1 | | - | - |
| Number of OIS per train consist | 1 | 3 | Number of OIS per train set * Number of train sets per train consist | - | - |
| Number of video surveillance camera per car | 2 | 6 | | - | - |
| Number of video surveillance camera per train consist | 8 | 36 | | - | - |
| Number of simultaneous video flow per train consist | 2 | 4 | | 3.2.5 | R04 |
| Number of simultaneous train video flow per line | 2 | 8 (Nuremberg) | | 3.2.5 | R04 |
| Number of simultaneous train staff voice calls per train consist | 1 | 2 | | 3.2.6.A | R03 |
| Number of simultaneous train staff voice calls per line | 20 | 140 | Number of simultaneous staff voice calls per train consist * Number of trains on the guideway during peak hours | 3.2.6.A | R03 |
| Number of simultaneous emergency passenger calls per train consist | 1 | 4 | | 3.2.6.A | R03 |
| Number of simultaneous train emergency passenger calls per line | 1 | 8 | The number of simultaneous train emergency passenger calls per line is limited by the number of staff persons available to answer those calls | 3.2.6.A | R03 |
| Number of simultaneous train staff/passenger phone calls per train consist | 30 | 30 | | 3.2.6.C | R04 |
| Number of simultaneous train staff/ passenger phone calls per line | 600 | 2100 | Number of simultaneous train passenger phone calls per train consist * Number of trains on the guideway during peak hours | 3.2.6.C | R04 |

| Parameter | Nom. | Max. | Comments | D39 section | Sub-section |
|---|---|---|---|---|---|
| Number of simultaneous Internet users per train consist | 20 | 20 | | 3.2.7 | R04 |
| Number of simultaneous Internet users per line | 400 | 1400 | Number of simultaneous Internet connection per train consist * Number of trains on the guideway during peak hours | 3.2.7 | R04 |

### 2.1.4 Reference wayside application configuration

| Parameter | Nom. | Max. | Comments | D39 section | Sub-section |
|---|---|---|---|---|---|
| Number of ZC per station | 0,3 | 1 | When the number of ZC is less than one, it means there is one ZC every 1/Number_of_ZC stations | - | - |
| Number of ZC per line | 7 | 38 | For nominal : Number of ZC per station * Number of station | - | - |
| Number of WIS per station | 1 | 1 | | - | - |
| Number of WIS per line | 23 | 38 | For nominal : Number of WIS per station * Number of station | - | - |
| Number of PDIU per station | 0 | 1 | | - | - |
| Number of PDIU per line | 0 | 38 | For nominal : Number of PDIU per station * Number of station | - | - |
| Number of OCC per line | 1 | 2 | The max value of 2 has been given in case of a full backup equipment | - | - |
| Number of DSU per line | 1 | 2 | The max value of 2 has been given in case of a full backup equipment | - | - |
| Number of MMS per line | 1 | 2 | The max value of 2 has been given in case of a full backup equipment | - | - |
| Number of NMS per line | 1 | 2 | The max value of 2 has been given in case of a full backup equipment | - | - |
| Number of video surveillance camera per station | 15 | 30 | | 3.2.5 | R14 |

| Parameter | Nom. | Max. | Comments | D39 section | Sub-section |
|---|---|---|---|---|---|
| Number of video surveillance camera per line | 345 | 1 140 | For nominal : Number of camera per station * Number of station | - | - |
| Number of simultaneous video flow per station | 4 | 8 | | 3.2.5 | R14 |
| Number of simultaneous station video flow per line | 92 | 304 | For nominal : Number of video flow per station * Number of station | - | - |
| Number of simultaneous emergency calls per station | 1 | 2 | | 3.2.6.A | R03 |
| Number of simultaneous emergency calls per line | 2 | 8 | The number of simultaneous emergency calls per line is limited by the number of staff persons available to answer those calls | 3.2.6.A | R03 |
| Number of simultaneous staff voice calls per station | 10 | 10 | | 3.2.6.C | R04 |
| Number of simultaneous station staff voice calls per line | 230 | 380 | For nominal : Number of staff voice calls per station * Number of station | 3.2.6.C | R04 |
| Number of simultaneous passenger phone calls per station | 30 | 30 | | 3.2.6.C | R04 |
| Number of simultaneous station passenger phone calls per line | 690 | 1 140 | For nominal : Number of passengers voice calls per station * Number of station | 3.2.6.C | R04 |
| Number of simultaneous Internet users per station | 5 | 5 | | 3.2.7 | R04 |
| Number of simultaneous station Internet users per line | 115 | 190 | For nominal : Number of Internet connection per station * Number of station | 3.2.7 | R04 |

## *2.2 Capacity and real time requirements*

In this section, the data rate values are the maximum needed by the application at the required delay and message error rate.

### 2.2.1 Network

| PARAMETER | Type of parameter (Performance/ Reliability/ Maintainability) | Value | Section/ Sub section | Paragraph Figure/ Table |
|---|---|---|---|---|
| Mobility :<br><br>Maximum interrupt times :<br>- for ATC<br>- for voice.<br>Values based on a non redundant radio link. The interrupt time is the time during which the link is unavailable for communication (as measured by interruption in a continuous stream of short packets). | P | 95% less than 150ms,<br>99% less than 1s,<br>99.99% less than 2.5s. | 4.4.1 | R03 |
| Addressing Plan :<br>Number of possible assigned sub-network addresses per train unit<br>Number of fixed users per station | P | At least 2<br>256 | 4.4.2 | R04 |
| Communication functions - Overall :<br>Time synchronisation differential accuracy between accesses. | P | 10 ms | 5.1.1 | R03 |
| Communication functions - Overall :<br>Maximum duration of topology reconfiguration following a DCS failure | P | 500 ms | 5.1.1 | R08 |
| Communication functions - Overall :<br>Maximum DCS start-up time (for individual DCS equipment) | P | 5 min | 5.1.1 | R15 |
| Communication functions - Overall :<br>Maximum DCS shutdown time (for individual DCS equipment) | P | 3 min | 5.1.1 | R16 |
| Network Management System :<br>Management delay starting from a physical failure to the diagnostic displayed on the Main management platform. | P | 10 s | 5.2 | R08 |
| Traffic prioritisation :<br>Number of 16 classes of service (4 bits) managed by the DCS | P | 16 (4 bits) | 5.3 | R01 |
| Traffic prioritisation :<br>Number of reserved priority levels (precedence) | P | 8 (3 bits) | 5.3 | R01 |

### 2.2.2 Ground to ground

Two tables are provided:
- the first table contains for each client service all logical ground to ground communication links using the DCS. For each logical link the relevant requirements are provided in the corresponding row of the table,
- the second table provides for each logical ground to ground link the cumulative data rates for the reference configuration (nominal) and for the maximum value of the configuration parameter.

Some fields have a range provided due to the fact that the ATC system protocols were not completed during the MODURBAN project. In this case the minimum and maximum values provided by the suppliers has been presented.

| | Link | | Mandatory/ Optional for user | Secured by DCS (1) | Applicative priority | Data rate | | | Delay average/ max | Delay variation | Msg Error Tolerance (3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Client Services** | Src | Dest | | | | **Value** | **Type** | **Scope** | | | |
| **ATC system** | | | | | | | | | | | |
| | ZC | ZC | M | Y | High | 2-10 kbps | C | per ZC | 10-55 / 35-124 | N/A | 1% |
| | OCC | ZC | M | Y | High | 1-50 kbps | C | per ZC | 10-54/ 35-124 | N/A | 1% |
| | DSU | ZC | M | Y | High | 5.0 kbps | S | per ZC | 10-54/ 35-124 | N/A | 1% |
| | OCC | DSU | M | N | High | 5.0 kbps | S | per DSU | 10-54/ 35-124 | N/A | 1% |
| | OCC | new IL | M | Y | High | 1-50 kbps | C | per new IL | 10-54/ 35-124 | N/A | 1% |
| | PDIU | OCC | O | N | Low | 1-25 kbps | C | per PDIU | 10-54/ 35-124 | N/A | 1% |
| **MMS** | | | | | | | | | | | |
| | MMS | ZC | M | N | Low | 100 kbps | P | per ZC | 100/200 | N/A | 0,5% |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | ms | | |
| | MMS | DSU | M | N | Low | 100 kbps | P | per DSU | 100/200 ms | N/A | 0,5% |
| | MMS | OCC | M | N | Low | 100 kbps | P | per OCC | 100/200 ms | N/A | 0,5% |
| | MMS | WIS | O | N | Low | 100 kbps | P | per WIS | 100/200 ms | N/A | 0,5% |
| | MMS | new IL | M | N | Low | 100 kbps | P | per new IL | 100/200 ms | N/A | 0,5% |
| | MMS | PDIU | O | N | Low | 100 kbps | P | per PDIU | 100/200 ms | N/A | 0,5% |
| | MMS | NMS | O | N | Low | 100 kbps | P | per NMS | 100/200 ms | N/A | 0,5% |
| **Video transmission** | | | | | | | | | | | |
| | video station | OCC | O | N | Low (2) | 500 kbps (nominal) to 1 Mbps | C | per camera | 100/150 ms | 50 ms | 0,5% |
| **Audio transmission** | | | | | | | | | | | |
| | audio station (Public address) | OCC | O | N | Low (2) | 1 voice channel (unidirectional, 64 kbps) | S/P | per platform | 100/200 ms | 50 ms | 0,5% |
| | audio station (Emergency call) | OCC | O | N | Low (2) | 2 voice channels (bidirectional, 64 kbps for each direction) | S | per interphone /help point | 30/50 ms | 10 ms | 0,5% |
| | audio station (staff call) | audio station (staff call) | O | N | Low (2) | 2 voice channels (bidirectional, 64 kbps for each direction) | S | per station | 30/50 ms | 10 ms | 0,5% |
| **Passenger information system** | | | | | | | | | | | |
| | WIS | OCC | O | N | Low (2) | 2 data channels (unidirectional 64 kbps) | S/P | per station | 100/200 ms | N/A | 0,5% |
| **SCADA** | | | | | | | | | | | |
| | SCADA | OCC | O | N | Low (2) | 100 kbps | P | per station | 50/100 ms | N/A | 0,5% |
| **Public Internet access** | | | | | | | | | | | |
| | Passenger | External | O | N | Low | 1000 kbps | P | Per station | | N/A | 0.5 % |

(1) That means secured by authentication by DCS for safety constraints.
(2) It should be High priority to cover emergency situations according to GOA modes, mainly for GOA3 and GOA4 modes.
(3) For audio and video applications, in case of streaming data flow, value is related to a bit error rate.

| Client Services | Elementary data | | | | | Link | | | | Cumulative Data rate per link (kbps) | | Cumulative Data rate (kbps) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Link | | Data rate | | | Nominal | | Max | | | | b/w OCC and Wayside | | | Intra Wayside including OCC | | |
| | Src | Dest | Value | | Scope | Src | Dest | Src | Dest | Nominal | Max | | Nominal | Max | | Nominal | Max |
| ATC system | ZC | ZC | 10 | Kpps | per ZC | 7 | 7 | 38 | 38 | 60 | 370 | | | | x | 60 | 370 |
| | OCC | ZC | 5 | Kbps | per ZC | 1 | 7 | 2 | 38 | 35 | 380 | x | 35 | 380 | x | 35 | 380 |
| | DSU | ZC | 20 | Kbps | per ZC | 1 | 7 | 2 | 38 | 140 | 1520 | | | | x | 140 | 1520 |
| | OCC | DSU | 20 | Kbps | per DSU | 1 | 1 | 2 | 2 | 20 | 80 | x | 20 | 80 | x | 20 | 80 |
| | OCC | new IL | 5 | Kbps | per new IL | 1 | 7 | 2 | 38 | 35 | 380 | x | 35 | 380 | x | 35 | 380 |
| | PDIU | OCC | 2 | Kbps | per PDIU | 0 | 1 | 38 | 2 | 0 | 152 | x | 0 | 152 | x | 0 | 152 |
| MMS | MMS | ZC | 100 | Kbps | per ZC | 1 | 7 | 2 | 38 | 700 | 7600 | | | | x | 700 | 7600 |
| | MMS | DSU | 100 | Kbps | per DSU | 1 | 1 | 2 | 2 | 100 | 400 | | | | x | 100 | 400 |
| | MMS | OCC | 100 | Kbps | per OCC | 1 | 1 | 2 | 2 | 100 | 400 | x | 100 | 400 | x | 100 | 400 |
| | MMS | WIS | 100 | Kbps | per WIS | 1 | 23 | 2 | 38 | 2300 | 7600 | | | | x | 2300 | 7600 |
| | MMS | new IL | 100 | Kbps | per new IL | 1 | 7 | 2 | 38 | 700 | 7600 | | | | x | 700 | 7600 |
| | MMS | PDIU | 100 | Kbps | per PDIU | 1 | 0 | 2 | 38 | 0 | 7600 | | | | x | 0 | 7600 |
| | MMS | NMS | 100 | Kbps | per NMS | 1 | 1 | 2 | 2 | 100 | 400 | | | | x | 100 | 400 |
| Video transmission | video station | OCC | 1000 | Kbps | per camera | 92 | 1 | 304 | 2 | 92000 | 608000 | x | 92000 | 608000 | x | 92000 | 608000 |
| Audio transmission | audio station (Public address) | OCC | 64 | Kbps | per platform | 46 | 1 | 76 | 2 | 2944 | 9728 | x | 2944 | 9728 | x | 2944 | 9728 |
| Audio transmission | audio station (Emergency call) | OCC | 256 | Kbps | per interphone/help point | 2 | 1 | 8 | 2 | 512 | 4096 | x | 512 | 4096 | x | 512 | 4096 |
| Audio transmission | audio station (staff call) | audio station (staff call) | 256 | Kbps | per station | 23 | 23 | 38 | 38 | 5632 | 9472 | x | 5632 | 9472 | x | 5632 | 9472 |
| Passenger information system | WIS | OCC | 128 | Kbps | per station | 23 | 1 | 38 | 2 | 2944 | 9728 | x | 2944 | 9728 | x | 2944 | 9728 |
| SCADA | SCADA | OCC | 100 | Kbps | per station | 23 | 1 | 38 | 2 | 2300 | 7600 | x | 2300 | 7600 | x | 2300 | 7600 |
| Public Internet access | Passenger | External | 1000 | Kpbs | per station | 23 | 1 | 38 | 2 | 23000 | 38000 | x | 23000 | 38000 | x | 23000 | 38000 |
| | | | | | | | | | | | **Total** | | 129522 | 688016 | | 133622 | 721106 |

Note : Cumulative data per link = number of Src * number of Dest * Data rate value, except for ZC-ZC link and Audio Station-Audio station link where (Src –1) * Data rate value is used (for example 6 ZC-ZC link when 7 ZC are used for line.

### 2.2.3 Train to ground

Three tables are provided:
- the first table contains for each client service all logical train to ground communication links using the DCS. For each logical link the relevant requirements are provided in the corresponding row of the table,
- the second table provides for each logical train to ground link the cumulative data rates per train consist for the reference configuration (nominal) and for the maximum value of the configuration parameter.
- the third table provides for each logical train to ground link the cumulative data rates for a whole line for the reference configuration (nominal) and for the maximum value of the configuration parameter.

Some fields have a range provided due to the fact that the ATC system protocols were not completed during the MODURBAN project. In this case the minimum and maximum values provided by the suppliers has been presented.

| | Link | | Secured by the DCS | Applicative priority | Data rate | Delay | Delay variation | Msg Error Tolerance |
|---|---|---|---|---|---|---|---|---|
| **Client Services** | Train | Ground | | | **Value (per link)** | | | |
| **ATC system** | | | | | | | | |
| | CC | ZC | Yes | High | 1-10kbps | 10-110/35-280 | Not relevant | 1% |
| | CC | OCC | Yes | High | 1-25kbps | 10-110/35-280 | | 1% |
| | CC | DSU | Yes | High | 5 kbps | 10-110/35-280 | | 1% |
| **MMS** | | | | | | | | |
| | OIS | MMS | No | Low | 0.5kbps | 1s | Not relevant | 0.5% |
| | CC | MMS | No | Low | | 1s | | 0.5% |
| **Video transmission** | | | | | | | | |
| | Train Video | OCC | No | Low | 2000kbps | 0.5s | +-0.1s | 0.5% |
| **Audio transmission** | | | | | Example for 1 link | | | |
| | Audio in Train | OCC | No | Low | 64kbps | 0.5s | +-0.1s | 0.5% |
| **Passenger information system** | | | | | 10kbps | | | |
| | OIS | OCC | No | Low | | 1s | +-0.1s | 0.5% |
| **Other** | | | | | | | | |
| | Public address | OCC | No | Low | | 1s | +-0.1s | 0.5% |

Note: The data rate values are given per train consist.

Some fields have a range provided due to the fact that the ATC system protocols were not completed during the MODURBAN project. In this case the minimum and maximum values provided by the suppliers has been presented.

**Accumulated data rates per train consist**

| | Src | Dest | Data rate | Scope | Number of links per train consist | | | | Cumulative data rate (in kbps) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | (in kbps) | | nominal | | maximal | | nominal | maximal |
| | | | | | src | dest | src | dest | | |
| ATC systems | CC | ZC | 2 | per CC | 1 | 1 | 6 | 1 | 2 | 12 |
| | CC | OCC | 2 | per CC | 1 | 1 | 6 | 2 | 2 | 24 |
| | CC | DSU | 2 | per CC | 1 | 1 | 6 | 2 | 2 | 24 |
| MMS | MMS | CC | 0,5 | per CC | 1 | 1 | 2 | 6 | 0,5 | 6 |
| | MMS | OIS | 0,5 | per OIS | 1 | 1 | 2 | 3 | 0,5 | 3 |
| Video transmission | train video | OCC | 1 000 | per video flow | 2 | 1 | 4 | 1 | 2 000 | 4 000 |
| Audio transmission | train audio for emergency | OCC | 64 | per interphone | 1 | 1 | 4 | 4 | 64 | 1 024 |
| | staff call | | 64 | per interphone | 1 | 1 | 2 | 1 | 64 | 128 |
| Passenger info system | OIS | OCC | 10 | per OCC | 1 | 1 | 1 | 3 | 10 | 30 |
| Public Internet Access | | | 10 | per passenger | 20 | 1 | 20 | 1 | 200 | 200 |
| | | | | | | | | | | |
| | | | | | | | **Total** | | **2 345** | **5 451** |

**Accumulated data rates for a whole line**

| | Src | Dest | Data rate (in kbps) | | Scope | Number of links per line | | Cumulative data rate (in kbps) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | nominal | maximal | | nominal | maximal | nominal | maximal |
| ATC systems | CC | ZC | 2 | 10 | per train consist | 20 trains | 70 trains | 40 | 700 |
| | CC | OCC | 2 | 24 | per train consist | 20 trains | 70 trains | 40 | 1680 |
| | CC | DSU | 2 | 24 | per train consist | 20 trains | 70 trains | 40 | 1680 |
| MMS | MMS | CC | 0,5 | 6 | per train consist | 20 trains | 70 trains | 40 | 420 |
| | MMS | OIS | 0,5 | 3 | per train consist | 20 trains | 70 trains | 40 | 210 |
| Video transmission | train video | OCC | 2 000 | 4 000 | per video flow | 2 video flows | 4 video flows | 2 000 | 8 000 |
| Audio transmission | train audio | OCC | 64 | 64 | per interphone | 1 for emergency | 8 for emergency | 64 | 512 |
| | | | 64 | 64 | per interphone | 20 for staff calls | 140 for staff calls | 1 280 | 8 960 |
| Passenger info system | OIS | OCC | 10 | 30 | per train consist | 20 trains | 70 trains | 200 | 2 100 |
| Public Internet Access | | | 10 | 10 | per passenger | 400 passengers | 1400 passengers | 4000 | 14 000 |
| | | | | | | | | | |
| | | | | | | | **Total** | **7 744** | **38 262** |

### 2.2.4 Within trains or between coupled trains

In the train, the data rates within trains or between coupled trains are in addition to those from the train to ground section.

Two tables are provided:

- the first table contains for each client service all logical communication links using the DCS within trains or between coupled trains. For each logical link the relevant requirements are provided in the corresponding row of the table,
- the second table provides for each link within trains or between coupled trains the cumulative data rates per train consist and for a whole line for the reference configuration (nominal) and for the maximum value of the configuration parameter.

Some fields have a range provided due to the fact that the ATC system protocols were not completed during the MODURBAN project. In this case the minimum and maximum values provided by the suppliers has been presented.

| | **Link** | | **Secured by DCS** | **Applicative priority** | **Data rate** | **Delay** | **Delay variation** | **Msg Error Tolerance** |
|---|---|---|---|---|---|---|---|---|
| **Client Services** | Train | Train | | | **Value** | | | |
| **ATC system** | | | | | | | | |
| | CC | HMI | No | Low | 2 kbps | 5-54 ms | 0,1s | 1% |
| | CC | CC | No | High | 2 kbps | 5.54 ms | 0,1s | 1% |
| | CC | Public Address | No | Low | 1 kbps | 5-54 ms | 0,1s | 1% |
| | Video display for driver | Train video | Optional | Low | 500kbps | 500 ms | 0,1s | 0,5% |
| | CC | OIS | No | Low | 10 kbps | 1s | 0,1s | 0,5% |

**Accumulated data rates per train consist and for a whole line**

| | Src | Dest | Data rate | Scope | Number of links per train consist | | | | Cumulative data rate (in kbps) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | (in kbps) | | nominal | | maximal | | nominal | maximal |
| | | | | | src | dest | Src | dest | | |
| ATC systems | CC | HMI | 20 | per CC | 1 | 1 | 6 | 1 | 20 | 120 |
| | CC | CC | 50 | per CC | 1 | 1 | 6 | 2 | 50 | 600 |
| | CC | Public address | 64 | per CC | 6 | 1 | 6 | 1 | 384 | 384 |
| | Video display for driver | CC | 1 000 | per video flow | 1 | 2 | 1 | 4 | 2 000 | 4 000 |
| | CC | OIS | 10 | per OIS | 1 | 1 | 6 | 3 | 10 | 180 |
| | | | | | | | | | | |
| | | | | | | | **Total** | | **2 464** | **5 284** |
| | | | | | | | | | | |
| **For a whole line with 20 trains nominal and 70 trains maximal)** | | | | | | | **Total** | | **49 280** | **369 880** |

### 2.2.5 Power reduction

| PARAMETER | Type of parameter (Performance/ Reliability/ Maintainability) | Value | Section/ Sub section | Paragraph Figure/ Table |
|---|---|---|---|---|
| Low consumption in power saving mode :<br><br>Minimum power reduction (%) between 'normal operation' and 'power saving mode' | P | 50 % | 05060100 | R01 |
| Low consumption in power saving mode :<br><br>Number of indicators showing onboard DCS device is working in 'normal power operation' | M | 1 | 05060100 | R01 |
| Low consumption in power saving mode :<br><br>Maximum time to re-enter in 'normal mode' from 'power saving mode' since activity is detected | P | 0,5s | 05060100 | R02 |
| Low consumption in power saving mode :<br><br>Number of indicators showing onboard DCS device is working in 'power saving mode' | M | 1 | 05060100 | R02 |

### 2.2.6 Downloading capacity

| PARAMETER | Type of parameter (Performance/ Reliability/ Maintainability) | Value | Section/ Sub section | Paragraph Figure/ Table |
|---|---|---|---|---|
| Downloading capacity :<br><br>Minimum local downloading guaranteed bit rate | P | 1 Mbps | 05060200 | R01 |
| Downloading capacity :<br><br>Number of standard interfaces to locally connect a downloading tool | M | At least 1 | 05060200 | R01 |
| Downloading capacity :<br><br>Number of standard tools for downloading | M | At least 1 | 05060200 | R01<br><br>R02 |
| Downloading capacity :<br><br>Minimum remote downloading guaranteed bit rate | P | 100 kbps | 05060200 | R02 |

Note: 2 standard downloading tools can be necessary if 2 different communication links are available such as character and packet serial links.

# 3. RELIABILITY REQUIREMENTS

## *3.1 General*

The DCS must provide communication links between individual components of an ATC system or between components of other applications. As such, the availability of an individual communications link, for example between a train and wayside, must be much higher than for the overall DCS network or the overall ATC system.

Note: The links in this section are only logical communication links provided by the DCS to the applications. The arrangement of physical communication links is to be defined during the DCS network design to meet the requirements related to these logical communication links.

### 3.1.1 Link availability

Any individual end-to-end link between two user interfaces of the reference DCS network involved in part or in total with an ATC application shall have an availability of 99,999%.

Any individual end-to-end link between two user interfaces of the reference DCS network that has no involvement whatsoever with an ATC application shall have an availability of 99,99%.

These requirements include individual radio links as necessary. The availability of an individual radio link is that fraction of the time when the performance parameters of the link are fully met, and therefore includes equipment and propagation availability.

#### *3.1.1.1 Single Links*

Any individual end-to-end link between two user interfaces of the reference DCS network involved in part or in total with an ATC application shall have an availability of 99,95%.

Any individual end-to-end link between two user interfaces of the reference DCS network that has no involvement whatsoever with an ATC application shall have an availability of 99,9%.

These requirements include individual radio links as necessary. The availability of an individual radio link is that fraction of the time when the performance parameters of the link are fully met, and therefore includes equipment and propagation availability.

#### 3.1.1.2 *Pairs of Links*

Any two end-to-end links between two user interfaces of the reference DCS network involved in part or in total with an ATC application shall have a joint availability of 99.999%. This joint availability means that the probability of both links being unavailable at the same time is 1 - 0,99999 = 0,00001.

Any two end-to-end links between two user interfaces of the reference DCS network that has no involvement whatsoever with an ATC application shall have a joint availability of 99,99%. This joint availability means that the probability of both links being unavailable at the same time is 1 - 0,9999 = 0,0001.

### 3.1.2 Network availability

From the figure above and from the composition of the complete DCS (number and nature of the links) the DCS network overall availability can be deduced.
For example,

- a DCS network with 200 links used as redundant pairs (400 single links) in ATC applications reach a an overall availability of 99,8%
- a DCS network with 100 link used singly in ATC application reach an overall availability of 95%....

Time in this context refers to the entire lifetime of the DCS, and the percentage refers to percentage of time that all links in the reference network are available.

### 3.2 *Reliability*

The DCS shall be built from individual components that have sufficient reliability to meet the availability and maintainability requirements.

### 3.3 *Redundancy*

The DCS architecture shall include sufficient internal equipment and connection redundancy to allow the availability requirements to be met.

As a minimum the DCS shall provide redundant radio links to a train set in order to meet the availability requirements for those links involving a radio connection.

## 4. MAINTAINABILITY REQUIREMENTS

### *4.1 General*

The network architecture, redundancy features and lifetimes of individual components of the network shall be consistent with the availability requirements of the DCS.

The maintenance and spares philosophy for replacing failed components of the network shall be consistent with the availability requirements of the DCS. The relationships between quantities and locations of spare parts and the DCS availability are defined below.

Note: The links in this section are only logical communication links provided by the DCS to the applications. The arrangement of physical communication links is to be defined during the DCS network design to meet the requirements related to these logical communication links.

#### 4.1.1 Mean Time to Restore (MTTR) in hours

The MTTR for any failed link component shall be 12 hours, including travel time. Note that components may fail in locations that cannot be accessed during service hours.
This MTTR value is a mean for all equipment whether accessible or not during service hours.

The unavailability of a component shall therefore be U = 12 / (12 + MTBF).

### *4.2 Diagnostics*

The DCS network shall include a SNMP-enabled Network Management System (NMS).

It shall be possible to monitor the status of all active DCS devices (including redundant devices) of the network, and to specifically identify any such devices that have failed in a manner that prevents the normal operation of the DCS.

The time to deliver the maintenance request and initiate the response shall be less than 1 s.

### *4.3 Requirements related to levels of maintenance*

Maintenance activities are commonly broke down in 3 separate levels:

- Level 1 maintenance is related to on-site replacement of failed units.
- Level 2 is related to in-lab replacement of failed electronic boards.
- Level 3 is related to in-lab repair of failed electronic boards.

#### 4.3.1 Level 1 maintenance

The equipment provided for the DCS should contain LRU to allow fast replacement of failed units.

The weight of each LRU should not exceed 10 kg to be easily handle by the level 1 maintenance team.

#### 4.3.2 Level 2 maintenance

When an LRU contains replaceable parts by level 2 maintenance, the replacement should be possible in less than 4 hours.

#### 4.3.3 Level 3 maintenance

Not applicable to the DCS. The electronic boards will be only replaced and not repaired.

## 5. REQUIREMENTS RELATED TO MULTIPLE APPLICATIONS ON THE SAME DCS

### *5.1 Performance*

The minimum throughput and delay of data packets related to ATC applications shall be met regardless of the transmission of data for any other application.

### *5.2 Reliability*

The availability of communications links related in part or entirely to ATC applications shall be met regardless of the connection of any equipment related to any other application.

### *5.3 Maintenance*

The availability of communications links related in part or entirely to ATC applications shall be met during the maintenance, repair or replacement of any equipment in the DCS related to applications other than ATC.

# APPENDIX

## A. MEAN TIME BETWEEN FAILURE

The failure rates of all the parts in a particular component shall be considered in calculating the MTBF of that component.

The reliability is the key parameter to plan the activity of the maintenance team.

The relationships between MTBF and availability of components of the DCS, and the DCS as a whole, are defined below.

**Mean Time Between Failures (MTBF):**

The MTBF of any link component shall be consistent with the availability requirements, the redundancy features of the network, and the MTTR of the components.

The MTBF of a particular component of a system is defined as 1/h, where h is the failure rate (failures per hour) of that component for a constant-rate failure model. The probability of failure in a constant-rate model is given by p(t)=hexp(-ht). The MTBF is expressed in hours.

The availability of a single link component is defined as A = (1-U), where U = unavailability of the component given by U = MTTR/(MTBF+MTTR). The availability of a chain of components configured in series is A = 1 – sum(U), where the sum extends over all the components in the chain. This formula is an approximation for small U<<1.

The availability of a redundant component, or chain of components, configured in parallel is defined as A = (1-Ur), where Ur is the unavailability of both components or chains simultaneously, plus the unavailability of any common switching components Uc. Therefore Ur = U^2 + Uc.