TETRA + Critical Communications Association
14 Blandford Square
Newcastle upon Tyne
NE1 4HZ
UK
Tel: +44 191 231 4328
Fax: +44 191 245 3802

USER REQUIREMENTS SPECIFICATION – RAIL

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Registered Office,
Richmond House, Broad Street
Ely, Cambridgeshire, CB7 4AH, UK
Registration No.4155039 in UK
VAT Registration Number GB 755 4236 24

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1 Foreword

The European Telecommunications Standards Institute (ETSI)'s digital trunked radio standard, has been adopted by a variety of transportation and railway users around the world. The utilisation of TETRA in the railway environment has been so successful that transportation has now overtaken public safety in terms of the number of networks deployed around the world.

In today's environment where passengers and the travelling public demand the most from the transportation companies, mission critical communications systems have to ensure that operations can run smoothly whatever the event, not simply guarantee new levels of service reliability and cost effectiveness'.

TETRA technology has enjoyed wide support from over 20 manufacturers of core equipment as well as many more suppliers of test equipment, peripheral products, specialized on-board units and applications providers, making it the most widely available and future-proof PMR technology. This ensures a highly competitive market place and provides transport operators with plenty of choice at a good price.

Railway Transportation modernisation programmes could benefit from TETRA

Specific to railways, no-one can deny that radio communications technology has made giant strides over the past 15 years or so since the decision was taken during the mid-1990s to develop GSM-R technology for European railways, in order to enable cross-border operation for international service. It should be remembered that at that time TETRA was in its infancy compared with GSM, and has matured and evolved since.

A large number of rail operators around the world have embarked on extensive and expensive modernisation programmes. These include, in many cases, the re-evaluation of the most appropriate and most cost effective digital radio technology for next-generation radio communications which will effectively complement existing and future operations.

It is vital for rail operators to be provided with the most up-to-date information about existing alternative technologies. TETRA is able to provide rail operators with all of the following:

- Comprehensive, inherent, built-in PMR (private mobile radio) voice call functionality which is essential for railway operation.
- Direct Mode Operation, for direct communications outside the main radio network infrastructure, essential for operations such as shunting.
- Fast and consistent voice call set-up even over wide area connections.
- Flexibility in choice of frequency bands, especially in UHF – e.g. 350-370, 380-400, 410-430 and 450-470 MHz bands.
- Improved spectrum efficiency (up to 4 times more channels for communications using an equivalent amount of spectrum) and reduced bandwidth requirements compared with 200kHz GSM-R channels.
- Operation at the lower end of UHF band – resulting in better coverage and leading to fewer base stations to cover the same length of railway.

- Narrow and wideband packet data services (multi-slot packet data and TEDS) for mission-critical and safety critical applications support.
- Multi-vendor support and competition for the core system, subscriber radios and peripherals.

Latest developments and discussions in the industry very much see IP as the medium for connecting up the digital world. In addition radio technologies such as TETRA and LTE will deliver a raft of mission critical services to users. Recognising that TETRA alone will not serve all the future needs of critical communications users, in particular for broadband data applications, the industry body the TETRA Association has recently changed its name to the TETRA and Critical Communications Association (TCCA).

This document has been produced by the main contributors of the TCCA Transportation forum as a guide to enable manufactures, users and operators understand what the future requirements of TETRA in the railway environment may be. Whilst it is not an exhaustive document it can be used as an aid to help future developments in technology, interoperability and integration with wider rail systems.

In closing, I would like to particularly thank David Taylor of Analysys Mason, Tony Gray of P3, Peter Clemons of Teltronic and David Chater-Lea of Motorola Solutions, all of which without them we would not of been able to produce this valuable document.

Robin Davis, Chairman of TCCA Transportation Group and Project Director, Actica Consulting.

2 Scope

This User Requirements Specification (URS) is a statement of the requirements of rail users, for radio communications associated with the operation of railway services. It includes all types of railway service, including heavy rail, light rail, metro and tram services.

The radio requirements are for both voice and data services.

The URS is in two parts. The first is identification of the current requirements while the second part details the expected requirements needed in the future.

The requirements are gathered from a number of tender documents, and implemented systems.

3 References

Various tender documents for Rail and Metro systems

UIC Project EIRENE System Requirements Specification

ETSI EN 300 019-1-5 Environmental conditions and environmental tests for telecommunications equipment; Part 1-5: Classification of environmental conditions; Ground vehicle installations

ETSO EN 301 489-1 ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements

4 Definitions and abbreviations

4.1 Definitions

Definitions	Meaning
Calling Party information	Information about the calling party, passed and displayed on the Called Party terminal
Direct Mode	Back-to-back or set-to-set radio communications without the use of any infrastructure.
Duplex call	A call where both parties can talk and listen simultaneously.
Functional addressing/numbering	The process of addressing a call using a number representing the function a user is performing, rather than a number identifying the user's terminal equipment.
Group call	A call made to all members of a pre-defined group. Only one member of the group may talk at any instant with all other group members listening only. A group may be over a defined area which is configurable.
Handover	The process of a call moving from one cell to another cell, without the call having to be re-established by the user.
High speed packet data	Packet data with a transmission rate of greater than 150kbps
Location dependant addressing	The process of addressing a particular function (typically a controller) based on the current location of the user (typically a train).
Pre-emption	The process where resources will be cleared to allow a more urgent call to succeed.
Talking Party information	In a group call, information about the party currently talking, passed and displayed on the terminals of other group members.
Unit to Unit call	A call between two individuals.

4.2 Abbreviations

Abbreviation	Meaning
DTMF	Dual Tone Multiple Frequency (used for telephony signalling)
GPS	Global Positioning System
Q0S	Quality of Service
SDS	Short Data Service
SIL	Safety Integrity Level
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
URS	User Requirement Specification

5 User Requirement Specification – Current

5.1 Voice services

Voice is a primary requirement, required in all systems. A number of voice services are required:

5.1.1 Duplex speech

There must be the capability for a controller to talk to a driver or other user, on a one to one basis, with full duplex speech. The driver or other user must be able to communicate at all times with the controller: it is not acceptable for the controller receive audio to be muted when the controller is talking. Parties in the call must receive Calling Party information. It must be possible to interrupt such calls if a pre-emptive call is initiated to the called or calling party.

Speech services must be of good quality with good intelligibility and low delay.

Calls between a driver and controller must support location dependent addressing, where the call will be routed to the relevant controller dependant on the location of the train.

5.1.2 Unit to Unit calls (within network)

There must be a capability for drivers and other users to communicate on an individual call basis. This call does not need to be duplex, but parties must receive Calling Party information. It must be possible to interrupt such calls if a pre-emptive call is initiated to the called or calling party.

This call will typically be used between users operating on a train, or between a train and local trackside user.

5.1.3 Unit to Unit calls (outside network)

There must be a capability for drivers and other users to communicate on an individual call basis. This call does not need to be duplex, but parties must receive Calling Party information.

This call will typically be used between users operating on a train, or between a train and local trackside user. This type of call may be used when there is insufficient coverage, either by design or due to network problems.

5.1.4 Group calls - one to many (inside network)

There must be a capability for users to be able to talk to a group of users, and for another party in the group to respond. This call will be simplex, but parties in the group must receive Talking Party information. It must be possible to interrupt such calls if a pre-emptive call is initiated to the originating party or called group.

Group calling must be configurable to allow calling from a controller to pre-defined areas. Group calling between trackside workers , shunting staff and station staff must be configurable to operate over a local area.

This call will typically be used in shunting and marshalling yards, where it is necessary for the users to work together.

5.1.5 Group calls – one to many (outside network)

There must be a capability for users to be able to talk to a group of users, and for another party in the group to respond. This call will be simplex, but parties in the group must receive Talking Party information.

Group calling between trackside workers, shunting staff and station staff must operate over a local area. This call will typically be used in shunting and marshalling yards, where it is necessary for the users to work together.

5.1.6 Call set up

Group and emergency pre-emptive calls must be set up within 500 milliseconds.

5.1.7 Pre-emption

It must be possible for suitably authorised users and controllers to be able to initiate emergency calls, which will pre-empt any non-emergency calls if necessary to ensure the resources are available to set up the emergency call.

Certain specified duplex calls have to be configurable to be pre-emptive, should no resources be available on the receiving cell at the time of call set up.

5.1.8 Handover

There must be seamless handover while transmitting in a call; at speeds up to 300km/hr. Seamless is defined as less than a 300 milliseconds break in connection.

5.2 Data services

5.2.1 Types of data

The following types of data must be provided:

- Status messages, where a code representing the status of an item is sent over the network
- Short data transmission – where an alphanumeric or binary number is sent over the network – typical uses would be a GPS location update or an alarm status update
- Circuit mode data – providing an end to end data circuit
- Packet data – IP packet data, using TCP or UDP.

Depending on application, not all types of data will be required.

5.2.2 Data speeds

There are no requirements for large volumes of data from current system requirements. There is a requirement for status, SDS and limited circuit or packet data, but no large volumes of data.

5.2.3 Data performance

Data signalling must provide capacity for error checking and correction to achieve the specified end to end error rate.

End to end latency must be less than 500 msec (for a one way 32 byte packet from PEI port of MS to an infrastructure port).

5.3 Numbering

Functional addressing and numbering, where an alias or temporary function number rather than the terminal number is used, must be supported.

Train Run Numbers must be supported.

5.4 Encryption

All voice and data services must be capable of being encrypted. This includes unit to unit and group calls.

5.5 Coverage requirements

Coverage will be a system characteristic, but must be able to be engineered to provide at least 96% of locations along the track, and several hundreds of metres away from the track. Coverage must be able to be engineered to provide handover, with travelling speeds on main line networks of greater than 300km/hr.

It must be able to engineer solutions for confined space solutions such as tunnels, including handover with less than a 1 second break at speeds of up to 100 km/hr.

5.6 Resilience

Resilience and redundancy is a system characteristic, but the usual requirement for railway communications systems will be an availability of at least 99.95%, with no single point of failure. This will include redundant duplicated equipment on board trains.

5.7 Environmental requirements

Rail mounted and trackside equipment is located in a hostile environment, with extremes of temperature, shock and vibration. In addition power sources will not provide a clean power supply, but will suffer from fluctuations and high noise levels. The equipment must be able to work in this environment.

Equipment mounted in metro and light rail trains will be located in confined spaces, often with inadequate ventilation, and is likely to be subject to high RF fields from cellular radio devices operating close to the equipment.

Typical specifications for train mounted equipment will be:

Temperature (operating)	°C	-20 to +55		
Stationary vibration, sinusoidal:				
displacement amplitude (peak)	mm	3,3		
acceleration amplitude (peak)	m/s^2		10	15
frequency range (see	Hz	2 to 9	9 to 200	200 to 500

Stationary vibration, random:			
acceleration spectral density	m^2/s^3	1	0,3
frequency range	Hz	10 to 200	200 to 500
Non-stationary vibration, including shock: (IEC 60721-3-5)			
shock response spectrum type I			
peak acceleration (â)	m/s^2	100	
duration	ms	11	
shock response spectrum type II			
peak acceleration (â)	m/s^2	300	
duration	ms	6	
EMC			
Frequency range		Radio frequency electromagnetic field (80 MHz to 1 000 MHz and 1 400 MHz to 2 700 MHz)	
Level	V/m	3 V/m (measured unmodulated)	
Modulation		amplitude modulated to a depth of 80 % by a sinusoidal audio signal of 1 020 Hz	

5.8 Terminal requirements

The terminal must support the transmission of DTMF tones.

6 User Requirement Specification – Future

6.1 Overview

Future rail requirements are likely to divide into two main types of requirement:

- Communications systems used to provide voice and data services to the operational railway system, as a back up to a fully signalled railway.
- Data communication systems used for train control, and for lineside signalling replacement.

Therefore there may be rail systems in the future with no requirement for voice.

Future rail radio communications networks may be hybrid solutions and are expected to be carried over IP infrastructure.

6.2 Voice services

Where voice is required, the requirements will be as current requirements.

Future voice services may increasingly be provided by non-circuit mode services, When non-circuit mode services are used, measures must be used to ensure QoS for voice calls is available, with priority access arrangements.

6.3 Data services

6.3.1 Types of data

The following types of data must be provided:

- Status messages, where a code representing the status of an item is sent over the network
- Short data transmission – where an alphanumeric or binary number is sent over the network – typical uses would be a GPS location update or an alarm status update
- Packet data – IP packet data, using TCP or UDP
- High speed packet data.

Depending on application, not all types of data will be required.

6.3.2 Data speeds

Requirement for bi directional high speed, high capacity data services, for both train personnel and the travelling public.

6.3.3 Data performance

High speed, low latency data services for real time applications, including signalling.

6.4 Data prioritisation

Where networks are used to support both train operational and travelling public use, data prioritisation must be provided for operational use.

6.5 Coverage requirements

Coverage will be a system characteristic, but must be able to be engineered to provide at least 96% of locations along the track, and several hundreds of metres away from the track. Coverage must be able to be engineered to provide handover, with running speeds on main line networks of greater than 500km/hr.

It must be able to engineer solutions for confined space solutions such as tunnels, including handover with less than a 1 second break at speeds of up to 150 km/hr.

6.6 Resilience

Resilience and redundancy is a system characteristic, but the usual requirement for railway communications systems will be an availability of at least 99.95%, with no single point of failure. This will include redundant duplicated equipment on board trains.

6.7 Safety Critical Software Level

Where radio communications is used for safety critical control, the overall application will have to be SIL certified at the required points, and will be subject to local approvals, but there is no requirement for the radio network to have SIL compliance.

6.8 Environmental requirements

Rail mounted and trackside equipment is located in a hostile environment, with extremes of temperature, shock and vibration. In addition power sources will not provide a clean power supply, but will suffer from fluctuations and high noise levels. The equipment must be able to work in this environment.

Equipment mounted in metro and light rail trains will be located in confined spaces, often with inadequate ventilation, and is likely to be subject to high RF fields from cellular radio devices operating close to the equipment.

Future temperature, shock and vibration environmental requirements will the same as current specifications. EMC immunity requirements will be higher, with equipment having to be more tolerant of interfering wide band data sources operating at higher frequencies

6.9 Encryption –

Encryption requirements will be as for current, with additional requirements as a result of increased data services and non-circuit mode voice services

Cryptographic integrity checking will be required.

6.10 Other requirements

6.10.1 Spectrum efficiency

Future radio communications networks will be required to be spectrum efficient.

6.10.2 Easily deployable

Deploying radio communications into existing rail networks is problematic, where track access has to be arranged, and there are very limited time windows when access can be arranged.

Future radio communications networks will be required to be easily deployable, to minimise the access restrictions and planned outages required for an operational railway.

6.10.3 Economic and value for money

Future radio communications networks will be required to demonstrate value for money, within the constraints of providing mission critical voice and data communications for the safe operation of the railway and the safety of the staff.

7 Summary of requirements

	Available in TETRA Standard	Available in TETRA solutions	Future requirement
Current Requirements			
Duplex speech	✓		
Calling Party Information	✓		
Pre-emptive voice call	✓		
Good intelligibility and low delay	✓		
Location dependent addressing		✓	
Individual call (within network)	✓		
Individual call (outside network)	✓		
Group Call (inside network)	✓		
Talking Party Information	✓		
Group Call (outside network)	✓		
Group Call to pre-defined area	✓		
Call set up within 500 milliseconds	✓		
Configurable pre-emption on duplex calls		✓	
Seamless handover	✓		
Track speeds of 300 km/hr	✓		
Status data	✓		
Short data	✓		

Circuit mode data	✓		
IP packet data	✓		
Error checking and correction		✓	
Functional numbering and addressing		✓	
Train Run Numbers		✓	
Encryption of voice and data	✓		
At least 96% coverage along the track		✓	
Confined space (tunnel) solutions with speeds up to 100 km/hr		✓	
Availability of at least 99.95%		✓	
Future requirements			
Non-circuit mode voice			✓
QoS for voice services			✓
High speed packet data			✓
Low latency high speed data services for real time applications			✓
Running speeds of up to 500 km/hr	✓		
Confined space (tunnel) solutions with speeds up to 150 km/hr		✓	
Cryptographic Integrity Checking			✓