Introduction to TETRA

(TErrestrial Trunked RAdio)

SELEX Communications

A Finmeccanica Company

Introduction to TETRA (TErrestrial Trunked RAdio)

TETRA, the digital standard for professional communications is the first real open standard for the digital professional mobile radio system, contributing to open the international market in the professional radiocommunications.

The Professional Mobile Radio market, which includes Private and Public Access Mobile Radio (PMR and PAMR), has traditionally been scattered in many dimensions in terms of technologies, frequency allocation etc.

The first clear change towards international standardisation was the introduction of the analogue MPT1327 trunked radio standard, that lead to a market success in leads parts of the world.

TErrestrial Trunked RAdio (TETRA) is the first truly open digital private mobile radio standard. TETRA is opening an even more international Professional Mobile Radio market.

The standard is defined by the European Telecommunications Standards Institute (ETSI), that joins the forces of network operators, national administrations, equipment manufacturers and users.

What is notable in the status of ETSI is that it publishes telecommunications standards that are mandatory for use in Europe, but also widely applicable outside Europe.

The Global Standard for Mobile telecommunication (GSM) is a good example of this. The essential parts of the TETRA standard have been approved in national voting's at the end of 1995 (22 countries voted for the approval and none against it).

New features and services will continue to be standardised to TETRA for years to come, just has been the case with GSM.

The standard has gone through a thorough approval procedure with its vast number of commenting that as such ensures high quality compared with the development of proprietary solutions.

User impact can be seen clearly on the development of TETRA, especially the emergency service users have contributed strongly in the creation of the standard. As a result, the TETRA standard contains high functionality for emergency services and is also very well suited for commercial trunked radio users.

The high level of user involvement in the creation of the standard ensures that it will meet the needs of the demanding users.

To ensure an open multivendor market, TETRA specifies the following essential interfaces:

1. **Air Interface** ensures the interoperability of terminal equipment from different manufacturers.
2. **Terminal Equipment Interface (TEI)** facilitates the independent development of mobile data applications.
3. **Inter-System Interface (ISI)** allows the interconnection of TETRA networks from different manufacturers.
4. **Direct Mode Operation (DMO)** guarantees communication between terminals also beyond network coverage.

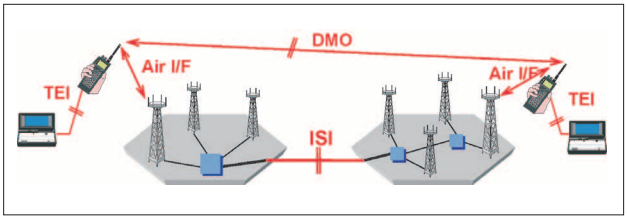
Also a line station interface is standardised. It should be noted that the interfaces inside the Switching and Management Infrastructure are not standardised. This provides the essential benefits of an open market, but leaves the manufacturers the freedom to implement the most cost-efficient network solutions.

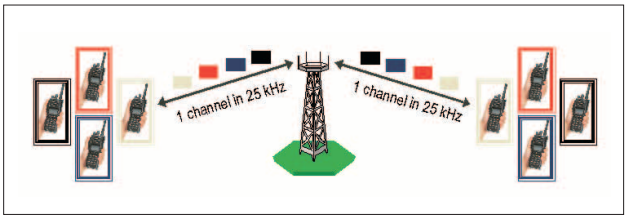
Major user organisations, network operators, system manufacturers, regulators, test houses and application software developers have all signed the TETRA Memorandum of Understanding (MoU), a joint effort to support and promote fast and consistent implementation of TETRA systems in the member countries. To ensure a wide open market, the TETRA MoU strives for the maximum interoperability of equipment from different manufacturers. The TETRA MoU publishes a quarterly newsletter called "TETRA News" and has an informative website in the Internet at "www.tetramou.com".

TETRA is thus the first and only approved digital trunking standard in Europe or in any other part of the world.

TETRA - A HIGHLY SOPHISTICATED PMR PLATFORM

TETRA is a highly advanced technical platform providing integrated voice and data service. This combined with outstanding connectivity possibilities set a whole new level in Professional Mobile Radio technology.





ADVANCED TECHNICAL CHARACTERISTICS

TETRA is a fully digital system providing consistent voice quality and low bit error rate for data accordingly.

It supports voice, circuit switched data and packet switched data services with a wide selection of data transmission rates and error protection levels.

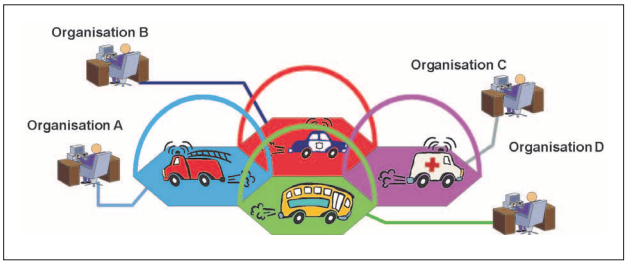
TETRA uses TDMA (Time Division Multiple Access) technology with four user channels interleaved into one carrier with 25 kHz carrier spacing.

This means excellent efficiency of frequency spectrum. Cost savings are also achieved in base stations were only one radio unit is needed for every four user channels.

Higher data transfer rates up to 28.8 Kbit/s are implemented by reserving up to four channels for the same user connection - bandwidth is allocated by demand.

TETRA has from the beginning been designed as a trunked system that effectively and economically supports shared usage of the network by several organisations, yet maintaining privacy and mutual security.

Virtual networking inside the TETRA network enables each organisation to operate independently, but still enjoys the benefits of a large, high-functionality system with efficient resource employment.



TETRA is a high security technology that inherently includes encryption of voice, data, signalling and user identities. Two encryption mechanisms are defined: **Air**

interface encryption, which encrypts the radio path between the terminal and the base station.

> **End-to-End encryption** for the most critical applications where encryption is required for the transmission throughout the system to the other terminal.

TETRA provides very fast call set-up time (300 ms), that is crucial for the public safety and emergency services. Naturally, TETRA supports both semi-duplex operations for efficient group communication and duplex operation for telephony type individual calls. The advanced group and announcement call features included in TETRA meet the needs of the most critical user applications.

Multiple call priority schemes ensure effective resource allocation to the most urgent traffic in the network. The TETRA frame structure has four time slots per TDMA frame. This is further organised as 18 TDMA frames per multiframe. In circuit mode voice and data operation traffic from an 18 frame multiframe length of time is compressed and conveyed within 17 TDMA frames, thus allowing the 18th frame to be used for control signalling without interrupting the flow of data.

This 18th frame is called the control frame and provides the basis for slow associated control channel (SACCH). The SACCH provides the background control channel signalling that is always present, even in minimum mode when all channels are allocated to traffic, one of the most powerful features of the TETRA protocol. The gross bit rate of one channel is 9 Kbit/s, into which speech is coded with 4.8 Kbit/s net bit rate using ACELP coding, one of the most efficient voice coding methods to date.

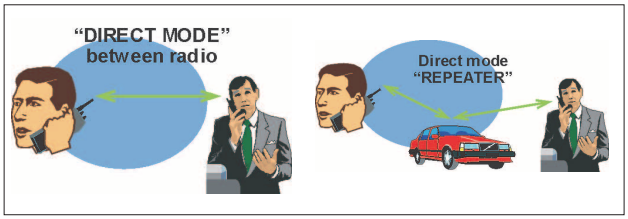
The modulation method applied in TETRA is $\Pi/4$-DQPSK - a linear modulation. TETRA includes direct mode operation between mobile radios without the need for network infrastructure.

Also repeater and gateway functions are defined to extend the coverage of hand portable radios in both direct mode and network operation. The defined power classes of TETRA radio equipment are 25W, 10W, 3W and 1W. TETRA radios can automatically adjust the output power according to the needed field strength.

Connectivity

Connectivity between networks of different type is becoming increasingly important. This has been taken into account in the development of TETRA technology. TETRA networks facilitate a wide range of connections to external networks. A TETRA network can be connected to, for example, public and private telephone networks different types of data networks as well as large command and control systems. All these networks, can be accessed from the mobile terminal.

Connectivity combined with bandwidth-on-demand makes TETRA a superior platform for data application development.



TETRA Telecommunications Services

The TETRA standard defines the following basic services for voice and data.

Teleservices provide complete communication capability for between users, including all terminal functions. In TETRA standards teleservices cover voice communications services.

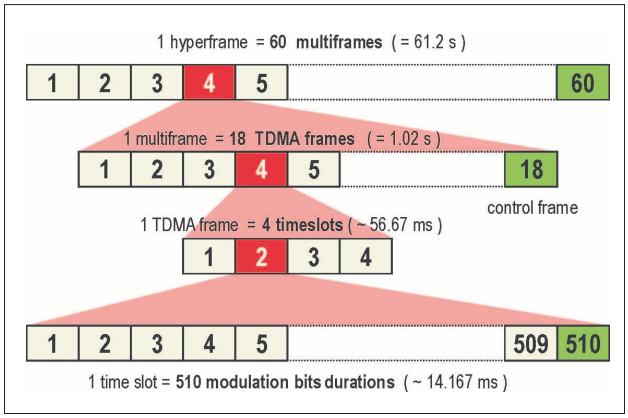
A bearer service provides communication capability between terminal network interfaces, excluding the functions of the terminal. TETRA bearer services are defined for data transfer.

Harmonised TETRA Frequencies

TETRA technology is independent of frequency, but harmonised use of frequencies gives significant economies of scale.

The North Atlantic Treaty Organisation (NATO) has given up 20 MHz of radio frequencies in Europe for emergency and public safety services. This new frequency band resides in between 380÷400 MHz.

National authorities have allocated two sets 5 MHz each in this 20 MHz band for Public Safety TETRA



networks. Due to a common frequency, a large market for TETRA products will be created guaranteeing product supply and competitive prices. European national authorities have also begun allocating frequencies for commercial TETRA. Various plans exist to implement commercial TETRA networks starting in the 410÷430 frequency band.

The UK has already awarded two licences to operate commercial TETRA networks in this band. Other frequencies for these commercial TETRA applications in the worldreside in the following bands:

> 350÷370 / 380÷400 MHz
> 410÷430 / 450÷470 MHz
> 870÷876 / 915÷921 MHz.

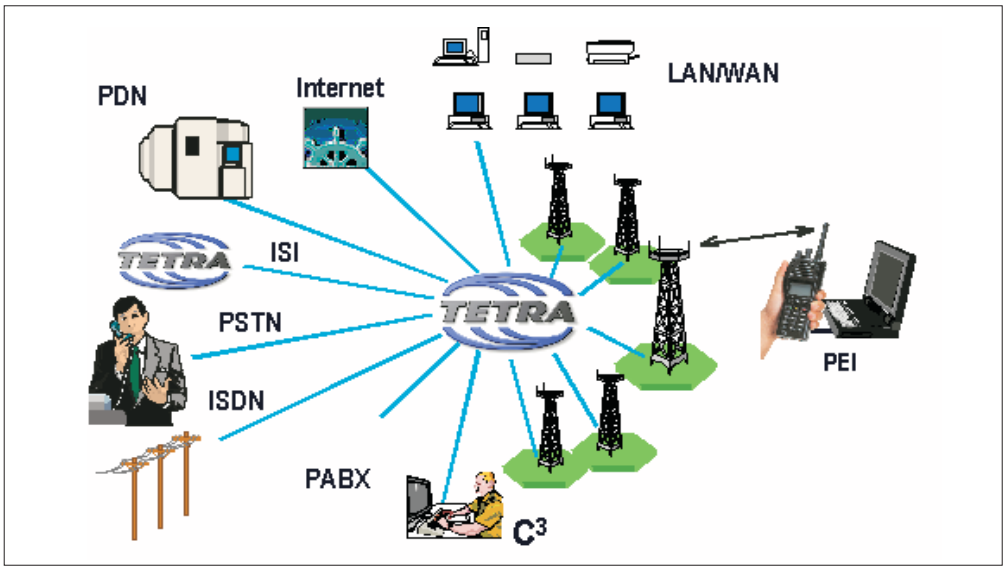
TETRA Fulfils European Police Requirements

The ETSI Technical Sub-Committee RES 06 has conducted an extensive investigation and comparison of the TETRA standard and the requirements defined in the Schengen Telecom Group document "Draft - Digital Radio Communications Network for Security Organisations (Tactical and Operational Requirements)".

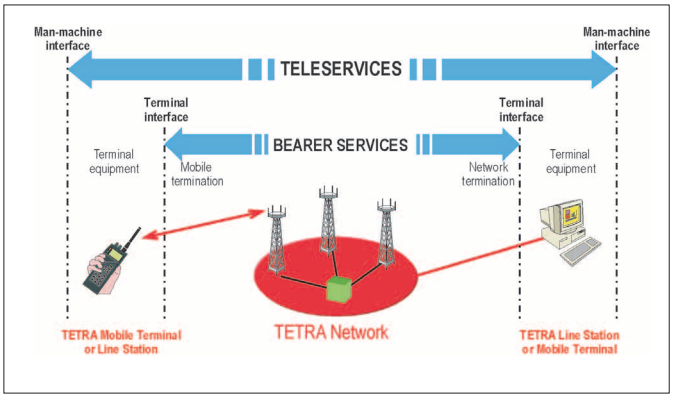
The conclusion of this investigation was that the TETRA standard fulfils these highly demanding requirements, with the small exception of end-to-end delay, which is an insignificant 15 msec longer than desired.

Various European authorities have also conducted their own comparisons of the technological possibilities available. The answer has consistently been that TETRA technology is superior for European police requirements.

In addition, TETRA is the only digital trunking standard approved and recommended by ETSI. The



emergence of other competing standards is highly unlikely, since ETSI will not approve different standards with the same scope.



TETRA Teleservices

Types of call:

- Individual;
- Group;
- Broadcast;
- Acknowledged Group.

TETRA Bearer Services

- Circuit mode protected data 4.8/9.6/14.4/19.2 kbits/s
- Circuit mode heavily protected data 2.4/4.8/7.2/9.6 kbits/s
- Connection oriented packet data

• Connectionless packet data

ETSI REFERENCES

More information concerning the TETRA standard can be found from the following European Telecommunications Standards. In addition, the standard defines supplementary services for very flexible system applications.Supplementary services modify or supplement the above

ESSENTIAL SUPPLEMENTARY SERVICES

Call Authorized by Despatcher:	• Calls can proceed only if approved by the Despatcher.
Access priority:	• Enable the user to gain access to the system in case of radio link congestion.
Priority Call:	• Calls are assigned a priority value, so that in case of need a call with lower priority can be released by the network to allow a user with higher priority to setup a call.
Late entry:	• For joining an ongoing group call.
Discreet Listening:	• For intercepting ongoing connection without alerting the involved parties.
Ambience Listening:	• For forcing to transmission the addressed radio terminals (if not already engaged).
Dynamic Group Number Assignment:	• For dynamically creating/modifying/deleting groups of users.
Talking party identification:	• For listeners to know the calling party during a group call.
Pre-emptive priority calls:	• Which are allowed to disrupt ongoing calls at lower priority level if no resources are available.

OPTIONAL SUPPLEMENTARY SERVICES

Area Selection:	• The user can define the areas to which the calls have to be routed; if the called user is outside the selected areas, he will not be alerted.
Calling line Identification presentation:	• For displaying on called user's terminal the identifier of the caller.
Connected line Identification presentation:	• For displaying on the caller's terminal the identifier of the called user.
Connected line identification restrictions:	• For enabling/disabling the possibility to identify the called user.
Calling line identification restrictions:	• For enabling/disabling the possibility to identify the caller.
Call Report:	• To inform user B that user A has tried to call him (user A can be informed when user B is again reachable).
Call Forwarding unconditional:	• To redirect incoming calls to a defined number.
Call Forwarding busy:	• To redirect incoming calls when the called user is busy.
Call Forwarding on no reply:	• To redirect incoming calls when the called user does not answer.
Call Forwarding on not reachable:	• To redirect incoming calls when the called user is not reachable.
List Search Call:	• A call is routed to the first relatable address contained in a list of attendants.
Short Number Addressing:	• The user can dial predefined abbreviated addresses.
Call Waiting:	• For alerting an engaged user about another incoming call; this call can be accepted, ignored or refused.
Call Hold:	• For interruption and later retrieval of a call.
Call Completion to busy subscriber:	• The network delays the call of user A until user B is available.
Call Completion on no reply:	• The call of user A is delayed by the network until user B has made/received a call and has become again available.
Transfer of control:	• Allows an originator to transfer the control of a group call to another user and to leave the call without causing its releasing.
Include Call:	• Allows user A, engaged with user B, to make a third user C join the call.
Barring of incoming calls:	• To enable/disable categories of incoming calls (e.g. international calls...).
Barring of outgoing calls:	• To enable/disable categories of outgoing calls (e.g. international calls...).
Call Retention:	• For avoiding of being pre-empted upon resources contention.
Advice of Charge:	• For informing the charged user about the charge of the call.

In addition, the standard defines supplementary services for very flexible system applications. Supplementary services modify or supplement the above mentioned services.

TETRA Voice Plus Data
ETSI ETS 300 392

Part 1 - General network design
Part 2 - Air Interface
Part 3 - Inter-working
Part 4 - Gateways
Part 5 - Terminal equipment interface
Part 6 - Line connected stations
Part 7 - Security
Part 8 - Network management services
Part 9 - Performance objectives
Part 10 - Supplementary services stage 1
Part 11 - Supplementary services stage 2
Part 12 - Supplementary services stage 3
Part 13 - SDL model for air interface
Part 14 - PICS Proforma
Part 15 - Interworking-extended operations
Part 16 - Gateways for supplementary services

TETRA Packet Data Optimised ETSI ETS 300 393

Part 1 - General network design
Part 2 - Air Interface
Part 3 - Inter-working
Part 4 - Gateways
Part 5 - Terminal equipment interface
Part 6 - Line connected stations
Part 7 - Security
Part 8 - Network management services
Part 9 - Performance objectives
Part 10 - SDL model for air interface
Part 11 - PICS Proforma

TETRA Conformance Test
ETSI ETS 300 394

Part 1 - Radio conformance testing
Part 2 - Protocol conformance testing - voice + data

TETRA Codec
ETSI ETS 300 395

Part 1 - General description of speech functions
Part 2 - Codec
Part 3 - Specific operational features
Part 4 - Codec conformance testing

TETRA Direct Mode
ETSI ETS 300 396

Part 1 - General network design
Part 2 - Direct MS - MS air interface - radio aspects
Part 3 - Repeater
Part 4 - Gateway
Part 5 - Security

MAIN DEFINITIONS

ACELP	Adaptive Code Excited Linear Predictive, the voice codec used in TETRA.
DMO	Direct Mode Operation, the signalling standard for direct terminal to terminal calls
P/4 DQPSK	Digital Quadrative Phase Shift Keying, the modulation method used in TETRA.
ISDN	Integrated Serviced Digital Network
ISI	Inter-System Interface, the standard interface between two TETRA networks
LAN/WAN	Local/Wide Area Network
MPT 1327	Ministry of Posts & Telecommunications (UK), the defacto signalling standard for analogue trunking.
PABX	Private Automatic Branch Exchange
PAMR	Public Access Mobile Radio
PMR	Professional Mobile Radio or Private Mobile Radio
PSTN	Public Switched Telephone Network
TDMA	Time Division Multiple Access
TEI	Terminal Equipment Interface, the standard data interface in TETRA terminal equipment.
TETRA	TErrestrial Trunked RAdio, the ETSI standard for digital trunking.

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