



14 July 2015

# Tetrapol Factsheet

## Trunked radio system for emergency services

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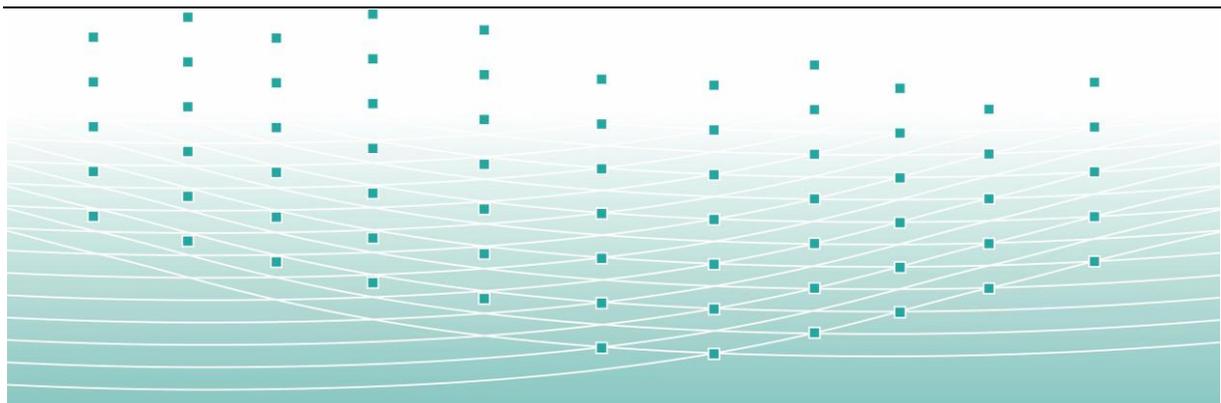
### Summary

Tetrapol is a digital, cellular trunked radio system primarily for voice communications though also for data. Tetrapol was originally developed by Matra Communication (now EADS), France. The first Tetrapol customers were the gendarmerie (mid-1992) and the police (early 1995) in France.

Potential users of trunked radio systems include closed user groups such as transport services, airports, energy companies and the emergency services. All these user groups either have their own private trunked radio system or use the services of a trunked radio systems operator. Tetrapol is primarily designed for the needs of emergency services and is very successful in this market segment.

The modulation method used is GMSK (Gaussian Minimum Shift Keying) and in Switzerland the channel spacing is 10 kHz.

In Switzerland, the Tetrapol system has been adopted for the POLYCOM national emergency radio network.



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## 1 Introduction

Tetrapol is a digital, cellular trunked radio system for voice and data communications. Tetrapol<sup>1</sup> was originally developed by Matra Communication (now EADS), France. Today, Tetrapol technology is supported and is being further developed by two organisations: the Tetrapol Forum (predominantly manufacturers) and the Tetrapol User's Club (user organisations). The first customers for Tetrapol were the gendarmerie (mid-1992) and the police (early 1995) in France.

Digital trunked radio systems are modern radio systems for private and public professional radio applications and for emergency radio applications (PMR/PAMR<sup>2</sup>). Unlike earlier conventional analogue fixed-channel systems (a specific radio channel was allocated to each service and each user for the whole time), in the case of trunked radio systems frequencies are allocated dynamically to individual users and services. It is therefore possible to fully utilise so-called trunking gain and to increase spectrum efficiency. In addition, the quality and security of radio systems could be considerably improved using digital technology.

As early as the first half of the 'eighties, initial attempts were being made to seek appropriate solutions for digital PMR systems. This step was essential in order to increase spectrum efficiency, improve technical reliability and facilitate encryption of the connection. It was at this time that the first proprietary digital PMR systems appeared, including ASTRO and iDEN (both by Motorola), EDACS (Ericsson), SR 440 (Bosch/Ascom) and Tetrapol (Matra Communication).

Potential users of trunked radio systems include closed user groups such as transport services (taxis, Swiss Federal Railways, haulage companies, etc.), airports, energy companies and the emergency services (e.g. police, the fire brigade, ambulance services, the army, civil defence, the frontier police, etc.). All these user groups either have their own private trunked radio system or use the services of a trunked radio systems operator.

Trunked radio systems differ from public mobile radio systems such as GSM or UMTS primarily in terms of their faster call set-up, group calls, priority calls, end-to-end encryption and the possibility of direct calls from mobile station to mobile station without a connection via a base station (this is known as direct mode).

Tetrapol must not be confused with the similar sounding TETRA system. TETRA was developed by the recognised European Telecommunications Standardisation Institute (ETSI) – in co-operation with the industry – and is therefore the recognised standard for digital trunked radio systems in Europe. A brief comparison of Tetrapol and TETRA is provided in section 5.

In Switzerland, Tetrapol digital trunked radio technology has been chosen for the national emergency network, POLYCOM.

## 2 Development in Europe

The market for professional mobile radio systems world-wide is approximately 9 billion dollars per year, with a conservative estimate of some 22 million users in 2010<sup>3</sup>. Of this, about one quarter, or 2 billion dollars, relates to Europe – with some 5 million users. The number of *potential* users in Europe is estimated to be 10 million<sup>4</sup>. A growth rate of 5% - 6% per year is being forecast from various sides. This growth is expected because market penetration of PMR systems in Europe amounts to only 2%. Compared with the USA this is low; there, penetration is already up to 8%<sup>5</sup>. In addition, approximately 65% of the PMR systems are still currently based on outmoded analogue technology, which will eventually be replaced by more modern digital systems.

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<sup>1</sup> At that time the system was still known as "Matracom 9600".

<sup>2</sup> The market for professional mobile radio is designated PMR (Private Mobile Radio) or PAMR (Public Access Mobile Radio). In the case of PMR the radio system is operated by the user himself; with PAMR the trunked radio services are obtained from an independent network operator. PAMR operators also generally offer access to the fixed network.

<sup>3</sup> Analysys Mason: DMR Market Report, 21 December 2011.

<sup>4</sup> Funkschau 5/98, p. 80 ff.

<sup>5</sup> Tetrapol PAS Conversion by ETSI, Explanatory report, Part 1.

The market trend in PMR and in emergency radio applications in particular (about 30% of the PMR market) clearly points in the direction of large, jointly used networks. Traditional users of PMR systems such as public utility companies (electricity, gas and water supply) as well as the transport industry are outsourcing their radio activities more and more to specialist trunked radio operators.<sup>6</sup>

### 3 Licences in Switzerland

The Tetrapol standard is being applied in Switzerland to establish a national emergency radio network. The network is being constructed by Siemens and operated by POLYCOM. POLYCOM is a closed user group operating a network for its own use.

Potential users of the POLYCOM radio network are organisations which have a common requirement to communicate in extraordinary or emergency situations. The circle of users is substantially identical to the institutions listed in Article 91 of the Telecommunication Services Ordinance (TSO Verordnung über Fernmeldedienste - FDV), which are entitled to use the services mentioned in Article 90 of the Ordinance, namely:

- a. the army, civil defence, national economic procurement authorities and civil administrations;
- b. the police, fire brigade and those organisations which are entrusted by the community with rescue and public health tasks;
- c. those bodies which according to Article 67 of the Swiss Military Act may be brought in to assist the civil authorities.

OFCOM grants each participating organisation its own professional radio licence for the mobile and fixed stations operated on the POLYCOM network. The operating company POLYCOM, which unites all the participating organisations, is also granted a professional radio licence for the jointly operated network infrastructure.

The frontier police commissioned an initial sub-network in autumn 2000 in the canton of Ticino.

### 4 Services

Tetrapol offers an extensive range of services some of which are not (yet) available in public mobile radio systems. The list below is not exhaustive. For further information, please refer to the Tetrapol specification (Part 1-2: "Voice & Data Services in Network and Direct Mode") (see also chapter 5).

#### Teleservices:

- **Individual Call:** This service corresponds to a call in a public mobile radio system (GSM, UMTS, LTE). One user calls another individual user and is connected with the latter.
- **Group Call:** One user calls a predefined group. Each member of the group can hear everything and can speak. The group call can be set up so that the individual members must acknowledge or not. A group can be modified dynamically, i.e. members can be added or removed.
- **Direct Mode:** In direct mode, two or more mobile stations communicate with each other, without involving a base station (walkie-talkie).
- **Broadcast Call:** This is a unidirectional point-to-multipoint call within a specified area. The area and the users are defined in advance. The individual users do not acknowledge the call and therefore the caller is unable to verify who has and who has not received the call.
- **Emergency Call:** An emergency call button sets up a high-priority call to a dispatcher or a

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<sup>6</sup> See also: ERC Report 52, "Methodology for Assessment of PMR Systems in terms of Spectrum Efficiency, Operation and Implementation".

predefined group of users.

- **Include Call:** During a call, this function makes it possible to ring one or more additional users and include them in the call.
- **Open Channel:** A group of users can converse with each other on a specific channel for a specific period. Within the group, all participants can hear each other and can speak at any time. In TETRA this service is not explicitly standardised. However, it can be installed with the aid of a broad range of extra services (e.g. Pre-emptive Priority Call and Call Retention).

#### Data services:

- **Paging:** Brief messages can be sent by a dispatcher to the mobile station. The messages are not acknowledged.
- **Status Transmission:** Very short, predefined messages can be transferred from dispatcher to the mobile stations and vice versa, or between mobile stations.
- **Short Data Messaging:** This data service allows users to exchange very short messages.
- **X.25 Packet Data Services:** This data service allows an X.25 call to be set up between two terminals. It is also possible to set up a connection from a mobile station to a PDN (Packet Data Network).
- **TCP/IP Access:** This data service allows the mobile stations to access the Internet or servers supporting the TCP/IP protocol.

#### Supplementary services:

- **Ambience Listening:** This supplementary service allows the dispatcher to listen in unnoticed to a vehicle in unclear or dangerous situations. This service is important above all for the police or other emergency services
- **Priority Call:** This supplementary service allows a user to allocate a priority to the call. The call is then processed before all other calls which have a lower priority. If no more network resources are available (e.g. all channels are busy), the necessary resources can be released by means of the so-called Pre-emptive Priority Call. The calls with the lowest priority are consequently aborted in this case.
- **Late Entry:** This supplementary service allows a user to connect at a later time to a group call, for example if he was engaged at the time of the call or if he had not yet switched his equipment on

## 5 Technology

Tetrapol was developed mainly for the important and challenging "emergency radio applications" market segment.

Development of Tetrapol started in 1987 on the basis of an invitation to tender from the French gendarmerie for a national digital trunked radio system. The chosen channel access method was **FDMA** (Frequency Division Multiple Access). FDMA is the classic channel access method in which each user is allocated a specific frequency for a connection. In Switzerland the channel spacing is 10 kHz (12.5 kHz channel spacing is also provided for in the Tetrapol system).

In each cell, a control channel is emitted continuously on a specific carrier. This control channel is used to transfer the network's system data to the mobile equipment.

In principle, Tetrapol can be used on frequencies between 70 and 520 MHz. In practice, however, only the typical frequencies authorised for PMR in the 80, 160 and 400 MHz band are used (see chapter 6).

As with most radio systems, the frequency duplex method is also used by Tetrapol. The uplink and downlink are handled on two different frequencies, which are separated from each other by so-called duplex separation. The size of this duplex separation depends on the frequency band in which the system is operated. TETRAPOL terminals (like those of most PMR systems) generally work in half-duplex mode, i.e. it is not possible to send and receive simultaneously.

The modulation method used is GMSK (Gaussian Minimum Shift Keying). This modulation method is also used for GSM and has the advantage that simple and relatively cheap transmitters can be used with a high level of efficiency.

The Tetrapol specification may be viewed and downloaded from the following address: [http://www.tetrapol.com/downloads/publicly\\_available\\_specifications/](http://www.tetrapol.com/downloads/publicly_available_specifications/).

Tetrapol and TETRA are the most well-known digital trunked radio systems in Europe. A brief comparison of these two systems is therefore appropriate and is shown in Table 1 (a separate factsheet is available for TETRA).

**Table 1: Advantages and disadvantages of Tetrapol compared with TETRA**

<i>Advantages of Tetrapol compared with TETRA</i>	<i>Disadvantages of Tetrapol compared with TETRA</i>
<ul style="list-style-type: none"> <li>▪ The maximum possible cell radii of Tetrapol are up to 50% larger than those of TETRA, assuming the same <u>peak</u> transmission power. Subject to this assumption, Tetrapol requires only approximately half the number of base stations as TETRA to cover a specific area. However, this advantage applies only as long as the traffic is low and the peak transmit power, not the mean transmit power, are identical.</li> <li>▪ The channel spacing is 10 kHz or 12.5 kHz, i.e. good co-existence with existing systems and low out-of-band emissions (complies with ETSI EN 300 113).</li> <li>▪ Simulcast is easier to implement with Tetrapol.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Duplex operation is not simple to implement (antenna splitter in the mobile station).</li> <li>▪ Tetrapol's data rates are clearly lower than those of TETRA.-</li> <li>▪ Tetrapol's spectrum efficiency is lower than that of TETRA (by a factor of 1.16 to 2.0 depending on the environment)</li> <li>▪ TETRA is an acknowledged European standard, whereas Tetrapol has not yet been accepted as an ETSI standard.</li> </ul>

Table 2 summarises the most important radio parameters of TETRA.

**Table 2: Major Tetrapol radio parameters**

Parameter	Value
Channel spacing	10 kHz, 12.5 kHz <sup>b)</sup>
Transmission power of base station per carrier frequency (typically)	25 W ERP
Transmission power of mobile equipment	1 W, 2 W, 10 W <sup>e)</sup>
Receiver sensitivity, static (BER = 1.5%)	MS: -119 dBm BS: -121 dBm
Receiver sensitivity, dynamic (TU50; BER = 1.5%)	MS: -111 dBm BS: -113 dBm
Mode	Semi-duplex <sup>c)</sup>
Channel access method	FDMA
Modulation	GMSK, BT = 0.25
Channel bit rate	8 kbit/s
Maximum data rate, non-protected (gross bit rate)	7.6 kbit/s
Net data rate	Protected: 4.8 kbit/s Non-protected: 7.2 kbit/s
Speech coding	RP-CELP; 6 kbit/s
Spectrum efficiency in interference-limited environment (high traffic, many cells)	43 bit/(s*kHz*cell)
Spectrum efficiency in noise-limited environment (an isolated cell)	192 bit/(s*kHz)
Range <sup>f)</sup>	Rural: ca. 20 km <sup>a)</sup> Suburban: ca. 6 km
Co-existence standard <sup>d)</sup>	ETSI EN 300 113-1
<b>Notes:</b> a) In Report ITU-R M.2014 "Spectrum efficient digital land mobile systems for dispatch traffic" a maximum cell radius of 28 km is specified for the mobile/rural environment. b) In Switzerland, the channel spacing for Tetrapol is 10 kHz. c) Duplex possible at some cost (antenna splitter in the mobile station). d) This standard contains only the spectrum parameters on the air interface; it defines no protocols or services which would guarantee interoperability of equipment from different manufacturers. e) Radio handsets typically have an output power of 2 W. f) Dynamic; f = 400 MHz; P <sub>MS</sub> = 2 W, interference margin = 1 dB; $\sigma_s$ (shadowing) = 6 dB; reliability of coverage at edge of cell = 90%; antenna height BS = 30 m; antenna height MS = 1.5 m; propagation model SE21; antenna gains and feed losses = 0 dB.	

## 6 Frequencies

In Switzerland, a national emergency and rescue radio network (POLYCOM) has been constructed in the 380 - 383/390 - 393 MHz frequency ranges (see also chapter 7). It is not envisaged to establish another national Tetrapol network in the other bands suitable for trunked radio: 385 - 390/395 - 400 MHz, 410 - 430 MHz, 450 - 470 MHz and 870 - 876/915 - 921 MHz. However, there is the possibility that frequencies will be made available for local Tetrapol networks (e.g. at airports) if necessary.

## 7 Networks

Digital trunked radio systems for PMR – compared with public mobile radio systems such as GSM or UMTS – generally have small numbers of users with short call durations. Consequently traffic is low and in general large cells can be built. The radiated transmission power per base station carrier frequency is of the order of 25 W ERP.

The various PMR systems differ very greatly in terms of the number of users, the coverage area, volume of traffic and services provided. Some systems are noise-limited (system limits are determined by the receiver noise) or interference-limited (high common-channel interference from adjacent channels is present). The spectrum efficiency is heavily dependent on these parameters (see also Table 2).

For each base station, typically 4 to 8 (which can be extended to 16) radio channels are installed in Tetrapol networks<sup>7</sup>. One channel is the control channel and is used to transmit the system information from the base station to the mobile stations. The remaining channels are communication channels and are used to transmit voice and data.

Tetrapol can be operated either in network mode or direct mode. In the case of network mode, the mobile station is linked to the base station (infrastructure) and monitored by it. In this mode, when two mobile stations communicate with each other the call is always conducted via a base station. In direct mode, two or more mobile stations communicate without involving a base station (walkie-talkie). Direct mode can therefore be used even in areas where there is no radio coverage (e.g. in a tunnel or the basement of a building).

If traffic is low and coverage is ample, Tetrapol can also make use of common-channel technology (co-channel radio, simulcast). In this case, all base stations transmit on exactly the same frequency. Both the high-frequency signal and the modulation signal are sent synchronously from the base stations. The network can be considered as a single giant macrocell, which is fed by multiple base stations. With this procedure, it is possible to achieve excellent coverage of a large but low-traffic location, with simultaneous high frequency economy.

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<sup>7</sup> See: ACROPOL, the French police radiocommunication network, in "Commutation & Transmission" 3/1994.

## Abbreviations

BER	Bit Error Rate
BPUK	Swiss Conference of Directors of Planning and Environmental Protection
BS	Base station
BT	Relative filter bandwidth
DETEC	Federal Department for the Environment, Transport, Energy and Communications
ERC	European Radiocommunications Committee
ERP	Effective Radiated Power
ETSI	European Telecommunications Standards Institute
FDMA	Frequency Division Multiple Access
FDV	Telecommunication Services Ordinance (TSO)
GMSK	Gaussian Frequency Shift Keying
GSM	Global System for Mobile communications
ITU-R	International Telecommunication Union - Radiocommunication Sector
MS	Mobile station
OFCOM	Federal Office of Communications
PAMR	Public Access Mobile Radio
PAS	Publicly Available Specifications
PDN	Packet Data Network
PMR	Private Mobile Radio (or Business Private Radio)
RP-CELP	Regular Pulse - Code Excited Linear Predictive
SBB	Schweizerische Bundesbahnen (Swiss Federal Railways)
SE21	ERC Working Group Spectrum Engineering, Project Team 21
TDMA	Time Division Multiple Access
TETRA	Trans-European Trunked Radio
TU50	Typical Urban, 50 kph
UMTS	Universal Mobile Telecommunications System