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Reference

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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

1 Scope

The present document defines the requirements for radio frequency usage for TETRA Enhanced Data Service (TEDS).

TEDS is a technical development that integrates a high speed data delivery with V+D as opposed to TETRA TAPS that is a non-integrated supplementary service. The market requirements and priorities set out in the present document are covering the user views and are generic to TAPS and TEDS. TEDS however is considered a better match for the emergency services than TAPS because of its integrated nature and security level common to TETRA V+D.

It includes necessary information to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT), including:

- Detailed market information (annex A).
- Technical information (annex B).
- Expected compatibility issues (annex C).

2 References

For the purposes of this Technical Report (TR) the following references apply:

[1] ETSI EN 300 392-2: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 2: Air Interface (AI)".

[2] ETSI EN 300 392-3 (all sub-parts): "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 3: Interworking at the Inter-System Interface (ISI)".

[3] ETSI ETS 300 392-4 (all sub-parts): "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 4: Gateways basic operation".

[4] ETSI EN 300 392-5: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 5: Peripheral Equipment Interface (PEI)".

[5] ETSI EN 300 392-9: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 9: General requirements for supplementary services".

[6] ETSI EN 300 392-10 (all sub-parts): "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 10: Supplementary services stage 1".

[7] ETSI EN 300 392-11 (all sub-parts): "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 11: Supplementary services stage 2".

[8] ETSI EN 300 392-12 (all sub-parts): "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 12: Supplementary services stage 3".

[9] ETSI EN 300 395 (all parts): "Terrestrial Trunked Radio (TETRA); Speech codec for full-rate traffic channel".

[10] ETSI EN 300 396 (all parts): "Terrestrial Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO)".

[11] ETSI TS 100 392-2 (V3.1.1): "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 2: Air Interface (AI)".

[12] ETSI TS 101 747: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); IP Interworking (IPI)".

[13] ERC/DEC(96)01: "ERC Decision of 7 March 1996 on the harmonised frequency band to be designated for the introduction of the Digital Land Mobile System for the Emergency Services".

[14] ERC/DEC(96)04: "ERC Decision of 7 March 1996 on the frequency bands for the introduction of the Trans European Trunked Radio System (TETRA)".

[15] ECC/DEC/(04)06: "ECC Decision of 19 March 2004 on the availability of frequency bands for the introduction of Wide Band Digital Land Mobile PMR/PAMR in the 400 MHz and 800/900 MHz bands".

[16] ETSI TR 102 001: "Electromagnetic compatibility and Radio spectrum Matters (ERM);Systems reference document for TETRA Advanced Packet Service (TAPS)".

[17] ETSI TR 102 260: "Electromagnetic compatibility and Radio spectrum Matters (ERM);Code Division Multiple Access Public Access Mobile Radio (CDMA-PAMR); System reference document".

[18] ECC Report 42: "Spectrum efficiency of CDMA-PAMR and other wideband systems for PMR/PAMR".

[19] CEPT Recommendation T/R 25-08: "Planning criteria and coordination of frequencies in the Land Mobile Service in the range 29.7-921 MHz".

[20] Civ-Mil(05)26: "Minutes of the meeting, Tallinn, 18-20 October 2005".

[21] ERC Report 25: "The European table of frequency allocations and utilisations covering the frequency range 9 kHz to 275 GHz".

[22] ETSI TR 102 021-2: "Terrestrial Trunked Radio (TETRA); User Requirement Specification TETRA Release 2; Part 2: High Speed Data".

[23] CEPT/ERC/REC 74-01E: "Spurious emissions".

[24] ECC/REC 02-05: "Unwanted emissions".

[25] ETSI EN 300 113: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Land mobile service; Radio equipment intended for the transmission of data (and/or speech) using constant or non-constant envelope modulation and having an antenna connector".

[26] ETSI EN 300 390: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Land Mobile Service; Radio equipment intended for the transmission of data (and speech) and using an integral antenna".

[27] ETSI EN 301 166: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Land Mobile Service; Radio equipment for analogue and/or digital communication (speech and/or data) and operating on narrow band channels and having an antenna connector".

[28] ETSI EN 300 910: "Digital cellular telecommunications system (Phase 2+) (GSM); Radio transmission and reception (GSM 05.05)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Air interface (Um interface): the interface between Mobile Station and TEDS network

Gb interface: the interface between an SGSN and a BSS

Gi interface: the interface between Packet Domain and an external packet data network

Gn interface: the interface between two GSNs within the same PLMN

Gp interface: the interface between two GPRS Support Nodes (GSNs) in different PLMNs

Gr interface: the interface between the Serving GPRS Support Node and the Home Location Register

TETRA Release 2: Work Programme with new terms of reference within ETSI Project TETRA to enhance the services and facilities of TETRA in order to meet new user requirements, utilize new technology and increase the longevity of TETRA within the traditional market domains of PMR and PAMR

Ud interface: Direct Mode Air Interface

Um interface: the interface between a TETRA MS and TETRA BS

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3G	3rd Generation
AGA	Air Ground Air
AI	Air Interface
API	Application Programming Interface
BSS	Base Station System
CDMA	Code Division Multiple Access
CEPT	European Conference of Post and Telecommunications Administrations
D8PSK	Differential Octal Phase Shift Keying
DMO	Direct Mode Operation
DQPSK	Differential Quaternary Phase Shift Keying
DVB-T	Digital Video Broadcast - Terrestrial
ECC	European Communications Committee
ERC	European Radio Committee (superseded by ECC)
ERM	ETSI Electromagnetic compatibility and Radio spectrum Matters
GoS	Grade of Service
GPRS	General Package Radio Service
GSM	Global System for Mobile communication
GSM-R	GSM-Railway
HSD	High-Speed Data
IP	Internet Protocol
IPI	IP Interworking
ISDN	Integrated Services Digital Network
LLC	Logical Link Control
MAC	Medium Access Control
MS	Mobile Station
OTA	Over The Air
PAMR	Public Access Mobile Radio
PCCC	Parallel Concatenated Convolutional Code
PDN	Packet Domain Network
PEI	Peripheral Equipment Interface
PLMN	Public Land Mobile Network
PMR	Private Mobile Radio
PSTN	Public Switched Telephone Network
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
RF	Radio Frequency
SGSN	Serving GPRS Support Node
SIM	Subscriber Identity Module
SNDCP	SubNetwork Dependent Convergence Protocol
SwMI	Switching and Management Infrastructure
TAPS	TETRA Advanced Packet data Service
TEDS	TETRA Enhanced Data Service
TETRA	TErrestrial Trunked RAdio
TMO	Trunked Mode Operation
TRX	Transmitters/Receivers
UIC	Union International des Chemins de fer
V+D	Voice plus Data

4 Executive summary

4.1 Status of the System Reference Document

The present document has been reviewed at ERM RM#32. It is now forwarded to CEPT ECC-SE19 for consideration.

4.2 Technical Issues

4.2.1 Short background information

4.2.1.1 System description

TETRA Enhanced Data Service (TEDS) has been developed to provide a High Speed Data service in response to user needs and according to a mandate issued by the ETSI Board to develop TETRA Release 2. The mandate included the requirement that TEDS should provide a packet data solution that is integrated with existing TETRA systems, and within the spectrum constraints of some existing TETRA users.

TEDS aims to enhance the services and facilities of TETRA in order to meet the emerging user requirements for high speed and multimedia services, utilize new technologies and, by maintaining the competitiveness with other wireless technologies, increase the future proofness of TETRA as the standard for PMR and PAMR world-wide.

TETRA Enhanced Data Service (TEDS) provides high-speed packet data at speeds approximately 10 times that available in existing TETRA, to support multimedia and other high-speed data applications required by existing and future TETRA users.

TEDS physical layer uses a range of modulations (see annex B) in addition to the present $\pi/4$ DQPSK and a number of different carrier sizes from 25 kHz to 150 kHz. This provides the users with a flexibility of tailoring the maximum air interface speed from the present TETRA to those provided by 3G systems. Also the required spectrum allocation can be selected to suit particular requirements.

TEDS introduces adaptive link control to the TETRA system whereby modulation type and coding rate can be changed adaptively to improve link performance under different propagation conditions.

Within TEDS the IP packet data service over the air interface is a high speed version of the present TETRA IP service with point-to-point and point-to-multipoint capabilities. The TEDS IP service maintains backward compatibility with the existing TETRA IP service. A number of new facilities have been added to ensure that transmission of several multimedia services with speeds approaching 500 kbit/s is possible. The following classes of service are provided over the air interface in TEDS implementation with associated speeds, priorities and QoS attributes;

- Real-time class.
- Telemetry class.
- Background class.

The requirements for TEDS are stated in TS 100 392-2 [11].

4.2.1.2 Applications

TEDS enables the cost-effective and efficient use of network resources for packet mode data applications [13], e.g. for applications that exhibit one or more of the following characteristics:

- intermittent, non-periodic (i.e. bursty) data transmissions, where the time between successive transmissions greatly exceeds the average transfer delay;
- frequent transmissions of small volumes of data, for example transactions consisting of less than 500 bytes of data occurring at a rate of up to several transactions per minute;

- infrequent transmission of larger volumes of data, for example, transactions consisting of several k/bytes of data occurring at a rate of up to several transactions per hour.

4.2.1.3 New technology

The TEDS standard uses adaptive multi-carrier modulation to achieve the required data rates. Turbo coding is used to optimize data throughput.

4.2.1.4 Short market information

See annex A.

4.2.1.5 Market size, forecasts and timing

As can be seen in annex A, the TETRA MoU Association at the 2004 TETRA World Congress indicated that over 622 significant contracts for TETRA had been notified by members totalling 70 countries. These figures represented an increase of over 90 % in the number of contracts and a 30 % country growth since the 2003 TETRA World Congress. Analysis of these figures also indicated that Public Safety was the largest market followed by the transportation market, both of which are predicted to be large users of applications requiring high speed data.

Although no figures exist, a conservative estimate by the ETSI Project TETRA is that once TEDS products become available, over 50 % of all existing TETRA terminals will be replaced with new TETRA terminals offering TEDS. Similarly, over 50 % of all new TETRA terminals will provide TEDS.

At present no TEDS products exist simply because the TEDS standard is not yet completed. However, current plans within EP TETRA indicate that the TEDS standard will be completed in 2005. On past performance it is therefore likely that first generation TEDS products could be available in the market as early as 2007.

4.2.2 Spectrum requirement and justifications

The TEDS standard is designed to cover the same frequency bands as TETRA V+D, i.e. 380 MHz to 400 MHz, 410 MHz to 430 MHz, 450 MHz to 470 MHz, 870 MHz to 876 MHz/915 MHz to 921 MHz with uplink in the lower half of the band and downlink in the upper half. The duplex separation is 10 MHz for the 400 MHz bands and 45 MHz for the 800/900 MHz band. Channel numbering has been adapted to allow for a flexible frequency allocation within the boundaries of the frequency bands. TEDS is fully integrated with TETRA V+D and provides the much needed high speed data service. The "Emergency Services" are the primary users initially according to the results of the ETSI project TETRA Release 2 market study, and it is anticipated that additional spectrum in the 380 MHz to 400 MHz is required adjacent to the currently allocated spectrum in 380 MHz to 385 MHz/390 to 395 MHz.

Equipment will be available from a number of different suppliers in the 2007 timeframe.

4.2.3 Spectrum parameters

4.2.3.1 Radiated power

The detailed technical description of TEDS can be found in annex B.

The transmitter powers for the mobile and base stations are the same as specified in EN 300 392-2 (Air Interface) [1] for TETRA V+D with some additional classes at lower powers for TEDS MSs.

4.2.3.2 Transmitted bandwidth

TEDS cover frequency separations of 25 kHz, 50 kHz, 100 kHz and 150 kHz.

The 25 kHz air interface is as specified in EN 300 392-2 [1] for TETRA V+D for common control channel and for enhanced data using D8PSK.

Details of the proposed transmissions mask can be found in annex B. The proposed masks are compared to CEPT/ECC Recommendations [23], [24] in the following figures. The proposed TEDS standard has two masks depending on transmitter power level. Figure 1 shows comparison of worst case levels which occur at maximum BS transmitter power. Figure 2 compares masks for the maximum transmitter power allowed with the second mask (i.e. +35 dBm), these plots also represent a worst case situation. It will be seen that in all cases the proposed spectrum masks meets or exceeds CEPT/ECC minimum requirements.

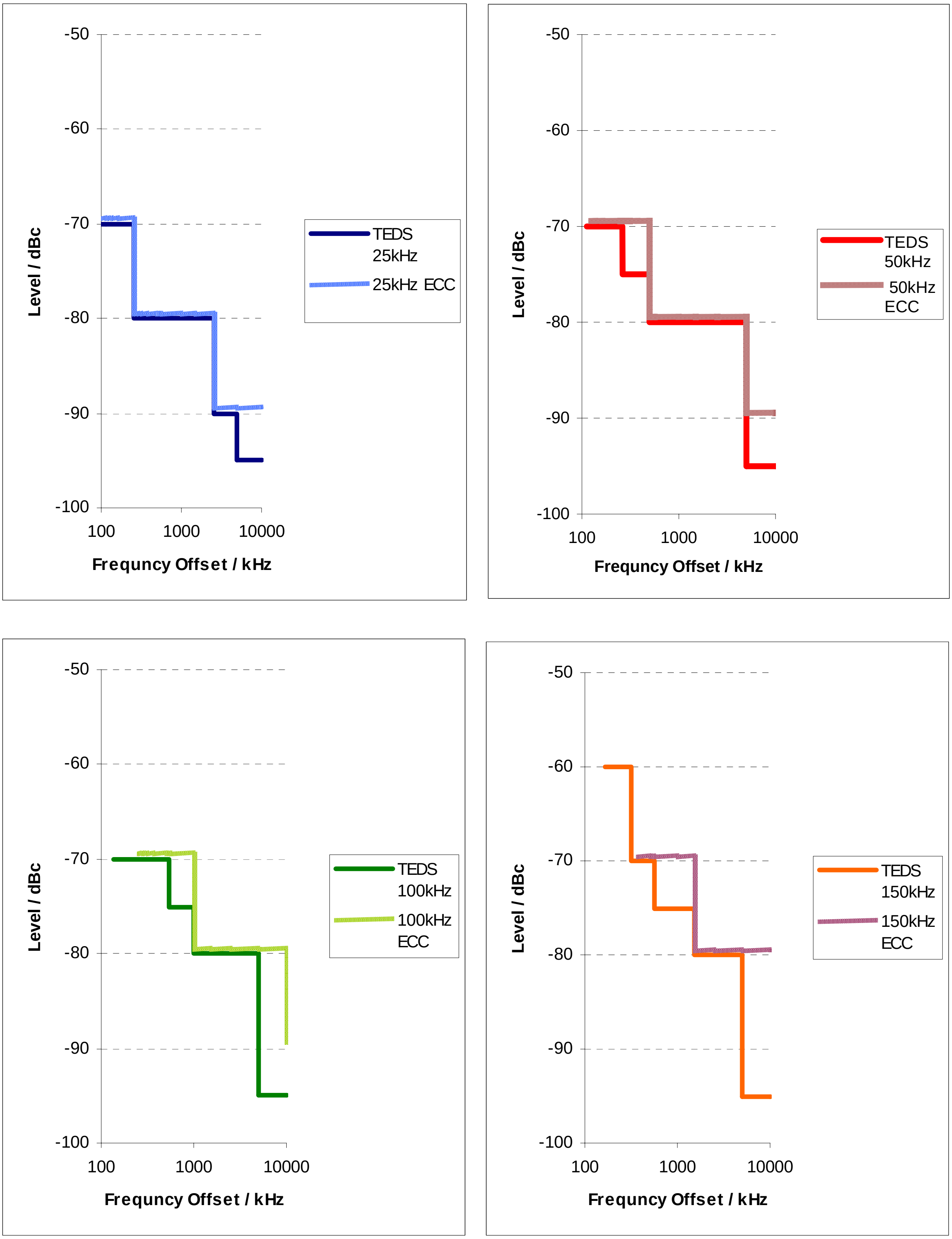

Figure 1: Comparisons of TEDS spectrum mask at maximum BS Tx Power (+46 dBm) and T/R 74-01E mask

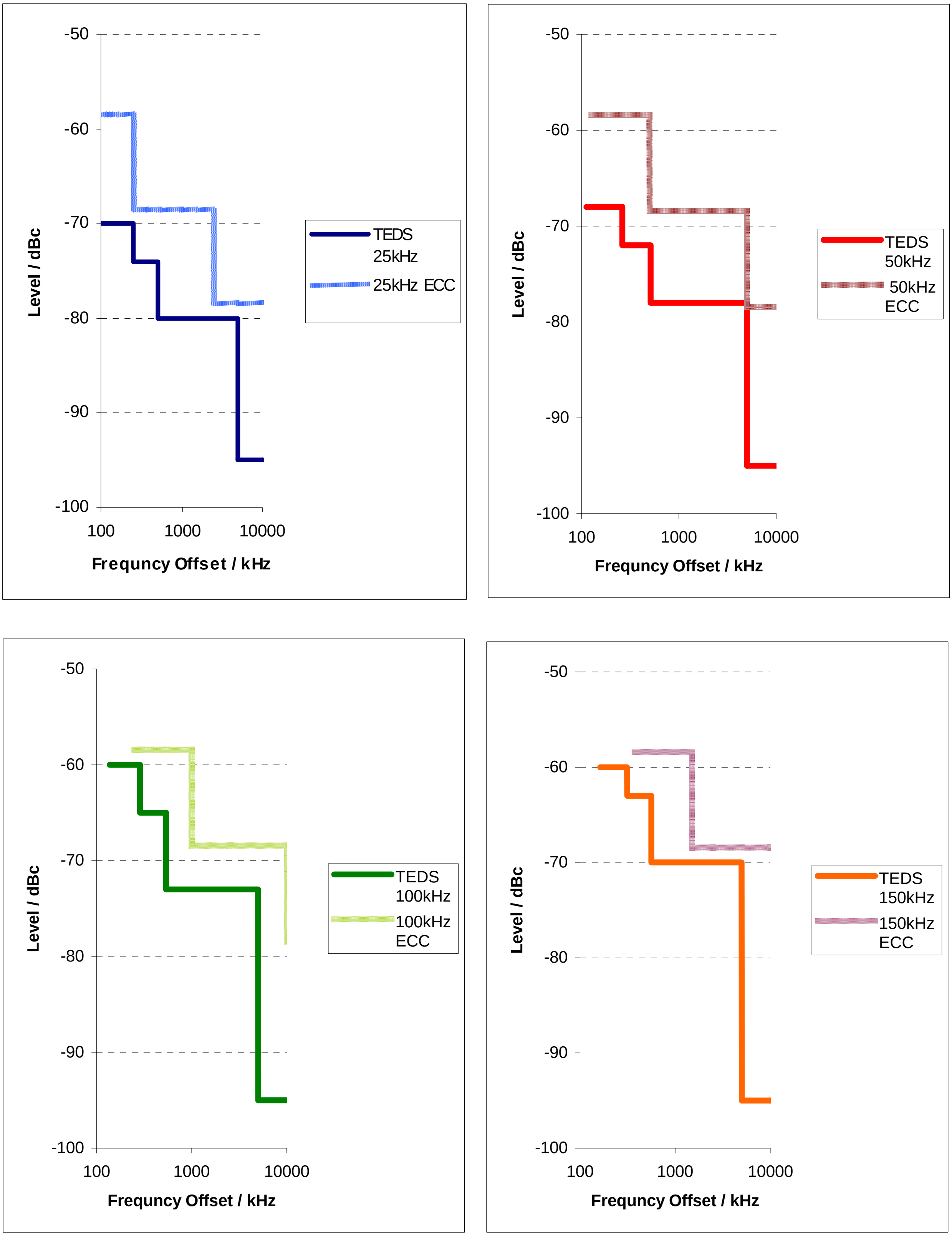

Figure 2: Comparisons of TEDS spectrum mask at Tx Power (+35 dBm) and T/R 74-01E mask

4.2.3.3 Frequency considerations

In the light of the importance and priorities during the market study for TETRA release 2 it is expected that additional spectrum for wide-band carriers will be required in the 380 MHz to 400 MHz band adjacent to the currently allocated spectrum in 380 MHz to 385 MHz/390 MHz to 395 MHz where the current allocation to Emergency Services are utilized in a structured way to allow DMO (both national and international), TMO and AGA services to operate without producing undue interference to each other.

4.2.3.4 Frequency usage

TEDS is a fully integrated Enhanced Data System for TETRA V+D. It is, for some variants of TEDS, possible to upgrade existing TETRA V+D, other variants require additional infrastructure. The frequency usage will therefore be dependent on the variant of TEDS deployed.

4.2.4 Current regulations

The frequency bands 380 MHz to 400 MHz, 410 MHz to 430 MHz, 450 MHz to 470 MHz, 870 MHz to 876 MHz/915 MHz to 921 MHz are covered by ERC/DEC(96)01 [13], ERC/DEC(96)04 [14] for TETRA V+D, and ECC/DEC(04)06 [15] is anticipated to cover TEDS.

4.2.5 Compatibility issues

See annex C.

5 Main conclusions

Issues of prominence in consideration of this SRDoc are the need for competition, harmonized spectrum and open standards.

5.1 Business importance

From the market information collected from the users (see annex A), it is clear that the most needed facility to complement the existing V+D services of TETRA is high-speed data. This is not a surprise considering all the applications becoming available from IT and the cellular market. The modern user is not prepared to carry several communications devices around and a number of users want a grade of service that can only be guaranteed if they are in control of the network. TEDS provide this guaranteed grade of service that can be negotiated with the network according to the dynamic availability.

The market survey (see annex A, figure A.2) also gave a clear indication of that there is a need for this service, especially for emergency services. Some of the manufacturers promise field trials and possibly equipment according to the TEDS specification to become available by 2006.

5.2 Expected timing for products to market

The first utilization of TEDS is expected to be by the Emergency Services in the 380 MHz to 400 MHz band in 2007.

5.3 Requested ECC actions

ETSI requests the support of the ECC to enable the users to take advantage of the TEDS high-speed data system around the 2006 time frame. Specifically this request comprises:

- co-existence studies outlined in clause C.1;
- the sharing studies outlined in clause C.3;

- the appropriate actions to include TEDS in ECC/DEC/(04)06 relating to wideband digital land mobile PMR/PAMR expanded also to cover the full frequency range 380 MHz to 400 MHz;
- the additions of the frequency range 385 MHz to 390 MHz/395 MHz to 399,9 MHz to ERC/DEC(96)01 [13] (as a supplement to the frequencies already available to emergency services), a note is proposed to be inserted in the ERC Report 25 [21] (ECA) for these frequency ranges: "emergency services extension";
- if required, a deletion of the 385 MHz to 390 MHz/395 MHz to 399,9 MHz from ERC/DEC(96)04 [14].

NOTE: WG FM has decided to separate the TEDS frequency issues in two parts:

- Use of TETRA TEDS for emergency services in the 385 MHz to 390 MHz/395 MHz to 399,9 MHz.
- Use of TETRA TEDS in the other frequency bands above 400 MHz.

See also reference [20], the minutes of the Civil-Military Meeting in Tallinn.

In addition, a questionnaire to administrations to identify spectrum in 410 MHz to 430 MHz (as an alternative to the use below 400 MHz) is in progress.

Annex A: Detailed market information

EP TETRA carried out a market survey in 2001 to identify what enhancements the users wanted for TETRA Release 2. Figure A.1 shows the relative weighted importance of the new requirements collected from the survey:

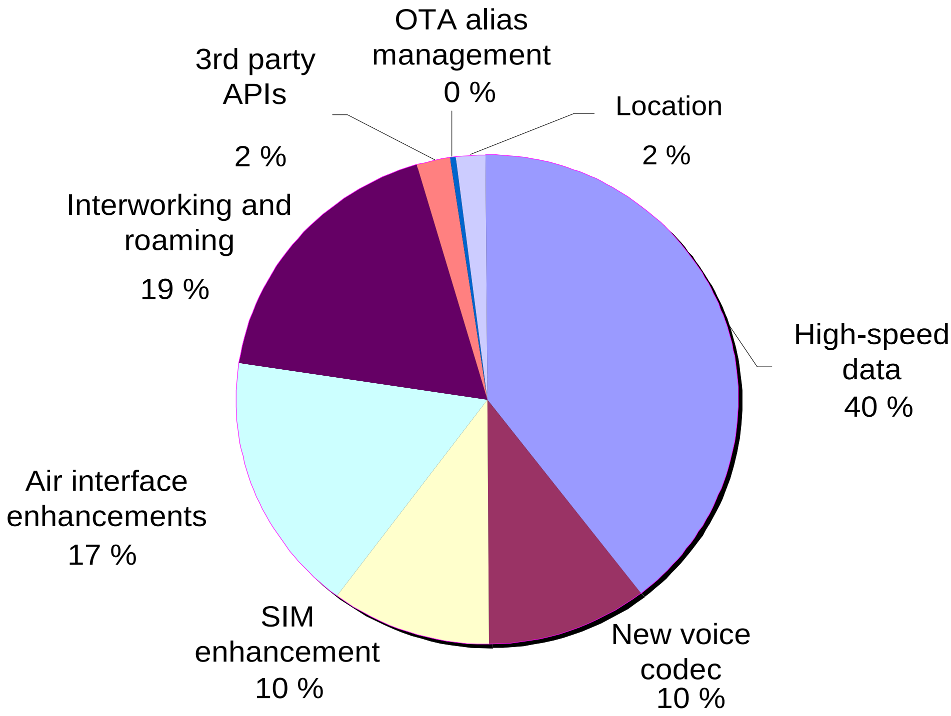

Figure A.1: Data interworking requirements (2001)

As can be seen from the survey the most important enhancement is high-speed data. However, since 2001 significant market changes have occurred resulting in the need for Interworking and Roaming, and SIM enhancement being currently dropped from the TETRA Release 2 list of deliverables.

In figure A.2 it can be seen that there is a great deal of variation between the needs of different market sectors. Only the Military has not put a high importance on high-speed data. This may be because they have other means of providing data.

Figure A.2 shows that there is a high variation of the prioritization across the market segments.

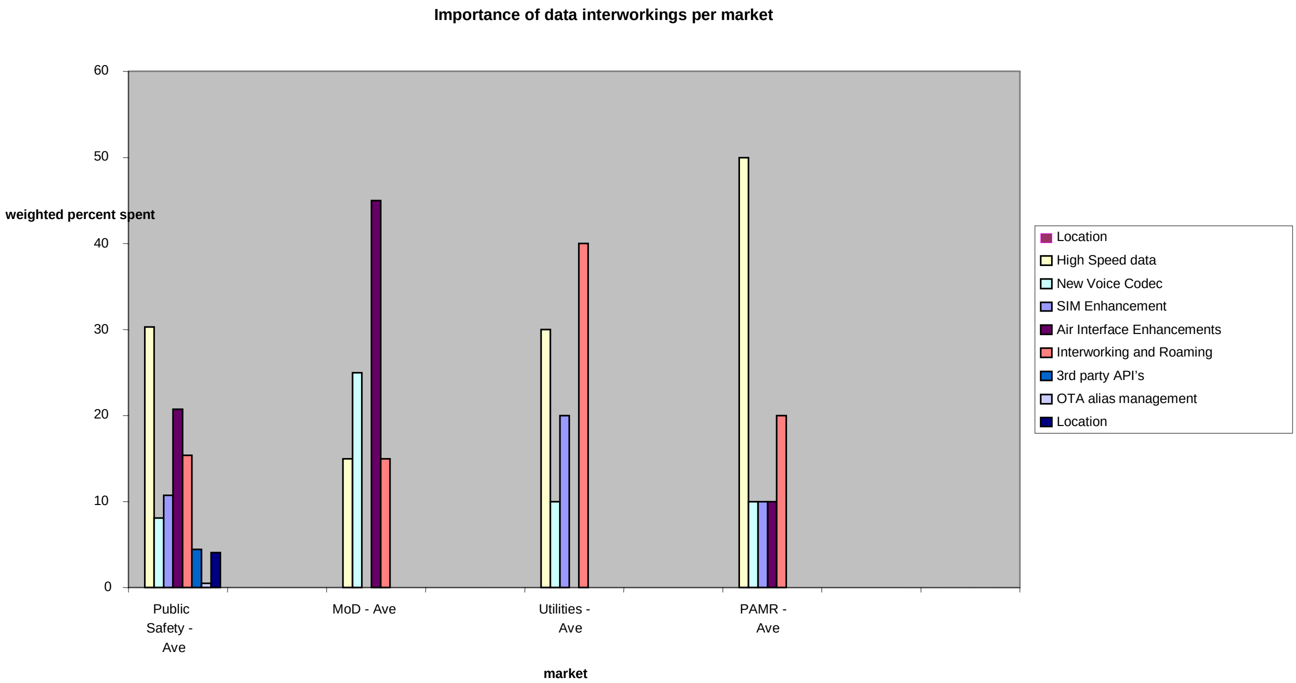

Figure A.2: Importance of high speed data and data interworkings per market

A.1 Range of applications

A.1.1 HSD applications and net data rates to support non-voice applications

The net data rates to support non-voice applications on HSD are listed in table A.1. For ease of understanding the requirements, the table has been sorted by net data rates.

Table A.1: Net data rates to support non-voice applications

Non-voice Applications	2005 Voice % impact	kBytes	kbits	Transfer time (seconds)	kbit/s (Net)	Application group
Location Services	-2 %	0,1	0,8	1	0,8	Real time short data
Telemetry (real time transfer)	0 %	0,2	1,6	0,5	3,2	Real time short data
Operation and control	0 %	0,2	1,6	0,5	3,2	Real time short data
Biodynamic vital data sampling, inc. ECG	0 %	5	40	10	4	Real time short data
Telemetry (Real time - 5 kbyte)	0 %	5	40	10	4	Real time short data
WAP/on-line forms	0 %	3	24	5	4,8	Database Interaction
People & Vehicles status/location/messaging(1 kbyte-)	-2 %	1	8	1	8	Real time short data
Data tasking e.g. command and control/work management	-5 %	5	40	5	8	Database Interaction

Non-voice Applications	2005 Voice % impact	kBytes	kbits	Transfer time (seconds)	kbit/s (Net)	Application group
Fingerprint data abstracted from the fingerprint image	0 %	10	80	10	8	File transfer
Content Push (10 kbyte)	1 %	10	80	4	20	File Transfer
Interagency Communications inc. Intranet (10 kbyte)	0 %	10	80	4	20	File Transfer/Office Application
Database inquiries 10 kbyte to 100 kbyte	0 %	12.5	100	5	20	Database Interaction
Mobile computing - office applications	0 %	12.5	100	5	20	Office Application
Connect to hospitals and national health comm. network	0 %	100	800	20	40	File Transfer
Connect to hospitals and national health comm. network	1 %	50	400	10	40	Office Application
Internet incl. web browsing 10 kbyte to 50 kbyte (per page)	0 %	50	400	10	40	Office Application
Video streaming (surveillance)	0 %			delay a few seconds	50	Video Transfer
Graphics, maps, location 100 kbyte to 1 Mbyte	-1 %	125	1 000	20	50	Image Transfer
e-mails incl. Attachments 2 Mbytes	0 %	2 000	16 000	300	53	File Transfer
Video Conferencing 64 kbit/s	0 %				64	Video Transfer
Image transfer (image JPEG ± 50 kbyte)	0 %	100	800	10	80	Image Transfer
Fingerprint image	0 %	100	800	10	80	Image Transfer
Video clips 1 Mbytes to 2 Mbytes	0 %	2 000	16 000	32	500	Video Transfer

From the table it can be seen that a significant percentage of applications can be supported with net data rates of 80 kbit/s and below. Some as yet undefined applications may require higher data rates. Higher data rates may also be required to improve transfer time of applications identified above. Many of the listed applications could also be supported on a V+D network.

Although the information provided in this table is useful, it is important to note that the mix of applications supported on a network and the amount of non-voice traffic varies considerably between different users.

It is also important to note that the applications listed could be rationalized further within categories. However, as the GoS requirements (transfer time in seconds as shown in the table) vary between the identical applications, their individuality has been retained.

Analysis of the non-voice application requirements listed in table A.1 has identified that the new HSD service will have very little impact in reducing voice traffic levels in TETRA networks. For this reason, the provision of HSD on existing networks will require separate capacity to support non-voice applications dependent on type of applications, levels of traffic and GoS.

Based on past experience, the types of non-voice applications, traffic levels and GoS will vary greatly between different user organizations. As a result, some organizations will have a low demand for HSD services and others a high demand.

For these reasons, the HSD technology solution should be designed to support varying amounts of data as spectrum efficiently as possible balanced against technology constraints. In addition, the HSD solution should be such as to minimize impact on network RF planning and compatibility with TETRA Release 1 networks already deployed and/or being deployed.

A.2 Market size and value

It is obviously not possible to get any manufacturer to reveal their business plans. However, the TETRA MoU Association at the 2004 TETRA World Congress indicated that over 622 significant contracts for TETRA had been notified by members in 70 countries. These figures represented an increase of over 90 % in the number of contracts and a 30 % country growth since the 2003 TETRA World Congress. Analysis of these figures also indicated that Public Safety was the largest market followed by the transportation market, both of which are predicted to be large users of applications requiring high speed data.

Because of the confidential and competitive nature of TETRA manufacturers and suppliers, it is not possible to accurately predict market size and value for TEDS high speed data products and services. However, as the transfer of data is becoming more and more important (as indicated by market surveys and users organizations participating in EP TETRA) a large number of existing TETRA network users, as well as new users, will require TEDS services in the future. Although no figures exist a conservative estimate is that once TEDS products become available, over 50 % of all existing TETRA terminals will be replaced with new TETRA terminals offering TEDS. Similarly, over 50 % of all new TETRA terminals will provide TEDS.

At present no TEDS products exist simply because the TEDS standard is not yet completed. However, current plans within EP TETRA indicate that the TEDS standard will be completed in 2005. On past performance it is therefore likely that first generation TEDS products could be available in the market as early as 2007.

A.3 Traffic evaluation

The following is an example that estimates how many high-speed data users can be supported in a hypothetical area of Central London and using a minimal frequency allocation. Let us assume that we are deploying TEDS based on a classic (TBD) reuse pattern and we are using for simplicity a uniform inter-site spacing.

Using the following Network assumptions:

Assuming the session activity follows a Poisson Distribution and a blocking rate of 10 %, the hypothetical area would support around 10 000 users.

A packet call should not last more than 8-10 seconds on average, and the average size of a web page is estimated to be 53 k Bytes. Therefore, a TRX can only support 4 simultaneous packet calls. A session is composed of an average of 12,58 packets. During a session, viewing time (IDLE) represents 80 % of time. Based on our user requirements, we can make the simplistic assumption that a user has a 48 % probability of establishing a session during peak hour. Therefore we can model the Web traffic as a 10 second event (packet call) where a user generates in average:
$0,48 \times 12,58 = 6,1$ packets per busy hour. Using Erlang B table and N=4, we find that a TRX can support 2,05 data Erlang. For a user generating 0,0172 data Erlang, a TRX would support 120 users.

Annex B: Technical information

B.1 Detailed technical description

B.1.1 TEDS air interface

In order to add high-speed packet data services to the TETRA standard whilst allowing backward compatibility to the existing TETRA systems, the following developments have taken place in the TEDS standard:

1) A new physical layer has been defined.

2) The existing TETRA higher protocol layers (upper MAC, LLC and SNDCP) have been modified to enable transmission of significantly higher-speed IP traffic over the air interface.

Figure B.1 shows the TEDS air interface protocol stack and its relation to IP applications. Note that TEDS services are IP based. Circuit mode data is only available in an integrated V+D part at speeds up to 28,8 kbit/s. For the ease of compatibility TEDS uses the same control channel as the existing TETRA standard.

In figure B.1 Um is the air interface, and Gi is the IP packet mode gateway to the IP application hosts.

The details of the TEDS standard are given in [11].

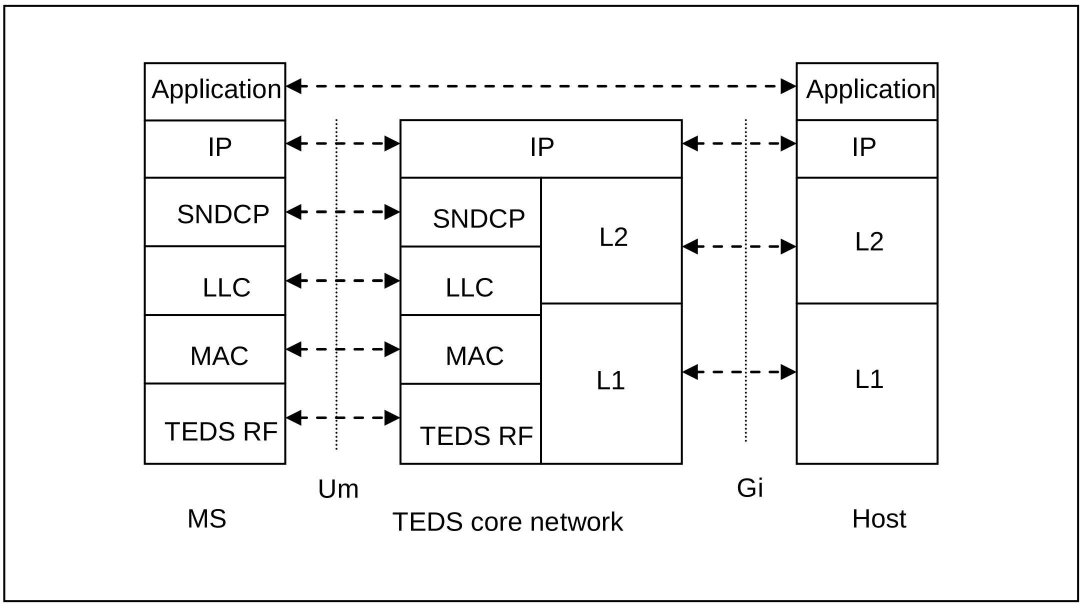

Figure B.1: EDS air interface protocol stack

B.1.1.1 Physical layer

The following text describes in general the adaptations to the physical layer for TEDS. The key features of the physical layer (including lower MAC) are listed below:

- Multi-carrier platform with TDMA carriers.
- Carrier bandwidths: 25 kHz, 50 kHz, 100 kHz and 150 kHz.
- Adaptive selection of modulation and coding according to propagation conditions.

- A number of modulation schemes:
    - 4 QAM for efficient links at edge of coverage;
    - 16 QAM for moderate speeds;
    - 64 QAM for high speed;
    - π/4 DQPSK for common control channel;
    - π/8 D8PSK for early migration to modest increase in speed within 25 kHz carriers.
- Parallel Concatenated Convolutional Coding (PCCC) for channel coding.
- Pilot symbol used for channel estimation.
- Use of full and half slot sizes:
    - 14,167 ms.
    - 7,08 ms.
- Each QAM carrier is composed of a number of sub-carriers at base-band (8 sub-carriers in 25 kHz).
- Expected user bit rates in the region of 30 kbit/s to 500 kbit/s.

In an integrated TEDS and TETRA V+D base station, one or more of the above TEDS carriers can run alongside TETRA V+D carriers. Because of the range of carrier bandwidth and modulation types available in TEDS, the users have the flexibility of procuring systems which match their speed and spectrum requirements. However the TEDS higher layers, once implemented, could cater for both traditional TETRA V+D and TEDS high-speed IP data services.

The above system allows the traditional TETRA V+D terminals as well as TEDS plus V+D terminals to operate within the same network.

B.1.1.2 MAC layer

For details of the MAC layer refer to the TEDS standard [11].

B.1.1.3 LLC layer

For details of the LLC layer refer to the TEDS standard [11].

B.1.1.4 SNDCP layer

For details of the SNDCP layer refer to the TEDS standard [11].

B.1.2 TEDS other interfaces

B.1.2.1 Existing V+D interfaces

The existing TETRA standards define a number of interfaces to support mobile services as shown in figure B.2. The central component of the standard reference model is the Switching and Management Infrastructure (SwMI) which provides circuit and packet switched telecommunication services to mobile stations (MS).

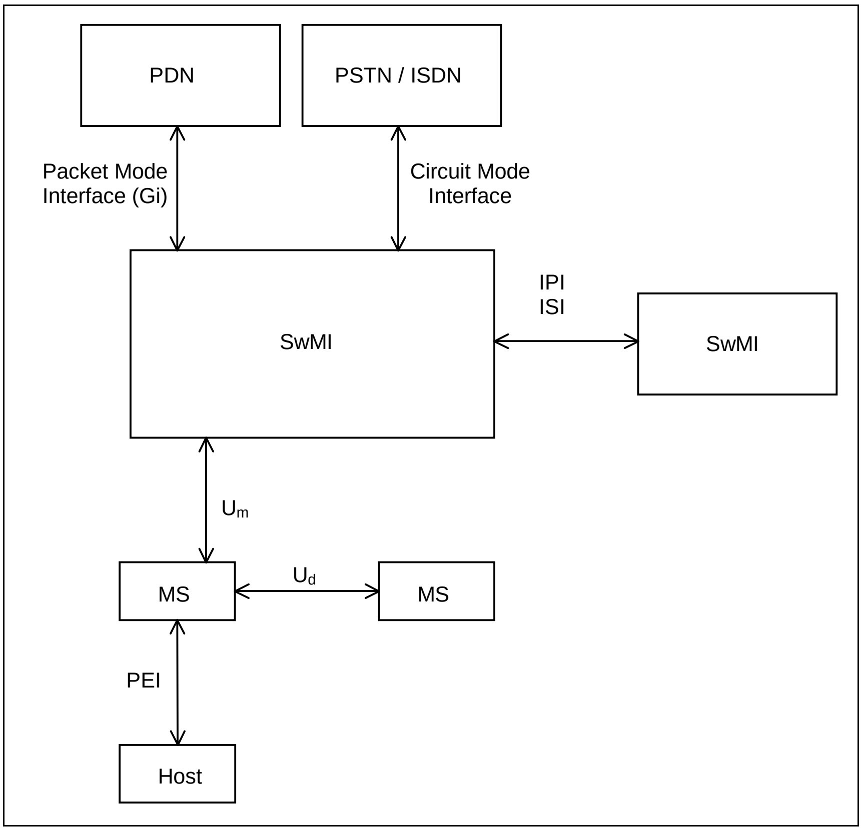

Figure B.2: Existing TETRA V+D interfaces

The internal SwMI architecture is not defined by the standard but only the external interfaces between the SwMI and other entities. The standardized interfaces are:

1) Trunked Mode Air Interface (Um) EN 300 392-2 [1].

2) Direct Mode Air Interface (Ud) EN 300 396 [10].

3) IP Interface (IPI) [12].

4) Inter-system Interface (ISI) EN 300 392-3 [2].

5) Peripheral Equipment Interface (PEI) EN 300 392-5 [4].

6) PSTN/ISDN Network Interface ETS 300 392-4 [3].

There are also standards related to operation across multiple interfaces such as the speech codec EN 300 395 [9] and supplementary services EN 300 392-9 [5], EN 300 392-10 [6], EN 300 392-11 [7], EN 300 392-12 [8].

B.1.2.2 TEDS interfaces

The TETRA TEDS standard described in the present document seeks to enhance the capability of TETRA to support enhanced data rate capability for packet data. In order to achieve this, additional standard interfaces are proposed as shown in figure B.3.

Figure B.3 shows the general case of an integrated TEDS plus V+D network connected with:

1) TETRA V+D networks.

2) EGPRS/3G networks.

3) External IP packet data networks.

In addition to TEDS air interface (Um) described in clause B.1.1, the following interfaces are added to the TEDS network for high speed connectivity to other networks:

- Packet data network interface (Gi).
- TETRA-EGPRS (or 3G) interfaces Gp and Gr.

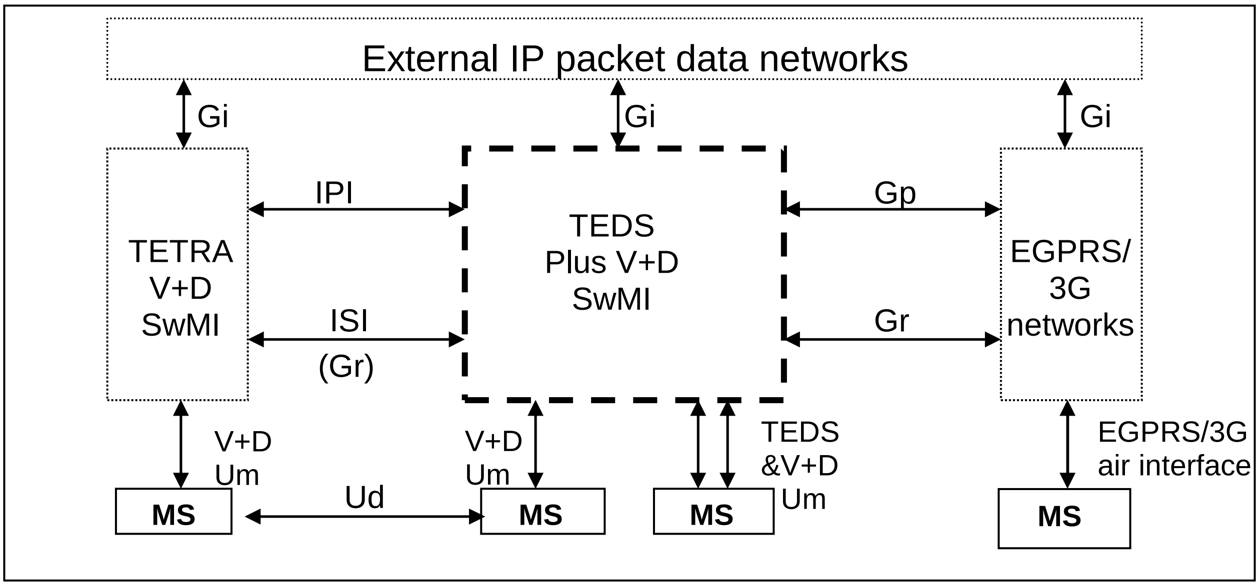

Figure B.3: Integrated TEDS plus TETRA V+D interfaces

B.2 Technical justifications for spectrum

B.2.1 Power

Proposed power classes are the same as EN 300 392-2 [1] except that two lower power classes of +25 dBm and +22,5 dBm will be added for MS with QAM modulation.

Table B.1: Nominal power of QAM transmitters

Power class, MS	Nominal power, MS	Power class, BS	Nominal power, BS
1 (30 W)	45 dBm	1(40 W)	46 dBm
1L (17,5 W)	42,5 dBm	2 (25 W)	44 dBm
2 (10 W)	40 dBm	3 (15 W)	42 dBm
2L (5,6 W)	37,5 dBm	4 (10 W)	40 dBm
3 (3 W)	35 dBm	5 (6,3 W)	38 dBm
3L (1,8 W)	32,5 dBm	6 (4 W)	36 dBm
4 (1 W)	30 dBm	7 (2,5 W)	34 dBm
4L (0,56 W)	27,5 dBm	8 (1,6 W)	32 dBm
5 (0,32 W)	25 dBm	9 (1 W)	30 dBm
5L (0,18 W)	22,5 dBm	10 (0,6 W)	28 dBm

B.2.2 Frequency

TEDS does not specify operating frequencies but is intended to operate below 1 GHz.

B.2.3 Bandwidth and other radio parameters

B.2.3.1 Transmission mask

For 25kHz π/4-DQPSK and π/8-D8PSK modulation spectrum parameters of EN 300 392-2 [1] shall be met.

For QAM carriers the levels given in tables B.2, B.3, B.4 and B.5 shall not be exceeded at the listed frequency offsets from the nominal carrier frequency. Measurements are made in the TETRA modulation filter as defined in clause 5.6 of EN 300 392-2 [1].

NOTE: For evalation of spectrum parameters a 18kHz filter bandwidth is a good approximation to the specified filter.

Table B.2: Maximum adjacent power levels for 25 kHz QAM

Frequency offset	Maximum level for MS and BS
25 kHz	-55 dBc
50 kHz	-65 dBc
75 kHz	-67 dBc

Table B.3: Maximum adjacent power levels for 50 kHz QAM

Frequency offset	Maximum level for MS and BS
37,5 kHz	-55 dBc
62,5 kHz	-63 dBc
87,5 kHz	-65 dBc

Table B.4: Maximum adjacent power levels for 100 kHz QAM

Frequency offset	Maximum level for MS and BS
62,5 kHz	-55 dBc
87,5 kHz	-60 dBc
112,5 kHz	-60 dBc

Table B.5: Maximum adjacent power levels for 150 kHz QAM

Frequency offset	Maximum level for MS and BS
87,5 kHz	-55 dBc
112,5 kHz	-60 dBc
137,5 kHz	-60 dBc

In any case, no requirement in excess of -36 dBm shall apply.

The specifications assume that the centre frequency is at the above listed frequency offsets from the nominal carrier frequency. The measured values shall be averaged over the useful part of the burst. The scrambled bits shall have a pseudo-random distribution from burst to burst.

B.2.3.2 Reception mask

The TEDS receiver will have adjacent channel performance of 40 dB C/I_a for MS and 45 dB C/I_a for BS in the case of π/4 -DQPSK and π/8-D8PSK. The adjacent channel performance for QAM is given in table B.6.

Table B.6: Adjacent channel interferer frequency offsets and mean power levels for QAM

QAM Channel bandwidth	TETRA1 Interferer offset from f_o	TETRA1 Interferer level for MS	TETRA1 Interferer level for BS
25 kHz	25 kHz	-67 dBm	-62 dBm
50 kHz	37,5 kHz	-72 dBm	-67 dBm
100 kHz	62,5 kHz	-75 dBm	-70 dBm
150 kHz	87,5 kHz	-75 dBm	-70 dBm

The blocking levels used are the same for QAM and π/4-DQPSK and are the levels already specified in EN 300 392-2 [1] although frequency offsets are adjusted depending on channel bandwidth as shown in tables B.7, B.8, B.9 and B.10.

Table B.7: Blocking levels of the 25 kHz (8 subchannels) QAM receiver

Offset from nominal Rx freq.	Level of interfering signal
50 kHz to 100 kHz	-40 dBm
100 kHz to 200 kHz	-35 dBm
200 kHz to 500 kHz	-30 dBm
> 500 kHz	-25 dBm

Table B.8: Blocking levels of the 50 kHz (16 subchannels) QAM receiver

Offset from nominal Rx freq.	Level of interfering signal
100 kHz to 200 kHz	-40 dBm
200 kHz to 400 kHz	-35 dBm
400 kHz to 1 000 kHz	-30 dBm
> 1 000 kHz	-25 dBm

Table B.9: Blocking levels of the 100 kHz (32 subchannels) QAM receiver

Offset from nominal Rx freq.	Level of interfering signal
200 kHz to 400kHz	-40 dBm
400 kHz to 600 kHz	-35 dBm
600 kHz to 1 000 kHz	-30 dBm
> 1 000 kHz	-25 dBm

Table B.10: Blocking levels of the 150 kHz (48 subchannels) QAM receiver

Offset from nominal Rx freq.	Level of interfering signal
300 kHz to 500 kHz	-40 dBm
500 kHz to 800 kHz	-35 dBm
800 kHz to 1 000 kHz	-30 dBm
> 1 000 kHz	-25 dBm

The above blocking limits are for in-band blocking. Other PMR standards (e.g. EN 300 113 [25], EN 300 390 [26], EN 301 166 [27]) only specify in-band blocking however some standards such as public mobile systems (e.g. GSM, EN 300 910 [28]) also specify out-of-band blocking. Similar limits for TETRA, particularly at 800 MHz, could be considered.

Intermodulation and spurious response rejection also follow levels already used in EN 300 392-2 [1].
The static reference sensitivity level shall be:

- for MS: π/4 DQPSK modulation -112 dBm;
- for MS: π/8 D8PSK modulation: -107 dBm;
- for BS: π/4 DQPSK modulation -115 dBm;
- for BS: π/8 D8PSK modulation: -110 dBm.

The minimum required static reference sensitivity performance for MS and BS in QAM modes is specified in tables B.11 and B.12.

Table B.11: TEDS Sensitivity levels for MS

Channel BW	Number of sub channels	Noise BW	4 QAM 3 % BER Sensitivity	16 QAM 3 % BER Sensitivity	64 QAM 3 % BER Sensitivity
		(kHz)	(dBm)	(dBm)	(dBm)
25 kHz	8	19,2	-113	-106	-101
50 kHz	16	38,4	-110	-103	-97
100 kHz	32	76,8	-107	-100	-95
150 kHz	48	115,2	-105	-99	-93

Table B.12: TEDS Sensitivity levels for BS

Channel BW	Number of sub channels	Noise BW	4 QAM 3 % BER Sensitivity	16 QAM 3 % BER Sensitivity	64 QAM 3 % BER Sensitivity
		(kHz)	(dBm)	(dBm)	(dBm)
25 kHz	8	19,2	-116	-109	-104
50 kHz	16	38,4	-113	-106	-100
100 kHz	32	76,8	-110	-103	-98
150 kHz	48	115,2	-108	-102	-96

B.2.3.3 Spurious emissions

For 25kHz π/4-DQPSK and π/8-D8PSK modulation spectrum parameters of EN 300 392-2 [1] shall be met.

These unwanted emissions are emissions (discrete, wideband noise, modulated or un-modulated) occurring at offsets of equal to, or greater than, 100 kHz from the carrier frequency, measured in the frequency range 9 kHz to 4 GHz.

a) Discrete spurious:

   - the maximum allowed power for each spurious emission shall be less than -36 dBm measured in 100 kHz bandwidth in the frequency range 9 kHz to 1 GHz and -30 dBm measured in 1 MHz bandwidth in the frequency range 1 GHz to 4 GHz (1 GHz to 12,75 GHz for equipment capable of operating at frequencies above 470 MHz). Specific measurement method are required both when measuring within $\pm f_{rb}$ of carrier frequency, due to the presence of wideband noise, and in the lower part of the spectrum.

b) Wideband noise:

   - the wideband noise levels, measured through the modulation filter defined in clause 5.6 in EN 300 392-2 [1] should not exceed the limits shown in tables B.13, B.14, B.15 and B.16, for the nominal power levels as stated, and at the listed offsets from the nominal carrier frequency. When applicable, relative measurements (dBc) shall refer to the power level measured at the nominal centre frequency as defined in clause 6.4.8 of EN 300 392-2 [1]. The requirements apply symmetrically to both sides of the transmitter band.

NOTE: For evaluation of spectrum parameters a 18 kHz filter bandwidth is a good approximation to the specified filter.

Table B.13: Wideband noise limits 25 kHz QAM

Frequency offset	Maximum wideband noise level for MS and BS	
	MS nominal power level ≤ 3 W (class 3)	MS nominal power level ≥ 5,6 W (class 2L) BS all classes
100 kHz to 250 kHz	-70 dBc	-70 dBc
250 kHz to 500 kHz	-74 dBc	-80 dBc
500 kHz - *2* 500 kHz	-80 dBc	-80 dBc
2 500 kHz - f_{rb} kHz	-80 dBc	-90 dBc
> f_{rb}	-95 dBc	-95 dBc
NOTE: f_{rb} denotes the frequency offset corresponding to the near edge of the receive band or 5 MHz (10 MHz for frequencies above 520 MHz) whichever is greater.		

Table B.14: Wideband noise limits 50 kHz QAM

Frequency offset	Maximum wideband noise level for MS and BS	
	MS nominal power level ≤ 3 W (class 3)	MS nominal power level ≥ 5,6 W (class 2L) BS all classes
112,5 kHz to 262,5 kHz	-68 dBc	-70 dBc
262,5 kHz to 500 kHz	-72 dBc	-75 dBc
500 kHz - f_{rb} kHz	-78 dBc	-80 dBc
> f_{rb}	-95 dBc	-95 dBc
NOTE: f_{rb} denotes the frequency offset corresponding to the near edge of the receive band or 5 MHz (10 MHz for frequencies above 520 MHz) whichever is greater.		

Table B.15: Wideband noise limits 100 kHz QAM

Frequency offset	Maximum wideband noise level for MS and BS	
	MS nominal power level ≤ 3 W (class 3)	MS nominal power level ≥ 5,6 W (class 2L) BS all classes
137,5 kHz to 287,5 kHz	-60 dBc	-70 dBc
287,5 kHz to 537,5 kHz	-65 dBc	-70 dBc
537,5 kHz - 1 000 kHz	-73 dBc	-75 dBc
1 000 kHz - f_{rb} kHz	-73 dBc	-80 dBc
> f_{rb}	-95 dBc	-95 dBc
NOTE: f_{rb} denotes the frequency offset corresponding to the near edge of the receive band or 5 MHz (10 MHz for frequencies above 520 MHz) whichever is greater.		

Table B.16: Wideband noise limits 150 kHz QAM

Frequency offset	Maximum wideband noise level for MS and BS	
	MS nominal power level ≤ 3 W (class 3)	MS nominal power level ≥ 5,6 W (class 2L) BS all classes
162,5 kHz to 312,5 kHz	-60 dBc	-60 dBc
312,5 kHz to 562,5 kHz	-63 dBc	-70 dBc
562,5 kHz - 1 500 kHz	-70 dBc	-75 dBc
1 500 kHz - f_{rb} kHz	-70 dBc	-80 dBc
> f_{rb}	-95 dBc	-95 dBc
NOTE: f_{rb} denotes the frequency offset corresponding to the near edge of the receive band or 5 MHz (10 MHz for frequencies above 520 MHz) whichever is greater.		

All levels in tables B.13 to B.16 are expressed in dBc relative to the actual transmitted power level, and in any case no limit tighter than -55 dBm for offsets < f_{rb} or -70 dBm for offsets > f_{rb} shall apply.

B.3 Information on current version of relevant ETSI standard

The TEDS standard reference is: ETSI TS 100 392-2 (V3.1.1): "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 2: Air Interface (AI)" [11].

Annex C: Expected compatibility issues

C.1 Coexistence studies (if any)

There will be a need for studies to be conducted into compatibility between TEDS and other systems and services that may operate in adjacent frequency bands, with a number of issues needing to be explored in relation to such adjacent band compatibility. TEDS is expected to have properties not dissimilar to those of TAPS [16] and CDMA-PAMR [17], and will therefore need to be studied for the same adjacent bands and services. These adjacent bands and services are:

- UIC, GSM-R and the use of Direct Mode just above 876 MHz.
- Short Range Devices at frequencies below 870 MHz.
- PMR, TETRA, TAPS and CDMA-PAMR services in the 400 MHz bands.
- Broadcasting systems receivers above 470 MHz, both analogue and digital (DVB-T) (see note).

NOTE: This is a known problem for all radio services in the same bands as CDMA-PAMR and for those countries who use TV Channel 21.

- GSM BS receivers just below 915 MHz because of the transition at 915 MHz between the uplink and downlink;
- TETRA, TAPS and CDMA-PAMR in the bands 870 MHz to 876 MHz and 915 MHz to 921 MHz;
- Compatibility with military radio applications in adjacent bands of 380 MHz to 385 MHz/390 MHz to 395 MHz.

In addition, if considered necessary, a spectrum efficiency study similar to that of ECC Report 42 [18] could be performed.

An update of CEPT Recommendation T/R 25-08 [19] to include the different band widths of TEDS is also anticipated.

C.2 Current ITU allocations

None affected.

C.3 Sharing issues

Sharing with Military TRRs in the band 870 MHz to 876 MHz/915 MHz to 921 MHz.

Sharing with Military radio applications in the band 380 MHz to 400 MHz.

History

Document history		
V1.1.1	June 2005	Publication
V1.2.1	May 2006	Publication