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TECHNICAL REPORT

Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D): Designers' guide; Part 7: TETRA High-Speed Data (HSD); TETRA Enhanced Data Service (TEDS)

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee TETRA and Critical Communications Evolution (TCCE).

The present document is part 7 of a multi-part deliverable covering Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D): Designers' guide, as identified below:

ETSI ETR 300-1: "Overview, technical description and radio aspects";

ETSI TR 102 300-2: "Radio channels, network protocols and service performance";

ETSI TR 102 300-3: "Direct Mode Operation (DMO)";

ETSI ETR 300-4: "Network management";

ETSI TR 102 300-5: "Guidance on numbering and addressing";

ETSI TR 102 300-6: "Air-Ground-Air";

ETSI TR 102 300-7: "TETRA High-Speed Data (HSD); TETRA Enhanced Data Service (TEDS)".

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

1 Scope

The present document is aimed at a readership with a technical background wishing to have an overall understanding of the TEDS architecture, parameters and features for embarking on any of the following activities *before reading the standard*:

1) design and development of TETRA 2 network and equipment;

2) system and technical support activity in procurement phases of a TETRA 2 network;

3) upgrading of an existing TETRA network to a TEDS capable network;

4) applications development activity.

This list is not exhaustive. Although the emphasis is on a readership with a technical background a selective reading of the contents will also be of benefit to non-technical personnel engaged on other aspects of a TETRA 2 network. No market or user type information nor a competitive analysis with respect to other technologies or standards are included.

If any conflict is found between the present document and the clauses in the TETRA standard ETSI EN 300 392-2 [i.2] V3.7.1, or later versions, then ETSI EN 300 392-2 [i.2] takes precedence. In addition to describing TEDS architecture, parameters and features, the present document provides detailed system simulation results and typical link budget calculations to assist readers in their outline radio coverage planning. The effect of using TETRA 2 terminals in high velocity environments such as trainborne, not included in the standard, is also evaluated in the present document.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long-term validity.

The following referenced documents may be useful in implementing an ETSI deliverable or add to the reader's understanding, but are not required for conformance to the present document.

[i.1] ISO/IEC 8348: "Information technology — Open Systems Interconnection — Network service definition".

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

[i.3] ETSI EN 300 394-1: "Terrestrial Trunked Radio (TETRA); Conformance testing specification; Part 1: Radio".

[i.4] ETSI EN 301 344: "Digital cellular telecommunications system (Phase 2+) (GSM); General Packet Radio Service (GPRS); Service description; Stage 2 (GSM 03.60)".

[i.5] ETSI TS 122 060: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); General Packet Radio Service (GPRS); Service description; Stage 1 (3GPP TS 22.060)".

[i.6] IETF RFC 1144: "Compressing TCP/IP headers for low-speed serial links".

[i.7] IETF RFC 2507: "IP Header Compression".

[i.8] IETF RFC 2508: "Compressing IP/UDP/RTP Headers for Low-Speed Serial Links".

[i.9] IETF RFC 1977: "PPP BSD Compression Protocol".

[i.10] IETF RFC 1978: "PPP Predictor Compression Protocol".

[i.11] IETF RFC 3095: "RObust Header Compression (ROHC): Framework and four profiles: RTP, UDP, ESP and uncompressed".

[i.12] ETSI EN 300 392-1: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 1: General network design".

[i.13] ETSI EN 300 396-3: "Terrestrial Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 3: Mobile Station to Mobile Station (MS-MS) Air Interface (AI) protocol".

[i.14] ETSI ETR 300-1 (1997): "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Designers' guide; Part 1: Overview, technical description and radio aspects".

[i.15] ETSI TR 102 491: "Electromagnetic compatibility and Radio spectrum Matters (ERM); TETRA Enhanced Data Service (TEDS); System reference document".

[i.16] ETSI EN 300 113-1 (V1.6.1): "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; Part 1: Technical characteristics and methods of measurement".

[i.17] CEPT ERC Report 68: "Monte-Carlo Simulation Methodology for the use in Sharing and Compatibility Studies between Different Radio Services or Systems", Naples, February 2000, revised in Regensburg, May 2001 and Baden, June 2002.

[i.18] ERO: "SEAMCAT-3 User Manual", November 2005.

[i.19] ETSI EN 300 392-7: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 7: Security".

[i.20] ETSI EN 302 109: "Terrestrial Trunked Radio (TETRA); Security; Synchronization mechanism for end-to-end encryption".

[i.21] G. Cherubini, E. Eleftheriou, and S. Olcer: "Filtered Multitone Modulation for High-Speed Digital Subscriber Lines", IEEE™ J. Select. Areas Commun. vol. 20, no. 5.

[i.22] T. S. Rappaport, Wireless Communications: "Principles & Practice", Prentice-Hall, 1996.

[i.23] S. Le Goff, A. Glavieux and C. Berrou: "Turbo-Codes and High Spectral Efficiency Modulation", IEEE™ ICC 99, pp. 645-649, May 1994.

[i.24] S. M. Kay, Fundamentals of Statistical Processing volume I: "Estimation Theory", Prentice-Hall, 1993.

[i.25] D. O. Reudink: "Properties of Mobile Radio Propagation above 400 MHz", IEEE™ Transactions on Vehicular Technology, Vol. 2, VT-23, pp. 1-20, November 1974.

[i.26] CEPT ECC Decision (08)05: "The harmonisation of frequency bands for the implementation of digital Public Protection and Disaster Relief (PPDR) narrow band and wide band radio applications in bands within the 380-470 MHz range".

[i.27] CEPT ECC ERC Report 25: "The European table of frequency allocations and applications in the frequency range 8.3 KHz to 3000 GHz".

[i.28] CEPT ECC Decision (04)06: "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".

[i.29] CEPT ECC Decision (16)02: "Harmonised technical conditions and frequency bands for the implementation of Broadband Public Protection and Disaster Relief (BB-PPDR) systems".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

access code: subdivision of mobiles for random access opportunities

acknowledged data transfer: service provided by the layer below which gives an acknowledgement back over the air interface from the lower layer peer entity

NOTE: This service is used by the layer 3 entities to get a secure transmission including retransmissions.

adjacent-channel interference: interference caused by coupling from a signal in an adjacent channel

advanced link: bidirectional connection-oriented path between an MS and a BS using the acknowledged service - or unidirectional connection-oriented path between a BS and one or several MSs using the unacknowledged service - with provision of windowing, segmentation, extended error protection and choice among several throughputs

NOTE: The advanced link requires a set-up phase.

air-interface: wireless interface between a base station and a mobile station (trunked mode) or between two mobile stations (direct mode)

announced cell reselection: cell reselection where the MS MLE informs the SwMI both in the old cell (leaving cell) and in the new cell (arriving cell) that cell change is performed

assessment: act of estimating the path loss parameter of the serving cell main carrier or of a channel class (on the serving cell or an adjacent cell), based on measurements made on another channel or carrier radiated from the same site and applying conversion factors to those measurements

assigned channel: channel allocated by the infrastructure to certain MSs using channel allocation command(s) addressed to those MSs

NOTE: An assigned channel may be allocated for secondary control purposes or for a circuit mode call.

Associated Control CHannel (ACCH): dedicated signalling channel associated with a channel that has been assigned for circuit mode traffic

NOTE: It comprises the Fast Associated Control CHannel (FACCH) which uses frames 1 to 18 when there is no traffic in a given direction or the Slow Associated Control CHannel (SACCH) which is always available in frame 18 when there is traffic.

background class data: data that requires high delivery reliability but can tolerate delay

background measurement: measurements performed by the lower layers while maintaining the current service to the service users, i.e. the MS MLE

basic link: bidirectional connectionless path between one or several MSs and a BS, with provision of both unacknowledged and acknowledged services on a single message basis

baud rate: equivalent to signalling rate or symbol rate

broadcast: unidirectional point to multi-point mode of transmission

burst header: burst identifier (carrying a SICH channel for all burst types, plus an AACH channel for the NDB)

burst payload: section of burst carrying traffic channel information

C-plane: plane for control and packet data signalling

carrier specific signalling: additional π/4-DQPSK common signalling channel allocated in conjunction with a traffic channel specific to the carrier

cell reselection: act of changing the serving cell from an old cell to a new cell

NOTE: Cell reselection is performed by procedures located in the MLE and in the MAC. When the reselection is made and possible registration is performed, the MS is said to be attached to the cell.

channel class: set of values indicating the general RF characteristics of a concentric channel or fully super-sectored channel

channel estimation: process of estimating the degradation of a digital radio channel by the propagation effect to apply correction

cipher key: value that is used to determine the transformation of plain text to cipher text in a cryptographic algorithm

cipher text: data produced through the use of encipherment

co-channel interference: interference between two different communication channels re-using the same frequency

coherent detection: conversion of the intermediate frequency (IF) signal to I and Q components so that the phase of the components is preserved

Common Cipher Key (CCK): cipher key that is generated by the infrastructure to protect group addressed signalling and traffic

NOTE: CCK is also used for protection of SSI identities (ESI) in layer 2.

common control channels: control channels transmitted by the infrastructure to control the MS population

NOTE: The common control channels comprise the π/4-DQPSK Main Control CHannel (MCCH) or QAM Main Control CHannel (MCCH-Q), and common Secondary Control CHannels (common SCCH).

concentric channel: channel that has essentially the same azimuthal radiation pattern as the main carrier and is radiated from the same site as the main carrier

conforming channel: channel that has essentially the same azimuthal radiation pattern as the main carrier, is radiated from the same site as the main carrier and has essentially the same range and coverage area as the main carrier

NOTE: A conforming channel is a special case of a concentric channel.

Conventional Access (CA): method of operation in which the main carrier uses phase modulation

Conventional Access (CA) cell: cell on which the main carrier uses phase modulation

Conventional Access (CA) MS: MS that is currently camped on a conventional access cell

Cyclic Redundancy Check (CRC): algorithm for detection and correction of accidental errors in a data stream

D8PSK channel: channel on which signalling and data messages are sent using either π/4-DQPSK bursts or π/8-D8PSK bursts

delay spread: measure of channel time dispersion due to multipath propagation

NOTE: The larger the delay spread (i.e. the relative propagation delays along the various paths), the more pronounced the channel frequency selectivity.

Derived Cipher Key (DCK): key generated during authentication for use in protection of individually addressed signalling and traffic

Direct Access (DA): method of operation in which the main carrier uses QAM

Direct Access (DA) cell: cell on which the main carrier uses QAM

Direct Access (DA) MS: MS that is currently camped on a direct access cell

doppler bandwidth: Same as doppler spread.

doppler spread: maximum doppler shift undergone by the received carrier, i.e. product of carrier frequency by the ratio of MS speed to light propagation speed

NOTE: The larger the doppler spread, the more pronounced the channel time selectivity.

duplex frequency spacing: fixed frequency spacing between uplink and downlink frequencies

eccentric channel: channel that is not radiated from the same site as the main carrier

NOTE: The TETRA standard ETSI EN 300 392-2 [i.2] supports up to a maximum separation of 4 km between the eccentric channel's transmitter site and the main carrier's transmitter site.

Encryption Cipher Key (ECK): cipher key that is used as input to the encryption algorithm where an air interface encryption algorithm from TEA set A is in use

NOTE: This key is derived from one of SCK, DCK, MGCK or CCK and modified using an algorithm by the broadcast data of the serving cell.

Extended Cipher Key (CKX): value that is used to determine the transformation of plain text to cipher text in a cryptographic algorithm where an air interface encryption algorithm from TEA set B is in use

Extended Common Cipher Key (CCKX): cipher key that is generated by the infrastructure to protect group addressed signalling and traffic where an air interface encryption algorithm from TEA set B is in use

NOTE: CCKX can also be used to protect SSI identities (ESI or MAE) in layer 2.

Extended Derived Cipher Key (DCKX): key generated during authentication for use in protection of individually addressed signalling and traffic where an air interface encryption algorithm from TEA set B is in use

Extended Group Cipher Key (GCKX): cipher key known by the infrastructure and MS to protect group addressed signalling and traffic where an air interface encryption algorithm from TEA set B is in use

Extended Modified Group Cipher Key (MGCKX): cipher key known by the infrastructure and MS to protect group addressed signalling and traffic that is composed algorithmically from CCKX and GCKX where an air interface encryption algorithm from TEA set B is in use

Extended Static Cipher Key (SCKX): predetermined cipher key that may be used to provide confidentiality in class 2 systems with a corresponding algorithm and may also be used in DMO or for fallback where an air interface encryption algorithm from TEA set B is in use

end-to-end encryption: encryption within or at the source end system, with the corresponding decryption occurring only within or at the destination end system

fading bandwidth: Same as doppler spread

foreground measurement: measurements performed by the lower layers while employing the whole capacity, e.g. no concurrent service is maintained

frequency-selective fading: distortion on channel frequency response due to multipath propagation, giving rise to variable attenuation (selectivity) and phase rotation with frequency

fully super-sectored channel: super-sectored channel that is radiated from the same site as the main carrier, and has an azimuthal extent that is greater than, and entirely contains, the azimuthal extent of the main carrier

generator polynomial: polynomial with binary coefficients used to define the relationship between a bit at the encoder output and the sequence of input bits

gross bit rate: number of modulation bits transmitted in a channel per second

Group Cipher Key (GCK): cipher key known by the infrastructure and MS to protect group addressed signalling and traffic

NOTE: Not used directly at the air interface but modified by CCK to give a modified group cipher key (MGCK).

Group TETRA Subscriber Identity (GTSI): identity used to set up and receive group calls and messages

NOTE: A TETRA user may have multiple GTSIs associated to its ITSI. Multiple users may have the same GTSI as a valid reception address.

half duplex operation: each MS asks for permission to transmit for each transaction

NOTE: In TETRA trunked mode operation half duplex means two-frequency simplex operation.

Individual TETRA Subscriber Identity (ITSI): identity used to specify an individual TETRA user

NOTE: An ITSI cannot be shared by multiple users.

initial cell selection: act of choosing a first serving cell to register in

NOTE: Initial cell selection is performed by procedures located in the MLE and in the MAC. When the cell selection is made and possible registration is performed, the MS is said to be attached to the cell.

Initialization Value (IV): sequence of symbols that randomize the KSG inside the encryption unit

interleaving: way to arrange data in a non-contiguous way in order to increase performance

intermodulation products: unwanted signals generated when two or more signals are present in a non-linear circuit

interrupting measurement: measurements performed by the lower layers interrupting current services

inter-symbol interference: distortion of the received signal caused by temporal spreading and consequent overlap of adjacent modulation symbols

IP packet data: packetized data according to the Internet Protocol

irregular channel: non-conforming channel that needs to be monitored by the MS in order for the MS to discover whether the channel would be usable as an assigned channel

NOTE: Sectored channels and semi-super-sectored channels are irregular channels. An eccentric channel is an irregular channel, if it does not fully cover the area of the cell. The SwMI may broadcast information about a fully super-sectored channel as either a channel class or an irregular channel, if broadcast is needed (for example, if the channel does not fully cover the area of the cell).

irregular channel monitoring: monitoring of irregular channels on the serving cell or on adjacent cells

key stream: pseudo-random stream of symbols that is generated by a KSG for encipherment and decipherment

Key Stream Generator (KSG): cryptographic algorithm which produces a stream of symbols that can be used for encipherment and decipherment

NOTE: The initial state of the KSG is determined by the IV value.

Key Stream Segment: (KSS): key stream of arbitrary length

link adaptation: process of adaptively changing the modulation level on a D8PSK channel, or the modulation level and/or coding rate on a QAM channel

logical channel: generic term for any distinct data path

NOTE: Logical channels are considered to operate between logical endpoints.

MAC block: unit of information transferred between the upper MAC and lower MAC for a particular logical channel

NOTE: Logical channels are e.g. SCH/F, SCH/HD, SCH/HU, SCH-P8/F, SCH-P8/HD, SCH-P8/HU, SCH-Q/D, SCH-Q/U, SCH-Q/HU or SCH-Q/RA. The lower MAC performs channel coding for insertion into the appropriate physical slot, half slot or subslot.

main carrier: carrier containing the common control channel(s) transmitted by the infrastructure to control the MS population

NOTE: The frequency of the main carrier is broadcast by the infrastructure.