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Terrestrial Trunked Radio (TETRA);
Voice plus Data (V+D);
Part 3: Interworking at the Inter-System Interface (ISI);
Sub-part 7: Speech Format Implementation for Packet Mode Transmission

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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
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Foreword

This Technical Specification (TS) has been produced by ETSI Project Terrestrial Trunked Radio (TETRA).

The present document is part 3, sub-part 7 of a multi-part deliverable covering Voice plus Data (V+D), as identified below:

EN 300 392-1: "General network design";

EN 300 392-2: "Air Interface (AI)";

EN 300 392-3: "Interworking at the Inter-System Interface (ISI)";

Sub-part 1: "General design";

Sub-part 2: "Additional Network Feature Individual Call (ANF-ISIIC)";

Sub-part 3: "Additional Network Feature Group Call (ANF-ISIGC)";

Sub-part 4: "Additional Network Feature Short Data Service (ANF-ISISDS)";

Sub-part 5: "Additional Network Feature Mobility Management (ANF-ISIMM)";

Sub-part 6: "Additional Network Feature for Speech Format Implementation for Circuit Mode Transmission" (TS);

Sub-part 7: "Additional Network Feature for Speech Format Implementation for Packet Mode Transmission" (TS);

ETS 300 392-4: "Gateways basic operation";

EN 300 392-5: "Peripheral Equipment Interface (PEI)";

EN 300 392-7: "Security";

EN 300 392-9: "General requirements for supplementary services";

EN 300 392-10: "Supplementary services stage 1";

EN 300 392-11: "Supplementary services stage 2";

EN 300 392-12: "Supplementary services stage 3";

ETS 300 392-13: "SDL model of the Air Interface (AI)";

ETS 300 392-14: "Protocol Implementation Conformance Statement (PICS) proforma specification".

TS 100 392-15: "TETRA frequency bands, duplex spacings and channel numbering";

TS 100 392-16: "Network Performance Metrics";

TS 100 392-17: "TETRA V+D and DMO Release 1.1 specifications".

Introduction

There are two different speech format options defined for the TETRA InterSystem Interface (ISI) speech transmission one for circuit mode support and another for packet mode support.

The two options allow different techniques in designing and interconnecting TETRA Switching and Management Infrastructure (SwMIs). Those based on circuit mode transmission technology can use the complementary circuit mode based option, and those based on packet mode transmission technology can take advantage of the present document of the ISI.

The reason for having two options shall be found in the nature of existing TETRA SwMIs from various manufacturers. The existing SwMIs can generally be divided into two types: those that use packet switched technology and those that are using a circuit switched technology.

When connecting a circuit switched SwMI to a packet switched SwMI there must be a conversion performed from one technology to the other. However, if connecting two circuit switched SwMIs or two packet switched SwMIs, then a conversion is not necessary.

When a circuit switched and a packet switched SwMI is connected, a TETRA ISI Transport Converter (ISI-TC) is required. The ISI-TC does not necessarily need to be provided by the SwMI manufactures.

The location of the ISI-TC will be dependent on the backbone network that is used to interconnect the two systems. If a packet switched backbone is available, then the location of the ISI-TC is best in the circuit switched SwMI end. If a circuit switched backbone is available, then the location of the ISI-TC is best at the packet SwMI.

1 Scope

The present document specifies Speech Format Implementation for Packet Mode Transmission in TETRA ISI.

The present document defines the format of user information that is transported between two SwMIs using the TETRA ISI and supporting packet mode speech transmission for ISI connections. It is complementary to the subpart of the ISI specification describing a circuit mode approach.

The present document covers how TETRA traffic e.g. speech, circuit mode data is encapsulated in standard HDLC frames for transport over various media.

For present document the media is a 2 Mbit/s E1 link (ITU-T Recommendations G.703 and G.704 (see bibliography)). The E1 link is the primary transport layer between the network gateway elements in the two SwMI's that are interconnected via TETRA ISI.

The present document does not cover:

- any signalling issues (e.g. how speech circuits are reserved on the ISI interface, how call set up is done).

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

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

[2] ETSI ETS 300 395-2: "Terrestrial Trunked Radio (TETRA); Speech codec for full-rate traffic channel; Part 2: TETRA codec".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document the following terms and definition applies:

Mobile Station (MS): physical grouping that contains all of the mobile equipment that is used to obtain TETRA services

NOTE: By definition, a mobile station contains at least one Mobile Radio Stack (MRS).

3.2 Abbreviations

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

ACELP	Algebraic CELP
ATM	Asynchronous Transfer Mode
BFI	Bad Frame Indication
DLCI	Data Link Connection Identifier
E1	European format for digital transmission
FCS	Frame Check Sequence
FT	Frame Type
FN	Frame Number
HDLC	High level Data Link Control
ISDN	Integrated Services Digital Network
ISI	Inter System Interface
ISI-TC	Inter System Interface Transport Converter
MRS	Mobile Radio Stack
MS	Mobile Station
O	Originator
PVC	Permanent Virtual Circuit
PID	Protocol IDentifier
STCH	STealing CHannel
SwMI	Switching and Management Infrastructure
TBN	Traffic Block Number
TCH	Traffic Channel
TETRA	Terrestrial Trunked Radio
V+D	Voice plus Data

4 Overview

In a packet based SwMI, TETRA traffic is carried in frames. When connecting two packet based SwMIs the most optimal way to handle the transport of user plane information (e.g. ACELP) between the SwMIs is via a frame capable connection. In the packet switched approach, TETRA traffic is carried inside standard HDLC frames.

In ISI phase 1 one TETRA ISI call is carried per 64 kbit/s slot on the 2 Mbit/s E1 link, but the use of HDLC frames allows for adaptation of other transport medias such as e.g. ATM.

Since the transmission defined in the present document is 'packet mode', packets may be subject to jitter. The maximum jitter is a SwMI specific characteristic. The value of the allowable maximum jitter value is outside the scope of the present document.

5 Frame format and procedures

5.1 HDLC Frame Format

HDLC framing is used to encapsulate the address, payload and checksum content with $7E_H$ flags as presented in table 1.

The bit number 8 is the most significant bit. The bit number 1 is the least significant bit and shall be sent first (standard for HDLC protocol).

NOTE: The bits of an octet are numbered from 1 to 8 in the present document.

Table 1: HDLC Frame

	8	7	6	5	4	3	2	1
Start Flag	$7E_H$							
Address 1	Upper DLCI						C/R	EA0
Address 2	Lower DLCI				FECN	BECN	DE	EA1
Payload	TETRA Payload ….							
FCS 1	FCS							
FCS 2	FCS							
Stop flag	$7E_H$							

Information elements in the table 1:

Start Flag: $7E_H$;

DLCI: Used to indicate the TETRA ISI Channel number;

C/R (Command Response) = 1 = Command;

EA0 = 0 = One more address byte follows;

EA1 = 1 = Last address byte;

FECN and BECN = 0 (default values);

DE = 0 (default value);

TETRA Payload: see clause 5.2;

FCS: Frame Check Sequence;

FCS1: most significant 8 bits of FCS;

FCS2: least significant 8 bits of FCS;

Stop Flag: $7E_H$.

Cyclic redundancy check

Cyclic redundancy check shall be calculated with generation polynomial: $X^{16} + X^{12} + X^5 + 1$.

Zero Bit Insertion

Since $7E_H$ is used as a packet delimiter it is vital that this pattern does not appear within the packet itself causing the receiver of the packet to falsely detect an end of packet condition. Zero bit insertion is therefore used by the sending device so that after every 5 consecutive "1"s an additional "0" is inserted into the bit stream, i.e.:

0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0

becomes after zero insertion:

0 1 1 1 1 1 0 1 1 1 1 1 0 0 1 1 1 1 1 0 0

5.2 TETRA ISI payload

5.2.1 General

The protocol has been designed to support TETRA CODEC packets (single/dual), circuit mode data and extended U-plane services. However, this version of the document only describes in detail the packet formats for TETRA CODEC packets (single and dual) and extended U-plane services. Nevertheless, this principle applies equally to the other remaining U-plane packet formats. Generic payload structure is presented in figure 1.

Payload Header	Payload Block 1	Payload Block 2	Payload Block 3

Figure 1: TETRA payload structure

The payload header is comprised of the following information elements, see figure 2:

- Protocol IDentifier (PID): this information element shall identify the type of circuit mode speech/data service;
- Frame Type (FT): this information element shall identify the configuration of the payload;
- Originator (O): this information element shall identify whether the circuit mode speech/data originated from the SwMI or an MS;
- Frame Number (FN): this information element shall indicate the sequence of packets (and shall indicate where frame 18 occurs); and
- Traffic Block Number (TBN): this information element shall indicate the order of the traffic blocks when those are sent using separate payload messages but belong to the same frame number.

Together these information elements determine the number of blocks (0, 1, 2 or 3) and the type of data within those blocks, which form the remaining part of the payload.

Table 2: Payload header format

Bit Number								Octet No.
8	7	6	5	4	3	2	1	
PID				FT				1
O	FN					TBN		2

Table 3: PID values

Values	Description
0_H	Reserved
1_H	TCH_S (TETRA CODEC)
2_H	Reserved (TETRA2 CODEC)
3_H	Reserved
4_H	Reserved (TCH_D/7,2)
5_H	Reserved (TCH_D/4,8)
6_H	Reserved (TCH_D/2,4)
7_H	Reserved
etc.	etc.
F_H	Reserved

Depending on the value of PID, refer to table 3, the FT information element shall identify the exact format and number of the remaining blocks in the payload. The FT values used in the present document for PID = "TCH_S" are given in table 7.

The use of the originator field allows the destination SwMI to determine the characteristics of the circuit mode speech/data packet stream, refer to table 4. Different buffering schemes may then be applied to optimise audio delay for ISI calls.

Table 4: Originator (O) values

Values	Description
0_H	Originating from an MS
1_H	Originating from the SwMI

The Frame Number (FN) information element should be used by the destination SwMI to monitor the sequence of packets and, when used in conjunction with the originator field, identify when the frame 18 gap will occur in the packet stream. The FN information element shall be as defined in table 5.

When the payload message originates from an MS, the frame number in the payload header shall represent the frame number associated with the packet when base station received it over the air interface.

When the payload message originates from the SwMI, the FN in the payload header shall be used as a sequence counter only.

Table 5: FN values

Values	Description
0_H	Frame 1
1_H	Frame 2
etc…	etc…
10_H	Frame 17
11_H	Reserved
etc…	etc…
$3E_H$	Reserved
$3F_H$	FN not available

When the SwMI sources packets containing only single traffic blocks, the traffic block number field shall be used to differentiate between traffic blocks that logically belong to the same FN as defined in table 6. The recipient should use it to monitor the sequence of packets.

Table 6: TBN values

Values	Description
0_H	Bundled Traffic Blocks
1_H	Traffic Block 1
2_H	Traffic Block 2
3_H	Traffic Block 3 (note)
NOTE: TBN 3 is not used in the present document.	

5.2.2 TCH_S (TETRA CODEC)

If the PID is set to "TCH_S (TETRA CODEC)" then the FT field shall be interpreted according to table 7.

Table 7: "TCH_S" Frame Type values

Values	Description
0_H	ACELP + ACELP Blocks
1_H	STCH_C + ACELP Blocks
2_H	STCH_C + STCH_C Blocks
3_H	STCH_U + ACELP Blocks
4_H	STCH_U + STCH_U Blocks
5_H	STCH_C + STCH_U Blocks
6_H	STCH_U + STCH_C Blocks
7_H	ACELP Block only
8_H	STCH_C Block only
9_H	STCH_U Block only
A_H	Reserved
etc.	etc.
F_H	Reserved

An ACELP block contains 137 bits of ACELP data corresponding to 30 ms of speech. The next bit is used for Bad Frame Indication (BFI), the last 6 bits of the ACELP block are used for byte alignment padding, refer to table 8. The padding bits shall be set to "0".

Table 8: ACELP block

<table>
<tr><th colspan="8">Bit Number</th><th rowspan="2">Octet No.</th><th rowspan="2">Length</th></tr>
<tr><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th></tr>
<tr><td colspan="8" rowspan="2">ACELP</td><td>1</td><td rowspan="3">144</td></tr>
<tr><td>etc.</td></tr>
<tr><td></td><td>BFI</td><td colspan="6">padding</td><td>18</td></tr>
</table>

A STealing CHannel C-plane (STCH_C) block is zero length and represents capacity that has been taken away from the traffic channel in order to send control information between MS and SwMI.

A Stealing Channel U-plane (STCH_U) block contains 124 bits of U-plane stealing data used to send data between the SwMI and the MS or between MSs. The last 4 bits of the STCH_U block are used for byte alignment padding, refer to table 9. The padding bits shall be set to "0".

Table 9: U-Plane STCH block

<table>
<tr><th colspan="8">Bit Number</th><th rowspan="2">Octet No.</th><th rowspan="2">Length</th></tr>
<tr><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th></tr>
<tr><td colspan="3">Reserved</td><td colspan="5" rowspan="2">STCH_U</td><td>1</td><td rowspan="3">128</td></tr>
<tr><td colspan="3" rowspan="2"></td><td>etc.</td></tr>
<tr><td></td><td colspan="4">padding</td><td>16</td></tr>
<tr><td colspan="10">NOTE: The reserved bits shall be set to "000".</td></tr>
</table>

5.2.3 Payload examples

The tables 10 to 19 contain examples of TCH_S (TETRA CODEC) payload messages. In those tables "-" means any value.

Table 10: ACELP+ACELP message

Payload Fields	Octet	Length	Value
PID	1	4	1_H
FT	1	4	0_H
O	2	1	-
FN	2	5	-
TBN	2	2	0_H
ACELP	3 to 20	144	-
ACELP	21 to 38	144	-

Table 11: STCH_C+ACELP message

Payload Fields	Octet	Length	Value
PID	1	4	1_H
FT	1	4	1_H
O	2	1	-
FN	2	5	-
TBN	2	2	0_H (note)
ACELP	3 to 20	144	-
NOTE: This message is marked to be bundled although the STCH_C information is not included. The ACELP information originates from the second half-slot of the air interface message.			

Table 12: STCH_C+STCH_C message

Payload Fields	Octet	Length	Value
PID	1	4	1_H
FT	1	4	2_H
O	2	1	-
FN	2	5	-
TBN	2	2	0_H
NOTE: This message is marked to be bundled although the STCH_C information is not included.			

Table 13: STCH_U+ACELP message

Payload Fields	Octet	Length	Value
PID	1	4	1_H
FT	1	4	3_H
O	2	1	-
FN	2	5	-
TBN	2	2	0_H
STCH_U	3 to 18	128	-
ACELP	19 to 36	144	-

Table 14: STCH_U+STCH_U message

Payload Fields	Octet	Length	Value
PID	1	4	1_H
FT	1	4	4_H
O	2	1	-
FN	2	5	-
TBN	2	2	0_H
STCH_U	3 to 18	128	-
STCH_U	19 to 34	128	-

Table 15: STCH_C+STCH_U message

Payload Fields	Octet	Length	Value
PID	1	4	1_H
FT	1	4	5_H
O	2	1	-
FN	2	5	-
TBN	2	2	0_H (note)
STCH_U	3 to 18	128	-
NOTE: This message is marked to be bundled although the STCH_C information is not included. The STCH_U information originates from the second half-slot of the air interface message.			

Table 16: STCH_U+STCH_C message

Payload Fields	Octet	Length	Value
PID	1	4	1_H
FT	1	4	6_H
O	2	1	-
FN	2	5	-
TBN	2	2	0_H
STCH_U	3 to 18	128	-
NOTE: This message is marked to be bundled although the STCH_C information is not included.			

Table 17: ACELP message

Payload Fields	Octet	Length	Value
PID	1	4	1_H
FT	1	4	7_H
O	2	1	-
FN	2	5	-
TBN	2	2	1_H or 2_H
ACELP	3 to 20	144	-

Table 18: STCH_C message

Payload Fields	Octet	Length	Value
PID	1	4	1_H
FT	1	4	8_H
O	2	1	-
FN	2	5	-
TBN	2	2	1_H or 2_H

Table 19: STCH_U Message

Payload Fields	Octet	Length	Value
PID	1	4	1_H
FT	1	4	9_H
O	2	1	-
FN	2	5	-
TBN	2	2	1_H or 2_H
STCH_U	3 to 18	128	-

5.3 Physical layer

The default physical media is copper cable carrying 2 Mbit/s signal according to ITU-T Recommendation G.703 (see bibliography) and having 64 kbit/s framing according to ITU-T Recommendation G.704 (see bibliography) on it.

5.4 Mapping structure

For TETRA ISI Phase 1 the figure 2 illustrates the mapping structure between the TETRA ISI traffic frames and the TETRA ISI E1 media between two SwMIs.

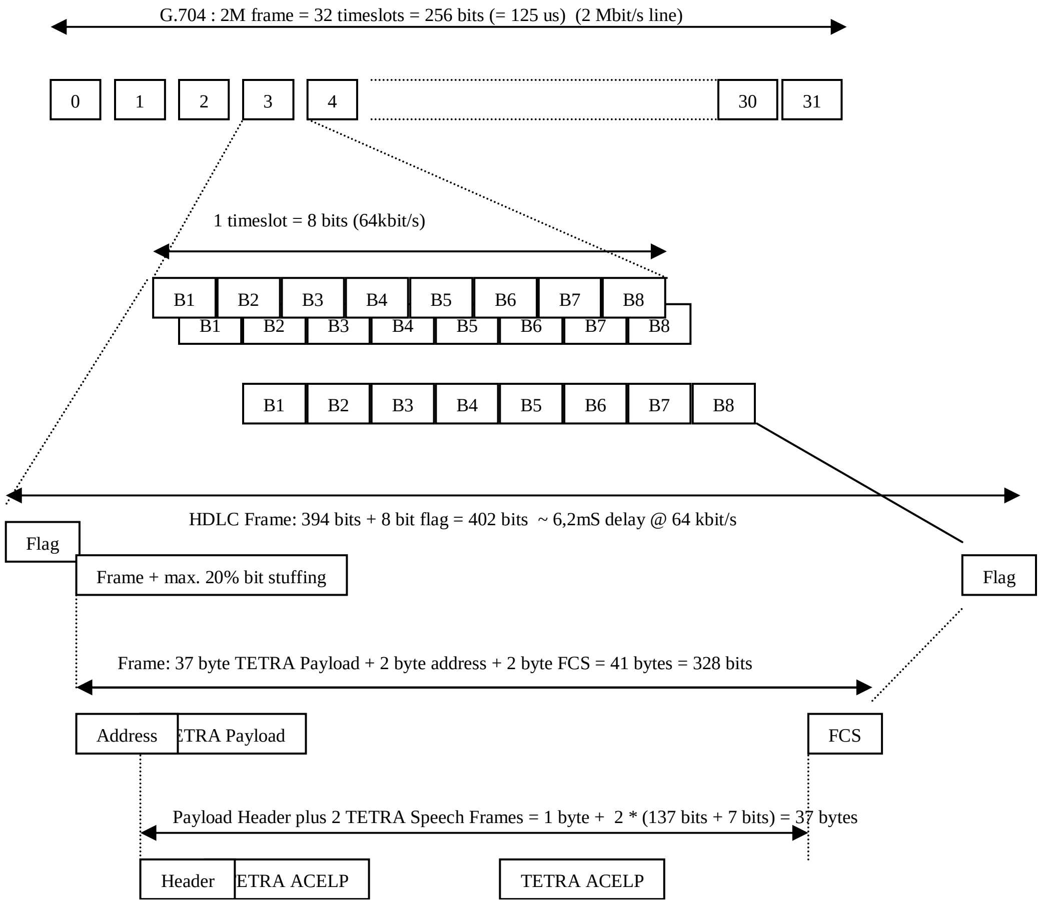

Figure 2 Mapping Structure

The figure above indicates how a typical TETRA voice call will be carried over TETRA ISI using industry standards:

- the ITU-T Recommendations G.703 and G.704 (see bibliography) framing are ITU-T standards for the physical layer;
- the ITU-T Recommendations Q.921 and ITU-T Recommendations Q.921 Amendment 1 (see bibliography) define the HDLC structure; and
- ETS 300 395-2 [2] defines the TETRA ACELP coding.

5.5 TETRA ISI Channel Mapping

The HDLC address is used to indicate the address of the specific TETRA ISI channel. The TETRA ISI channels are carried over Permanent Virtual Circuits (PVCs), i.e. the DLCI for the TETRA ISI channels are statically configured.

In phase one, 30 TETRA ISI channels are provided and each TETRA ISI channel will use a specific E1 B-channel.

TETRA ISI Channels shall be assigned PVC DLCIs and E1 B-channels according to table 20.

NOTE: As the channels are assign so that there is only a single packet data channel per 64 kbit/s channel, then the HDLC DLCI values are redundant is the present document.

Table 20: TETRA ISI channel addressing

TETRA ISI Channel	HDLC DLCI (Decimal)	E1 Slot B-Channel
1	21	1
2	22	2
3	23	3
4	24	4
5	25	5
6	26	6
7	27	7
8	28	8
9	29	9
10	30	10
11	31	11
12	32	12
13	33	13
14	34	14
15	35	15
CC	36	Q-SIG
16	37	17
17	38	18
18	39	19
19	40	20
20	41	21
21	42	22
22	43	23
23	44	24
24	45	25
25	46	26
26	47	27
27	48	28
28	49	29
29	50	30
30	51	31

NOTE: In later phases more TETRA channel capacity can be achieved in several ways:

- Multiple TETRA ISI channels can be carried over each B-Channel in separate PVCs.
- All TETRA ISI channels can be carried over common bandwidth in separate PVCs.

Annex A (informative): Bibliography

- ITU-T Recommendation G.703: "Physical/electrical characteristics of hierarchical digital interfaces".
- ITU-T Recommendation G.704: "Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels".
- ITU-T Recommendation Q.920: "ISDN user-network interface data link layer -General aspects".
- ITU-T Recommendation Q.920 Amendment 1: "ISDN user-network interface data link layer -General aspects. Amendment 1".
- ITU-T Recommendation Q.921: "ISDN user-network interface - Data link layer specification".
- ITU-T Recommendation Q.921 Amendment 1: "ISDN user-network interface - Data link layer specification. Amendment 1".

History

Document history		
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