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Foreword

This document is the Publicly Available Specification (PAS) of the TETRAPOL land mobile radio system, which shall provide digital narrow band voice, messaging, and data services. Its main objective is to provide specifications dedicated to the more demanding PMR segment: the public safety. These specifications are also applicable to most PMR networks.

This PAS is a multipart document which consists of:

Part 1 General Network Design

Part 2 Radio Air interface

Part 3 Air Interface Protocol

Part 4 Gateway to X.400 MTA

Part 5 Dispatch Centre interface

Part 6 Line Connected Terminal interface

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Part 12 Network Management Centre interface

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1. Scope

This subpart belongs to the TETRAPOL Specifications; Air Interface protocol (part 3).

It describes at the Switching and Management Infrastructure (SwMI) and Terminal (RT) interface (see PAS 0001-1 [1]) :

- the protocol used to enable the exchanges on the Voice Traffic Channel (TCH) ,

- how to use the end to end signalling capability on an established voice path to exchange :
  - The specific information formats for the talking party identification,
  - The key partitioning
  - The ambience listening (using the end to end signalling).

This protocol also applies to the Line Connected Terminal interface. The end to end signalling capability also applies to direct mode .

2. Normative references

This PAS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this PAS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] PAS 0001-1-1: "TETRAPOL Specifications; General Network Design; Reference Model".

[2] PAS 0001-1-2: "TETRAPOL Specifications; General Network Design; Voice and Data Services in Network and Direct Mode".

[3] PAS 0001-2: "TETRAPOL Specifications; Radio Air Interface".

[4] PAS 0001-3-1: "TETRAPOL Specifications; Air Interface Protocol; Air Interface Application Protocol".

[5] PAS 0001-3-2: "TETRAPOL Specifications; Air Interface Protocol; Air Interface Application Messages".

[6] PAS 0001-3-3: "TETRAPOL Specifications; Air Interface Protocol; Air Interface Transport Protocol".

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3. Abbreviations

For the purposes of this PAS, the following abbreviations apply:

A/I	Air Interface
BN	Base Network
BS	Base Station
CCH	Control CHannel
CRP	Connection Reference Point
CUG	Closed User Group
DB	DataBase
DC	Dispatch Centre
DCN	Delivery Confirmation Notification
DCS	Dispatch Centre Server
DFN	Delivery Failure Notification
DM	Direct Mode
DM/NM	Direct Mode / Network Monitoring
DP	Dispatch Position
DPS	Dispatch Position Switch
DPSI	Dispatch Position Switch Interface
EDT	External Data Terminal
FBM	FallBack Mode
FCS	Frame Check Sum
HRSW	Home RadioSWitch
ISI	Inter System Interface
KMC	Key Management Centre
LCIU	Line Connection Interface Unit
LCT	Line Connected Terminal
LLC	Logical Link Control
LPDU	Link Protocol Data Unit
LSDU	Link Service Data Unit
MAC	Medium Access Control
MM	Mobility Management
MOCH	Multisite Open CHannel
MRI	Mobile Random Identity
MS	Mobile Station
MSG APPLI	Messaging APPLIcation
NMC	Network Management Centre
OG	Operational Group
OMC	Operation and Maintenance Centre
PABX	Private Automatic Branch eXchange
(P)DN	(Public) Data Network
PAS	Publicly Available Specification
PCH	Paging CHannel
PDU	Protocol Data Unit
PMR	Private Mobile Radiocommunications
PSTN	Public Switched Telecommunications Network
PTT	Push-To-Talk
Ri	Reference point index i
RP	RePeater
RSW	RadioSWitch
RT	Radio Terminal
SADP	Stand Alone Dispatch Position
SCH	Signalling CHannel (by stealing)
SCH-TI	Signalling CHannel for Transmitter Interruption
SDL	Specification and Description Language
SDP	Submit Delivery Protocol
SFN	Submit Failure Notification
SIM	Subscriber Identity Module
ST	System Terminal

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SwMI	Switching and Management Infrastructure
TCH	Traffic CHannel
TCP/IP	Transmission Control Protocol/Internet Protocol
TDX	Telephone and Data eXchange
TMSG-Id	Temporary MeSsaGe Identifier
TP	TransPort layer
TTI	Temporary Terminal Identifier
UA	User Agent
UDT	User Data Terminal
UI	Unnumbered Information
UI_CD	Unnumbered Information for Circuit Data
UI_VCH	Unnumbered Information for Voice CHannel
VCH	Voice CHannel
VRSW	Visited RadioSWitch
X.400 MTA	X.400 Message Transfer Agent

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4. General Description

The circuit protocol describes transmission negotiations and the end to end signalling capability when one or several RTs are on TCH (engaged in a voice call).

A voice call uses one TCH per cell involved in the call.

Individual RTs shall switch to TCH only when ordered by the SwMI (private call) or on SwMI indication (group communication) (see PAS 0001-3-1 [4]) and shall remain there until the SwMI asks them to quit TCH. This phase is called **"voice session"**.

One voice session includes one or more transmissions:

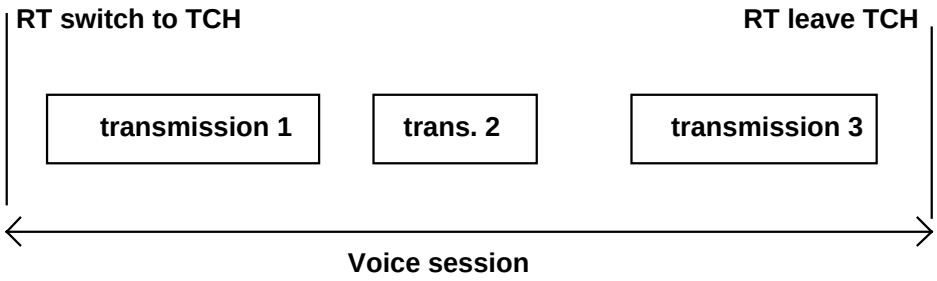

Figure 1 : Voice session

The voice session ends

- for private calls; at the end of the call (see PAS 0001-3-1 [4]).

- for group communications, When the SwMI starts to permanently broadcast the D_GROUP_IDLE application message on SCH, all the RTs present on the channel shall switch immediately to CCH. This procedure is described in PAS 0001-3-1 [4].

The SwMI shall end the voice session in the following two cases:

- The SwMI/RT interface is in "Channel free" status for more than T seconds;
- The voice session is open for more than T' seconds.

T = T610 (group communication), T620 (emergency group communication), T630 (private call).

T' = T611 (group communication), T621 (emergency group communication), T631 (private call).

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4.1 Physical Level Organisation on TCH

A traffic channel is a duplex radio channel with 2 physical radio channels in opposite directions.

The physical uplink TCH is a single VCH.

The physical downlink traffic channel TCH is divided into 3 logical channels (see PAS 0001-2 [2]):

- SCH_TI Signalling channel for transmitter interruption (by stealing);
- SCH Signalling channel by stealing;
- VCH Voice channel.

- SCH and SCH_TI are constructed by stealing VCH channel blocks. Their use is described in PAS 0001-3-3 [6].

- Three types of blocks are conveyed on VCH: non transparent data blocks, transparent data blocks and voice blocks:

  - (Transparent) Voice blocks transport voice frames which are processed by the vocoder;

  - Non transparent data blocks transport UI_VCH type data frames (see PAS 0001-3-3 [6]) conveying voice application layer LSDU;

  - Transparent data blocks transport end-to-end data frames (from RT to RT) without any action on the SwMI part ; this transparent mode may be used for end to end signalling purposes in voice sessions .

Transparent and non transparent data blocks shall be characterised by the use of two associated signalling bits (ASB) defined in PAS 0001-3-3 [6].

These two bits (X and Y) shall be present in each uplink or downlink "voice" or "data" block except in SCH_TI blocks.

On TCH:

- The transmitting RT shall set the X bit to 1 in end-to-end blocks; it shall not be modified by the SwMI;
- The Y bit is reserved and shall be set to 0.

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4.2 Organisation

Physical Channel	Logical channel	L1 Block type	L2 frame	Use
Uplink TCH	VCH	Speech block		Voice
		Data block (non transparent)	UI_VCH	Voice protocol control
		Data block (transparent)	UI_CD	End to end signalling
Downlink TCH	VCH	Speech block	-	Voice
		Data block (transparent)	UI_CD	End to end signalling
		Data block (non transparent)	UI_VCH	Voice protocol control
	SCH		UI	Signalling
	SCH_TI		-	transmit interruption

The circuit protocol handles voice frame or transparent data transmission.

The circuit protocol shall be organised in three layers:

- Physical layer: described in PAS 0001-2 [2];
- Link layer: described in PAS 0001-3-3 [6];
- Application level described in PAS 0001-3-1 [4] and PAS 0001-3-2 [5].

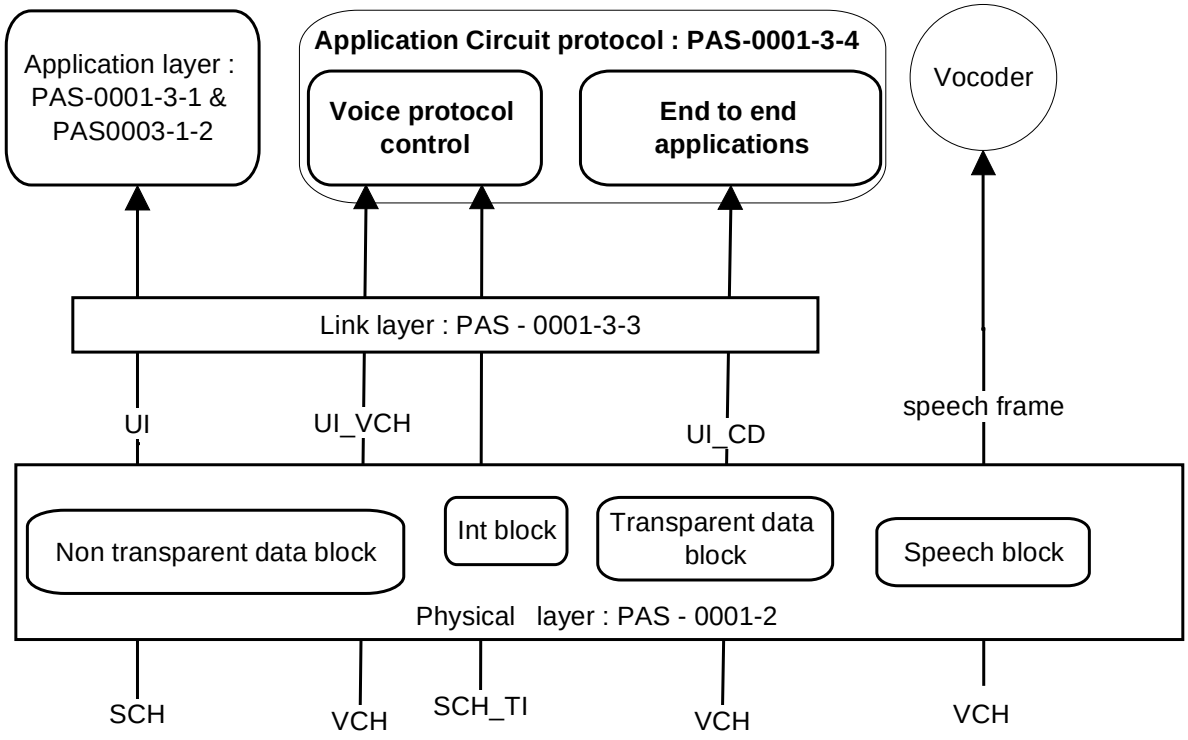

Figure 2 : circuit protocol organisation (RT side)

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5. VOICE PROTOCOL CONTROL

5.1 Voice control frame structure (UI_VCH)

UI_VCH is a single block frame, the format is defined in PAS 0001-3-3 [6].

- "Address field" contains a level 2 address derived from:

  - sender terminal's TTI for uplink frames or "all terminals" TTI;
  - "all terminals" TTI for all downlink frames.

- "Command field" UI_VCH type frame defined in PAS 0001-3-3 [6].

- "Information field" contains 3 octets (circuit protocol LSDU).

- "FCS field" is defined in PAS 0001-3-3 [6].

5.2 Broadcast / Selection Principle

The RTs shall communicate in half-duplex mode.

All the TCHs involved in the call shall broadcast identical information. It is a SwMI element which shall supply the information **(broadcast function)**.

The information shall include:

- Control frames (voice protocol LSDU);
- Voice or transparent data frames sent by the RT selected by the **selection function** of the SwMI.

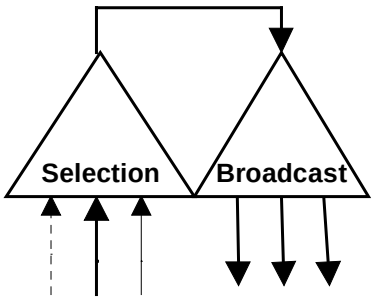

Figure 3 : Selection / Broadcast function.

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5.3 Procedures

5.3.1 SwMI/RT link states

The SwMI/RT link status is defined on the radio interface by the kind of LSDU broadcast on the downlink VCH. There are three possible states:

- **Channel free**: the SwMI shall permanently broadcast the "D_CHANNEL_FREE" LSDU.
- **Forced listening**; the SwMI shall broadcast the "D_FORCED_LISTENING" LSDU.
- **Channel busy**: the SwMI broadcasts either voice frames or other LSDUs according to the procedure

5.3.2 RT procedure for transmission request

The SwMI shall periodically inform all the participants in the D_START_SPEECH or D_VOICE_STUFFING LSDU of the selected RT's "TRANSMIT_PRIORITY".

Until any RT gets to know the selected RT's transmission priority, this RT shall consider the selected RT's transmission priority to be identical to its own priority

On PTT request, RT shall start a timer corresponding to the maximum delay during which the request can be transmitted.

Then, it shall wait for either a D_CHANNEL_FREE LSDU or D_VOICE_STUFFING or D_START_SPEECH LSDUs with a lower transmission priority; in these cases, RT shall cancel the timer and send its transmission request with the U_START_SPEECH LSDU immediately followed by voice or transparent data frames. .

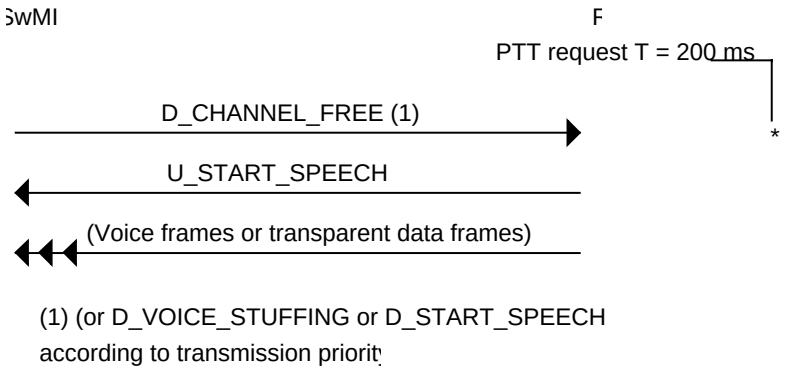

Figure 4: Transmission in "Channel free" status

The U_START_SPEECH LSDU shall contain its transmission priority. The RT shall not change to receive mode. The RT ignores whether it is selected.

On timer expiry, the PTT request is lost ; PTT shall be pushed again to run another request . The timer duration is 200ms .

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5.3.3 End of transmission (Transmitting RT side)

- Case 1: a transmitting RT must always listen to SCH_TI. If the block is present and if the RT is concerned with the TTI in the SCH_TI block, the RT shall **immediately** cease to transmit transparent frames (voice or data).

- Case 2: the selected RT shall set an anti-gossip time-out (T600) when transmission rights are granted and shall stop transmitting when T600 expires.

- Case 3: transmissions shall also be stopped either by the user.

When transmission is to be stopped, the selected RT shall send successive U_END_SPEECH_1, U_END_SPEECH_2, U_END_SPEECH 3 LSDU then shall switch to receive mode.

In cases 2 and 3: the selected RT shall

- set a time-out (T640) and shall listen to the downlink channel without generating a voice receive signaling until the first D_CHANNEL_FREE or D_START_SPEECH messages reception or when T640 expires.
- set a time-out (T650) and shall refuse any PTT request from the user until T650 expires.

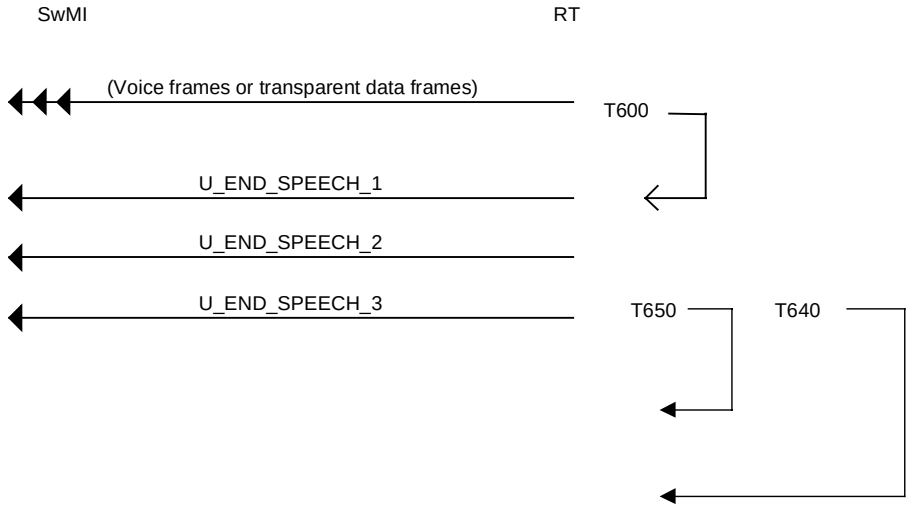

Figure 5 : End of transmission (Transmitting RT side)

5.3.4 RT Selection by the SwMI

A transmission grant request is due to :

- U_START_SPEECH LSDU reception, containing the RT transmission priority .
- or N601 successive voice or transparent data frames (in this case SwMI will not know the selected RT identity and shall set the default priority to STANDARD.

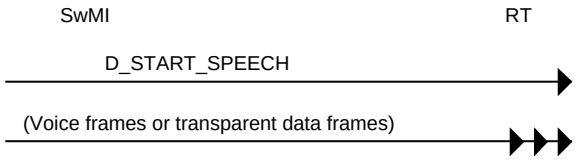

Figure 6 : RT Selection by the SwMI

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If the SwMI receives a transmission grant request when another RT is "selected", it shall compare the transmission priorities of the two RTs:

- The transmission priority of the new RT is higher than that of the selected RT, the SwMI shall select the new RT.

- The transmission priority of the new RT is lower or equal to that of the selected RT, the SwMI shall ignore the request.

The D_START_SPEECH LSDU containing the "selected RT's transmission priority is then broadcast on all the VCHs in the coverage area, followed by the voice or transparent data frames.

Each voice or transparent data frame not received by the SwMI (errored frame) shall be replaced by the D_VOICE_STUFFING LSDU on the downlink VCHs.

5.3.5 Transmission delay s in the coverage area

The voice or transparent data frames transmitted by the selected RT are received by other RT's with a delay due to the link path. The delay varies from one cell to another and depends on the number of elements employed to ensure coverage.

There are at least two errored frames per superframe (when the transmitter changes back to listen to SCH_TI).

The SwMI shall supply all the participants with the method for calculating positions in the superframe of the 2 D_VOICE_STUFFING LSDU;

Additionally to selected RT's priority, each downlink D_START_SPEECH and D_VOICE_STUFFING LSDU shall contain the information element NUM_BLOCK.

5.3.6 End of transmission (SwMI side)

When the SwMI receives one of the three U_END_SPEECH_n LSDUs, it shall end the selected RT transmissions.

The SwMI should also end transmissions when the rate of errored received voice or transparent data frames exceeds a certain threshold (typically 50%).

The SwMI shall start send N600 D_FORCED_LISTENING LSDUs then shall permanently broadcast the D_CHANNEL_FREE LSDU.

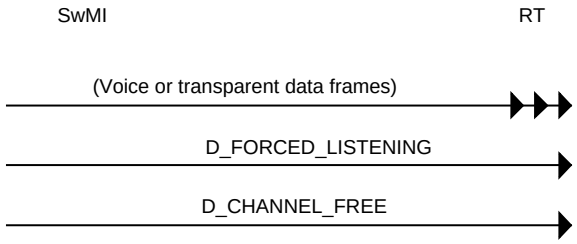

Figure 7 : End of transmission (SwMI side)

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5.4 Voice control LSDU and parameters

5.4.1 Parameters

T600 Anti-gossip time-out; value defined by the configuration management.

N600 Number of D_FORCED_LISTENING LSDUs before the D_CHANNEL_FREE LSDU; defined by the system configuration management.

T610 Voice inactivity time-out for a group communication; the value is defined by the configuration management.

T611 Maximum session duration for a group communication; the value is defined by the configuration management.

T620 Voice inactivity time-out for an emergency group communication; the value is defined by the configuration management.

T621 Maximum session duration for an emergency group communication; the value is defined by the configuration management.

T630 Voice inactivity time-out for a private call; the value is defined by the configuration management.

T631 Maximum session duration for a private call; the value is defined by the configuration management.

T640 Delay for a RT, between end of transmission and reception activity, typically 1,5 S

T650 Delay for a RT, between end of transmission and next user PTT request
Typically : 200 mS for Radio RT and 20 mS for Line Connected Terminal

5.4.2 Isdu descriptions

5.4.2.1 D_VOICE_STUFFING

Direction: SwMI --> RT
Short description: replaces an errored block in a voice or transparent data block.
Carried by LPDU: UI_VCH

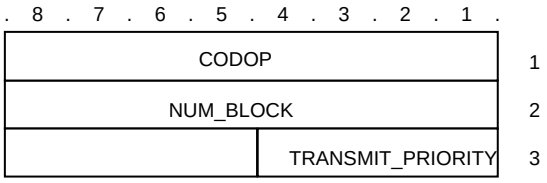

Figure 8 : D_VOICE_STUFFING LSDU format

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5.4.2.2 D_VOICE_STUFFING_2

Direction: SwMI --> RT
Short description: Replace a D_VOICE_STUFFING when SwMI is in BSC disconected mode.
Carried by LPDU: UI_VCH

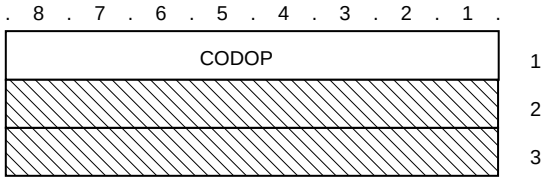

Figure 9 : D_VOICE_STUFFING_2 LSDU format

5.4.2.3 D_CHANNEL_FREE

Direction: SwMI --> RT
Short description: The channel is free, terminals may transmit.
Carried by LPDU: UI_VCH

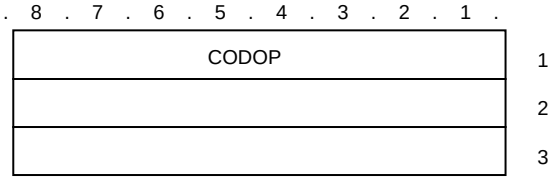

Figure 10 : D_CHANNEL_FREE LSDU format

5.4.2.4 D_START_SPEECH

Direction: SwMI --> RT
Short description: precedes a flow of voice or transparent data blocks.
Carried by LPDU: UI_VCH

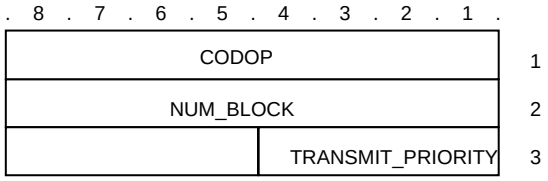

Figure 11 : D_START_SPEECH LSDU format

5.4.2.5 U_START_SPEECH

Direction: RT --> SwMI
Short description: precedes a flow of voice or transparent data blocks.
Carried by LPDU: UI_VCH

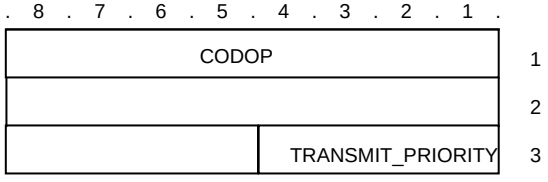

Figure 12 : U_START_SPEECH LSDU format

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5.4.2.6 D_FORCED_LISTENING

Direction: SwMI --> RT
Short description: the channel is free but the terminals receiving this order cannot transmit.
Carried by LPDU: UI_VCH

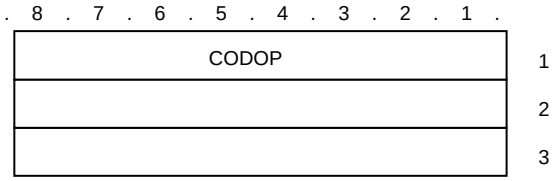

Figure 13 : D_FORCED_LISTENING LSDU format

5.4.2.7 U_END_SPEECH_1

Direction: RT --> SwMI
Short description: Ends a flow of voice or transparent data blocks.
Carried by LPDU: UI_VCH

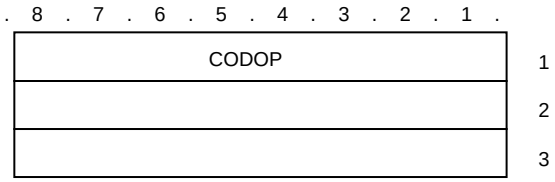

Figure 14 : U_END_SPEECH_1 LSDU format

5.4.2.8 U_END_SPEECH_2

Direction: RT --> SwMI
Short description: Ends a flow of voice or transparent data blocks.
Carried by LPDU: UI_VCH

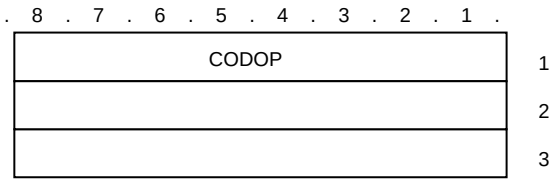

Figure 15 : LSDU: U_END_SPEECH_2 LSDU format

5.4.2.9 U_END_SPEECH_3

Direction: RT --> SwMI
Short description: Ends a flow of voice or transparent data blocks.
Carried by LPDU: UI_VCH

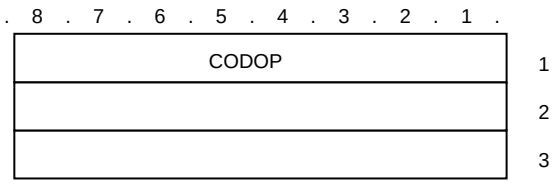

Figure 16 : U_END_SPEECH_3 LSDU format

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5.4.3 Information elements

CODOP	Downlink: 0..... D_CHANNEL_FREE 1.....D_FORCED_LISTENING 2.....D_VOICE_STUFFING 3..... D_START_SPEECH 4.....D_VOICE_STUFFING_2 Uplink: 16..... U_START_SPEECH 17.....U_END_SPEECH_1 18.....U_END_SPEECH_2 19.....U_END_SPEECH_3 Uplink and Downlink: from 240 to 254 : .... Reserved for RT - RT signalling in direct mode
TRANSMIT_PRIORITY	Priority of RT transmissions..... 4 bit field Indicates the priority of the RT requesting transmission rights or the priority of the selected RT. ZERO: = 0 0 0 0 STANDARD = 0 0 0 1 Level2 = 0 0 1 0 Level3 = 0 0 1 1 Level4 = 0 1 0 0 Level5 = 0 1 0 1 ..... Level15 = 1 1 1 1
NUM_BLOCK	SCH_TI Block number.....field of one octet Binary coded, Indicates the SCH_TI block number (in the transmitter's cell).

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6. End To End Signalling

6.1 Principle

The information to send is delivered in transparent mode instead of voice frames for the selected RT .

The use of this capability may cause voice disruptions which are fully linked to the frequency of such messages and to the choices of sending moments .

The possible loss of frames, due to radio or link problem or when the transmitter changes back to listen to SCH_TI for example shall also be considered to choose a good compromise .

As soon as an RT receives an indication by SCH_TI to force the end of transmission, it shall stop to transmit end to end signalling .

6.2 End to end signalling frame structure (UI_CD)

UI_CD is a single block, bi-block or multi-block UI_CD frames ; the information field is limited to 59 bytes .

The address field in the UI_CD frame shall be "All STs" . See UI_CD field description in PAS 0001-3-3 [6] for UI_CD frame format

6.3 Procedures

6.3.1 End to end transmitting

To send "end to end information", the RT shall execute a procedure for transmission request (see voice control protocol) and replace one or several voice frames with end to end signalling frames.

6.3.2 End to end reception

6.3.2.1 Talking Party Identification & Key partitioning

On reception of TP_ADDRESS or TP_ALIAS, the RT may display the current transmitting RT identity (alias or address).

Additionally, the LSDU contains characteristics of a specific key ; this key is applied in order to cipher the voice frames ; unauthorised participants shall not be able to understand the voice communication even if they are in the same group communication . (see PAS 0001-16-3)

6.3.2.2 Ambience listening

On reception of AMBIENCE_LISTENING LSDU with information field containing its own RFSI, the RT shall immediately acts likes if the user has done a PTT request.

The RT shall execute a transmission request (see voice control protocol) with the transmission priority and duration furnished by AMBIENCE_LISTENING LSDU.

At the end of the specified delay (or anti gossip) time out, the RT shall return in reception mode.

Depending on the value of the MODE information element from the AMBIENCE_LISTENING TSDU, the RT shall :

- the RT shall return in reception mode as soon as the user strikes any key.
- ignore any key stroke from the user

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6.4 End To End Protocol LSDU and parameters

6.4.1 Parameters

6.4.2 LSDU descriptions

6.4.2.1 TP_ADDRESS, TP_ADDRESS_INHIB

Direction: RT --> RT

Carried by LPDU: UI_CD

Short description: This service shall enable all connected parties of a call to be aware of the Talking Party Identity (address) and ciphering key characteristics.

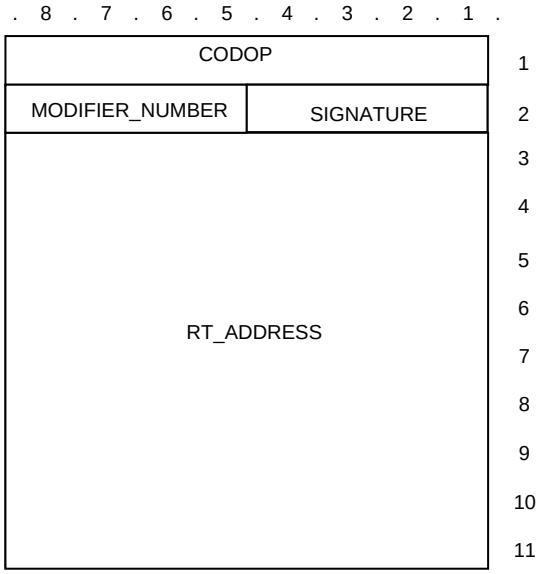

Figure 17 : TP_ADDRESS LSDU information field formats

Table 1: TP_ADDRESS LSDU information elements list

IE	K	Condition	F	Length
CODOP	M		V	8 bits
MODIFIER_NUMBER	M	(see PAS 0001-16-3)	V	4 bits
SIGNATURE	M	(see PAS 0001-16-3)	V	4 bits
RT_ADDRESS	M	(see PAS 0001-16-3)	V	9 octets

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6.4.2.2 TP_ALIAS

Direction: RT --> RT

Carried by LPDU: UI_CD

Short description: This service shall enable all connected parties of a call to be aware of the Talking Party Identity (alias) and ciphering key characteristics.

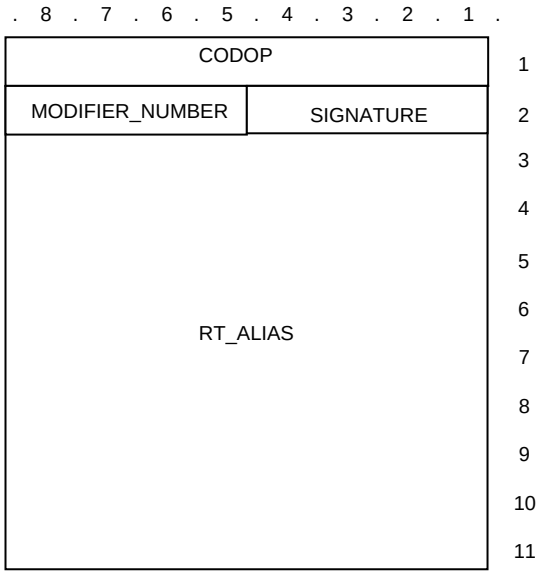

Figure 18 : TP_ALIAS LSDU : information field formats

Table 1: TP_ALIAS LSDU information elements list

IE	K	Condition	F	Length
CODOP	M		V	8 bits
MODIFIER_NUMBER	M	(see PAS 0001-16-3)	V	4 bits
SIGNATURE	M	(see PAS 0001-16-3)	V	4 bits
RT_ALIAS	M	(see PAS 0001-16-3)	V	9 octets

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6.4.2.3 AMBIENCE_LISTENING

Direction: RT --> RT

Carried by LPDU: UI_CD

Short description: This service allows to force an indicated terminal to transmit without any action and without notification during a desired delay ; the request shall specify the desired delay, the logical identifier (RFSI) which identifies the ST, the transmission priority for the indicated terminal.

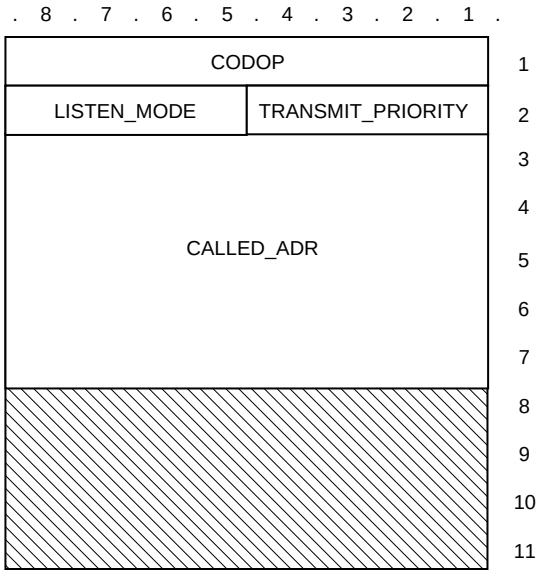

Figure 19 : AMBIENCE_LISTENING LSDU : information field formats (numeric address or alias)

Table 2: AMBIENCE_LISTENING LSDU information elements list

IE	K	Condition	F	Length
CODOP	M		V	8 bits
LISTEN_MODE	M		V	4 bits
TRANSMIT_PRIORITY	M		V	4 bits
RT_ADDRESS	M		V	5 octets

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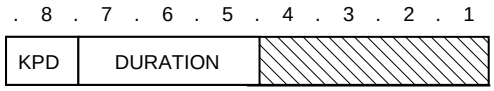
6.4.3 Information elements

CODOP	0 .....Reserved 1..... TP_ADDRESS 2..... TP_ALIAS 3.....AMBIENCE_LISTENNING 4..... TP_ADDRESS_CHIF 5..... TP_ADDRESS_INHIB 6..... TP_ADDRESS_CHIF_INHIB

TRANSMIT_PRIORITY	Priority of RT transmissions..... 4 bit field Indicates the priority of the RT requesting transmission rights or the priority of the selected RT. See TRANSMIT_PRIORITY information element in the VOICE CONTROL PROTOCOL subclause
CALLED_ADR	The format is the ADDRESS format described in PAS 0001-3-2.
LISTEN_MODE	Define called RT behaviour .....Field of 4 bits  • **KPD .....Field of 1 bits** Keypad mode; 0.....Keypad avalaible 1.....Keypad locked • **DURATION .....Field of 3 bits** Listening duration, defined per step of 4s ; 0.....no limitation, 1..... 4s ; 2..... 8s ; ..... 6..... 24s ; 7..... 28s ;
MODIFIER_NUMBER	(see PAS 0001-16-3)
RT_ADDRESS	(see PAS 0001-16-3)
RT_ALIAS	(see PAS 0001-16-3)
SIGNATURE	(see PAS 0001-16-3)

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7. History

Document history		
Date	**Status**	**Comment**
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28 February 1996	Edition	Version 0.0.3
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30 April 1996	TETRAPOL Forum approval	Version 1.0.0
31 July 1996	Formatting	Version 1.0.1
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16 December 1997	Corrections	version 1.1.1
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