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Digital cellular telecommunication system (Phase 2+); Discontinuous Transmission (DTX) for Adaptive Multi-Rate (AMR) speech traffic channels (GSM 06.93 version 7.1.1 Release 1998)

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Foreword

This European Standard (Telecommunications series) has been produced by Special Mobile Group (SMG).

The present document describes the general baseband operation of Adaptive Multi Rate speech traffic channels in the transmitter and in the receiver of GSM Mobile Stations and Base Station Systems during Discontinuous Transmission (DTX) within the digital cellular telecommunications system.

The present document corresponds to GSM technical specification, GSM 06.93 AMR, version X.X.X.

The contents of the present document is subject to continuing work within SMG and may change following formal SMG approval. Should SMG modify the contents of the present document it will be re-released with an identifying change of release date and an increase in version number as follows:

Version 7.x.y

where:

7 indicates Release 1998 of GSM Phase 2+

x the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

y the third digit is incremented when editorial only changes have been incorporated in the specification.

National transposition dates	
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Date of withdrawal of any conflicting National Standard (dow):	30 September 2000

1 Scope

The present document gives a description of the general baseband operation of Adaptive Multi Rate speech traffic channels in the transmitter and in the receiver of GSM Mobile Stations (MS)s and Base Station Systems (BSS)s during Discontinuous Transmission (DTX).

For clarity, the description is structured according to the block diagrams in figures 1 and 3. Except in the case described next, this structure of distributing the various functions between system entities is not mandatory for implementation, as long as the operation on the air interface and on the speech decoder output remains the same.

In the case of BSSs where the speech transcoder is located remotely in the Base Station Controller (BSC), the implementation of the interfaces between the DTX handlers and the Radio Sub System (RSS) as described in the present document together with all their flags is mandatory, being part of the A-bis interface as described in GSM 08.60 [13].

The DTX functions described in this technical specification are mandatory for implementation in the GSM MSs. The receiver requirements are mandatory for implementation in all GSM BSSs, the transmitter requirements only for those where downlink DTX will be used.

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, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.
- For this Release 1998 document, references to GSM documents are for Release 1998 versions (version 7.x.y).

[1] GSM 01.04: "Digital cellular telecommunication system (Phase 2+); Abbreviations and acronyms".

[2] GSM 04.08: "Digital cellular telecommunication system (Phase 2+); Mobile radio interface layer 3 specification".

[3] GSM 05.03: "Digital cellular telecommunication system (Phase 2+); Channel coding".

[4] GSM 05.05: "Digital cellular telecommunication system (Phase 2+); Radio transmission and reception".

[5] GSM 05.08: "Digital cellular telecommunication system (Phase 2+); Radio subsystem link control".

[6] GSM 06.71: "Digital cellular telecommunications system (Phase 2+); Adaptive Multi-Rate (AMR) speech processing functions; General description".

[7] GSM 06.73: "Digital cellular telecommunications system (Phase 2+); ANSI-C code for the GSM Adaptive Multi-Rate speech codec".

[8] GSM 06.74: "Digital cellular telecommunications system (Phase 2); Test vectors for the GSM Adaptive Multi-Rate speech codec".

[9] GSM 06.90: "Digital cellular telecommunications system (Phase 2+); Adaptive Multi-Rate speech transcoding".

[10] GSM 06.91: "Digital cellular telecommunications system (Phase 2+); Substitution and muting of lost frame for Adaptive Multi-Rate speech traffic channels".

[11] GSM 06.92: "Digital cellular telecommunications system (Phase 2+); Comfort noise aspects for Adaptive Multi-Rate speech traffic channels".

[12] GSM 06.94: "Digital cellular telecommunications system (Phase 2+); Voice Activity Detector (VAD) for Adaptive Multi-Rate speech traffic channels".

[13] GSM 05.09: "Digital cellular telecommunication system (Phase 2+); Link Adaptation".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purpose of the present document, the following terms and definitions apply.

frame: Time interval of 20 msec. corresponding to the time segmentation of the Adaptive Multi Rate speech transcoder (GSM 06.90 [9]), also used as a short term for a traffic frame.

traffic frame: Block of 95.244 information bits transmitted on the TCH/AFS or TCH/AHS speech traffic channels.

SID frame: Frame characterised by the SID (Silence Descriptor) gross bit pattern. It may convey information on the acoustic background noise.

speech frame: Traffic frame that has been classified as a SPEECH frame.

VAD flag: Boolean flag, generated by the VAD algorithm defined in GSM 06.94 [12] indicating the presence ("1") or the absence ("0") of a speech frame.

RX_TYPE: flag with eight values, generated by the RX radio subsystem, indicating to the RX DTX handler the type of data in the current frame. Refer to Table 2.

TX_TYPE: flag with four values, generated by the TX DTX handler, indicating to the TX radio subsystem the type of data in the current frame. Refer to Table 1.

hangover period: A period of 7 frames added at the end of a speech burst in which VAD flag ="0" and TX_TYPE is ="00".

3.2 Symbols

For the purpose of the present document, the following symbols apply.

$N_{elapsed}$ Number of elapsed frames since the last updated SID frame.

3.3 Abbreviations

For the purpose of the present document, the following abbreviations apply.

BSC	Base Station Controller
BSS	Base Station System
CHD	Channel Decoder
CHE	Channel Encoder
DTX	Discontinuous Transmission
ETS	European Telecommunication Standard
FACCH	Fast Associated Control CHannel
GSM	Global System for Mobile Telecommunications
MS	Mobile Station

RSS	Radio Sub System
RX	Receive
SACCH	Slow Associated Control CHannel
SID	Silence Descriptor (Really Background Descriptor)
TX	Transmit
VAD	Voice Activity Detector

For abbreviations not given in this subclause, see GSM 01.04 [1].

4 General

Discontinuous Transmission (DTX) is a mechanism which allows the radio transmitter to be switched off most of the time during speech pauses for the following two purposes:

- to save power in the Mobile Station (MS);
- to reduce the overall interference level over the air interface.

DTX shall be in operation in GSM MS if commanded so by the network, see GSM 04.08 [2].

4.1 General organisation

The overall DTX mechanism described in the present document requires the following functions:

- a Voice Activity Detector (VAD) on the transmit (TX) side;
- evaluation of the background acoustic noise on the transmit (TX) side, in order to transmit characteristic parameters to the receive (RX) side;
- generation on the receive (RX) side of a similar noise, called comfort noise, during periods where the radio transmission is switched off.

The Voice Activity Detector (VAD) is defined in GSM 06.94 [12] and the comfort noise functions in GSM 06.92 [11]. Both are based partly on the speech transcoder and its internal variables, defined in GSM 06.90 [9].

In addition to these functions, if the parameters arriving at the RX side are detected to be seriously corrupted by errors, the speech or comfort noise must be generated from substituted data in order to avoid seriously annoying effects for the listener. This function is defined in GSM 06.91 [10].

An overall description of the speech processing parts can be found in GSM 06.71 [6].

5 Transmit (TX) side

A block diagram of the transmit side DTX functions is shown in figure 1.

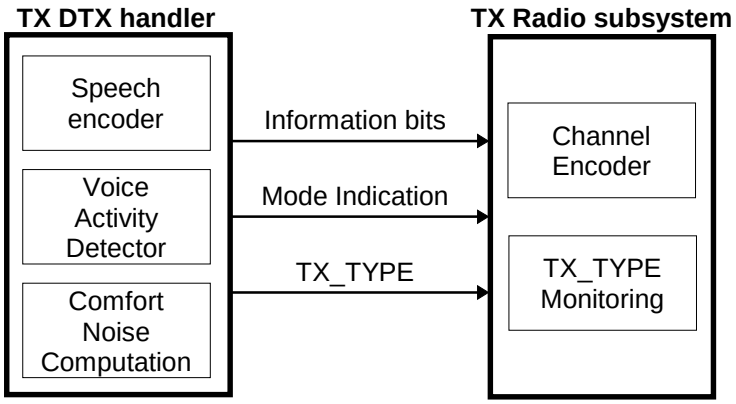


Figure 1: Block diagram of the transmit side DTX functions

5.1 General operation

The TX DTX handler passes traffic frames, individually marked by TX_TYPE, to the Radio Subsystem (RSS). Each frame passed to the RSS consists of bit fields containing the information bits, the codec mode indication, and the TX_TYPE. TX_TYPE shall be used to specify the contents of the frame. The table below provides an overview of the different TX_TYPEs used and explains the required contents in the information bit and the mode indication bit fields.

Table 1: TX TYPE identifiers

TX_TYPE	Legend	Information Bits	Mode Indication
00	SPEECH	speech frame, size 95.244 bits depending on codec mode	current code mode
01	SID_FIRST (END-MARKER)	no useful information	the codec mode that would have been used if TX_TYPE had been 00 (SPEECH)
10	SID_UPDATE	comfort noise, 35 bits	the codec mode that would have been used if TX_TYPE had been 00 (SPEECH)
11	NO_DATA	no useful information	no useful information

TX_TYPE = "11" indicates that the Information Bit and Codec Mode fields do not contain any useful data (and shall not be transmitted over the air interface). The purpose of this TX_TYPE is to provide the option to save transmission between the transcoder and the radio base station if a packet oriented transmission is used.

The scheduling of the frames for transmission on the air interface is controlled by the TX DTX handler by the use of the TX_TYPE field.

5.1.1 Functions of the TX DTX handler

To allow an exact verification of the TX DTX handler functions, all frames before the reset of the system are treated as if there were speech frames of an infinitely long time. Therefore, the first 7 frames after the reset are always marked with TX_TYPE= "00"", even if VAD flag ="0" (hangover period, see figure 2).

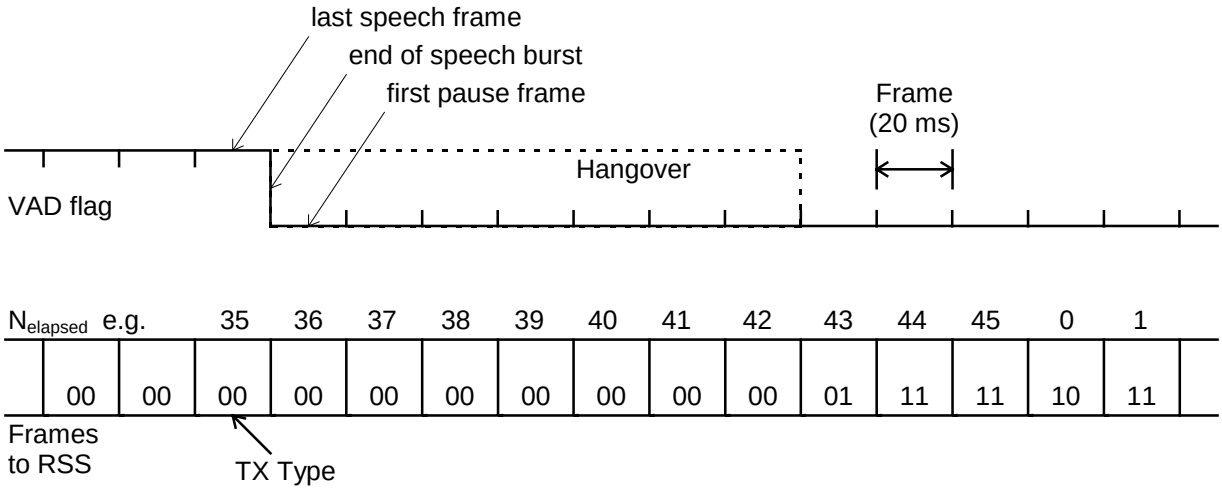
The Voice Activity Detector (VAD) shall operate all the time in order to assess whether the input signal contains speech or not. The output is a binary flag (VAD flag ="1" or VAD flag ="0", respectively) on a frame by frame basis (see GSM 06.94 [12]).

The VAD flag controls indirectly, via the TX DTX handler operations described below, the overall DTX operation on the transmit side.

Whenever VAD flag ="1", the speech encoder output frame along with mode information shall be passed directly to the radio subsystem (RSS), marked with TX_TYPE ="00"

At the end of a speech burst (transition VAD flag ="1" to VAD flag ="0"), it takes 8 consecutive frames to make a new updated SID analysis available (see GSM 06.92 [11]). Normally, the first 7 speech encoder output frames after the end of the speech burst shall therefore be passed directly to the RSS, marked with TX_TYPE ="00" ("hangover period").

The end of the speech is then indicated by passing frame 8 after the end of the speech burst to the RSS, marked with TX_TYPE = "01" (SID_FIRST) (see figure 2).



TX Types: “00” = SPEECH; “01” = SID_FIRST; “10” = “SID_UPDATE; “11” = NO DATA
$N_{elapsed}$: No. of elapsed frames since last SID_UPDATE

Figure 2: Normal hangover procedure ($N_{elapsed}$ > 23)

If, however, at the end of the speech burst, less than 24 frames have elapsed since the last SID_UPDATE frame was computed and passed to the RSS, then this last analysed SID_UPDATE frame shall repeatedly be passed to the RSS whenever a SID_UPDATE frame (TX_TYPE="10") is to be produced, until a new updated SID analysis is available (8 consecutive frames marked with VAD flag ="0").This reduces the activity on the air in cases where short background noise spikes are taken for speech, by avoiding the "hangover" waiting for the SID frame computation.

Once the first SID analysis after the end of a speech burst has been computed and the SID_FIRST frame (TX_TYPE = "01") has been passed to the Radio Subsystem, the TX DTX handler shall at regular intervals compute and pass updated SID_UPDATE (Comfort Noise) frames (TX_TYPE = "10") to the Radio Subsystem (RSS) as long as VAD flag = "0". SID_UPDATE frames shall be generated every 8^{th} frame. The first SID_UPDATE shall be sent as the third frame after the initial SID_FIRST frame.

The speech encoder is operated in full speech modality if TX_TYPE = "00" and otherwise in a simplified mode, because not all encoder functions are required for the evaluation of comfort noise parameters and because comfort noise parameters are only to be generated at certain times.

5.1.2 Functions of the TX Radio Subsystem

The TX Radio Subsystem has the following overall functionality. The radio transmission is cut after the transmission of a SID_FIRST frame when the speaker stops talking. During speech pauses the transmission is resumed at regular intervals for transmission of one SID_UPDATE frame, in order to update the generated comfort noise on the RX side (and to improve the measurement of the link quality by the RSS). Note that the transcoder knows what frames to send. In the case when nothing is to be transmitted it outputs frames marked with TX_TYPE = "11".

Within the TX Radio Subsystem the TX_TYPE Monitoring unit controls the operation of the Channel Encoder (as specified in GSM 05.03 [3]) and the Transmission of the frame. Control input to the TX_TYPE Monitoring unit is the TX_TYPE. Control output and input to the Channel Encoder are indicators specifying the frame format. These frame format indicators are defined in GSM 05.03 [3], they are different for TCH/AFS and TCH/AHS.

5.1.2.1 Functions of the TX Radio Subsystem for TCH/AFS

The TX Radio Subsystem operates in the following way regarding DTX:

- all frames marked with TX_TYPE = "00" (SPEECH) are scheduled for normal channel coding and transmission. The frame format for CHE operation shall be SPEECH. If, however, the previous frame was not of TX_TYPE = "00" or of TX_TYPE = "01", an ONSET frame format followed by SPEECH shall be signalled to the CHE;

- for frames marked with TX_TYPE = "01" (SID_FIRST) a SID_FIRST frame format is signalled to the CHE. Normally, only the first 4 TDMA frames carrying bits of this frame (and carrying the second half of the preceding SPEECH frame) shall be transmitted. The remaining bits of the SID_FIRST frame pre-set the interleaver buffer with a special bit pattern for the case a frame marked with TX_TYPE = "00" (SPEECH) is immediately following;

- frames marked with TX_TYPE = "10" (SID_UPDATE) are scheduled for SID_UPDATE frame channel coding and transmission. The frame format signalled to CHE is SID_UPDATE;

- for frames marked with TX_TYPE = "11" (NO_DATA) no processing or transmission is carried out.

If a SID_FIRST frame or the first SID_UPDATE frame after a SID_FIRST frame, is stolen for Fast Associated Control Channel (FACCH) signalling purposes, then the subsequent frame shall be scheduled for transmission of the SID_FIRST or SID_UPDATE frame (whichever applies) instead.

When operating in non-speech after a handover the GSM-MS shall schedule its most recent SID_UPDATE (TX_TYPE = "10") frame instead of the first incoming (TX_TYPE = "11") frame to update the remote speech decoder's Comfort Noise states. This action is aborted if the transcoder schedules a new SID_UPDATE (TX_TYPE = "10") frame.

SPEECH frames shall override possible SID_FIRST or SID_UPDATE frames in these exceptional cases.

5.1.2.2 Functions of the TX Radio Subsystem for TCH/AHS

The TX Radio Subsystem operates in the following way regarding DTX:

- all frames marked with TX_TYPE = "00" (SPEECH) are scheduled for normal channel coding and transmission. The frame format for CHE operation shall be SPEECH. However, if the previous frame was of TX_TYPE = "01" (SID_FIRST), a SID_FIRST_INH frame format followed by SPEECH shall be signalled to the CHE. If the previous frame was of TX_TYPE = "10" (SID_UPDATE), a SID_UPDATE_INH frame format followed by SPEECH shall be signalled to the CHE. If the previous frame was of TX_TYPE "11" (NO_DATA), an ONSET frame format followed by SPEECH shall be signalled to the CHE;

- for frames marked with TX_TYPE = "01" (SID_FIRST) a SID_FIRST_P1 frame format is signalled to the CHE. All 4 TDMA frames carrying the bits of this frame shall be transmitted. The Mode Indication received with the frame is stored for potential use in the next frame;

- for frames marked with TX_TYPE = "10" (SID_UPDATE) a SID_UPDATE frame format is signalled to the CHE. All 4 TDMA frames carrying the bits of this frame shall be transmitted;

- for frames marked with TX_TYPE = "11" (NO_DATA), no processing or transmission is carried out. However, if the preceding frame was marked with TX_TYPE = "01" (SID_FIRST), a SID_FIRST_P2 frame format is signalled to CHE. The 2 TDMA frames carrying bits of this frame shall be transmitted. If, depending on the current frame number, the Mode Indication is to be transmitted with these TDMA frames, the Mode Indication shall be used that was stored during the processing of the preceding SID_FIRST frame.

If a SID_FIRST frame or the first SID_UPDATE frame after a SID_FIRST frame, is affected by Fast Associated Control Channel (FACCH) signalling purposes, then the SID_FIRST or SID_UPDATE frame (whichever applies) shall be rescheduled for transmission immediately after the FACCH signalling.

When operating in non-speech after a handover the GSM-MS shall schedule its most recent SID_UPDATE (TX_TYPE = "10") frame instead of the first incoming (TX_TYPE = "11") frame to update the remote speech decoder's Comfort Noise states. This action is aborted if the transcoder schedules a new SID_UPDATE (TX_TYPE = "10") frame.

SPEECH frames shall override possible SID_FIRST or SID_UPDATE frames in these exceptional cases.

6 Receive (RX) side

A block diagram of the receive side DTX functions is shown in figure 3.

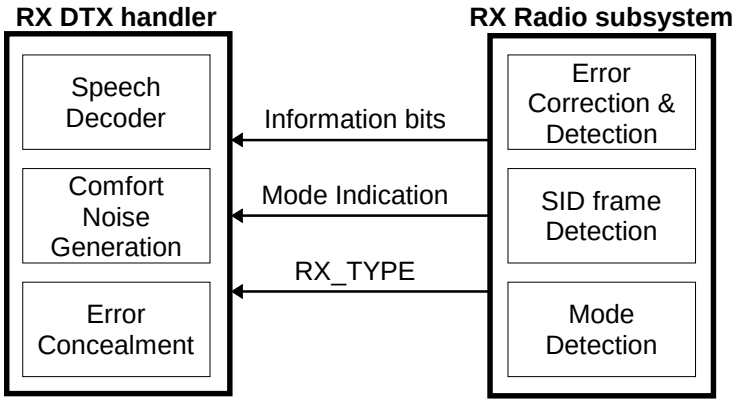


Figure 3: Block diagram of the receive side DTX functions

6.1 General operation

Whatever their context (speech, SID, FACCH or none), the RSS continuously passes the received traffic frames to the RX DTX handler, individually marked by various pre-processing functions with a 3 bit type indicator RX_TYPE described in subclause 6.1.1 and table 2, which serve to classify the traffic frame. This classification allows the RX DTX handler to determine in a simple way how the received frame is to be handled.

Table 2: RX_TYPE identifiers

RX_TYPE	Legend	Description
000	**SPEECH_GOOD**	Speech frame with CRC OK, Channel Decoder soft values also OK
001	**SPEECH_PROBABLY_DEGRADED**	Speech frame with CRC OK, but 1B bits and class2 bits may be corrupted
010	**SPEECH_BAD**	(likely) speech frame, bad CRC (or very bad Channel Decoder measures)
011	**SPARE**	Spare
100	**SID_FIRST**	first SID marks the beginning of a comfort noise period
101	**SID_UPDATE**	SID update frame (with correct CRC)
110	**SID_BAD**	Corrupt SID update frame (bad CRC; applicable only for SID_UPDATE frames)
111	**NO_DATA**	Nothing useable was received

6.1.1 Functions of the RX radio subsystem

The RX radio subsystem uses a combination of gross-bit markers, receiver measurements, and CRC checks to classify each received frame. The basic operation for each frame is outlined below:

- the receiver first searches for the SID_UPDATE or SID_FIRST gross bit markers. If the SID_FIRST marker is detected the frame is passed to the RX DTX handler as a SID_FIRST frame. If the SID_UPDATE marker is detected, the frame is decoded and passed to the RX DTX handler as a SID_UPDATE or a SID_BAD frame (depending on the CRC) along with the comfort noise parameters.

- if neither SID_UPDATE nor SID_FIRST markers are detected, the frame is channel decoded assuming it to be a speech frame. Depending on the CRC for speech frame channel decoding along with other receiver measurements the frame is then passed to the RX DTX handler marked as either SPEECH_GOOD,

SPEECH_PROBABLY_DEGRADED, SPEECH_BAD or NO_DATA frame. The decoder enters mode SPEECH when a SPEECH_GOOD or a SPEECH_PROBABLY_DEGRADED frame is decoded.

6.1.2 Functions of the RX DTX handler

The RX DTX handler is responsible for the overall DTX operation on the RX side.

The DTX operation on the RX side shall be as follows:

- whenever a frame classified SPEECH_GOOD is received the DTX handler shall pass it directly on to the speech decoder;
- when a frame classified as SPEECH_PROBABLY_DEGRADED, SPEECH_BAD or SID_BAD is received the substitution and muting procedure defined in GSM 06.91 [10] shall be applied;
- frames classified as SID_FIRST and SID_UPDATE shall result in comfort noise generation, as defined in GSM 06.92 [11], until the next SID_UPDATE frame has arrived or frames classified as SPEECH_OK or SPEECH_PROBABLY_DEGRADED are detected. During this period, the RX DTX handler shall ignore any unusable frames (NO_DATA) delivered by the RSS;
- if the decoder is not in Comfort Noise Generation mode, frames classified as NO_DATA shall be handled as SPEECH_BAD frames without valid speech information;
- frames classified as SPARE shall be handled as NO_DATA frames;
- in the speech decoder a single frame classified as SID_BAD shall be substituted by the last valid SID frame information and the procedure for valid SID_UPDATE frames be applied. If the time between SID information updates (updates are specified by SID_UPDATE arrivals and occasionally by SID_FIRST arrivals see 06.92) is greater than one second this shall lead to attenuation.

Annex A (informative): Document change history

SMG#	SPEC	CR	PHA	VERS	NEW_VER	SUBJECT
29	06.93	A001	R98	7.0.0	7.1.0	Changed SID update rate for AMR codec on TCH/AFS
29	06.93	A002	R98	7.0.0	7.1.0	Specification of handling of SPARE and NO_DATA RX_TYPEs
	06.93			7.1.0	7.1.1	Update to Version 7.1.1 for Publication

History

Document history		
V7.1.0	July 1999	One-step Approval Procedure OAP 9952: 1999-07-28 to 1999-11-26
V7.1.1	December 1999	Publication